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Report to the Chairman, Subcommittee on Defense, Committee on Appropriations, House of Representatives

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COMPUTER ACQUISITION

Navy's Aviation Logistics System Not Ready for Deployment

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Information Management and
Technology Division

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The Honorable John P. Murtha
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

This report is in response to your predecessor's October 19, 1988, request to review the Naval Aviation Logistics Command Management Information System (NALCOMIS). As agreed with your office, we responded orally on September 19, 1989, to questions concerning the accuracy and disclosure of NALCOMIS cost estimates and the appropriateness of fiscal year 1990/1991 budget requests. This report addresses the question of whether the risks and benefits of NALCOMIS warrant its scheduled deployment. We conclude that the second phase of NALCOMIS is not ready for deployment because the Navy has not adequately performed some key software development steps. As a result, chapter 4 of the report contains recommendations to the Secretary of the Defense outlining certain conditions that should be met before deployment approval is granted.

As arranged with your office, we are providing copies of this report to the Secretary of Defense and the Secretary of the Navy, select congressional committees and members, and to other interested parties upon request.

Sincerely yours,

Ralph V. Carlone
Assistant Comptroller General

Executive Summary

Purpose

Naval aviation maintenance and supply represents a formidable management challenge. The Navy and Marine Corps are responsible for maintaining roughly 6000 aircraft worth $75 billion. These aircraft average about 1.6 million maintenance actions each year, and the replacement parts for these aircraft are valued at over $18 billion.

To improve management of these operations, the Navy is acquiring a large management information system. This system, called Navy Aviation Logistics Command Management Information System (NALCOMIS), has an estimated life cycle cost of $1.34 billion.

Because of concern about the system's cost, development, and testing, the former Chairman, Subcommittee on Defense, House Committee on Appropriations, asked GAO to determine if NALCOMIS' risks and benefits warrant its scheduled deployment.

Background

The Navy plans to use NALCOMIS at 88 intermediate maintenance activities (e.g., Naval air stations, Marine air groups, aircraft carriers, etc.) and about 400 organizational maintenance activities (i.e., squadrons). It is currently in the second of a three-phased approach to acquiring the system. Because Phase I quickly provided some limited functions, it was adopted as an interim system with the understanding that phase II would replace it. Phase I is currently operating at 29 intermediate-level sites. Phase II offers considerably more capability, and is operating at nine intermediate-level maintenance sites. Phase III includes phase II functions and some additional functions, and will be deployed to the organizational-level sites.

Results in Brief

To minimize the cost and performance risks associated with building information systems like NALCOMIS, Navy and Defense guidance requires the performance of certain software development steps. While omitting or only partially performing one or more of these steps does not categorically condemn systems to failure, such actions increase the risk that they will not adequately perform and will cost more to develop and maintain than necessary.

Phase II NALCOMIS is not ready for deployment because the Navy has not adequately performed some key software development steps. Specifically, the Navy confined phase II operational testing to sites that are not representative of the heavy processing workloads and stringent on-line system availability requirements of some sites scheduled to receive

phase II. Additionally, NALCOMIS security features were not based on the required assessment of system risks and cost-effective countermeasures, and its security certification is questionable because security test results do not indicate that important system controls were tested. Further, the Navy either did not develop or did not maintain certain documentation (e.g., program maintenance manual) necessary to efficiently maintain the system. The Navy also has not evaluated whether the operational readiness benefits expected from phase II are accruing. To the Navy's credit, it has taken steps to address problems GAO raised with system regression testing and portability to new hardware, and it has demonstrated that phase II can operate at the small to medium-size sites. Further, it appears that NALCOMIS users are pleased with the system.

Principal Findings

Further Testing and Documentation Needed

Navy instructions require that information systems be (1) thoroughly tested, (2) certified as secure, and (3) supported by adequate documentation. However, GAO found that the Navy has not fully satisfied each of these requirements. For example, the Navy has not field tested phase II at representative sites. The larger of the two phase II test sites, Naval Air Station-Norfolk, processes only about one-third the number of items that the largest site scheduled to receive the system does. Further, both test sites' requirement for on-line system availability is less stringent than the requirement aboard aircraft carriers.

The Navy has also not performed stress testing to determine how system resources (e.g., processors, channels, primary storage) will perform under more demanding workload and system availability conditions than those encountered at the two test sites. Thus, the Navy does not know if the system will perform effectively in the more taxing environments found at large air stations and aboard aircraft carriers. After GAO alerted Navy officials to this concern, the officials stated that they are acquiring the tools necessary to predict and monitor system requirements for a given site.

Additionally, the Navy has not followed Navy and Defense guidance requiring that risk assessments be developed and used to determine the type and extent of security measures that should be built into a system during development. As a result, the Navy does not know if it has designed the most appropriate security features into NALCOMIS. Further,

the Navy's testing of the security features it did build into NALCOMIS omitted requisite tests, such as controls to prevent users from executing operating system commands/privileged instructions. Such omissions raise serious doubt about the basis for its recent certification of phase I and II software as secure.

Further, the Navy has yet to develop a NALCOMIS program maintenance manual, as required by Navy instructions, and it has failed to either develop or maintain certain testing documentation, such as the specific results of the tests performed. According to NALCOMIS officials, the maintenance manual was not contractually required because they planned to use system specifications and source code in lieu of the manual, and they have maintained the system for over a year with this documentation. Without this manual and the testing documents, system maintenance will be more difficult and costly than necessary.

User Reaction to Phase II Is Positive

Navy users at the phase II sites GAO visited stated that they are pleased with the system, and officials with the Navy's Atlantic and Pacific Commands echoed these sentiments. Additionally, NALCOMIS oversight officials told us that their impressions of phase II user reactions are positive. GAO's observation of phase II operations at these two sites showed user familiarity and comfort with the system, and disclosed no apparent system performance problems.

