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REPORT TO THE CONGRESS

BY THE COMPTROLLER GENERAL OF THE UNITED STATES

Management Action Needed In The Department Of Defense To Realize Benefits From A New System Of Aircraft Maintenance

A new maintenance concept has been used successfully by major commercial airlines, greatly reducing aircraft maintenance costs and improving aircraft availability for operations.

Many of these same results can be achieved by the military services. Defense has applied the concept on a trial basis and expects to expand its use throughout the Department. But the services will need a better management system for controlling the application of the concept so that maximum benefits can be obtained.

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

B-169217

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

This report shows that Department of Defense management action is needed to maximize the benefits of a new aircraft maintenance concept called reliability-centered maintenance, which promises savings and improved aircraft availability.

We made our review pursuant to the Budget and Accounting Act, 1921 (31 U.S.C. 53), and the Accounting and Auditing Act of 1950 (31 U.S.C. 67).

We are sending copies of this report to the Director, Office of Management and Budget; the Secretary of Defense; and the Secretary of the Navy.

Elmer B. Staats
Comptroller General
of the United States

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ABBREVIATIONS

DOD	Department of Defense
GAO	General Accounting Office
IMP	improved maintenance program

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

MANAGEMENT ACTION NEEDED IN THE DEPARTMENT OF DEFENSE TO REALIZE BENEFITS FROM A NEW SYSTEM OF AIRCRAFT MAINTENANCE

D I G E S T

Commercial airlines have adopted a new aircraft maintenance concept which limits routine maintenance to that which is meaningful to safety, reliability, and economics.

The concept has not degraded safe aircraft operation but it has greatly reduced aircraft maintenance costs and improved aircraft availability for operations. One major airline said it saved $65 million over 5 years by using the new concept. (See pp. 2 to 10.)

The Federal Aviation Administration has reviewed and approved numerous applications of the concept over a number of years.

The Navy has tested the new concept on its P-3 antisubmarine aircraft. The Secretary of Defense said this had resulted in a 40-percent reduction in scheduled maintenance. He also said he wanted the concept applied throughout the Department of Defense by 1978.

However, full benefits have not been obtained on the P-3 aircraft because the Navy needs

--better information systems with which to appraise maintenance programs and

--to take more specific action to capture program benefits.

These are matters of critical importance. The Department of Defense should establish a mechanism so that these matters are considered before other military services widely implement the improved-maintenance concept or before the concept is applied to other aircraft systems. (See ch. 5.)

With Defense aircraft maintenance costs currently aggregating over $6 billion annually and with an investment in aircraft and components and parts totaling almost $60 billion, the potential for savings is considerable.

MAXIMUM BENEFITS NOT ACHIEVED BY THE NAVY

An inherent aspect of the new maintenance concept is that data gathering and constant monitoring are necessary to bring about initial cost reductions and to identify new reductions.

GAO found that the Navy may not have achieved maximum benefits from the new concept. For example, although some P-3 aircraft maintenance tasks were eliminated and labor hours were reduced, the Navy cannot show that there have been personnel reductions or personnel reassignments to other duties.

This is because the Navy has not established a management system to estimate benefits and measure results. In addition to needing better information, the Navy needs more aggressive action to capture specific cost savings as they occur. These are the principal areas where the Navy has fallen short and the areas that should be emphasized before more widespread use of the new concept in Defense. (See pp. 12 to 25.)

AIRLINE EXPERIENCE USING THE CONCEPT

The airline concept says maintenance cannot increase aircraft reliability beyond the capability of its design. By analysis and data surveillance, unnecessary tasks are eliminated, thus reducing costs and improving safety by minimizing human error or part failure. Less scheduled maintenance means that less downtime is required. (See pp. 2 to 10.)

POTENTIAL FOR SAVINGS

Although the Navy has realized savings and improvements from the new concept, there are certain areas where it has not followed through to obtain maximum benefits. (See pp. 12 to 25.) For example:

--Although tasks were greatly reduced and could be reduced even more, no definitive action was planned or taken to reduce personnel requirements or reallocate labor resources.

--The potential increase in operational readiness was not achieved because scheduled maintenance was not reduced as task reductions indicated it should be.

--No actions were planned to reduce depot-visit time, which would improve aircraft availability or allow reduced purchases of aircraft to compensate for those in the depot (pipeline aircraft). For example, by achieving the realistic reduction from 80 to 52 days--even 36 days is possible--in P-3 depot-visit time, two pipeline aircraft (valued at $26 million) could be eliminated.

Total potential savings from applying the improved maintenance concept throughout Defense are substantial. Savings are possible through reduced procurements of aircraft, their spare parts and components, and labor costs to maintain aircraft.

The military services had over $48 billion invested in aircraft; in fiscal year 1976 they requested additional funds of $4.5 billion for purchasing new aircraft. The services had inventories of aircraft components and parts totaling $11 billion; in fiscal year 1976 they requested $1.5 billion to increase these inventories.

No one has been able to quantify savings on aircraft and aircraft parts purchases, but Defense and airline industry representatives believe that maintenance labor savings of

20 percent are achievable. On the basis of current aircraft maintenance costs of over $6 billion annually, savings could aggregate as much as $1 billion. (See pp. 26 to 32.)

RECOMMENDATIONS

The Secretary of Defense, through the Assistant Secretary of Defense (Installations and Logistics), should take a more active role in approving and monitoring concept applications and:

--Provide specific guidance to the military services on carrying out the concept, including criteria for the benefits which should be realized.

--In approving new applications, emphasize the importance of having well-defined and quantified goals and adequate provisions for monitoring project implementation.

--Require specific reporting on each concept application to insure appropriate action has been taken to maximize and capture resulting benefits, and reduce maintenance budgets or reallocate resources by the projected savings.

--Require the services to change their requirement computations for aircraft to include the higher operational-available time of aircraft. (See p. 34.)

AGENCY COMMENTS AND GAO's EVALUATION

The Department of Defense said that this report would be of significant benefit to Defense and that the report confirms certain areas as being crucial to successful implementation of the total Defense reliability-centered maintenance program.

The Department of Defense generally agreed with GAO's recommendations, except that it suggested GAO delete the recommendation on giving priority to new project applications with established goals and provisions for monitoring project implementation. GAO has

modified this recommendation in light of Defense's concern about possible delays in project implementations. But GAO believes it is important to emphasize the early establishment of goals and provisions for monitoring projects as a means for more effective achievement of the benefits of the reliability-centered maintenance concept. These factors should influence the choice of projects. (See pp. 35 to 38.)

CHAPTER 1

INTRODUCTION

In the late 1960s the airline industry adopted a new maintenance concept which enabled airlines to reduce costs and increase safety. The Secretary of Defense acknowledged the potential value of the new concept in his annual Department of Defense (DOD) report for fiscal year 1976 and pointed out that the Navy had realized a 40-percent reduction in scheduled maintenance during a P-3 squadron's trial application. The Secretary of Defense has established a goal of Department-wide application of the concept by June 1978.

Because its adoption represents a basic change in traditional military maintenance policy and offers the potential for considerable savings, we evaluated the new concept as it was applied to the Navy's P-3 program. We attempted to (1) compare the Navy's application to airline experience and (2) determine whether there were lessons from the Navy's early application which could improve later use of the concept for other Navy aircraft or other military aircraft.

SCOPE OF REVIEW

We discussed aspects of aircraft maintenance with key officials of the military services and of the Office of the Secretary of Defense. In addition, we interviewed officials from a number of commercial airline companies, Lockheed Aircraft Corporation (the P-3 contractor), and the Air Transport Association.

We also reviewed, and tested as necessary, various Navy documents about and procedures for aircraft maintenance. The principal installations we visited were Moffett Field Naval Air Station and Alameda Naval Air Station, California.

We limited our review to the Navy P-3 program. However, the basic issues addressed and improvements needed should be considered as potentially applicable to all military maintenance operations and programs.

CHAPTER 2

NEW MAINTENANCE CONCEPT--

WHAT IS IT AND WHAT DOES IT OFFER?

The airline industry developed the new maintenance concept to maintain the new wide-bodied, or jumbo jets. (See photographs on the following page.) The airlines found the concept also applied to older aircraft, and as a result, the airlines are now using it widely and to a growing extent to achieve economies and increased safety.

DEVELOPING THE CONCEPT

Airline maintenance of less complex, early aircraft was dedicated to totally preventing component failure, because nearly all failures directly reduced safety. This thinking continued through the early 1960s, causing maintenance programs to be built around various time intervals--flight-hours or calendar days--established to prevent component failures. Scheduled maintenance thus became characterized by extensive disassembly and overhaul of each aircraft. Component parts were replaced without regard to their actual condition. This kind of maintenance was expensive in both labor and material costs.

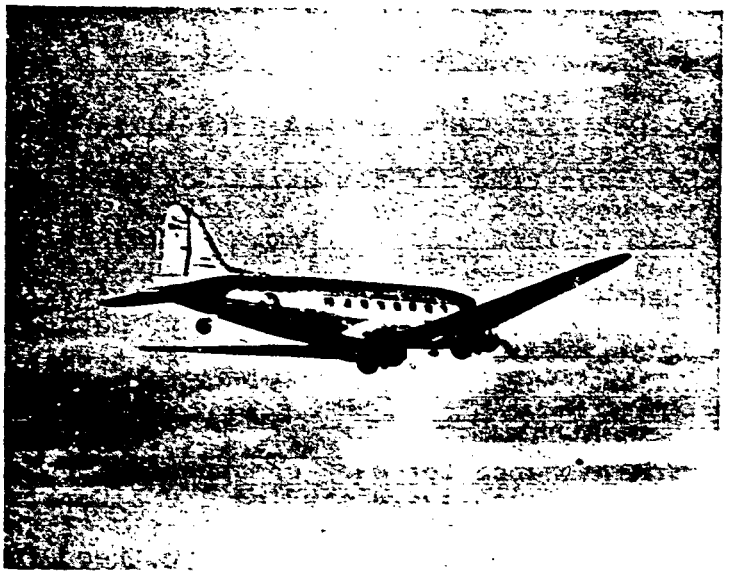
The following factors led to a search for an alternative to the traditional maintenance approach.

--System redundancies in modern aircraft designs lessened the critical nature of the relationship between reliability and safety.

