BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Data Processing Costs Can Be Reduced At Army And Air Force Exchange Service

On two recent computer buys, the Army and Air Force Exchange Service spent up to $4.5 million more than necessary because it did not buy the computers competitively and did not adequately define its computer needs. Further, its projects for developing software have substantially exceeded cost and time estimates because sound control practices have not been followed.

Such excess expenditures and delays will continue unless Department of Defense policies for computer acquisition and management are enforced at the Exchange Service and top management becomes actively involved. GAO recommends ways to improve data processing management, and recommends that a projected $20 million computer procurement be suspended until it is adequately justified.

GAO/AFMD-83-17
DECEMBER 21, 1982

Request for copies of GAO reports should be sent to:

U.S. General Accounting Office
Document Handling and Information
Services Facility
P.O. Box 6015
Gaithersburg, Md. 20760

Telephone (202) 275-6241

The first five copies of individual reports are free of charge. Additional copies of bound audit reports are $3.25 each. Additional copies of unbound report (i.e., letter reports) and most other publications are $1.00 each. There will be a 25% discount on all orders for 100 or more copies mailed to a single address. Sales orders must be prepaid on a cash, check, or money order basis. Check should be made out to the "Superintendent of Documents".

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

B-202494

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

This report suggests ways to improve data processing management at the Army and Air Force Exchange Service and to avoid excessive computer support costs--costs that are ultimately borne by active and retired military personnel and their families.

This report was prepared as part of our continuing effort to assess the effectiveness of data processing management in agencies that rely heavily on computer resources to accomplish their mission. Because our audit authority for nonappropriated fund activities, contained in the General Accounting Office Act of 1974, is relatively recent, this is our first review of the Exchange Service's data processing activities.

We provided a draft of this report to the Department of Defense on July 21, 1982, but did not receive official agency comments. The Department told us it needs to address the issues raised in this report before it can provide responsive comments.

We are sending copies to the Chairman, Nonappropriated Fund Panel, House Armed Services Committee; the Director, Office of Management and Budget; the Secretary of Defense; the Chairman of the Board of Directors, Army and Air Force Exchange Service; and the Commanding Officer of the Army and Air Force Exchange Service.

Charles A. Bowsher

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE CONGRESS

DATA PROCESSING COSTS CAN BE REDUCED AT ARMY AND AIR FORCE EXCHANGE SERVICE

D I G E S T

The Army and Air Force Exchange Service could have saved up to $4.5 million on two recent computer purchases. When acquiring computers, the Exchange Service has not followed Department of Defense policies calling for maximum practical competition and adequately defined needs. Moreover, project management problems have caused substantial cost and schedule overruns and costly delays in providing needed computer software support to data processing users. These costs are ultimately borne by active or retired military personnel and their families in the prices they pay for goods and services obtained through the Exchange Service.

GAO made this study as part of its continuing effort to assess the management of data processing resources in agencies that rely heavily on computers to accomplish their mission.

Exchange Service procedures for acquiring automatic data processing equipment encourage sole-source procurement, and such noncompetitive purchases have been the rule at the Exchange Service for years. The four major purchases of computers since 1978 were made noncompetitively. GAO reviewed the two largest of these and found that sole-source acquisitions were not justified.

In one case, the Exchange Service bought new computers for $6 million on a sole-source basis to replace the main computers in its central processing site, but GAO found sole-source procurement was not justified because:

--Equipment considerations favored the incumbent vendor. (See p. 6.)

--Lower costs (up to $3.25 million) of fully compatible, comparably sized equipment of another vendor were not considered in making the selection. (See p. 8.)

In the other case GAO reviewed, Exchange Service data processing managers did not competitively

GAO/AFMD-83-17
DECEMBER 21, 1982

Tear Sheet

award a $2.5 million procurement of 41 minicomputers, stating that the time needed for procurement and conversion of computer software would be unacceptable if competitive bids were obtained. GAO found, however, that

--procurement time frames were neither mandated nor critical, and

--software conversion time and costs would be minimal. (See p. 10.)