Demonstration of Phase II Benefits Needed

The Navy's principal justification for NALCOMIS is to improve aviation maintenance and supply readiness. However, the Navy has yet to demonstrate through analysis of operational performance at a phase II site that expected readiness improvements are actually being realized. Specifically, Defense and Navy instructions require evaluations of ongoing programs to ensure that expected benefits are actually being attained in the most cost-effective manner. Although the Navy has operated phase II at four sites for over 1 year and one site for over 2 years, the Navy's analyses of phase II benefits identify only administrative/clerical benefits (e.g., labor reductions associated with using and maintaining manual records and documentation). They do not link these benefits to the operational readiness improvements initially used to justify NALCOMIS or to personnel reductions. GAO performed a limited examination of some indicators of operational performance at four phase II sites to see if readiness benefits were actually accruing. Based on these indicators, GAO found that phase II was not consistently producing

improvements in aircraft readiness. While GAO's results do not demonstrate conclusively whether or not expected phase II benefits are accruing, they do reinforce the need for the type of in-depth program evaluation required by Navy and Defense instructions.

Recommendations

GAO recommends that the Secretary of Defense direct the Secretary of the Navy to defer any further phase II deployment until the NALCOMIS program office (1) fully stress tests the system, (2) successfully field tests the system aboard a carrier and at a large Naval air station, (3) clearly demonstrates that expected system benefits are being achieved, (4) fully assesses system security requirements and completely tests security features, and (5) develops a system maintenance manual. GAO further recommends that the Secretary of Defense direct the Major Automated Information System Review Committee to withhold its phase II deployment approval until the committee reviews the Navy's efforts to expeditiously satisfy the above conditions.

Agency Comments

As requested by the Chairman's office, GAO did not obtain official agency comments on a draft of the report. However, GAO discussed the report's findings with Navy and Office of the Secretary of Defense officials and has incorporated their comments where appropriate.

Contents

Abbreviations

GAO	General Accounting Office
IMTEC	Information Management and Technology Division
MAG	Marine Air Group
MAISRC	Major Automated Information System Review Committee
NALCOMIS	Naval Aviation Logistics Command Management Information System
NAS	Naval Air Station

Introduction

The Navy and Marine Corps' ability to fulfill their missions depends in part on how effectively and efficiently they repair, maintain, and supply parts for their aircraft. These services are responsible for the preventive and remedial maintenance on about 6000 aircraft, with an estimated value of $75 billion. These aircraft average about 1.6 million repair and maintenance actions each year. The Navy and Marine Corps are also responsible for managing an aircraft parts inventory valued at over $18 billion.

The Navy is currently in the second of a three-phase project designed to improve management of aircraft maintenance and supply support operations. The system, called Naval Aviation Logistics Command Management Information System (NALCOMIS), will automate the record keeping and management reporting associated with these operations. The estimated life cycle cost of NALCOMIS is $1.34 billion.

On October 19, 1988, the former Chairman, Subcommittee on Defense, House Committee on Appropriations, expressed interest in NALCOMIS' costs, budgetary disclosure, benefits, development and testing, and hardware procurement schedules, and asked us to review the program. On the basis of this request and subsequent discussions with the Chairman's office, we agreed to determine whether (1) the risks and benefits associated with NALCOMIS phase II warrant its scheduled deployment, (2) the NALCOMIS life cycle cost estimate is accurate and complete, (3) the Navy has fully disclosed the NALCOMIS life cycle cost estimate to Congress, and (4) the fiscal year 1990/1991 NALCOMIS operations and maintenance and procurement budget requests are appropriate in light of the number of installations either operating or scheduled to operate NALCOMIS during this period.

This report addresses the first objective (i.e., do the risks and benefits of phase II warrant its scheduled deployment). Our results on the other three objectives were provided to the Chairman's office during an oral briefing on September 19, 1989. A detailed explanation of our scope and methodology for the first objective is in appendix I.

Aircraft Maintenance and Supply: A Brief Description

Aircraft maintenance and repair in the Navy and Marine Corps is performed at three levels—organizational, intermediate, and depot--depending on the complexity of the maintenance being performed. In general, the organizational level performs less complex maintenance tasks while the depot level performs the most demanding repairs. The

supplies and parts required for each maintenance activity are managed by the supply centers that support each activity.

The organizational maintenance activities (i.e., organizational level) are the squadrons that possess the aircraft. These activities perform routine servicing, inspections, and replacement of parts. They also fix aircraft components that remain on the aircraft while repairs are being made.

The intermediate maintenance activities (i.e., intermediate level) include Naval air stations (NAS), Marine air groups (MAG), and aircraft carriers. These activities perform maintenance that is beyond the squadron's capabilities, such as equipment tuning or adjusting and repairs requiring special equipment or training. These activities also repair or replace damaged aircraft components that must be removed from the aircraft to be worked on, and they manufacture certain parts that are not available.

The Naval aviation depots (i.e., depot level) perform the most complex repairs, such as major overhauls and rework that are beyond the capabilities of the organizational and intermediate levels.

In brief, the aviation maintenance and supply support process begins when a maintenance activity requests a replacement part from supply and is completed when either a new part or the repaired part is delivered to the requesting maintenance activity. This process includes tracking the defective part from the time it is turned in for repair until it is returned to the supply shelf for immediate or subsequent issue.

What Is NALCOMIS?

NALCOMIS is an automated management information system for Navy and Marine Corps organizational and intermediate maintenance activities and supply support centers. It will automate a variety of record keeping and reporting requirements for these activities. For example, NALCOMIS will maintain a repair history for aircraft, track inventory levels at supply centers, track the status of parts under repair, and automate aviation repair and maintenance manuals. Prior to NALCOMIS, these functions were mostly performed manually.

The ultimate objective of NALCOMIS is to improve aircraft mission readiness through (1) improved availability of real-time information to support day-to-day aircraft maintenance and supply management decisions, (2) reduced work force levels needed to manually collect and validate

data during the maintenance and supply process, and (3) improved quality of information on parts repair and replacement actions reported to other Navy organizations for use in engineering, budgeting, parts provisioning, and other related decisions.

The Navy is following a three-phase approach to developing and deploying NALCOMIS. According to the Navy, the phased approach allows them to take advantage of some automated benefits while the system is still being developed. Phase I provides an automated capability at the intermediate maintenance activities for managing the extensive record keeping associated with the repair of aircraft parts.

Because phase I's functions are limited, it was adopted as an interim system with the understanding that phase II would replace it. Phase II will fully automate aviation maintenance functions at 88 intermediate maintenance activities and supply support centers.[1] Phase III includes certain phase II capabilities and a few new system functions, and will be deployed to about 400 additional sites (i.e., the organizational maintenance activities).