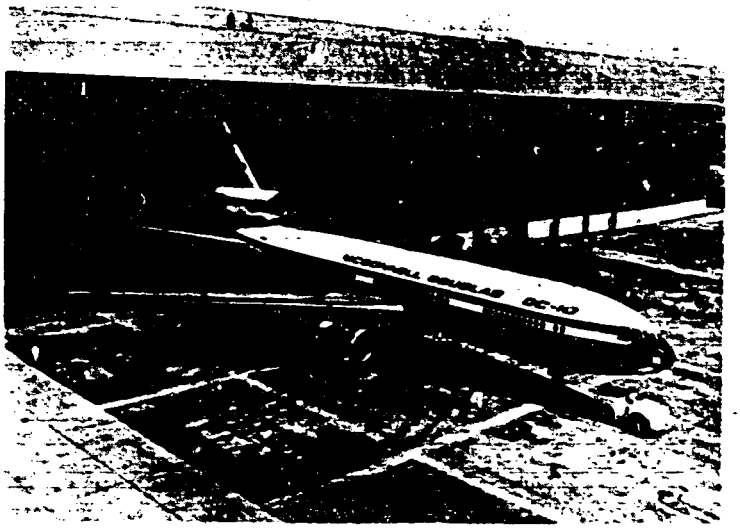
--Modern aircraft complexity and size made extensive overhauling uneconomical and impracticable.

--After 1964 the Federal Aviation Administration permitted airline operators to use statistical reliability results to adjust their maintenance programs.

The airlines were successful in developing the new concept. The concept has many names--reliability-centered maintenance, analytical maintenance, condition monitoring, or simply MSG-2 (after the handbook initiating its general use). The Federal Aviation Administration has approved many applications of the concept since the 1970 publication of handbook MSG-2. All the maintenance programs using the concept follow a common principle: perform only those tasks necessary to retain design levels of safety and reliability.



THE DOUGLAS DC-3 CAN TRANSPORT 21 PASSENGERS AND HAS A GROSS WEIGHT OF 24,000 POUNDS. AFTER ITS FIRST FLIGHT IN 1935, 803 COMMERCIAL AND 10,123 MILITARY AIRCRAFT WERE BUILT. EARLIER AIRCRAFT, SUCH AS THE DC-3, WERE SMALLER AND HAD FEWER REDUNDANCIES THAN TODAY'S WIDE-BODIED JETS.



THE MCDONELL DOUGLAS DC-10 CAN TRANSPORT 270 PASSENGERS AND HAS A GROSS WEIGHT OF 558,000 POUNDS. THE INTRODUCTION OF WIDE-BODIED JETS, SUCH AS THE DC-10, PROMPTED DEVELOPMENT OF RELIABILITY-CENTERED MAINTENANCE.

In other words, tasks which increase maintenance costs without increasing reliability or safety should not be scheduled.

Maintenance programs, based on reliability analysis, were developed partly because people were looking for the right time to schedule maintenance tasks. They found, however, that the right time did not exist for most items. Most assemblies were not subject to an effective, scheduled maintenance task to insure their continued reliability. This fact is not so surprising if it is remembered that (1) although all mechanical parts eventually deteriorate with age, many aircraft parts are designed not to do so during the aircraft's operating life and (2) modern aircraft components are often complex and have many interrelated parts.

These two facts account, in part, for the difficulty in scheduling maintenance for many components. United Airlines, for example, intensively studied 140 aircraft components from all aircraft types in its fleet. Of these components, 94 percent were found to have no need for a scheduled time limit for maintenance tasks. For components not subject to scheduled maintenance, periodic maintenance is wasteful and may actually be harmful, since the potential for mistakes by maintenance personnel is always present. Maintenance-caused failures occur not only from human error, which results in faulty installations or related-system disruptions, but also from defective replacement parts.

A Center for Naval Analyses study showed the effect maintenance can have on safety. The data studied, covering 3,176 Navy aircraft, showed an increasing rate of accidents and incidents after periodic depot-level maintenance. Specifically, there was an 8-percent increase in the accident rate and a 24-percent increase in the incident (less serious than an accident) rate during the five quarters after depot maintenance compared with the five quarters before depot maintenance. The new concept recognizes the unpredictable nature of failure for many complex assemblies and the possibility of maintenance-caused failures.

ANALYTICAL METHOD

The advanced-maintenance concept is based on the assumptions that:

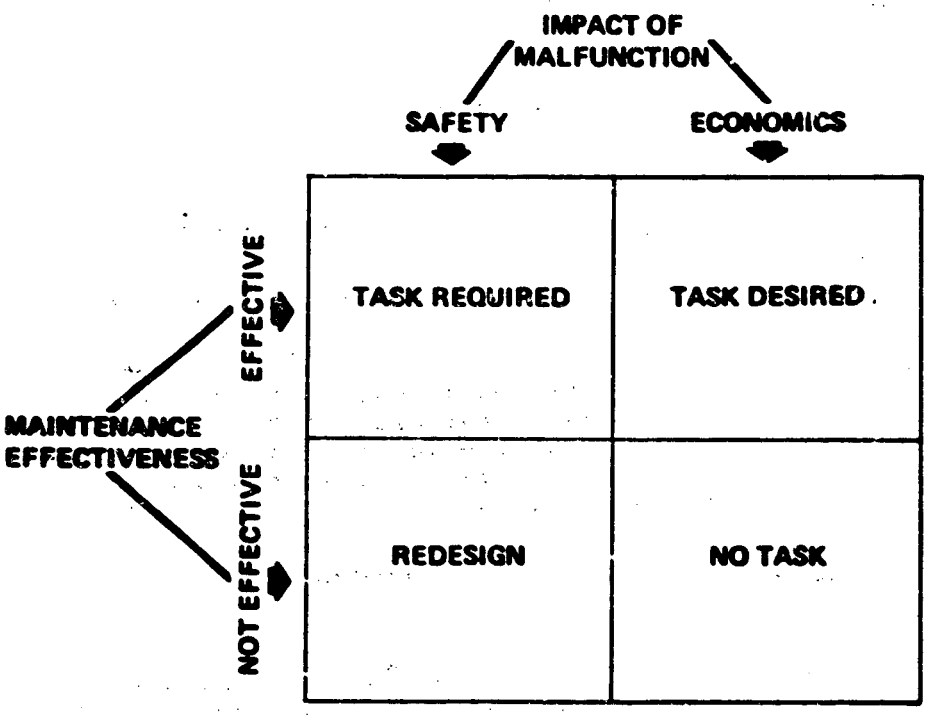
--Safety and reliability characteristics are inherent in design and good maintenance can only preserve these characteristics.

--Scheduled maintenance is not always effective, desirable, or economical.

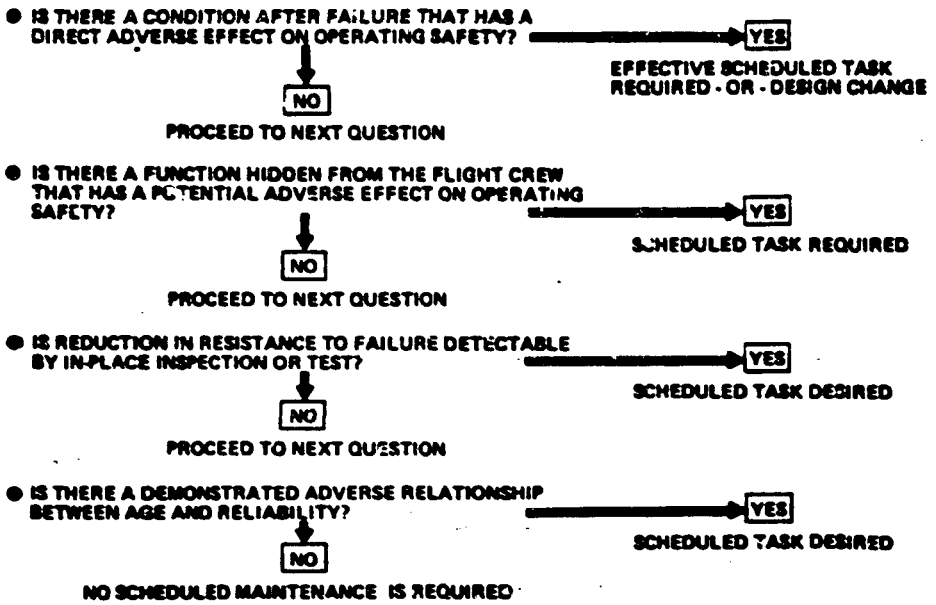
--A large percentage of aircraft components can fail without degrading flight safety or economics.

--The aircraft and its components, when properly analyzed, will dictate required maintenance.

The conceptual model for analyzing components and for deciding whether a maintenance task is required is illustrated in the following diagram.



On the basis of the assumptions and decision matrix above, analytical maintenance asks a logical series of questions to determine what kind of maintenance should be done for those items on the aircraft that are functionally significant.



MAINTENANCE CATEGORIES

The next step in the new maintenance concept concerns organizing the resulting scheduled maintenance program. Each task, which has been selected for the program because it is required or desirable, is designated for either "fixed frequency" or "on-condition maintenance." The remaining tasks are designated for "condition monitoring."

--Fixed-frequency or hardtime maintenance applies to those items which demonstrate a predictable relationship between age and reliability degradation. The items are normally removed at their maximum interval for overhaul and/or replacement with new units.

--On-condition maintenance applies to those items for which repetitive inspections or tests can be used to determine their condition. Such inspections or tests are scheduled in the maintenance program.

--Condition monitoring applies to those items which are not subject to an effective maintenance task. The failure history of these may be monitored for indications of a need for reclassification or redesign.

WHAT DOES THE NEW CONCEPT OFFER?

The nature of airline operations is such that their experience with maintenance techniques can be a useful guide to the military services. As the result of reliability-centered maintenance techniques, airlines have benefited from improved operations and cost effectiveness. Airlines have improved their operations by increasing aircraft availability and by increasing safety and reliability. Costs have been minimized by the elimination, reduced frequency, or more efficient arrangement of individual scheduled-maintenance tasks. The reduction in total maintenance performed has permitted savings from reduced (1) labor costs, (2) component inventories, and (3) aircraft purchases needed to service routes.

AIRLINE AND DEPARTMENT OF DEFENSE COMPARISONS

The Federal Aviation Administration regulates all aspects of the safety of commercial aircraft, including operations, maintenance, and flight crews. The success of the airline industry depends on its ability to operate safely and economically. The airlines listed below, which use reliability-centered maintenance, make up 72 percent of the U.S. air carrier fleet and are the guiding force in the industry. The tempo of their operations is fast. For example, for the year ended October 31, 1975, these airlines made 2.8 million scheduled departures to fly 1.6 billion miles. As of September 30, 1975, these airlines had 1,828 aircraft, as follows.