Exchange Service data processing personnel did not prepare adequate studies to document their computer needs for each hardware procurement. In each case, reliance on these studies resulted in the purchase of excess computer capacity, costing about $1.25 million. GAO found that these studies

--did not functionally define computer needs, and

--incorporated unvalidated or technically inaccurate assumptions that overstated expected computer workloads. (See p. 11.)

Exchange Service software development projects were consistently late and over budgeted costs, and therefore delayed the provision of intended service to users. These delays and overruns occurred because the projects were not adequately planned and managed. The Exchange Service did not fully comply with its own project management directives. Projects lacked required documentation and users were not always involved in project design. A cost accounting system was not in place to track the cost of software development. Top management neither monitored nor controlled the projects; it

--was not involved at key decision points, and

--did not have meaningful information on progress and cost. (See p. 23.)

Similar procurement and project management control weaknesses have also delayed the Exchange Service's 9-year, multimillion-dollar effort to install a nationwide point-of-sale system. In such a system, data on each sales transaction is recorded automatically by electronic cash registers and sent electronically to a computer or network of computers. There it is processed and used in sales and inventory management. The project's future is uncertain and it is likely to be more expensive than is necessary.

At the time of GAO's study, the point-of-sale project was at least 4 years behind schedule and had missed three implementation deadlines while Exchange Service managers changed the specifics of the system's hardware configuration. As a result, the Exchange Service bought specialized cash registers and spent more than $2.7 million for the point-of-sale equipment necessary to equip a 156-store system. However, the equipment is being used in only 34 stores; the remaining equipment is either installed but unused or simply stored. Whether all of it will ever be used is still in question. The Exchange Service has not adequately evaluated the results of its experience at the 34 stores and has not completed the system. Yet, it is testing another, more sophisticated concept that could supplant existing equipment and cost $20 million. (See p. 30.)

RECOMMENDATIONS

To increase competition, reduce costs, and strengthen software development practices, GAO recommends that the Secretary of Defense direct the Exchange Service and its Board of Directors to comply with Department of Defense policies governing competitive acquisition, proper definition of requirements, and management of computer resources.

GAO also recommends that the Secretary direct the Board of Directors of the Exchange Service to

--review and approve, as necessary, all major computer procurements to ensure that Department of Defense procurement policies and objectives are met; and

--approve and monitor the progress of all software development projects or major modifications that are essential to the Exchange Service's mission or involve significant costs.

To further strengthen software development practices, GAO recommends that the Secretary direct the Commander, Army and Air Force Exchange Service to

--assume an active role in project management to ensure that projects either proceed according to cost and time estimates and meet objectives or are resubmitted for revalidation;

--establish a system for accounting and charging the costs of systems development and operations to major users; and

--revise Exchange Service planning guidelines to comply with Federal Information Processing Standards and accepted practice in private industry.

GAO also recommends that the Secretary direct the Exchange Service and its Board of Directors to suspend pending procurement efforts for the point-of-sale project and validate the concept by thoroughly documenting the costs and benefits of the present point-of-sale system. If a study supports proceeding further with the project, the Exchange Service should first consider using its existing point-of-sale equipment and excess computer capacity for the life of that equipment before developing more sophisticated and costly follow-on systems.

AGENCY COMMENTS

GAO gave the Exchange Service a preliminary statement of the principal facts it developed during this study. Exchange Service officials agreed with many of the facts but expressed several reservations about possible conclusions and opinions GAO might draw from them. GAO considered these views in preparing the report.

GAO subsequently provided the Department of Defense with a draft of this report on July 21, 1982. However, the Department did not provide official comments on the report. The Department told GAO the report involves significant issues at the Exchange Service which need to be addressed fully by the Department before it could provide responsive comments.