Program History and Status

Since approval of the NALCOMIS concept in February 1977 by the Assistant Secretary of the Navy (Financial Management), NALCOMIS has experienced a lengthy development process caused by (1) failures in software design and (2) delays in awarding a Navy-wide hardware contract[2], which the NALCOMIS program was required to use. As stated by one program official, NALCOMIS did not get on track until after the Assistant Secretary of the Navy (Financial Management) June 1984 decision to adopt a three-phase approach to deploy an existing system, Status and Inventory Data Management System II,[3] on an interim basis until the NALCOMIS software was developed and tested. Following this decision, the Navy converted this existing system's software to operate on the NALCOMIS hardware, and in November 1984 the Assistant Secretary of the Navy (Financial Management) approved its deployment as phase I

[1]These 88 activities include all but one of the 33 activities that either has operated or is now operating phase I. In addition to the 88 activities, phase II will be implemented at 15 more sites used for training and contingency operations. The one phase I activity not scheduled for phase II is an aircraft carrier to be decommissioned.

[2]The contract is the Shipboard Non-Tactical Automated Data Processing Program, a Navy-wide contract intended to provide compatibility among the Navy's non-tactical information systems.

[3]This system was developed by the Naval Air Forces Atlantic Fleet to automate aircraft repair record keeping on aircraft carriers during deployment.

NALCOMIS. The Navy then competitively awarded a contract for phase II and III software development. Between 1985 and 1988, the Navy deployed phase I to 33 intermediate maintenance activities.

In September 1986, the Navy began operating phase II at one MAG on a prototype basis. After 6 months of operation, including a 10-day system performance test, the program office requested full fleet deployment approval. In June 1987, the Assistant Secretary of the Navy (Financial Management) approved phase II's deployment to four additional shore sites and one aircraft carrier. However, full fleet deployment approval was withheld pending the results of testing at an NAS. Also in June 1987, the Navy halted phase III after 90 percent of the software was developed. According to a program official, funds allocated to phase III completion were shifted to phase II to correct functional deficiencies. In December 1988, the Navy completed testing at the air station, and in July 1989, was granted conditional full fleet deployment (see next section for discussion of conditions).

Currently, phase I is operating at 29 intermediate activities, and phase II is operating at nine intermediate activities (seven MAGS, one NAS, and one non-deployed aircraft carrier[4]). During fiscal years 1990 and 1991, the Navy plans to deploy phase II to 17 more intermediate sites, and it plans to have deployed phase II to all 88 intermediate sites by fiscal year 1995. Additionally, the Navy plans to begin deploying phase III to its organizational sites in fiscal year 1992 and to complete phase III deployment in fiscal year 1997. Through fiscal year 1989, the Navy has expended $261 million on the three phases.

Office of the Secretary of Defense Program Oversight

The Office of the Secretary of Defense exercises its oversight responsibilities for major[5] automated information systems through its Major Automated Information Systems Review Committee (MAISRC).[6] However, the MAISRC did not regularly review NALCOMIS until July 1986. The system was exempted from review because it had progressed past its

[4]According to the program manager, this carrier has yet to be deployed and does not have a full air wing aboard. As a result, phase II is not yet operating on this carrier under normal workload conditions.

[5]Defense Directive 7920.1, Life Cycle Management of Automated Information Systems, defines major systems as those with estimated project costs over $100 million, those with estimated costs in any one year over $25 million, or those designated as special interest.

[6]MAISRC is a senior-level Defense review board responsible for guiding and directing major resource investments in general-purpose computer systems.

initial planning stages when the MAISRC was established in the late 1970s.

During the fiscal year 1986 appropriations process, the Committee on Appropriations expressed concern with NALCOMIS and directed the MAISRC to review the system. The review was held in July 1986, and it concluded that the Navy had proper management controls in place and that development was on schedule. As a result, NALCOMIS oversight authority was returned to the Navy. In February 1988, the Office of the Secretary of Defense found that NALCOMIS was experiencing schedule delays and conducted an on-site review in March 1988. As a result of the review's findings, the Navy's oversight authority was reclaimed by the MAISRC in June 1988.

In July 1989, the MAISRC reviewed NALCOMIS and conditionally approved phase II full fleet deployment. The conditions included the following actions and reports, which the Navy was directed to complete and submit to the MAISRC.

- Full configuration management and capacity management programs must be operational and their procedures followed.
- NALCOMIS testing program should proceed and full documentation of test results accomplished. This program should include capacity testing, performance testing, and available on-board carrier test results.
- A report on the alternatives for accelerating phases II and III implementation, including options for completing deployment by fiscal year 1993 and identifying the resource and benefit impacts of each alternative.
- A report clarifying the strategies for hardware acquisition after the current contract expires in 1992. This report should include transition and open competition considerations and these considerations should be coordinated with the implementation schedule.

In October 1989, the Navy submitted its response to the MAISRC. The MAISRC is reviewing the response and has yet to rule on whether it satisfies the conditions.

Further Testing and Management Actions Needed to Reduce Phase II Deployment Risks

The Navy's approach to managing the development of NALCOMIS has not met Navy and Defense system development requirements and has not included the prudent management actions needed to minimize system cost and performance risks. We found several deficiencies with phase II testing that cast serious doubt on whether the system is ready to be deployed. For example, the Navy tested the system at a MAG and an NAS that are not representative of the larger air stations and the aircraft carriers scheduled to receive it. Also, the Navy has not fully tested system security features, and it did not develop and use a risk assessment to determine if the security features it built into NALCOMIS were the most cost effective and appropriate. Further, the Navy has operated both phase I and II without obtaining the required security accreditations for the sites where phase II has been installed. In addition, the Navy has not developed and maintained certain system documentation (e.g., program maintenance manual) that is necessary for the cost effective maintenance of the system.

The Navy has, however, taken positive steps to address concerns we raised about phase II stress testing and portability to different hardware environments, and has demonstrated that the system can perform at a MAG and a medium size NAS. Additionally, users at these sites where phase II is performing stated that they are generally pleased with the system. In spite of these positive steps and reactions, more actions are needed to justify any further deployment.