Airline	Aircraft	Airline	Aircraft
United	395	Northwest	105
Trans World	262	Braniff	82
American	242	Western	76
Eastern	235	Continental	60
Delta	186	National	56
Pan American	129		
		Total	1,828

Although the airlines had a large aircraft inventory, the military aircraft inventory as of September 30, 1975, was even larger, as shown in the following table.

Army	8,554
Navy	6,133
Air Force	9,447
Total	24,134

Management of this military aircraft inventory is complex not only because of its size but also because of the variety of aircraft in it. The Navy, for example, has aircraft of about 100 different designs in its inventory.

AIRLINES' EXPERIENCE WITH ANALYTICAL MAINTENANCE PROGRAMS

We visited a number of airlines, different in size and route structure, to discuss their experience with analytical maintenance programs. All the airlines are using or planned to use reliability programs for their aircraft.

Modern airline maintenance techniques are aimed at reduced maintenance costs, increased aircraft availability, and improved safety. The officials we interviewed believed emphatically that their reliability-centered maintenance programs had produced solid benefits.

Some of the more important comments are summarized as follows:

--The primary inducement to introduce reliability programs was cost reduction. All the officials we talked with emphasized that maintenance costs were reduced initially and that with experience and constant monitoring new reductions can be identified. For example, one official of an airline that had used reliability techniques for over 10 years told us that the maintenance force had been reduced by about 10 percent only a few months ago. He attributed this reduction to experience gained in the last few years from the airlines's reliability program.

--The reduction in hardtime maintenance schedules was considerable--less than 20 percent of maintenance was being scheduled.

--No reliability program is worth the investment if management does not have a system to monitor results and identify problems quickly.

--To insure that benefits obtained from the new programs were maximized, the airlines stressed labor-hour controls, work-flow planning, and periodic budget reviews for cost control. Each airline had groups whose sole functions were to analyze data and modify maintenance tasks to improve reliability and economy. For example, parts and maintenance skills were prepositioned at maintenance facilities to prevent extended maintenance time for aircraft.

--Employees have been affected in various ways by the improved maintenance programs. One airline cited a 1-year reduction in a maintenance department from 106 to 90 employees. Another airline said it had increased its fleet without proportionately increasing its maintenance personnel. In general, maintenance employees' morale has improved because the employees know the work they do under the new program is considered necessary.

RESULTS OF ANALYTICAL MAINTENANCE PROGRAMS

The results of the airlines' rigorous application of analytical maintenance programs to both new and existing aircraft have been impressive. The table below, taken from a study by the Center for Naval Analyses, includes aircraft (707s) more than 16 years old as well as the new jumbo jets (747s). It shows what the percent of scheduled (hard-time) maintenance items was when the aircraft came into service and what the percent was on the same aircraft recently. Clearly these maintenance programs can be applied to aircraft of old designs as well as to those of new designs.

Type of Maintenance and Percent of Items Included

Aircraft model	Scheduled (hard-time)		On condition and condition monitored	
	Original	Recent	Original	Recent
707,720	99.0	40.0	1.0	60.0
727	55.5	40.0	44.5	60.0
737	53.0	29.0	47.0	71.0
747	-	.3	-	99.7
DC-10	-	2.0	-	98.0
L-1011	-	2.0	-	98.0

Private survey shows growth of use

Major U.S. and Canadian airlines are using the new reliability concept to a growing extent, according to a 1975 survey by Aviation Week and Space Technology Magazine. The survey also showed that an increasing number of smaller airlines were using the techniques or planning to use them as soon as they could afford the data equipment needed to analyze statistical reliability results.

Pan American and United were among the 19 respondents to the survey. Their responses highlight the airlines' experience with the concept. Both have converted their narrow-bodied aircraft, as well as their other aircraft, to

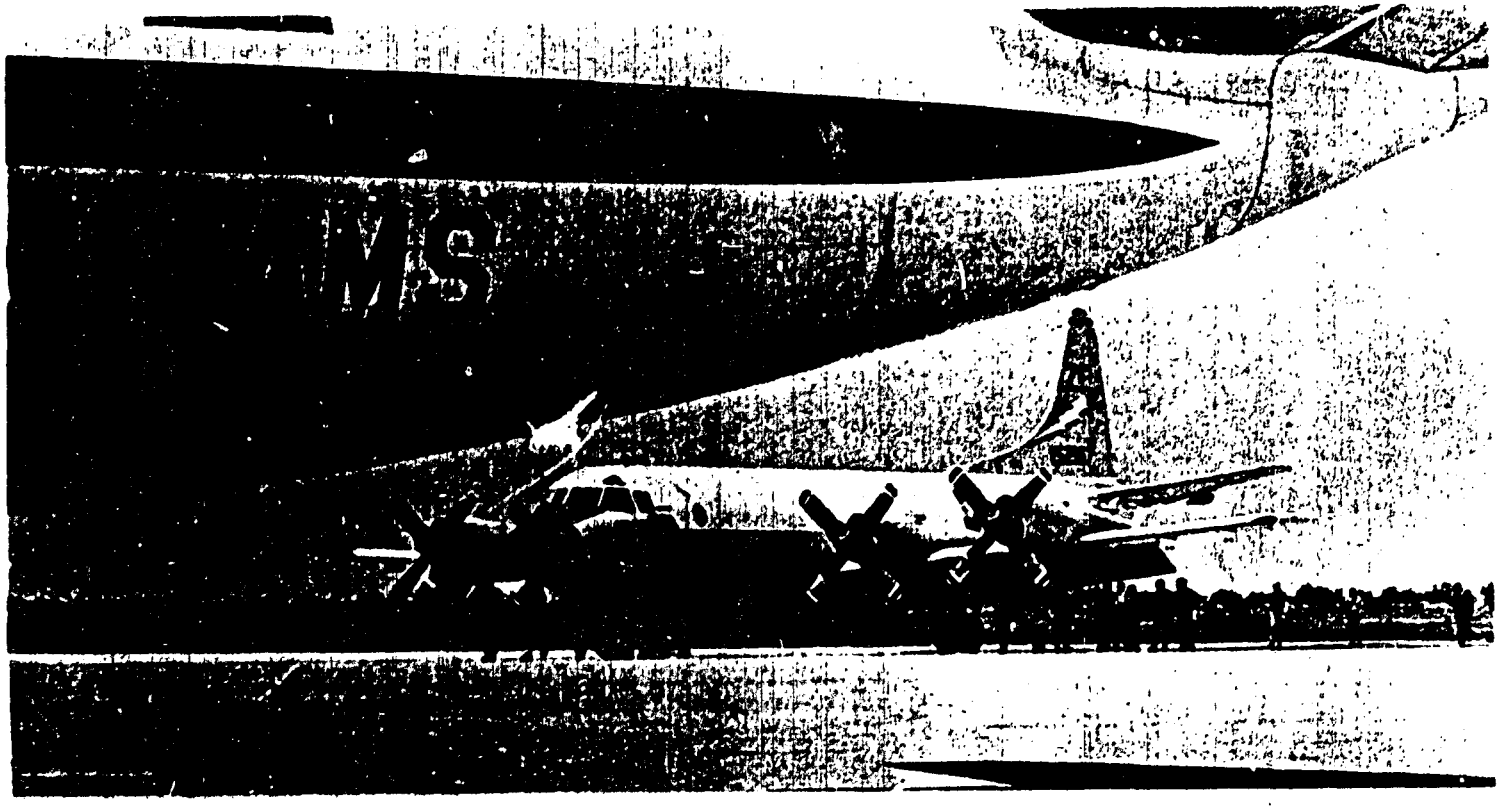
the new concept. Pan American's use of condition monitoring (no task is scheduled but data is analyzed) increased from 21 percent in 1970 to 85 percent in 1975. Both airlines returned some components to scheduled maintenance when they could save money or time. The following table, based on Pan American's figures, shows annual savings resulting from the advanced maintenance concept.

	Labor savings (note a)	Material savings
1971	$10,016,658	$ 2,058,221
1972	10,244,322	2,104,999
1973	11,382,570	2,338,888
1974	11,439,486	2,350,582
1975	11,496,294	2,362,276
	$54,579,330	$11,214,966

a/Savings were computed using an hourly rate of $18 and the hours Pan American saved.

CONCLUSIONS

The airline industry has successfully used this new maintenance concept. It has proved to be safe and has provided a basis for large reductions in labor and material costs. Since the military services have much larger investments in aircraft inventories and have much higher annual costs for aircraft maintenance, the potential for major savings in DOD is considerably greater. But the commercial airlines' experience has identified a number of matters that need to be emphasized if these savings are to be achieved. The Navy's test application of the maintenance concept on its P-3 aircraft substantiates the airlines' experience. (See ch. 3.)



P-3 PATROL AIRCRAFT

CHAPTER 3

SUMMARY OF AN EARLY MILITARY APPLICATION

The Navy, late in 1972, contracted with Lockheed Aircraft Corporation to develop at a price of $198,225 a pilot program to reduce scheduled organizational maintenance 1/ for P-3 aircraft 2/ using the new decisionmaking concept and techniques. The resulting improved maintenance program (IMP) was used at one Navy P-3 squadron for a 6-month trial period ended January 1974. On the basis of the results of the trial period, the Navy adopted the IMP and in July 1974 began implementing the program at other P-3 squadrons. Lockheed was awarded an additional contract for $113,287 to assist in the implementation.

Late in 1973, before the IMP trial period was completed, the Navy contracted with Lockheed to develop, at a cost to the Navy of $179,290, an improved depot maintenance 3/ program for the P-3 aircraft, again using the new maintenance concept. Lockheed issued its final report in June 1974, and the Navy issued its new depot-level maintenance program (often called the DLM program) requirements based on Lockheed's recommendations on July 1, 1975. At that time, the Naval Air Rework Facility, Alameda, California, received its first P-3 aircraft for depot processing under the new concept.

The next two sections summarize the Navy's goals and reported accomplishments (anticipated accomplishments for the depot-level maintenance program) for the IMP and depot-level maintenance program, respectively, and our observations on the reported and anticipated accomplishments.

1/The Navy assigns aircraft maintenance responsibility at three levels--organization, intermediate, and depot. Organizational maintenance is the least complex and is performed by military personnel of each squadron to which aircraft are assigned. (See app. III for a full description of each maintenance level.)

2/A long-range, land-based, four-engine, antisubmarine-warfare aircraft manufactured for the Navy by Lockheed. (See the photograph on the preceding page.)

