United States General Accounting Office

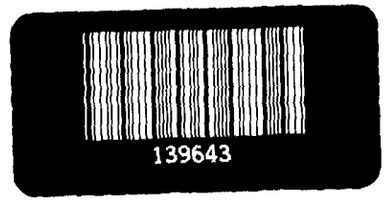
GAO

Report to the Secretary of Defense

September 1989

COMPUTER PROCUREMENT

Hardware Upgrades for Navy Inventory Control System Should Be Delayed



GAO/IMTEC-89-67

GAO

United States
General Accounting Office
Washington, D.C. 20548

Information Management and
Technology Division

B-224148

September 29, 1989

The Honorable Richard B. Cheney
The Secretary of Defense

Dear Mr. Secretary:

This report presents the results of our review of the Navy's plans to spend $22.1 million during fiscal years 1989 through 1991 to upgrade the hardware for its Uniform Inventory Control Point (UICP) computer system. The UICP system supports the inventory management functions of the Navy's Aviation Supply Office (ASO) and Ships Parts Control Center (SPCC). These two activities are responsible for buying, distributing, and managing the repair of the Navy's multibillion dollar equipment and spare parts inventory for aircraft and ships.

The review was performed as part of our continuing evaluation of logistics information systems within the Department of Defense. Our objective was to determine whether the planned $22.1 million UICP hardware upgrade is justified. Briefly, our approach was to examine (1) the basis and support for and assumptions behind the data used to justify the upgrades and (2) the thoroughness of the Navy's evaluations of ways to improve the performance of its existing UICP computer resources.[1] A detailed explanation of our objectives, scope, and methodology is contained in appendix I.

We found that the Navy has not adequately justified its planned expenditure of $22.1 million[2] for upgraded processors and storage devices (see appendix II for a breakout of the hardware requirements and associated costs by fiscal year). Specifically, the justification for the upgrades is based on questionable work load forecasts and limited application software design data as well as a software development schedule that has slipped 17 months. In addition, the Navy has not fully evaluated whether the UICP hardware currently in use can satisfy any part of its projected requirements for upgraded processors and storage devices.

[1]Computer resources include processors, storage devices, input/output devices, etc.

[2]The fiscal year 1989 funds have yet to be obligated. The program office plans to award the contract in September 1989. Additionally, the $22.1 million is part of an appropriation request spread over 3 years.

Although the UICP program office conducted performance evaluations,[3] these evaluations did not identify some significant opportunities for improving the use of existing computer resources.

UICP officials acknowledged that their support for the upgrades has limitations. However, they claim that they cannot wait for better information and still ensure that the hardware will be available when needed. We believe that unless the hardware upgrades are based on an effective capacity management process, a process that includes both reliable information about future work loads and thorough evaluations of current system resource utilization, the Navy is taking a risk that it is not buying the proper amount of processor and storage equipment. We further believe that UICP software development delays and opportunities to better use existing UICP computer resources provide additional time to better justify the upgrades. Therefore, the Navy should defer its planned $22.1 million upgrade of UICP hardware until the project office fully justifies it or unless the project office clearly demonstrates that current ASO and SPCC operations would be jeopardized while developing the justification.

Background

In 1976, the Navy began a three-phased UICP system modernization project. The three phases are (1) acquisition of state-of-the-art hardware, (2) conversion of application software to run on the new hardware, and (3) redesign and development of the converted applications to increase functionality. The first two phases are complete. The UICP project office within the Naval Supply System Command planned the $22.1 million in hardware upgrades as part of phase three to address the additional work load expected from the redesigned software applications as well as work load increases expected from existing applications. These hardware upgrades were planned and justified to coincide with a phased implementation of the redesigned software. However, the schedule for completing implementation of the redesigned software has slipped 17 months to November 1993.

The UICP hardware acquired under phase I of the UICP system modernization project was initially installed in September 1984. Since then, the project office has upgraded the hardware, with the most recent upgrade occurring in 1987. Until fiscal year 1989, the UICP hardware was leased,

[3]Evaluations to determine if existing computer system resources are being optimally used and identify ways to improve usage. Navy instructions require performance evaluations before upgrading system resources.

but the project office is currently exercising a purchase option to buy the leased hardware.

Capacity Management Is Integral to Computer Operations

Capacity management ensures that computer systems (1) are properly designed and configured to give efficient performance, and (2) have sufficient processing and storage capacity for present and future operations. Federal Information Resources Management Regulations generally require government agencies to conduct capacity management activities in planning, acquiring, and using computer resources.