Testing Has Not Demonstrated That Phase II Will Effectively Perform at All Sites

According to Navy Instruction 5232.1, Quality Assurance Program for Information System Projects, testing validates that an information system satisfies the functional and technical requirements and that the system can be used effectively. Accordingly, the instruction requires that information systems be thoroughly reviewed, tested, and evaluated before being deployed and that all deployed systems be accredited in accordance with Navy security requirements. The testing process is progressive, with each subsequent series of tests building on prior tests. It is designed to determine if the system performs as required under normal operational conditions as well as how the system performs under maximum workloads. We found several deficiencies in the Navy's testing of phase II NALCOMIS.

Test Sites Are Not Representative

Defense Directive 7920.1, Life Cycle Management of Automated Information Systems, and Navy Instruction 5231.1B, Life Cycle Management Policy and Approval Requirements for Information System Projects,

state that information systems, including those like NALCOMIS that will be deployed to multiple sites, should be field tested at one or more representative sites prior to deployment. However, neither MAG-14 nor NAS-Norfolk is representative of all sites scheduled for phase II deployment in terms of (1) expected workloads or (2) requirements for on-line system availability.

The workload at NAS-Norfolk, the larger of the two test sites, is only about one-third that of NAS-Oceana and NAS-Cecil Field, the two largest sites scheduled to receive phase II. Specifically, the number of items processed per year at NAS-Norfolk is about 33,000. In contrast, the number processed at NAS-Oceana is about 96,000 and the number at NAS-Cecil Field is about 95,000. Six other air stations also have workloads greater than NAS-Norfolk's.[1] NALCOMIS officials agree that NAS-Norfolk is not representative of the larger air stations. In fact, the officials responsible for software development stated that they are certain that the hardware configuration at NAS-Norfolk will not work at NAS-Oceana. According to the NALCOMIS officials, NAS-Norfolk was selected as the first air station to receive phase II because of its physical proximity to the Navy office responsible for software development, not because it is representative of all phase II sites.

Additionally, the requirement for on-line system availability to users at NAS-Norfolk and MAG-14 is less demanding than the on-line system availability requirement aboard aircraft carriers. NALCOMIS system requirements state that the system be up and on-line aboard an aircraft carrier 22 hours a day, 26 days a month. In contrast, the requirement for shore sites, like NAS-Norfolk, is 22 hours a day, but for only 21 days a month. According to officials in the Commander Naval Air Force, Atlantic Fleet, the difference reflects the fact that shore sites operate 5 days per week while carriers operate 7 days per week.

Moreover, the Navy has experienced difficulty in meeting the less demanding on-line availability requirement at shore sites. NAS-Norfolk system availability statistics show that on-line availability to users during the 5-day work week has averaged about 20 hours a day. However, this average availability has been achieved by performing some processing and system maintenance on the weekends, and thereby improving the daily average for on-line availability. This option would not be possible aboard a carrier because the system must be on-line every day of the week. When NAS-Norfolk's system availability is viewed over the 7-day

[1]These workloads range from about 41,000 to 78,000 items processed per year.

period, as it would be aboard a carrier, on-line availability drops to about 19 hours a day. Officials in the Office of the Secretary of Defense's Directorate for Operational Test and Evaluation and Comptroller's Office as well as NALCOMIS program officials agreed that NAS-Norfolk is not representative of a carrier in terms of on-line system availability.

Testing to Measure System Performance Under Maximum Workloads Not Adequate but Improvements Underway

Stress testing is an integral part of capacity management.[2] Its purpose is to (1) ensure that the total system will successfully process workloads expected during peak production periods and other extreme conditions and (2) determine the point at which major system resources (e.g., processor, channels, primary storage, etc.) will be exhausted. Volume II of Defense Software Test and Evaluation Manual and Federal Information Processing Standard Publication 102 advocate stress testing. Additionally, the official in the Office of the Director for Operational Test and Evaluation responsible for NALCOMIS oversight told us that system testing should have included tests for extreme and abnormal conditions, but did not.

Early in our review, NALCOMIS officials stated that the system configuration needed by each phase II site would be determined as the system was implemented at a given site. Additionally, NALCOMIS officials told us that they had no plans to stress test the system before deploying it to a large NAS. According to the official responsible for MAG-14 testing, stress testing was not possible because they did not have the capability to generate the heavy workloads needed to do so. After we expressed concern about using such a trial and error approach to configuring systems, the Navy took steps to acquire a commercially available capacity management tool that can emulate a specified transaction work load on a proposed system configuration and monitor the system's performance. The Navy has also analyzed and described the work loads expected at large air stations. According to NALCOMIS officials, they "hope" to have acquired the full emulation package necessary to simulate a large NAS before deploying phase II to NAS-Lemoore, currently scheduled for early 1990. In our opinion, acquiring the emulation package is a positive step, and it should be used to stress test the system before operationally testing it at a large site such as NAS-Lemoore.

[2]Capacity management ensures that computer systems (1) are properly designed and configured to give efficient performance and (2) have sufficient resources to support operating work loads. As part of this process, future work loads and required user service levels (e.g., system availability) are forecasted, and system configurations to meet the demands are proposed, modeled, and tested.

Identification and Testing of Security Features Not Adequate

The Navy has not complied with key provisions of Navy and Defense security requirements in (1) determining what security features should have been included in NALCOMIS and (2) testing those security features. Further, the Navy has operated, and in light of deficiencies in recent security testing, may still be operating NALCOMIS without satisfying its own requirements for system certification and site accreditation.

Navy Instruction 5239.1A, Department of the Navy Automatic Data Processing Security Program, states that information system security is intended to (1) protect data against accidental or intentional destruction, modification, or disclosure, and (2) protect users against denial of service that may result from such events as fraud, misuse, and sabotage. Additionally, this instruction requires the development and use of risk assessments in the system development process to systematically examine system threats and vulnerabilities and determine cost-effective countermeasures to use.

The Navy did not do the required risk assessment and, therefore, could not base the security features included in NALCOMIS on such an assessment. The reason for not doing so, according to the NALCOMIS deputy program manager, was that the security features built into NALCOMIS and described in the NALCOMIS functional description were devised before any requirement for such an assessment. However, that part of Chapter 5 of Navy Instruction 5239.1A addressing risk assessments is dated August 1982[3], while NALCOMIS officials stated that the NALCOMIS functional requirements were not "baselined" until 1985 and the latest version of the functional description is dated September 1988. The deputy program manager later agreed that the timing of NALCOMIS does not exempt the system from Navy Instruction 5239.1A. In our opinion, without a risk assessment, the Navy does not know whether the security features in NALCOMIS are either sufficient or cost effective.