3/Depot maintenance, in contrast to organizational maintenance, is the highest level provided and is done in large industrial-type facilities employing a primarily civilian labor force.

GOALS AND REPORTED ACCOMPLISHMENTS AT THE ORGANIZATIONAL LEVEL

Before award of the IMP contract, Navy and Lockheed officials met to review the program and to discuss several program elements. During this meeting--a record of which was incorporated in the IMP contract--it was agreed that it would be desirable to have quantitative measures for assessing the merits of the program. The parameters were (1) elapsed time, (2) labor-hours for each scheduled maintenance task, and (3) aircraft downtime for scheduled maintenance.

Although goals of reducing maintenance costs by 25 percent and increasing aircraft operational readiness by 20 percent were discussed during the meeting, they were not adopted as formal program measures, as indicated by the following extract from the record.

> "It was established that * * * [the Navy] understood that, with regard to the goals previously stated, that they are in the strictest sense 'goals' which, hopefully, will be achieved when the program has matured and is incorporated fleetwide. * * * the specific values * * * were derived from the gains realized by commercial airlines as a result of adopting programs similar to the proposed Improved Maintenance Program."

The section of the final contract dealing with evaluation simply states that the contractor will help the Navy evaluate the effectiveness of the new program and that operational readiness and maintenance labor-hours are the principal indicators to be measured.

Reported accomplishments

Lockheed issued its final report on the IMP contract in April 1974, or about 3 months after completion of the 6-month trial period at P-3 squadron VP-40 (the trial squadron). The final report stated that squadron VP-40 had reported the following trial results.

--A 38-percent savings in scheduled maintenance labor-hours.

--A 70-percent reduction in aircraft downtime for scheduled maintenance.

--A 75-percent reduction in quality assurance discrepancies after inspection.

--A downward trend in awaiting maintenance time.

--No adverse trend in unscheduled maintenance actions.

--An improvement in operational readiness.

--An annual squadron fuel savings of about 50,000 gallons resulting from eliminating a postinspection functional check flight.

Lockheed also reported the following changes to the scheduled maintenance work content.

Inspection type	Number of tasks		
	Before IMP	After IMP	Net decrease
Turnaround (preflight and postflight)	224	106	118
Daily	151	48	103
Special	151	96	55
Periodic (calendar)	795	434	361
Total	1,321	a/684	637

a/Of these 684 tasks, 269 had a decreased frequency and 22 had an increased frequency.

One month after Lockheed issued its final report on IMP, the Commanding Officer of squadron VP-40 issued an evaluation report strongly recommending that IMP be implemented throughout the P-3 community and that application of the maintenance concept to all Navy aircraft be studied.

Squadron VP-40 based its evaluation on data for 9 months--the 6-month trial period plus 3 additional months--and, among other benefits, reported

--a 35-percent savings in scheduled maintenance labor-hours and

--a 79-percent reduction in aircraft downtime for scheduled maintenance.

The Navy began implementing IMP at the other P-3 squadrons in July 1974. We were unsuccessful in identifying any Navy studies showing the labor-hour impact of IMP after fleet-wide implementation. However, we did note that a Navy official testified during the fiscal year 1976 appropriation hearings before the House Subcommittee on the Department of Defense, that:

"Our [Navy's] savings in maintenance manhours * * * at the [P-3] squadron level has been 25 to 30 percent with a concurrent increase in availability of the aircraft."

Evaluation of reported benefits

The benefits Lockheed reported for squadron VP-40 could not be directly evaluated because preimplementation maintenance data for squadron VP-40 had not been retained. We did make the following observations, however, which might increase understanding of the reported benefits.

1. Total squadron maintenance before the IMP test period included 38-percent scheduled maintenance and 62-percent nonscheduled maintenance. 1/ Assuming no increase in nonscheduled maintenance, the 38- and 35-percent reductions in scheduled maintenance reported by Lockheed and the Navy, respectively, would equate to actual reductions in total squadron maintenance of about 14 and 13 percent, respectively.

2. The gains in aircraft availability of 70 and 79 percent reported by Lockheed and the Navy, respectively, equate to actual improvements in scheduled maintenance downtime of about 8 and 12 percentage points, respectively. The higher values represent the percentage of change in reported downtime between the control and test periods.

To further evaluate IMP, we analyzed its recorded impact at the 11 other active Pacific Fleet squadrons (not including squadron VP-40) as of April 1, 1975. This analysis showed that scheduled maintenance labor-hours had decreased by an average of 17.6 percent, or 6.7 percent of the total organizational maintenance. Further, an increase in nonscheduled maintenance labor-hours more than offset this decrease in scheduled maintenance labor-hours.

1/Preimplementation data was not available for squadron VP-40. These percentages were based on an average of data reported by 11 other P-3 squadrons over 8- to 15-month periods before IMP implementation.

Categories of maintenance	Average monthly labor-hours for 11 squadrons: Before IMP (note a)	After IMP (note b)	Net change as a percent of total
Scheduled	26,159	21,554	-6.7
Nonscheduled	42,580	48,015	7.9
Total	68,739	69,569	1.2

a/From October 1973 through the last month each squadron was on the old system--an average of 10-months' data for each squadron.

b/From the month each squadron adopted IMP through March 1975--an average of 7 months' data for each squadron.

We were unable to determine the reason for the large increase in nonscheduled maintenance. Although it is reasonable (on the basis of commercial airline experience) to expect a small increase, the Navy's large increase was not typical. One possible explanation is that idle time was being charged. However, it was not possible to verify this because the controls over time charges were poor and we could not (1) account for all the maintenance personnel's time nor (2) state with any assurance that the time charged for P-3 aircraft maintenance did, in fact, represent actual work. We covered this problem in detail in our report, "Productivity of Military Below-Depot Maintenance--Repairs Less Complex Than Provided at Depots--Can Be Improved" (LCD-75-422, July 29, 1975).

The 6.7-percent reduction in scheduled maintenance as a percent of total maintenance is less than the 13- and 14-percent reductions experienced by squadron VP-40 and appears to be inconsistent with the large reductions in work tasks resulting from IMP.

To reconcile these differences, we compared the estimated standard labor-hours required for each task under the old concept with the estimated standard labor-hours required for each of the reduced number of IMP tasks. The analysis showed that after allowing for differences between frequency of task performance under the old and new concepts, the reduction in scheduled maintenance as a percent of total maintenance should have been about 16.8 percent. Such a reduction, as shown below, would be even more favorable than that experienced by squadron VP-40.

Impact of IMP	Reduction in scheduled maintenance as a percent of total squadron maintenance
Potential--based on analysis of task standards	16.8
Actual--based on Lockheed data for squadron VP-40	14 4
Actual--based on Navy data for squadron VP-40	13.2
Actual--based on analysis of 11 Pacific Fleet squadrons	6.7

Navy officials at Moffett Field Naval Air Station told us, and we confirmed, that there had been no maintenance staff reductions due to IMP.

Navy headquarters officials stated that maintenance staffing for P-3 squadrons was determined from a manpower survey team analysis of personnel required under at-war-at-sea conditions. In the officials' opinion, the squadrons apply any scheduled maintenance labor-hour savings which might have resulted from the new concept to other outstanding maintenance requirements. The officials concluded, therefore, that no additional actions, such as reducing maintenance staffing or shifting workload, were required to capture labor-hour benefits which might have resulted from the new concept. (Accountability for cost savings is discussed in detail in chapter 4.)

The Navy officials stated that P-3 operational readiness 1/ had increased 6 percent since the new concept was introduced. In their opinion, this improved readiness more than satisfied the objectives of the new concept and justified its application to other equipment maintenance programs.

GOALS AND ANTICIPATED BENEFITS ASSOCIATED WITH DEPOT-LEVEL MAINTENANCE

Lockheed's proposal for an improved depot maintenance program for P-3 aircraft indicated that the Navy's depot work package needed revision because, among other things, it:

--Generated redundant maintenance tasks and excessive labor-hours.

1/We did not verify the Navy's readiness figures. In past reviews we noted and reported problems in the accuracy of the Navy's aircraft readiness reports.

--Required repetitive calendar inspection tasks at the organizational level.

--Included many tasks which had no technical justification.

Lockheed proposed that it be allowed to develop an improved work package by employing the new analytical concept to challenge each specified maintenance task in the then-current work package. The contractor believed that this concept would (1) increase the interval between aircraft depot visits, (2) decrease the time aircraft spent in the depot, and (3) meet the overall objectives of reducing the cost of maintenance and increasing aircraft availability without affecting flight safety or aircraft reliability. Lockheed suggested that its proposed program could result in more than a 50-percent reduction in P-3 aircraft depot tasks and could reduce from 135 to about 50 the number of items having hardtime replacement limits.

The Navy accepted Lockheed's proposal and incorporated it in the resulting contract. The language of the contract does not expand on Lockheed's stated goals, nor does it establish more specific goals as to the degree of expected work-hour reductions or expected increase in the rate of aircraft availability.

Contractor-reported and Navy-anticipated benefits

Lockheed issued the final report on its improved depot maintenance program on June 1, 1974. The report stated, among other things, that the individual P-3 depot-level examination requirements were reduced from 900 to 447 tasks (see p. 20). It also recommended that the intervals between aircraft depot visits be extended as follows:

	Depot maintenance intervals	
	Old	New
First visit	36 months	60 months, or 4,800 flight-hours
Second visit	30 months	50 months, or 4,000 flight-hours
Third and subsequent visits	30 months	40 months, or 3,200 flight-hours

The final report concluded that the reduction in scheduled tasks would result in increased aircraft availability and lower costs for depot maintenance. The contractor recommended that the new program be adopted for all P-3 aircraft in the Alameda depot as soon as possible.

The Navy decided in favor of the new program, and Alameda was instructed to proceed with implementation. An implementation team was established on March 5, 1975, and the first P-3 aircraft was received for maintenance under the new program on June 30, 1975.

On August 4, 1975, the Alameda depot's Commanding Officer issued a newsletter to employees stating that about 500 fewer labor-hours should be required to process the first aircraft under the new program. He estimated that full capability under the new program would be achieved in about 4 months. He projected the impact of the new program at that time to be a reduction of 2,000 labor-hours for each aircraft processed and a reduction of 15 flow-days (from 51 to 36 days).

Evaluation of reported and anticipated benefits

The Alameda depot had begun to carry out the new depot program at the time of our visit. Although the new work package had been established, labor standards for individual tasks had not yet been fully revised. For this reason it was not possible for us to accurately measure the full benefits derived from the program, including the actual labor impact based on differences between old and new labor standards. Our evaluation, therefore, centered on the major changes or differences among the old program, the contractor-suggested program, and the Navy-adopted program.