Capacity management includes performance management and capacity planning. Performance management involves evaluating the performance of a computer system to determine how resources are currently used and how such use can be improved. Such evaluations involve collecting and analyzing information on the performance of an existing system and locating real or potential bottlenecks in system performance. Navy instructions require such performance evaluations.

Capacity planning involves forecasting computer resource requirements to ensure that system processing and storage capacity exists when needed. During this process, future work loads and required user service levels (response time and system availability, for example) are forecast, resources to meet these demands are proposed, planned upgrades are modeled and pilot tested, and the final upgrades are defined. Navy instructions do not specifically address capacity planning.

Work Load Forecasts and Application Design Data Used in Capacity Planning Are Questionable

According to Navy Instruction 5231.1B, Life Cycle Management Policy and Approval Requirements for Information System Projects, system resources are usually replaced or upgraded because existing resources become obsolete or cannot handle work load increases. Also, industry publications state that accurately measuring system resource needs depends on the quality of future work load estimates. Since projected work loads are a function of the applications to be used, accurately projecting work loads requires sufficient design information about new or modified application software as well as accurate estimates of when the applications will be implemented. Without such information, the validity of any system resource forecast is doubtful.

The UICP project office estimates that by fiscal year 1991 it will need to double its current UICP processing capacity as well as increase data storage capability at ASO and SPCC by 27 and 48 percent, respectively. The

growth is based on expected increases in work load for existing applications as well as work load increases resulting from the redesigned software applications.[4] To compensate for this growth, the Navy plans two successive upgrades of its UICP processors and direct access storage between fiscal year 1989 and 1991 at a cost of $22.1 million (see appendix II).

We found that the Navy's hardware upgrades are largely based on questionable growth projections and design assumptions. Specifically, the Navy's justification for hardware upgrades was based on:

- Work load estimates aggregated for an entire day (i.e., total work load for all three shifts) rather than work load for the prime shift only. This would overstate capacity requirements because they were determined as if an entire day's work load would be processed during one shift.
- Work load estimates that did not consider whether applications were running on-line during the prime (day) shift or running in batch mode during the non-prime (night) shift. UICP officials agreed that this should be considered, stating that accurately estimating work load requires analysis of how much on-line versus batch processing is occurring for each application.
- Work load estimates from user groups that were not supported by analysis or complete application design data. The estimates were based in part on the impact of redesigned, on-line processing functions. However, capacity needs resulting from these functions cannot be accurately forecast without certain application design data, and the Navy has yet to complete the application specifications that will provide this data. One SPCC user group described its estimates as a "wild guess." Similarly, ASO documents state that its estimates were based on limited design data.
- Data storage requirements that did not consider the additional storage capacity that will be available from a recent UICP procurement. UICP project officials told us that data storage usage should not exceed 60 percent of available storage capacity, and they provided data showing that usage at ASO and SPCC is consistently exceeding this limit. However, this data did not include added storage capacity from a recent procurement. When this added capacity is installed, we estimate that storage usage will be between 15 and 25 percent below the 60 percent target.

[4]According to UICP life cycle management documentation, the redesigned software will drastically change the way the UICP system processes transactions. Specifically, the system will change from a predominantly batch processing environment to a more complex, on-line processing environment.

Moreover, the implementation schedule for the redesigned application software is a major premise for the timing of the predicted growth in processing and data storage requirements. However, this schedule has already slipped 17 months[5] since 1988, when the Navy developed its budget requesting funds for the hardware upgrades. Additionally, there is potential for further schedule slippage. For example, the Navy has yet to resolve requirements for a major UICP subsystem, the aircraft portion of a configuration management application. The Navy originally planned to formalize the requirements for this subsystem in December 1985, but now estimates that they will not be formalized for another 2 years.

After discussing our capacity planning concerns with project officials, they provided additional data and revised work load estimates. However, we question the revised data because:

- Work load growth projections double-counted the work load increase resulting from the use of a new database query language.[6] ASO and SPCC officials admitted counting the work load associated with the new query language as both additional work load from existing applications as well as growth from redesigned applications.
- Work load and data storage growth projections for existing applications were not supported by actual trends. The revised estimates assumed increases in existing work load. Although these increases should be supported by 1988 trends, we found that actual work load was relatively constant during 1988 at both ASO and SPCC. Similarly, although data storage requirements were predicted to increase 27 and 48 percent at ASO and SPCC, respectively, actual data storage at ASO was steady during 1988, while it declined at SPCC.