According to Navy Instruction 5239.1A, a Navy activity cannot operate a computer system or network without first obtaining either site accreditation or a written interim authority to operate the system. Accreditation is approval by the designated approval authority[4] to operate based on a review of the site's total security posture for its computer systems

[3]Navy Instruction 5239.1A updated parts of Navy Instruction 5239.1 on April 1, 1985.

[4]Varies depending on the level of security required.

and networks. An interim authority to operate can be viewed as temporary accreditation for a fixed time period, usually one year. The instruction also states that systems to be deployed to multiple sites, like NALCOMIS, must be certified before site accreditation can be given to any site. System certification refers to a determination that the system's software is secure (i.e., system security features are functioning properly).

Key NALCOMIS security features were not tested as part of NALCOMIS security testing. As a result, the Navy's recent certification of NALCOMIS software as secure is questionable. In March 1989, the Navy developed a NALCOMIS security test plan and in June 1989 executed part of this plan. The remainder of the test plan, according to the NALCOMIS program manager, is to be completed by each phase II site. Based on the testing performed, the Navy certified the NALCOMIS phase I and II software as secure. However, we found instances where key security controls were not tested as part of the system security test. For example, the plan states that "users will not have access to the operating system" (i.e., users cannot execute operating system commands/privileged instructions). However, the results of security testing do not show that this restriction was tested prior to security certification. According to the NALCOMIS program manager, this requirement was to be tested by each site. In our opinion, not only does this approach represent a significant duplication of effort, but more importantly it raises serious doubt about whether the NALCOMIS security certification is based on adequate testing. NALCOMIS officials agreed with our opinion, stating that all software testing, including restrictions on execution of privileged instructions, should have been performed centrally before certification was given. However, they also stated that although certain security features were not tested as part of formal security testing, the features are exercised daily as a consequence of working with the system. The officials said that the problem is that they have not documented their efforts to exercise these features. Additional examples of security features relating to the operating system that were not identified as being tested in the security test results report, despite being cited in the test plan, include:

- all processor instructions/operation codes (e.g., load, add, subtract, etc.) will produce known responses by the computer;
- read, write, and execute access rights of the user will be verified each time a computer instruction is executed;
- unauthorized attempts to change, circumvent or otherwise violate system security features will be detectable and will abort or suspend the operation running; and

- an audit log or file will be maintained as a history of system use to permit regular security reviews.

The Navy began deploying NALCOMIS phase I in 1985 and phase II was installed at MAG-14 on a prototype basis in 1986; however, it did not certify phases I and II software, which is a prerequisite to NALCOMIS site accreditation, until July 1989. As a result, the Navy operated both NALCOMIS phase I and phase II for at least 3 years at various sites without meeting the conditions for site security accreditations. Additionally, the NALCOMIS program manager did not know whether any of the sites had an interim authority to operate and was unable to provide any evidence that they did. Thus, we believe that the Navy has operated NALCOMIS and, in light of our above-cited concern that NALCOMIS security testing may not provide sufficient basis for software certification, may still be operating it without satisfying the requisite conditions for doing so.

Regression Testing Limited but Improvements Planned

Regression testing is testing following a program change to (1) ensure that the change has corrected the problem and (2) demonstrate that no new problems have been introduced in any part of the system as a result of the change. Regression testing is important because new errors are often introduced when software is modified.

The Navy's current approach to NALCOMIS regression testing is to do it manually. According to NALCOMIS officials, 6-8 people manually enter test transactions at terminals for a 45- to 60-day period for each new software release. These officials stated that the tests cover "100 percent of the code directly affected by a change and a random sample of the remainder of the system." However, they admitted that they suspect that their people entering test transactions skip pages in the test procedures and sometimes misinterpret test results because of waning attention. In our opinion, such an approach to regression testing is inadequate. NALCOMIS officials agreed that this approach is limited, and since we first raised concerns about regression testing, the officials told us that they plan to use an emulation tool being acquired to develop and run an automated and repeatable regression test suite. On the basis of our discussions with representatives of the company selling the proposed emulation tool and a review of literature describing its features and functions, we believe that it will aid in correcting the Navy's regression testing problems.

Lack of Phase II Maintenance Manual and Test Documentation Will Make System Maintenance Unnecessarily Difficult and Costly

Navy Instruction 5231.1B, Life Cycle Management Policy and Approval Requirements for Information System Projects, requires that all components of an information system be identified and documented, and that changes to these components be controlled, recorded, and reported. Among the many components subject to these requirements are (1) system test plans and the associated test results and (2) system manuals (e.g., users manual, operators manual, and maintenance manual). These requirements are designed to help ensure that the system meets users requirements and can be operated and maintained efficiently and effectively.

We found that some key phase II documentation does not exist. As a consequence, the Navy has seriously amplified the risks associated with maintaining NALCOMIS. To illustrate, Navy Instruction 5232.1 as well as the NALCOMIS Configuration Management Plan and the Quality Assurance Plan require a program maintenance manual. According to Defense Standard 7935, Automated Data Systems Documentation, a program maintenance manual provides the maintenance programmers with the information necessary to effectively maintain a system. However, NALCOMIS officials stated that no such manual exists because a conscious decision was made not to require one under the terms of the NALCOMIS system development contract. The officials stated that maintenance personnel will rely on various system specifications and "heavily commented" application source code in lieu of such a manual, and given their knowledge of the system and the modular structure of the application code, they added that this is all the documentation they have needed to maintain the system for over 1 year. Additionally, the program manager told us that existing documentation will be augmented by word-of-mouth and on-the-job training. In our opinion, this approach is not adequate for a system as large and important as NALCOMIS. Although system maintenance may be possible without a manual, it will undoubtedly be more difficult and costly than necessary.

Limited phase II test documentation compounds the Navy's maintenance difficulties for NALCOMIS. Specifically, we found that only a report summarizing the results of phase II testing at MAG-14 exists. The detailed test results, according to the Navy official responsible for MAG-14 testing, were discarded. As stated in Defense Software Test and Evaluation Manual, Volume II, creating and maintaining the complete test documentation chain is important. Specifically, future events may produce questions that can be answered using existing test results, supplemented possibly with only limited new testing. If software test results are improperly recorded or lost, the benefits of such economies cannot be

realized. The manual further states that a lack of proper testing documentation can call into question the adequacy of testing in total.