Stretched maintenance intervals

One of the most important and obvious changes from the old program was extending time intervals between aircraft depot visits. All else being equal, this factor alone has an immediate, favorable impact on annual depot cost and aircraft operational availability by reducing the number of aircraft requiring depot maintenance. This factor also should result in a reduced depot cost for each aircraft flight-hour and a reduced total number of aircraft needed to fill the depot pipeline.

The contractor's final report noted that the depot maintenance intervals it proposed were consistent with increased intervals the Navy officially authorized about 3 months earlier. Inquiries about the basis for the increased intervals revealed that the Alameda depot had made an independent engineering analysis of P-3 aircraft maintenance intervals and in January 1974 (about 5 months before the contractor's final report) recommended the same increased intervals.

We concluded, on the basis of later discussions with responsible Alameda officials, and review of the Alameda analysis, that the use of the new concept was not a key element in deciding on the stretched intervals. The same decision, in our opinion, probably would have been reached even if the contract study had not been made.

Reduced task requirements

The contractor reported that applying the new concept had reduced from 900 to 447 the number of depot task requirements for each aircraft.

We examined the original depot work specification, the contractor-recommended specification, and the final Navy-approved specification and concluded that the following task changes had occurred.

	Task count		
Original depot specification		900	
Less:			
Tasks deleted by contractor	112		
Tasks judged by contractor to be responsibility of organizational maintenance level	501		
One-time tasks	30	643	
Remaining tasks			257
Tasks added as result of contractor's restructuring of the 257 remaining tasks			190
			447
Tasks added on basis of Navy's review of contractor-recommended specification			17
Navy-approved specification			464

The contractor concluded that only 257 of the 870 recurring tasks in the original depot specification should be done at the depot level. Many of the 257 tasks were general in nature and encompassed more than 1 of the contractor-defined aircraft zones. The contractor, in its recommended specification, rewrote these tasks and expanded them to 447.

We reviewed the work content of the two sets of tasks--the original 257 and the expanded 477--and estimated they were essentially the same in terms of actual work required. We concluded, therefore, that the contractor's reported 50-percent reduction in depot tasks (from 900 to 447) was conservative and that the actual reduction in repetitive depot tasks (870 to 257) more closely approximated 70 percent.

The final depot specification the Navy approved requires, as shown above, 17 more tasks than the contractor's recommended specification. A limited review of the added tasks--25 tasks were added and 8 tasks were deleted--showed that the Navy's adjustments were due largely to numbering differences and otherwise appeared reasonable.

The contractor's final report suggests that, in addition to doing its recommended rework the depot could do certain lower level tasks. It was not feasible to determine how much growth in depot tasks could be expected to result from performing these tasks. We estimate, however, that depot performance of the lower level's daily, special, turnaround, and next-phase-due required inspection alone could add about 300 depot tasks to the average aircraft processed.

Although the final Navy depot rework specifications include organizational tasks, the following points indicated such tasks should be done below the depot level.

1. The Navy's multilevel maintenance concept generally requires that maintenance tasks be done at the lowest level having the required capability.

2. Doing organizational level tasks at the lower level enhances the operational units' capability to sustain assigned missions without relying on the depot.

3. Because there was no apparent staffing reduction associated with the reduced workload resulting from applying the new maintenance concept at the lower level and because of the low productivity we have previously noted at the organizational level, 1/

1/As reported by GAO in its report to the Congress, "Productivity of Military Below-Depot Maintenance--Repairs Less Complex Than Provided at Depots--Can Be Improved," (LCD-75-422, July 29, 1975).

the lower level appears to be adequately staffed to do all of its assigned workload without depot assistance.

Although the number of tasks included in the basic depot rework specification has been reduced, many organizational level tasks will continue to be done during depot processing of each aircraft even though this may not be an economical use of available resources.

Reduced labor-hour requirements

The depot Commanding Officer's projection in August 1975 that the new maintenance concept would yield a 2,000-labor-hour reduction for each aircraft was a goal. Without revised work standards, this goal was only an educated estimate that was made without any documentary support. A September 1974 depot estimate of a 300-labor-hour saving for each aircraft was also found to be an unsupported estimate. The large difference between the two estimates, in our opinion, is less a product of hard facts than it is a product of increased familiarity with the revised program and a higher degree of optimism achieved between the two periods during which the estimates were made.

By reference to a higher degree of optimism, we do not intend to imply that the goal of saving 2,000 labor-hours will not be achieved. Indeed, it seems reasonable to expect the 10,300-labor-hour standard for each aircraft to drop by at least this amount on the basis of approximately 70-percent reduction in pure depot tasks the contractor recommended. Furthermore, eliminating the more than 300 organizational tasks we estimate are still included in the depot's work package would reduce the depot's required labor-hours even more--perhaps by as much as another 2,000 labor-hours.

The full labor-hour impact of the new concept will not be known until objective labor standards are set, but the impact should prove to be meaningful.

Reduced depot flow-days

The average days the depot takes to process P-3 aircraft becomes a factor in determining the total inventory of aircraft required to meet operational, training, and other needs. The Navy's computed P-3 requirement for fiscal year 1976, for example, shows that nine aircraft must be procured to offset the depot's average processing time of 80 calendar days for each aircraft rework. The impact of average flow-days on required procurements can be seen by reversing the

computation. Reducing the depot pipeline requirement from nine to eight aircraft, for example, would require reducing the average depot flow-days from 80 to 72. Similarly, the pipeline requirement can be reduced to seven aircraft by reducing the depot's average processing time to 56 calendar days.

The depot Commanding Officer estimated that applying the new maintenance concept should reduce the depot's P-3 processing time to about 36 workdays. If realized, this reduction would decrease the depot's average calendar day workflow from 80 days to about 52 days and would decrease the computed requirement by two aircraft.

We believe, on the basis of commercial airlines reported experience from adopting the new maintenance concept and of the large task reductions realized in the P-3 organization and depot-level maintenance packages, that adopting the concept for P-3 maintenance should reduce labor-hours required for scheduled P-3 maintenance and the flow-days required for P-3 depot processing. However, these major reductions will not be realized or maximized unless management acts to measure and control the labor and flow-time charged to each scheduled maintenance task. Without such action, there can be no assurance that labor-hours and flow-days will not be expanded to their historical levels but on a reduced number of tasks.

At the time of our review, the Alameda depot had not completed its planned shop consolidations and reorganizations for the new maintenance concept nor had it processed a P-3 under the new concept. Our evaluation of the reasonableness of the forecast reduction in aircraft flow-days, therefore, was limited to discussions with responsible officials and comparison of past, actual, and forecast workdays for major elements comprising total flow-days.

We concluded from this evaluation that:

--The 36-workday forecast represented a reasonable goal and, in our opinion, could be realized by the end of the first year of operation under the new concept.

--Elimination of remaining organizational level maintenance tasks included in the depot package could further reduce depot processing time to as low as 25 workdays, or about 36 calendar days.

Navy comments

We discussed our evaluation with Navy headquarters officials and were told that:

--The stretched-maintenance intervals for P-3 aircraft resulted from applying the new concept, and this factor alone justified further application of the concept to other programs.

--Some organizational level tasks might remain in the depot work specification and, although this was generally undesirable, no action had been planned for further review of this aspect.

--The stretched-maintenance intervals may result--despite the large decrease in scheduled depot tasks--in requiring more maintenance during each depot visit, since the aircraft will have been used longer and will have developed more problems. If there were any reduction in labor-hours required as a result of the new concept, the depot would productively apply the saved hours to doing more reworks and to doing other work which had been backlogged because of depot understaffing.

--Any forecast reduction in aircraft depot flow-days due to the new concept was speculative. The Navy therefore had not analyzed flow-days and did not plan to change this factor in its forthcoming annual publication of aircraft procurement-planning factors.

Subsequently we received written comments from DOD (see app. I). Our evaluation of the DOD comments is contained in chapter 5.

CONCLUSIONS

Applying the new maintenance concept to Navy's P-3 organizational and depot maintenance programs has improved maintenance scheduling, reduced unnecessary work tasks, corrected some task distribution between the two maintenance levels, and resulted in a generally more logical approach to the maintenance function.

The Navy believes that the new maintenance program has resulted in improved operational readiness of P-3 squadrons and increased depot maintenance intervals, and these two factors alone satisfy the major objectives of the program and justify its further application to other equipment maintenance programs.

Although we agree with the Navy that these improvements are commendable, we also believe the Navy may not have obtained maximum benefits from the new maintenance concept. The commercial airline experience has shown that systems and procedures need to be established to continually monitor the maintenance program based on the concept. The Navy has emphasized test and initial implementation of the new maintenance system but has not followed through with a data-gathering mechanism and with procedures for monitoring improvements. Accordingly, the Navy is not sure that one of the main benefits from the program--labor savings--has been realized.

CHAPTER 4

SAVINGS FROM ANALYTICAL MAINTENANCE

Management's challenge in analytical maintenance programs is to realize the savings from these new programs. To meet this challenge, the activities which request and approve new programs should fully understand the factors which can provide savings and should make provisions to insure those savings actually are realized.

Airline and Navy experience with analytical maintenance suggests the savings can be great from reduced labor-hours and aircraft procurement. Also savings can be achieved from reduced component inventories. But if management is to successfully capture these savings, it must establish ways to identify, measure, and document benefits as they are produced. This is necessary because conclusive demonstrations of positive effects usually are required to effect change in such cost elements as staffing levels and pipeline procurements. A 1974 report pointed out, for example, that Navy policy on scheduled intervals between depot maintenance visits has been slow to change and supports its point by showing that it took 7 years and six studies to get F-4 rework intervals officially extended from 15 to 20 months.

The airlines and the military share similar objectives. They both strive to be economical while stressing safety and operational readiness. Facilities, flight operations, and personnel structure, however, have many important differences. Nevertheless, the airlines' use of analytical maintenance and other techniques offers useful lessons for the military. The following comparative observations were made by a study team of an aircraft manufacturer-operator association. According to the study team, the Navy could benefit from using certain airline techniques as a model.