Project officials recognize that the work load and application design data they used to forecast UICP hardware requirements has limitations. However, they stated that they cannot wait for more reliable data. According to the officials, ensuring that funds are available to meet capacity requirements necessitates that budget requests be developed several years in advance of the need for the funds.

[5]The implementation schedule has slipped from June 1992 to November 1993.

[6]A database query language allows users to easily access and manipulate data using English-like commands.

The Navy Can Improve Use of Existing Computer Resources

Navy Instruction 5231.1B, Life Cycle Management Policy and Approval Requirements for Information System Projects, defines the process to be followed in planning, developing, and approving information system projects throughout their life cycle. This instruction requires the Navy to conduct system performance evaluations before defining resource upgrades. Similarly, industry publications state that any process for forecasting additional computer resource requirements should first include an evaluation of whether existing resources can be better used. These publications state that it is possible to dramatically improve a system's performance through such adjustments as rescheduling work load and eliminating processing bottlenecks.

While UICP project officials believe that existing system performance cannot be improved, we believe otherwise. Both ASO and SPCC have ongoing programs to evaluate the use of existing UICP system resources and, accordingly, have taken some actions to improve their systems' performance. These actions include rescheduling work loads, removing input/output bottlenecks, and managing data storage more efficiently. UICP project officials stated that as a result of these actions, their systems are currently efficient and additional capacity cannot be made available. However, our analysis showed that ASO and SPCC each had idle processing capacity available for use. Specifically, our analysis of processor utilization during ASO's and SPCC's prime (day) work shift showed that idle capacity averaged 29 and 33 percent, respectively, over the 6 month period we analyzed (March 1988 to September 1988).

Project officials do not agree with our analysis for two reasons. First, they contend that operating the system at 100 percent capacity is not realistic, and that a 15 percent buffer must be maintained to ensure adequate user response times (i.e., actual use must not exceed 85 percent of processor capacity). We are not suggesting that ASO or SPCC operate on a sustained basis with 100 percent utilization. The 85 percent goal could be an acceptable threshold providing the work load is entirely time-critical, on-line processing. However, during the prime shift, neither ASO's nor SPCC's systems are dedicated solely to time-critical, on-line work; low priority batch processing accounts for 9 and 19 percent, respectively, of system use during the prime day shift. Because of this low priority, processing can be delayed until the processor is idle and available for work. We believe that the size of the buffer should be based on a more thorough analysis of on-line and batch work load.

Second, the officials stated that peak period utilization, which comprises 5 of the 9 hours of the prime (day) shift, should be used to measure idle

capacity rather than the overall average of the shift. We agree. In fact, our analyses considered peak period utilization; however, as stated above, this peak period includes low priority batch jobs. These jobs could be delayed until the processor is available, either during the other 4 hours of the prime shift when utilization averages under 60 percent, or the two night shifts when utilization averages between 27 and 36 percent. In other words, job scheduling can better distribute work load over the prime (day) shift or over all three shifts and thereby increase available capacity during peak periods.

During our April 1989 exit conference with the Navy, UICP officials provided additional data covering the 3 month period following our analysis. This data indicated that processor use had increased by 8 and 6 percent at ASO and SPCC, respectively, during the peak period of the prime shift. Assuming the data are valid, our estimates of available capacity would be reduced. However, our position that excess system capacity is available and more efficient use of existing system resources is possible remains unchanged.

Our analysis of system utilization also revealed opportunities for reducing demands on the processors and improving system response times. These opportunities include:

- Rescheduling batch processing work load from the prime (day) shift, when processor use averages 70 percent, to the night shifts, when it averages between 27 and 36 percent. SPCC has already agreed to reschedule batch jobs comprising about 3 percent of their prime shift usage. ASO also agreed to examine its batch jobs to determine if any can be rescheduled.
- Moving an interoffice, electronic mail application to another computer. This application is used for operational, administrative, and informal communication among users on the UICP network,[7] and it accounts for about 8 percent of prime shift usage at ASO. UICP officials had originally taken a position that the electronic mail application should not be moved. However, we pointed out that the UICP system modernization was justified as a mission-critical supply system not as an administrative support system. The project manager subsequently agreed in June 1989 to examine options for moving it.
- Reducing the amount of processor time spent managing system resources (i.e., reducing system overhead). Our 6 month analysis

[7]Networks are host computers connected by a communications subsystem consisting of communications processors and communication media such as twisted pairs, fiber optic lines, or coaxial cables.