Also, the test plan for MAG-14 includes only ambiguous and general guidance, leaving the choice of specific test procedures and test data to the discretion of the individuals performing the tests. Documented, detailed test procedures for MAG-14 do not exist, according to the Navy official responsible for MAG-14 testing. As stated in Defense Standard 2167A, Defense System Software Development, test procedures should specify exactly what test inputs to provide, what steps to follow, what outputs to expect, and what criteria to use in evaluating the outputs. If any of these elements are absent, the test procedures are to be considered inadequate.

Navy Currently Taking Steps to Address Transition to New Hardware

Navy Instruction 5232.1, Quality Assurance Program for Information System Projects, states that quality requirements will be defined for each information system project and progress against these requirements will be assured. One quality factor the instruction identifies is portability, which is the effort required to transfer software from one hardware configuration or system software environment to another. According to Defense Guidelines for Software Test and Evaluation, portability is important to software that is expected to outlive its hardware.

Portability is a relevant and important issue for NALCOMIS. We found that the current NALCOMIS processors are old, and that the contract from which this hardware is being purchased expires in 1992. Specifically, NALCOMIS processors are bought off of a Navy-wide hardware and systems software contract. Awarded in 1982, this fixed-price contract spans 10 years with an option to extend for 10 additional years. However, the contractor does not plan to continue marketing the processors available under the contract, and Navy officials said that the processors were obsolete even before the NALCOMIS software was developed.

Although the contract includes a 10-year renewal option, a resolicitation appears likely. Under the terms of the contract, the Navy is to state technology improvement requirements by contract year 8 (i.e., 1990). If the contractor responds to the Navy's requirement at a reasonable cost to the government, then the 10-year option may be negotiated and awarded. If the contractor does not respond or if the response is not accepted by the Navy, a competitive procurement for phase II replacement hardware and phase III initial hardware will ensue. According to Automatic Data Processing Selection Office officials responsible for this

process, a competitive resolicitation and contract award is likely because of Competition in Contracting Act considerations.

Despite the importance and relevance of software portability to NALCOMIS, the Navy had not addressed this issue until our inquiries. We found early in our review that the Navy was not using an available software monitoring utility that flags deviations from standards for the programming language being used for all applications. Further, we found that they had not examined the extent to which software contractor's compiler complied with standards. Any deviations from standards will make the software more difficult to "port" to different hardware. According to the NALCOMIS program manager, portability was heretofore not examined because they did not plan to transfer the system to any other hardware in the near future. In our opinion, the Navy should have considered portability before it developed NALCOMIS, and we suggested that the Navy immediately develop a systematic approach to the systems inevitable migration to new hardware.

Since then, NALCOMIS officials told us that they have examined portions of the application code and estimate that about 30 percent is non-standard. They also stated that they plan to evaluate all of the code's compliance with the standards in the near future. Additionally, they recently began a study addressing, among other things, the impact of converting NALCOMIS to operate on new hardware.

User Reaction to Phase II Is Positive

During our review, we visited two phase II sites, NAS-Norfolk and MAG-39, to obtain users' reactions to the system and to observe the system in operation. We also interviewed NALCOMIS user representatives with the Navy's Atlantic and Pacific Commands as well as Office of the Secretary of Defense officials responsible for NALCOMIS oversight to obtain their impressions of user reaction to phase II. In general, we found that users are reacting positively. For example, users at NAS-Norfolk stated that phase II has improved the efficiency of aviation maintenance and supply at the air station and that since phase II, the air station has moved from a reactive to a proactive operation. Other users at NAS-Norfolk told us that phase II has greatly facilitated their work. Users at MAG-39 also offered favorable comments about phase II. For example, one user stated that he "feels that overall the staff are more productive" since phase II, and another summed up MAG-39 user reactions by stating that the general feeling among MAG-39 users is that operations are improving because of phase II.

Our interviews with user representatives and NALCOMIS oversight officials also revealed user satisfaction with phase II. Specifically, user representatives with both the Atlantic and Pacific Commands stated that users "like" phase II. Similarly, the official in the Office of the Secretary of Defense's Office of Operational Test and Evaluation who is responsible for oversight of testing stated that users "like" phase II. Likewise, the official in the Assistant Secretary of Defense (Program Analysis and Evaluation) responsible for oversight of system costs told us that the phase II users he talked to are "very happy" with the system.

In concert with our interviews of NAS-Norfolk and MAG-39 users, we witnessed the input, processing, and output of various ad hoc transactions in both the maintenance and supply areas. On the basis of this limited observation of the system, we found that users were generally comfortable with the system, and we observed no apparent problems in system performance.

Navy Needs to Demonstrate Phase II Benefits

The primary objective for NALCOMIS is to improve aircraft readiness, and the Navy has largely justified the system on this basis. Additionally, the Navy has been operating phase II at five sites for periods ranging from 1 year to over 2 years. Despite this, the Navy has yet to demonstrate through actual experience at any of these sites, as required by Defense and Navy instructions, that expected operational readiness benefits are being realized. Moreover, our quick look at certain indicators of phase II's operational impact at four sites provided mixed results, and thus we believe it is unclear whether readiness improvements are actually occurring. Without thoroughly evaluating and validating expected benefits, the Navy does not have sufficient information to assure Office of the Secretary of Defense and congressional decision makers that phase II is cost effective.

Navy Evaluations of Phase II Benefits Are Limited

Although the principal goal for NALCOMIS is to improve aircraft readiness, the Navy has yet to demonstrate through actual experience at a phase II site that expected readiness benefits are accruing. Further, while the Navy has analyzed phase II administrative and clerical benefits and has identified the potential for significant savings, we do not believe that these analyses adequately justify deployment of phase II.

The primary goal of aviation maintenance and supply is ensuring that the maximum number of aircraft in the Navy's inventory are mission ready and safe. Achieving this goal is the Navy's principal justification for NALCOMIS. Specifically, the Navy's fiscal year 1990/1991 budget submissions to the Congress state that the Navy is acquiring NALCOMIS to improve aircraft operational readiness. Similarly, Navy life cycle management documents state that a principal objective of NALCOMIS is to implement a system that will measurably improve aircraft readiness.