Differences Between Airlines and the Navy Attributable to Analytical Maintenance and Other Techniques

	Airline	Navy
Aircraft availability or operational readiness	96%	72%
Aircraft not available due to depot maintenance	1 to 3%	15 to 30%
Depot overhaul in-process time (DC-8 compared to P-3)	14 days	117 days
Aircraft not operational for supply reasons	1 to 3%	15 to 30%
Investment in spares as percent of aircraft cost	10%	20%
Flight time for each aircraft each year	3,000 hours	600 hours

LABOR SAVINGS

The logic of analytical maintenance limits work to be done to that which is meaningful to safety and reliability. (See task change examples in app. II.) As a result total work to be done is less than that dictated by personal judgment. Thus overhauls should be shorter and intermediate and organizational work should be minimized. The airlines have reaped considerable savings from this concept. As mentioned earlier, one major airline has identified more than 3 million labor-hours saved from 1971 to 1975 in maintaining its Boeing aircraft (747s, 727s, and 707s). The airlines stress labor-hour controls, work-flow planning, and periodic budget reviews to eliminate excessive costs. Similarly, the military services must emphasize controls to identify and measure labor savings.

During the next few years, the military services plan to spend $65 million to create new analytical maintenance programs for aircraft. One of the common justifications for analytical maintenance programs will be potential savings. For example, one major airline estimates its use of analytical maintenance techniques is saving more than $100,000 for each aircraft on a recurring annual basis. The military services' aircraft inventory is 10 times greater than the commercial airlines' aircraft inventory. If the military services do not take advantage of the

potential savings, they will not realize a satisfactory return on their investment in the new programs.

The military services are spending about $6 billion annually for aircraft maintenance at the organizational, intermediate, and depot levels. Defense and airline industry representatives have estimated that there is a potential for reducing maintenance costs by about 20 percent using this improved maintenance concept. Accordingly, annual savings could aggregate as much as $1 billion.

Once labor savings are identified, management must act to realize the potential benefits. Several alternatives are available. For example:

--The newly freed labor resource can be reassigned to other documented and programed maintenance requirements which are not otherwise being satisfied (backlogged work).

--Personnel can be reassigned to the maintenance programs for other equipment which are known to be understaffed.

--Personnel can be retained to meet other support- or operational-staffing requirements.

--Additional workload can be allocated to the affected maintenance organization from other sources (from one maintenance level to another).

--Staffing levels can be reduced or reallocated between the Active Forces and the Reserves.

AIRCRAFT PROCUREMENT SAVINGS

The reduced overhaul time made possible by eliminating unnecessary depot tasks can produce large savings in aircraft procurements. This is because the military services consider aircraft in overhaul (pipeline aircraft) as unavailable to meet mission requirements and therefore procure additional aircraft to compensate.

Airlines have lower pipeline inventories than do the military services--1 percent of total aircraft for the airlines versus 15 percent for the military services. One way airlines are able to minimize pipeline inventories is by keeping depot visits short--1 week for the airlines versus 8 to 12 weeks for the military services. If the task reductions resulting from the new concept lessen

depot-visit time for military aircraft, large savings in aircraft procurements result from reduced pipeline needs.

Without changing any other factor in the P-3C procurement computation, for example, a decrease in depot flow-days from 80 to 52--a target which we believe can be met--reduces the computed P-3C total-buy requirement by two or more aircraft valued at about $13 million each. It may be possible to further reduce flow-days if certain maintenance tasks were shifted to the organizational level. Comparable savings could be available in the purchase of other aircraft throughout the Department of Defense. In fiscal year 1976, the military services requested $4.5 billion for the purchase of aircraft.

Savings can also be realized in the cost of components. Analytical maintenance programs extend the life of many components, because (1) components which were previously removed automatically for replacement or rework after a specified period of operation can be used longer and (2) design changes may increase reliability of components (data analysis identifies high-failure-rate parts and points out the need to increase their reliability by redesigning them). As a result, part requirements could be adjusted and inventories could be reduced.

The potential savings resulting from reduced inventories of aircraft parts are considerable. For example, the Navy Aviation Supply Office estimates its reparable-item inventory to be valued at about $4.85 billion. Further, in fiscal year 1976 the military services requested about $1.5 billion for purchasing aircraft parts.

PROVISION FOR COLLECTING APPRAISAL INFORMATION

When management starts a major program, it should have an implementation plan. The plan should, among other things, specify the performance factors to be measured and should provide for collecting the data needed to evaluate changes in these factors between the base and implementation periods. Management can thus monitor implementation programs and identify potential problems while there is still time to take corrective action.

The Navy's implementation of the reliability-centered maintenance concept for P-3 aircraft has not provided for a complete and accurate evaluation of programs and results. For example:

--The Navy did not measure and evaluate the labor-hour impact of the new concept at the organizational level, except for evaluation of some results at the trial squadron.

--The Navy did not try to accurately measure or predict the labor-hour and aircraft flow-time impact of the concept at the depot level.

On the basis of results reported by commercial airlines and continuing congressional and DOD concern for limiting defense-support costs, the Navy should have anticipated major labor-hour and aircraft depot flow-time reductions from the concept. As implementation progressed, the Navy could have planned specific steps for collecting the data needed to insure potential program benefits. The minimum steps for measuring labor-hour impact, for example, might have included

--an assessment and statement of preimplementation baseline values showing labor-hours spent and personnel used at each maintenance level for doing all scheduled, unscheduled, and other maintenance;

--an assessment of the existing labor-hour accounting system at each level, to identify data which would normally be available to measure changes in performance factors;

--provision for collecting accurate performance data needed but not routinely available through the existing labor-hour accounting systems; and

--provision for collecting the specified performance data at stated regular intervals for management review and evaluation.

Had the Navy taken the above minimum steps for measuring each performance factor, management would have been in a good position to measure progress against its goals; identify areas requiring increased management attention; and, as discussed in the following section, take early action to capture benefits by reallocating newly freed resources or by taking other appropriate action.

ACTIONS TAKEN TO CAPTURE PROGRAM BENEFITS SHOULD BE FULLY DOCUMENTED

Management actions to capture the benefits of a new program--if the program is successful--will greatly affect the final program benefits. These actions, because of their importance, should be decisive and fully documented.

The Navy's actions and plans for capturing the labor-hour benefits from the new maintenance concept do not appear to have met these criteria. Although the number of scheduled maintenance tasks was greatly reduced at both the organizational and depot levels, the Navy took no definite action to reduce personnel requirements or to reallocate the labor resource. Navy management has assumed that any labor-hour savings have been or will be automatically absorbed by other maintenance requirements. Without adequate documentation, management cannot know if the newly freed labor resource is being suitably applied to higher priority work or is merely being absorbed by reduced productivity.

Any of several management actions can capture the benefits of labor-hour reductions resulting from a new program. The alternatives are assigning additional high-priority work to the affected personnel, reassigning affected personnel to other work locations, and reducing general staffing. If management is to be accountable for its decision in selecting the appropriate alternative in each case--and this would certainly appear desirable--the various factors considered should be recorded and the actions taken should be fully documented.

WHEN SHOULD THE NEW CONCEPT BE APPLIED?

The philosophy underlying the new concept--that is, maintenance should be scheduled only when it is shown to be effective--is applicable to all maintenance programs. We recognize, however, the limited resources available for designing or restructuring maintenance programs, so we believe any application of the concept to an equipment inventory should recognize that certain equipment may offer greater potential for savings than others. For example:

--Emphasis on maintenance programs for equipment being procured could reduce the cost of later program restructuring to meet the new concept.

--Emphasis on equipment lines for which all procurements have not been made would take advantage of the faster turnaround and reduced downtime under the new concept and could reduce procurements required to fill the maintenance pipeline. The same advantage could also occur when large investments in components remain to be made.

--Emphasis on existing maintenance programs which exhibit higher ratios of scheduled to total maintenance should produce greater percentage benefits.

--Emphasis on larger equipment lines and maintenance programs should result in a higher level of overall benefits.

The above listing is not all inclusive, nor does the list represent a ranking by priority. Instead, it shows that many factors should be considered before deciding where limited resources should be invested to achieve maximum benefits from the new maintenance concept.

CHAPTER 5

IS DEPARTMENT OF DEFENSE OBTAINING THE INTENDED BENEFITS OF ANALYTICAL MAINTENANCE?

DOD will not obtain the benefits of analytical maintenance unless its management and use are improved. Availability of these benefits is supported by the airlines favorable experience; our examination of the P-3 program; and in fact, the logic of the concept. But to obtain better pilot safety, operational readiness, and cost effectiveness, DOD must plan for and manage analytical maintenance as part of the total maintenance system. Further, the users must adhere closely to the principles of the new concept rather than rely on personal judgment, as was often the case with conventional programs.

As part of the total maintenance system, reliability-centered maintenance programs require:

--Information systems which can identify and quantify gains, thus enabling adequate program appraisal and redirection.

--Fully documented and aggressive management actions to capture resulting benefits.

OPERATIONAL READINESS

Operational readiness is a measure, expressed in percent, of the aircraft which are capable of performing their assigned missions. As such it is one of the indicators of a unit's total combat capability. The Navy's initiative in implementing analytical maintenance has resulted in a moderate improvement in operational readiness. A potential exists, however, for an even greater improvement. This potential is indicated by the fact that the reduction in scheduled maintenance achieved by the Navy appears inconsistent with the reductions in work tasks resulting from the P-3's new program.

Other gains in aircraft availability are possible if analytical maintenance is used as an effective tool to (1) reduce depot flow-time, (2) increase intervals between depot visits, and (3) increase aircraft operating life.

If analytical maintenance is properly managed, it could offer much to military readiness.

COST SAVINGS

DOD appears to have had little success in identifying cost savings resulting from the P-3 program. We believe this is because, in planning for the program, the Navy did not specify cost savings as one of its goals.

The savings from analytical maintenance programs are not automatically produced. Rather, management must design its system to identify savings so it can take advantage of them. The Navy did not do this. Thus such benefits as labor savings (see ch. 4) have not resulted in identifiable cost savings. However, the Navy can still take specific actions to capture such cost savings.

SAFETY

Analytical maintenance includes features, such as eliminating failures caused by unnecessary maintenance actions and identifying needed design changes, which can improve safety. To improve safety, however, maintenance personnel must understand and optimize these features. Lack of discipline in confining work to that which the logic of analytical maintenance says needs to be done can create unnecessary and potentially harmful maintenance task growth.

RECOMMENDATIONS

We recommend that the Secretary of Defense, through the Assistant Secretary of Defense (Installations and Logistics), take a more active role in approving and monitoring concept applications and:

--Provide specific guidance to the military services on carrying out the concept, including criteria, for the benefits which should be realized.