(March 1988 to September 1988) showed that system overhead increased from 14 percent in May 1988 to 25.3 percent in September 1988 at ASO. After alerting project officials of the problem in January 1989, a different version of the operating system[8] was installed, and the problem was corrected.

- Modifying the operating system's work load priorities. Certain applications can be assigned higher priority than others when competing for use of the processor. To achieve faster response times, higher priority is generally assigned to interactive applications[9] rather than to batch processing work load. We found that, although SPCC assigns a higher priority to interactive system use, ASO gives priority to batch processing applications. Following our inquiries, the UICP project office directed ASO to reassign its work load priorities.
- Improving the operating system's job entry system.[10] Industry publications state that the use of dynamic load balancing for multiprocessor systems like UICP can improve system performance and utilization. Dynamic load balancing permits the system's multiple processors to be effectively utilized (i.e., avoids having one processor idle while another is overloaded). Project officials told us that they have yet to examine whether dynamic load balancing could improve UICP operations. However, they agreed to study its cost effectiveness.

Conclusions

In our opinion, the Navy has not adequately justified its $22.1 million UICP hardware upgrades planned for fiscal years 1989 through 1991. Our analysis showed that application design information is insufficient and future work load estimates are too uncertain to justify the upgrades. As a result, the Navy has no assurance that its planned UICP hardware upgrades are needed to satisfy its processing and data storage requirements. Further, implementation schedules for new UICP software have slipped significantly, and there is potential for more delays which in turn would delay the need for any upgrades.

[8]An operating system is software within a computer system that controls system resources. It resolves conflicts, attempts to optimize performance, and simplifies the effective use of the computer system. It acts as an interface between the user's application programs and the physical computer hardware.

[9]Applications functioning in a conversational mode with a user (i.e., a terminal user types a request, and the computer processes it and immediately sends the response to the user's terminal).

[10]Work load access to the processors is controlled by the job entry system within the operating system.

Additionally, our analysis showed that the Navy is not using its existing UICP hardware as effectively as it could. As a result, the Navy does not know the extent to which its additional processing and data storage requirements can be met with existing hardware.

According to the UICP project officials, they cannot wait until the UICP software is complete to validate its design assumptions and work load data because budget requests for hardware must be prepared several years in advance of the need for the funds. Therefore, they prepared budget requests for hardware using limited information. We are not suggesting that the Navy complete the new UICP software before determining hardware requirements. However, it is essential for the Navy to have sufficient information about the software and the work load it will process to permit it to make prudent and informed hardware decisions. The Navy must, therefore, wait until application design specifications are sufficiently mature to permit hardware requirements to be defined accurately. While we recognize the difficulty in forecasting hardware requirements early in the design phase of a project and understand the need to develop budget requests in advance of the need for the funds, we do not believe that computer resource forecasts and purchase decisions should be made prematurely, using questionable data. Furthermore, because of delays in completing the new UICP software and the opportunities we identified to better use existing UICP capacity, upgraded hardware will not be needed as soon as expected. Therefore, additional time is available for the Navy to better forecast hardware requirements.

Recommendations

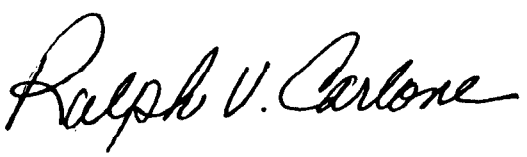
We recommend that you direct the Secretary of the Navy to defer the planned $22.1 million computer upgrade of UICP until the project office has adequately justified the need for the new hardware. Justification should include (1) valid work load projections and complete application design information to forecast resource requirements and (2) thorough performance evaluations to ensure that existing UICP system resources are being effectively used before the purchase of additional hardware is approved. In the interim, hardware purchases should be approved on a case by case basis only if the project office clearly demonstrates that current ASO and SPCC operations would be jeopardized if the purchases were delayed.

We conducted our review from July 1988 to May 1989 in accordance with generally accepted government auditing standards. Although we

did not obtain official agency comments on a draft of the report, we discussed its factual content with responsible Navy officials, and have incorporated their comments where appropriate.