Defense Instruction 7041.3, Economic Analysis and Program Evaluation for Resource Management, and Navy Instruction 7000.14B, Economic Analysis and Program Evaluation for Navy Resource Management, require that evaluations of ongoing programs be conducted to (1) ensure that expected benefits are being attained in the most cost effective manner and (2) determine how best to improve the programs. The instructions further require that these program evaluations be conducted as early in the acquisition process as practical and they state that the evaluations should, among other things, compare actual performance data against expected performance data.

The Navy's most recent evaluations of Phase II benefits are (1) the Benefit Analysis included in the life cycle management documentation dated February 1989 and reviewed by the MAISRC in July 1989, and (2) an Independent Benefit Analysis conducted by the Naval Regional Data Automation Command and dated February 1989. However, the former Benefit Analysis is the same one used in justifying the Navy's 1987 limited deployment decision, and thus is over 2 years old. As a result, this analysis only addresses phase II administrative and clerical savings. It does not address expected benefit areas such as increased productivity, efficiency, and readiness. According to the Benefit Analysis, the Navy deferred evaluating these productivity, efficiency, and readiness benefits until after it deployed the system because any such evaluation would require pre- and post-phase II mission effectiveness data for a given site. At the time the analysis was performed (i.e., over 2 years ago), phase II was operating for only a few months at one site and thus evaluating operational benefits was not viewed as feasible. However, since that time, phase II has operated at four sites for over 1 year and one site for over 2 years.

Although phase II's administrative and clerical benefits identified by the Benefit Analysis are significant, they represent potential benefits that the Navy has yet to demonstrate as actually accruing. Specifically, the analysis identifies benefits totalling about $113 million a year.[1] However, about $107 million or 95 percent of these benefits are attributable to more efficient use of supply and maintenance personnel (i.e., freeing supply and maintenance specialists from performing administrative and clerical tasks). Further, the analysis states that this $107 million is not a savings but a quantification of the potential value of technical labor productivity increases, and that reducing the work force cannot be justified by the productivity increases. In our opinion, the true measure of whether any benefits are accruing from this redirection of technical labor is whether aircraft maintenance and supply readiness effectiveness has increased and/or work force reductions are possible. However, the Navy has yet to analyze phase II's effect on maintenance and supply readiness, and the analysis states that it is not a basis for work force reductions. Thus, the analysis stops short of demonstrating actual benefits.

The more recent Independent Benefit Analysis also demonstrates only potential benefits and thus does not justify full fleet deployment of

[1]Primarily labor and other costs associated with the maintenance of manual records and input of data from forms.

phase II. Like the above discussed analysis, the Independent Benefit Analysis identifies significant administrative and related savings. However, this independent analysis also does not address readiness improvements. In our opinion, the only way to demonstrate any real benefit from the reported productivity increases is to show either (1) improvements in readiness, which have not been shown, or (2) planned reductions in work force levels, which are not planned based on the benefit analyses.

Office of the Secretary of Defense and Navy program officials agreed that program evaluations are needed to determine the actual operational impact of phase II on aircraft maintenance and supply readiness, and according to the deputy program manager, the evaluations will be performed. However, this official stated that no efforts are underway to plan for them, and no dates have been set for such actions to begin.

Indicators of Phase II Effect on Aircraft Readiness Are Mixed

We performed a limited examination of several operational performance indicators at four sites to see whether phase II was achieving its goal of improved aviation readiness. However, we did not attempt to perform the type of in-depth, thorough program evaluation required by Navy and Defense instructions and directives. Specifically, for each of the four sites, we looked at pre- and post-phase II statistics on:

- Turnaround Time (i.e., the amount of time a part spends in the repair cycle). This indicator should decrease with phase II.
- Ready For Issue Material (i.e., parts that are ready for issue). This indicator should increase with phase II.
- Awaiting Parts (i.e., the condition that exists when a part under repair must wait for needed material(s)). This indicator should decrease with phase II.
- Expeditious Repair (i.e., the processing of repairs requiring expeditious action because a replacement part is not in supply). This indicator should decrease under phase II.

We chose these statistics because Navy benefit analyses for phase I and II and Navy officials cited them as indicators of NALCOMIS' effect on site performance. The statistics covered the period beginning 5-6 months before phase II implementation at each site to the period 4-12 months following implementation.[2]

[2]Post-phase II time periods vary because site implementation dates differ as do the latest dates that statistics are available for each site.

Our comparison[3] of pre- and post-phase II statistics provided mixed results, and does not conclusively demonstrate the effect of phase II on sites' operational readiness posture. However, it does raise questions about the benefits of phase II and reinforces the need for a thorough program evaluation of phase II's impact on aircraft readiness. Specifically, we found that:

- Average Turnaround Time decreased about 3 and 5 percent at two sites, but increased about 9 percent and 18 percent at the other two sites;
- Ready For Issue Material increased about 1 percent at two sites, while it decreased about 2 percent and 7 percent at the other two sites;
- Average Awaiting Parts time decreased about 41 percent and 27 percent at two sites, while it increased about 13 and 14 percent at the other two sites;

Finally, our analysis of the number of Expeditious Repairs, although constrained by limited data, also provided inconsistent results. Specifically, at one site where only post-phase II data was available, the number of Expeditious Repairs consistently increased for 4 months and then consistently decreased for the next 3 months. At another site where only post-phase II data was available, the number of Expeditious Repairs fluctuated monthly. Last, at a site where both pre- and post-phase II data were available, the number of Expeditious Repairs increased by an average of about 3 percent after phase II implementation. No monthly statistics on Expeditious Repairs were available for the fourth site.

[3]We compared the percentage change between the average monthly pre-phase II and post-phase II statistics.

Conclusions and Recommendations

Conclusions

The Navy is attempting to deploy phase II NALCOMIS before it satisfies its own software development requirements and takes the prudent and necessary management steps to (1) minimize system cost and performance risks and (2) validate expected system benefits. Specifically, the Navy has limited phase II field testing to intermediate maintenance activities that are only representative of the small to medium size shore sites scheduled to receive the system. As a result, the Navy does not have reasonable assurance that the system can perform successfully on aircraft carriers or at large phase II sites. Further, although the Navy is acquiring a capacity management tool to assist in configuring the system at all sites, the entire tool may not be acquired before phase II is scheduled for deployment to the first large air station. Even if it is, use of the tool does not substitute for the need to operationally test phase II at representative sites. Additionally, although the Navy has performed system maintenance for over 1 year, it has not developed a system maintenance manual nor maintained certain system documentation which is essential to effective and economical system maintenance. Also, it has not conducted a security risk assessment, and its security test did not address important system controls. Finally, the Navy has not conducted the requisite program evaluations to determine whether readiness improvements in aviation maintenance and supply operations, which it expected phase II to deliver, are actually accruing.