--In approving new applications, emphasize the importance of having well-defined and quantified goals and adequate provision for monitoring project implementation.

--Require specific reporting on each concept application to insure appropriate action has been taken to maximize and capture resulting benefits, and reduce maintenance budgets or reallocate resources by the projected savings.

--Require the services to change their requirement computations for aircraft to include the higher operational-available time of aircraft.

DOD's COMMENTS AND OUR EVALUATION

DOD said our report would be of significant benefit to it since the report provides an unbiased description of the P-3 project and confirms certain areas as being crucial to successful implementation of the total DOD reliability-centered maintenance program.

DOD said they generally agreed with our report findings and recommendations. However, it suggested that we delete our recommendation on giving priority to new project applications with established goals and provisions for monitoring. We have modified this recommendation in the light of DOD's concern about possible delays in project implementations. But we believe it is important to emphasize the early establishment of goals and provisions for monitoring projects as a means for more effective achievement of the benefits of the reliability-centered maintenance concept. We believe these factors should influence which projects are selected.

Defense's role in concept applications

The Department of Defense said it agreed with our recommendation that the Secretary of Defense, through the Assistant Secretary of Defense (Installations and Logistics), should take a more active role in approving and monitoring applications of the reliability-centered maintenance concept. Defense said that the Assistant Secretary was currently serving as the focal point for applications of the maintenance concept to operational systems and to systems that were being developed by monitoring the services' overall planning and by reviewing selected applications to aircraft systems; also the Assistant Secretary was overseeing applications to developing systems by working jointly with the Defense Director for Research and Engineering.

We believe that the establishment of the Assistant Secretary as the focal point for controlling applications of reliability-centered maintenance is an essential first step to the expeditious adoption of the concept throughout DOD. The Assistant Secretary can facilitate exchange of experience among the services and can provide uniform policy, as appropriate. However, the Assistant Secretary needs to take certain specific actions at this time to assure that there will be maximum benefits from adopting the maintenance concept. Our other recommendations concerning guidance to be provided, emphasizing goals for new applications, reporting on concept applications, and computation of requirements address these specific actions.

Guidance to be provided

DOD agreed to provide appropriate guidance to the services on carrying out the concept, including criteria on expected benefits. DOD, however, pointed to the need for more extensive experience and said, therefore, that guidance would be provided in 12 to 18 months. DOD said that the Navy is making progress toward developing a good experience base, and that the Air Force and Army, while not so far advanced as the Navy, also are making progress.

We understand the need for additional experience to fully integrate related systems and comprehensively detail the entire program. We believe, however, that the military services should be given more detailed information on the various factors that need to be considered during the early stages of implementing the reliability-centered maintenance concept. Present guidance points out, for example, that necessary maintenance and supply information should be integrated, and should have mutually supportive objectives. A minimum of additional guidance at this level of detail has been provided to the services.

However, the services should be told of the problems and shortcomings that have become evident from early applications, such as the P-3 program. The additional specific guidance need not be comprehensive, but it should deal with such matters as the establishment of a reliable data baseline and the essential management information needed by the services and the Secretary of Defense.

Setting priorities for new applications

DOD did not concur with our recommendation to give priority in approving new applications to those projects with well-defined and quantified goals which include adequate provisions for monitoring project implementation. DOD felt the general goal set for the services by the Secretary of Defense to implement the reliability-centered maintenance concept by 1978 was adequate. DOD also felt that if specific goals are required for each program to which priority is given and if adequate provisions are required for monitoring project implementation, the result would be a delay in implementation. This would mean a loss of program benefits because of the need for time-consuming studies.

We have modified this recommendation in light of DOD's concern about possible delays in project implementations. But we believe it is important that project goals be well-defined by the services and that methods be

established to determine the benefits that accrue. These factors should influence the choice of projects. The establishment of goals and the creation of procedures for monitoring benefits can assist implementation of reliability-centered maintenance because they are controls for measuring progress. Rather than delaying more widespread adoption of the maintenance concept until 1978, the goals and monitoring procedures could aid in achieving that objective.

Reporting on concept applications

DOD said they agreed with our recommendation on reporting, but felt the Assistant Secretary of Defense (Installations and Logistics) should only review reports on concept applications for selected major system programs, while the military services' headquarters should monitor the concept application in more detail. DOD stated it is seeking to insure that the military services track results with more precision. Where savings would not be applied to other requirements, DOD commented it would lower mainteance budgets.

We agree (1) with the positive nature of major system reviews by the Assistant Secretary's office and (2) that the services should track all implementations in detail. However, we also believe the services should report to the Assistant Secretary of Defense on critical elements of every implementation, especially during the early phases, so that central visibility is provided management on all applications, including major systems. This would assure that the Secretary of Defense's objective for service-wide implementation is achieved.

The adoption of the reliability-centered maintenance concept necessitates a substantial investment by the military services. But the experience of the commercial airlines has shown that it provides a substantial payoff. As soon as payoffs, such as readiness improvements, material cost reductions, and labor savings can be accurately estimated, the potential for reallocation of resources should be considered or, where appropriate, budgets should be reviewed and appropriately amended.

Computation of requirements

DOD agreed with the principle of requiring the services to change their requirement computations for aircraft to include the higher operational-available time of aircraft. DOD believes it would be premature to make adjustments now, because additional study is needed of the other major factors which influence pipeline and maintenance float time. DOD

said that plans are being made to address these other factors.

We agree with the need to carefully approach the change of requirement computations, but we do not see the need for extensive delay to conduct detailed studies. We believe that, by strengthening management information systems at the program level, service headquarters level, and DOD level, benefits can be identified and requirement decisions influenced. We recognize the complex nature of requirement determinations, but we believe that requirement reductions should be made as soon as depot flowtime is reduced or when other benefits, such as increased aircraft availability, indicate that reductions are appropriate.

APPENDIX I

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

INSTALLATIONS AND LOGISTICS

13 AUG 1976

Mr. Fred J. Shafer, Director
Logistics and Communications Division
United States General Accounting Office
Washington, D. C. 20548

Dear Mr. Shafer:

This is in reply to your letter of June 1, 1976 to Secretary Rumsfeld transmitting copies of your draft report on "Management Action Needed to Maximize the Benefits of Reliability Centered Maintenance," (OSD Case #4383).

We believe it will be helpful at the outset to point out that our motivation for adapting Reliability Centered Maintenance (RCM) is to provide a common logic approach among the Services for systematically establishing maintenance requirements. The principal objective of the methodology is safety with improved aircraft availability. Increased opportunity for the prudent use of resources and possible savings is recognized as a potential major benefit.

We view transition from current maintenance practices in the DoD to maintenance under the RCM concept as an evolutionary process, as it was with the commercial airlines, requiring on the order of several years. The DoD now is in the learning phase of the overall transition time frame for full application of the process to our many types of aircraft. As a result, and as one would normally expect at this stage, relatively few maintenance plans have been developed for specific aircraft, full implementation at all maintenance levels has been effected on even fewer numbers and mature practical experience is yet to be accrued. Further and as generally recognized in the draft report, successful application of RCM requires that other logistics functions adapt to the changing maintenance requirements to provide effective support, if the maximum benefits of this new maintenance concept are to be achieved.

We concur with the general recommendation to establish the Assistant Secretary of Defense for Installations and Logistics as the focal point for

approving and monitoring specific applications of the RCM strategy to operational systems. The ASD(I&L) is currently exercising this responsibility by monitoring Service overall planning, as well as programs for selected aircraft systems. For new systems the ASD(I&L) participates with the DDR&E for maintenance and reliability planning through the DSARC process. We believe further formal mechanisms need not be established for approval and monitoring of the application of the RCM concept to DoD aircraft systems.

We concur in principle with the specific recommendations to (1) provide specific RCM implementation guidance to the Services, (2) require specific reporting to maximize and capture benefits, and (3) amend computational methods for aircraft quantities to reflect increased aircraft availability resulting from RCM. However it will be twelve to eighteen months before specific guidance can be issued since sufficient operational experience must first be acquired. With regard to reporting requirements we expect the Services to monitor all applications with the office of the ASD(I&L) monitoring selected applications. As to revision of computational methods for aircraft, we consider this recommendation premature pending further operational experience.

We recommend deletion of the specific recommendation to give priority to new RCM applications having well defined and quantified goals, and reduce maintenance budgets by the projected savings. Acceptance of the recommendation would require postponement of current efforts until completion of analyses on about twenty-five aircraft before proceeding with any implementations. This would delay RCM operations with several high-density fleet aircraft (e.g., B-52, F-4 and F-14) with attendant loss of early benefits. Further the arbitrary reduction of maintenance budgets by projected savings would deny the exercise of other viable alternatives, e.g., reallocation of "saved" resources to backlogged work.

More detailed comments on your recommendations and some comments on selected statements contained in the report are provided in the attachment.

We believe the report is of significant benefit to DoD since it provides an unbiased report on the P-3C project and confirms certain areas as being crucial to successful implementation of the total DoD RCM program.

My staff is available for further discussion should you so desire.

Sincerely,

JOHN J. BENNETT
Principal Deputy Assistant Secretary of Defense
(Installations and Logistics)

Attachment
Detailed Comments

DoD COMMENTS - GAO DRAFT REPORT, MANAGEMENT ACTION NEEDED TO MAXIMIZE THE BENEFITS OF RCM

Comments on Specific Action Recommendations

Specific Recommendation No. 1 - "Provide specific guidance to the Services on the implementation for the concept including criteria on the benefits which should be realized."

Comments: The recommendation is acceptable. Development of Service-common guidance is dependent upon the existence of a reasonably solid experience base. To this end, the Services need to further improve their capabilities for performing RCM analyses and to accumulate experience under operational conditions with representative DoD aircraft. Further, better definition should be acquired of how collateral and supporting functions will interface with the new maintenance activities and procedures. It is clear from the GAO draft report, progress is being made by the Navy towards a good experience base. While not so far advanced as the Navy, the Air Force and Army are making progress. The Services report that planning and some early action are underway for development of criteria intended to meet their needs for implementation of the concept and for measurement of benefits. We should be in a position to write appropriate guidance in twelve to eighteen months.

Specific Recommendation No. 2 - "Give priority in approving new applications to those projects which have well defined and quantified goals and adequate provisions for monitoring project implementation, and reduce maintenance budgets by the projected savings."