We are providing copies of this report to the Chairmen, House and Senate Committees on Appropriations; the Chairman, House Committee on Government Operations; the Chairman, Senate Committee on Governmental Affairs; and the Chairman, Subcommittee on Defense, House Committee on Appropriations. We are also providing copies to the Secretary of the Navy; the Director, Office of Management and Budget; and the Administrator, General Services Administration. We will make copies available to other interested parties upon request. This report was prepared under the direction of Samuel W. Bowlin, Director, Defense and Security Information Systems, who can be reached at (202) 275-4649. Other major contributors are listed in appendix III.

Sincerely yours,



Ralph V. Carlone
Assistant Comptroller General

Contents

Abbreviations

ASO	Aviation Supply Office
GAO	General Accounting Office
IMTEC	Information Management and Technology Division
SPCC	Ships Parts Control Center
UICP	Uniform Inventory Control Point

Objectives, Scope, and Methodology

As part of our continuing effort to evaluate management information systems supporting Department of Defense logistics programs, we reviewed the Navy's plans for upgrading its Uniform Inventory Control Point (UICP) computer hardware. Our objective was to determine whether the $22.1 million in hardware upgrades planned for fiscal years 1989 through 1991 are justified.

To accomplish our objective, we reviewed federal, Defense, and Navy regulations and instructions governing the development and approval of system resource requirements. We also reviewed UICP life cycle management, procurement, and budgetary documentation describing the project's acquisition strategy, system resource estimates, schedule, and funding requirements. Additionally, we interviewed officials in the UICP project office and at ASO and SPCC to determine how they derived system resource requirements, and we reviewed relevant documentation supporting these requirements.

Our review also included analyzing Aviation Supply Office (ASO) and Ships Parts Control Center (SPCC) system utilization data for 6 month periods ending in September 1988 to determine recent work load trends and the potential for improving the use of existing resources. The 6 months were chosen because (1) they followed completion of the second phase of the UICP modernization project which converted existing software to run on new hardware, and (2) September was the latest month for which ASO and SPCC data were available at the time we began our analysis. Our review also included examining ASO and SPCC evaluations of existing resource use as well as their efforts to identify and implement changes to improve system use.

Additionally, we interviewed project officials and reviewed life cycle management documentation to determine the status of UICP software redesign efforts and the effect of any schedule slippages on the timing of planned hardware upgrades. We also interviewed Navy officials responsible for project oversight. Lastly, we examined the feasibility of using a commercially available model to forecast UICP computer resource requirements.

Our review focused on the Navy's plans for hardware upgrades to the primary UICP production systems for fiscal years 1989 through 1991.

We performed our work between July 1988 and May 1989, primarily at the Naval Supply Systems Command UICP project office in Washington, D.C.; ASO in Philadelphia, Pennsylvania; and SPCC and the Fleet Material

Support Office in Mechanicsburg, Pennsylvania. We also conducted work at the Naval Data Automation Command in Washington, D.C.

We did not obtain official agency comments on a draft of the report. However, we discussed its content with responsible Navy officials, and have incorporated their comments where appropriate. We conducted our review in accordance with generally accepted government auditing standards.

Funding Profile for UICP Upgrades

Dollars in millions

	Fiscal Year			
Upgrade	**1989**	**1990**	**1991**	**Total**
Aviation Supply Office				
Processor (IBM 3090-500S)	•	$3.3	•	**$3.3**
Processor (IBM 3090-600Z)	•	•	3.8	**3.8**
Data Storage	•	2.0	1.4	**3.4**
Ships Parts Control Center				
Processor (IBM 3090-500S)	3.7	•	•	**3.7**
Processor (IBM 3090-600Z)	•	•	3.8	**3.8**
Data Storage	•	2.7	1.4	**4.1**
Total	**$3.7**	**$8.0**	**$10.4**	**$22.1**

Major Contributors to This Report

Information Management and Technology Division, Washington D.C.

John B. Stephenson, Assistant Director
Randolph C. Hite, Adviser
Bruce B. Herbert, Computer Specialist

Philadelphia Regional Office

Norman C. Berman, Evaluator-in-Charge
Lindley R. Higgins, Evaluator

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.

United States
General Accounting Office
Washington, D.C. 20548

Official Business
Penalty for Private Use $300

First-Class Mail
Postage & Fees Paid
GAO
Permit No. G100