In July 1989, the MAISRC reviewed NALCOMIS and established several conditions that the Navy must meet before phase II deployment would be granted. In October 1989, the Navy advised the MAISRC of the actions it took to address each condition. The Navy also advised the MAISRC that it was proceeding with phase II deployment. As of December 1989, the MAISRC was reviewing the Navy's actions and had yet to rule on whether it satisfied the conditions.

To deploy NALCOMIS phase II, the Navy plans to spend about $173 million over the next 5 years. In light of this substantial investment, it is essential to ensure before proceeding that the system will work as intended at all sites and that the expected benefits will be achieved. While we recognize that phase II is operating at nine sites, users at the sites we visited voiced their satisfaction with the system, and the Navy has taken some steps to reduce NALCOMIS deployment risks, more needs to be done. In our opinion, phase II should not be deployed until it has been operationally field tested at the more demanding intermediate maintenance activities. Additionally, the Navy must thoroughly evaluate its operational phase II system to ensure that the readiness benefits it expects from the system are occurring. To proceed with deployment without resolving these

shortcomings raises the risk that phase II NALCOMIS will not perform as expected and will take longer and cost considerably more to develop and maintain than is necessary.

Recommendations

We recommend that the Secretary of Defense direct the Secretary of the Navy to defer any further phase II deployment until the NALCOMIS program office (1) fully stress tests the system, (2) successfully completes operational testing aboard a carrier and at a large Naval air station, (3) clearly demonstrates that system benefits are actually being achieved, (4) fully assesses system security requirements and completely tests system security features, and (5) develops a system maintenance manual. We further recommend that the Secretary of Defense direct the MAISRC to withhold its phase II deployment approval until the council reviews the Navy's efforts to expeditiously satisfy the above conditions.

Objectives, Scope and Methodology

Concern about cost increases on the NALCOMIS program prompted the former Chairman, Defense Subcommittee, House Committee on Appropriations to ask us for an update on the program. The Chairman specifically expressed interest in NALCOMIS' costs, budgetary disclosure, benefits, development and testing, and hardware procurement schedules. On the basis of the October 19, 1988, request and subsequent discussions with the Chairman's office, we agreed to determine whether

- the benefits and risks associated with the second phase of NALCOMIS warrant its full deployment,
- the NALCOMIS life cycle cost estimate is accurate and complete,
- the Navy has fully disclosed the NALCOMIS life cycle cost estimate to Congress, and
- the fiscal year 1990-1991 NALCOMIS operations and maintenance and procurement budget requests are appropriate in light of the number of activities either operating or scheduled to operate NALCOMIS during this period.

This report addresses the first objective. We provided our results on the other three objectives during a September 19, 1989, briefing to the Chairman's office.

With respect to the risks associated with NALCOMIS phase II, we examined the type and extent of testing performed on the system, including the results of testing and how test findings were addressed. We also examined the Navy's approach for sizing the system (i.e., determining what hardware configuration was needed for each site) as well as its adherence to system life cycle management requirements. Concerning system benefits, we examined the Navy's justifications for NALCOMIS (i.e., statements of expected benefits) as well as its efforts to validate benefits from phase I and phase II NALCOMIS.

In accomplishing these tasks, we reviewed relevant Defense and Navy instructions and directives as well as federal requirements and generally accepted industry practices concerning system testing, sizing, and documentation. We also reviewed Defense and Navy requirements for defining and validating expected system benefits. Additionally, we reviewed NALCOMIS test plans and procedures, test results, and test reports as well as NALCOMIS benefit assessments, system sizing analysis, and other pertinent life cycle management and system documentation. We also collected and performed some analysis on aircraft maintenance and supply performance data from four phase II sites for the 5-6 month period

before system implementation and the 4-12 month period following system implementation to quickly see whether phase II benefits were actually accruing.

Our accomplishment of these tasks also included interviewing officials responsible for program management, contract management, system testing, and system development and maintenance as well as interviewing system users at four Naval air stations and one Marine air group and user representatives with the Navy's Atlantic and Pacific Commands. We also interviewed various officials within the Navy and the Office of the Secretary of Defense having system oversight and approval roles. Additionally, we interviewed representatives from Honeywell Federal Systems, Inc. and Neal Nelson & Associates, whose products are being used.

We performed our work from November 1988 to September 1989, at Navy and Office of the Secretary of Defense headquarters offices in Washington, D.C., and at selected Navy field activities. The principal Navy headquarters offices include the NALCOMIS program office, under the Naval Air Systems Command; the Navy Management Services Support Office, the central design agency for NALCOMIS; the Naval Data Automation Command; the Naval Aviation Maintenance Program Division within the Assistant Chief of Naval Operations for Air Warfare, the functional sponsor; and the Automated Data Processing Selection Office. Field activities visited include the Commander Naval Air Forces-Atlantic Fleet, Commander Naval Air Forces-Pacific Fleet, Naval Air Station-Jacksonville (no NALCOMIS), Naval Air Station- Cecil Field and Naval Air Station-Oceana (phase I NALCOMIS), Naval Air Station-Norfolk and Marine Air Group-39 (phase II NALCOMIS). The principal offices within the Office of the Secretary of Defense include the Office of the Deputy Assistant Secretary (Information Resources Management) within the Assistant Secretary of Defense (Comptroller), the Directorate for Operational Test and Evaluation, the Directorate for Forces Structure and Support Cost Analyses Division within the Assistant Secretary of Defense (Program Analysis and Evaluation), and the Directorate for Plans and System Implementation within the Assistant Secretary of Defense (Production and Logistics).

We discussed the facts in this report with Navy and Office of the Secretary of Defense officials and have incorporated their comments where appropriate. However, in accordance with the requester's wishes, we did

not obtain official agency comments on a draft of the report. We performed our review in accordance with generally accepted government auditing standards.

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