Comments: Comments on this multiple recommendation are provided in two parts. Relative to the first part of the recommendation for assignment of priority, we draw attention to the Secretary of Defense's guidance to the Services to implement the RCM concept throughout the DoD by 1978 (page i of the draft report). The Services are conforming to this guidance in their management and funding plans. Their aircraft scheduling arrangements for development and implementation are expected to provide aircraft in operations under the RCM concept according to larger fleet type size, remaining service life, system complexity and/or availability improvement. We believe this approach will provide early improved aircraft availability and opportunities for resource reallocations or savings. On the other hand, if we were to accept the draft recommendation, current efforts would have to be delayed for initiation and completion of a comparative analysis of individual study results on more than twenty-five aircraft systems. This

action would probably delay, on the order of two years, initiation of operations of several of our aircraft under the RCM concept with attendant loss of benefits -- aircraft such as the F-4, F-14, B-52, KC-135, and C-130.

The recommendation -- taken singularly -- to reduce maintenance budgets by projected savings from RCM is too narrow. For example, as suggested within the body of the report, labor savings due to RCM could be reallocated to backlogged work. Providing latitude for taking advantage of economic benefits of RCM is conducive to improving readiness without increasing the DoD budget and has the significant advantage of increasing acceptance of RCM by system managers and hands-on maintenance personnel, without which RCM can be expected to fail. Where it may be shown that resource savings are excess to overall maintenance requirements to meet availability requirements, maintenance budgets will be appropriately adjusted. DoD is seeking to insure the Services track the actual results with more precision. Such action is expected as a part of good management procedures.

We suggest this draft recommendation be deleted.

Specific Recommendation No. 3 - "Require specific reporting on each concept application to assure appropriate action has been taken to maximize and capture resulting benefits."

Comments: We concur with the intent of this draft recommendation; i.e., "maximize and capture resulting benefits." In accordance with OSD policy we expect the Military Departments to conduct day-by-day management and monitoring of their specific programs in appropriate detail; the application of RCM should be no exception. The influence of RCM on major system readiness and funding requirements is examined during our normal program planning and budgeting process. Further, an objective of our reviews of selected major systems includes working with the Services to assure appropriate iterative management actions are taken (as experience is accrued) to establish benefit goals and to track progress toward meeting those goals, as well as to assure advantage is taken of benefits derived. It would not be practical to extend our reviews to all aircraft systems to which RCM will be applied. We expect that the military department headquarters will follow each concept application and the ASD(I&L) review and monitor only selected major system programs to assure appropriate advantage is taken of derived benefits.

Specific Recommendation No. 4 - "Require the Services to change their requirements computation for aircraft, reflecting the higher operational available time of aircraft (reduce pipeline and maintenance float time)."

Comments: We concur in principle with this recommendation but believe it to be premature. The recommendation to change requirements computation for aircraft must be approached cautiously. Aircraft generations for depot rework have been significantly influenced by the results to date; program planning and budgeting currently reflect the actual and anticipated changes in aircraft depot rework interval. There is a potential for additional adjustments contingent upon the availability and prepositioning of critical logistic elements such as supply support. Plans are being made to address the other major factors which influence pipeline and maintenance float time, but it is premature to make further changes in requirements computation until the pacing logistic support elements have been more clearly defined and made available. Other factors such as design modification installation and corrosion control treatment will also require further experience before making further adjustments.

[See GAO note.]

GAO note: Deleted comments pertain to matters which were presented in the draft report but are not included in this final report.

EXAMPLES OF P-3 AIRCRAFT ORGANIZATIONAL-LEVEL MAINTENANCE TASKS REVISED BY APPLYING THE NEW MAINTENANCE CONCEPT (note a)

1. Item. Outflow valve (part of the air-conditioning, pressurization, and ice control system).

   Prior task. Remove every 2,000 flight-hours and overhaul.

   Task disposition. Deleted.

   Justification. A backup mode of operation exists (electromechanical).

2. Item. Engine-driven compressor (part of the air-conditioning, pressurization, and ice control system).

   Prior task. Remove every 2,400 flight-hours and overhaul.

   Task disposition. Deleted for all units with accessory change No. 192 installed.

   Justification. Low failure rate does not justify including task.

3. Item. Air turbine starter (part of the powerplant system).

   Prior task. Remove every 2,000 flight-hours and overhaul.

   Task disposition. Deleted.

   Justification. Failure data revealed that overhaul did not reduce failure rate. Engine can be restarted in flight without the starter.

4. Item. Low-level-light television (part of the radar navigation system).

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a/The changes in each case are premised on a determination that flight safety will not be degraded.

Prior task. Examine components, wires, and connections every 26 weeks.

Task disposition. Deleted.

Justification. The task will not detect an impending failure. Experience data does not justify the task.

5. Item. Oil cooler and its electric door actuator and accessory cowling (part of the powerplant system).

Prior tasks. Every 26 weeks, on each of four engines (a) examine oil cooler for leaks, dents, obstructions, and loose hinges, (b) examine flap actuator for security, (c) operate oil-cooler flap, and (d) examine cowling for cracks and dents.

Task disposition. Tasks (a) and (d) are included in the general zonal examination. Task (b) and (c) were deleted.

Justification. The deleted tasks were judged ineffective for detecting or predicting failures.

6. Item. Bomb-bay and wing stores (parts of the weapons delivery system).

Prior task. Do pylon release, wing-bomb release, and jettison release tasks every 26 weeks.

Task disposition. Deleted.

Justification. Mission-related tasks are performed before loading stores for each test mission. Greater frequency not justified.

7. Item. Asymetry-detector switch (part of the wing-flap system).

Prior task. Connect tester and check flap timing every 26 weeks.

Task disposition. Deleted.

Justification. Experience data indicated task was ineffective and that normal operational test would detect any hidden failures.

8. Item. Sonobuoy launchers (part of the weapons delivery system).

Prior tasks. Every 26 weeks (a) operate launcher, (b) remove and examine chute assembly, (c) check wiring and components for damage, cleanliness, and security, and (d) examine storage bins for damage, cleanliness, and security.

Task disposition. Task (a) was retained. The other three tasks were deleted.

Justification. Low failure rate indicated task (b) was not warranted. The other tasks will be covered by general zonal examination.

9. Item. Altimeter (part of the radar navigation system).

Prior task. Make altimeter simulator test 26 weeks.

Task disposition. Deleted.

Justification. Task ineffective in identifying faults. Test should be made only during corrective maintenance or when components are replaced.

10. Item. Cabin-pressure controller (part of the air-conditioning, pressurization, and ice control system).

Prior task. Every 26 weeks (a) check dehydrator dessicant for proper color and (b) replace line filter.

Task disposition. Reduce frequency of (a) to 800 flight-hours, or about every 52 weeks. Reduce frequency of (b) to 1,600 flight-hours, or about every 104 weeks.

Justification. Failure data did not justify more frequent tests.

11. Item. Magnetic compensator group (part of the bombing-navigation system).

Prior task. Make operational test every 26 weeks.

Task disposition. Deleted.

Justification. A small percentage of faults found during tests but many found during flights (requiring that flights be aborted) and between flights. Functional check should be made only when compensation degradation is declared by aircrew.

12. Item. Dual search radar set (part of the radar navigation system).

Prior task. Make functional test every 26 weeks.

Task disposition. Deleted.

Justification. Test ineffective because few faults were discovered through the test.

EXPLANATION OF THE MULTILEVEL MAINTENANCE STRUCTURE

Each service has adopted a multilevel structure which places maintenance responsibility at different levels, depending on the type and complexity of the work. The Navy's aircraft maintenance levels are structured as shown below.

--Organizational level. Maintenance at this level is normally the responsibility of, and is done by, the units or organizations to which the aircraft are assigned. Tasks assigned to these units include inspecting, servicing, and lubricating equipment and adjusting, removing, and replacing parts, minor assemblies, and subassemblies. Work beyond these activities' capabilities is usually forwarded to intermediate-level activities.

--Intermediate level. Maintenance at this level is normally a base-level responsibility and is done by designated activities for direct support of user organizations. Assigned work includes calibrating, repairing, or replacing damaged or unservicable parts, components, or assemblies; modifying material; and providing technical assistance to user organizations.

--Depot level. Depot-level maintenance is done by designated industrial-type activities. The depots are generally responsible for making major overhauls and modifications and for making repairs to end-items and components and returning them to the supply systems. Depots also manufacture parts not otherwise available in the supply system and use their more extensive shop facilities, equipment, and higher skilled personnel to support the lower level activities.

Because organizational- and intermediate-level maintenance activities directly support combat and combat-support units, they are staffed primarily with military personnel. Depots, in contrast, are generally fixed activities and employ a predominantly civilian work force.

Under the multilevel maintenance concept, maintenance generally is done at the lowest level having the required capability.

OTHER GAO REPORTS RELATING TO THE MATTERS DISCUSSED IN THIS REPORT

Potential For Greater Consolidation of the Maintenance Workload in the Military Services (B-178736, July 6, 1973)

Improving Productivity Through Better Management of Maintenance Operations in Europe (LCD-75-401, March 7, 1975)

Productivity of Military Below-Depot Maintenance--Repairs Less Complex than Provided at Depots--Can Be Improved (LCD-75-422, July 29, 1975)

Navy Aircraft Overhaul Depots Could Be More Productive (LCD-75-432, Dec. 23, 1975)

PRINCIPAL OFFICIALS

RESPONSIBLE FOR ACTIVITIES

DISCUSSED IN THIS REPORT

	Tenure of office	
	From	To
SECRETARY OF DEFENSE:		
Donald Rumsfeld	Nov. 1975	Present
James R. Schlesinger	June 1973	Nov. 1975
William P. Clements, Jr. (acting)	Apr. 1973	June 1973
Elliot L. Richardson	Jan. 1973	Apr. 1973
ASSISTANT SECRETARY OF DEFENSE (INSTALLATIONS AND LOGISTICS):		
Frank A. Shrontz	Feb. 1976	Present
John J. Bennett (acting)	Apr. 1975	Feb. 1976
Arthur T. Mendolia	Apr. 1973	Mar. 1975
Hugh McCullough (acting)	Jan. 1973	Apr. 1973
SECRETARY OF THE NAVY:		
J. William Middendorf	Apr. 1974	Present
John W. Warner	May 1972	Apr. 1974
CHIEF OF NAVAL OPERATIONS:		
Adm. James L. Holloway III	July 1974	Present
Adm. Elmo R. Zumwalt, Jr.	July 1970	July 1974
CHIEF OF NAVAL MATERIAL:		
Adm. Frederick H. Michaelis	Apr. 1975	Present
Adm. Isaac C. Kidd, Jr.	Dec. 1971	Apr. 1975