Contents

ABBREVIATIONS

AAFES	Army and Air Force Exchange Service
ADP	Automatic data processing
CPU	Central processing unit
DOD	Department of Defense
FPMS	Food Plant Management System
GAO	General Accounting Office
IBM	International Business Machines, Inc.
NCR	National Cash Register Company
POS	Point-of-sale
RAPIDS	Repair Automotive Parts Improvement Delivery System
SMF	System Management Facility
SPS	Sales Promotion System
SPSS	Statistical Package for the Social Sciences
VRR	Visual Rapid Recorder
WICRS	Warehouse Inventory Control and Replenishment System

CHAPTER 1

INTRODUCTION

The Army and Air Force Exchange Service (AAFES), with fiscal 1981 sales of more than $4.2 billion, is the Nation's eighth largest retailer and the military's largest resale activity. The Exchange Service operates approximately 16,000 sales facilities worldwide, including retail, food, and personal service sales outlets; motion picture theaters; service stations; and vending operations. These facilities support its mission of (1) providing necessity and convenience items and services not otherwise available to authorized patrons and (2) generating income to supplement Defense appropriations for Army and Air Force morale, welfare, and recreation programs.

The Exchange Service has automated the major components of its daily operations, including merchandise ordering, warehousing, and distribution; accounting; and personnel. Consequently, data processing directly affects its ability to deliver goods and services to more than 1.3 million military personnel and their families.

The Exchange Service has centralized the management, control, and operation of data processing at its headquarters in Dallas, Texas. All computer equipment planning and acquisition is managed by headquarters staff, as is all software development. The vast majority of its automated workload is processed on the headquarters main computer, which is linked to remote operating locations through a global telecommunications network. The central component of its data processing configuration is an IBM 3033 Multiprocessor computer supported by various peripheral equipment, including an IBM 3851 Mass Storage Facility. This state-of-the-art system is supported by a worldwide data processing staff of approximately 525 people. AAFES estimates the system's operating cost at more than $21 million annually. 1/

The Exchange Service is organized as a joint military command of the Army and the Air Force. As such it is an instrumentality of the Federal Government, governed by the service secretaries and administered by its commander and a joint-services Board of Directors. It receives some funding through Defense appropriations, largely to underwrite the overseas transportation of goods, and some support--such as military salaries and military facilities--from appropriated funds. However, most of its funding is self-generated through resale activities (that is, nonappropriated).

Because of its nonappropriated fund status, the Exchange Service has been specifically exempted by the Department of Defense

---

1/We believe this figure to be understated, since it represents predominantly personnel and equipment rental costs and does not include general overhead or all costs of major equipment acquisitions.

from the procurement and management directives applicable to other Defense components. However, all nonappropriated activities have been instructed to ensure maximum practical competition in procurement of computer resources and to employ Defense directives as management guidelines.

Because of the Exchange Service's mission and fund status, any economies and efficiencies in its operations most directly benefit the active and retired military personnel. Profits from exchange operations are usually redistributed to active and retired military patrons and their families as either (1) price reductions on resale goods, (2) capital improvements to facilities, or (3) direct dividend payments to supplement appropriations for military morale, welfare, and recreation funds.

OBJECTIVES, SCOPE, AND METHODOLOGY

This review was undertaken to assess the Exchange Service's management of its data processing resources by examining

--procurement and utilization of computer hardware,

--management of computer software development, and

--accounting and costing for data processing resources.

We made our review in accordance with generally accepted government audit standards.

Our basic field work was conducted from January to September 1981. The findings from our review were presented to Exchange Service officials both orally and in written fact sheets at the conclusion of our field work. These officials subsequently gave us written comments regarding several issues discussed in this report and we performed additional review work from November 5, 1981, to February 15, 1982, to address those comments.

Our field work was concentrated at Exchange Service headquarters in Dallas, where data processing activities are centralized. We also visited the merchandise distribution activities in Atlanta, Georgia, and Oakland, California, to validate the asserted need for main computer redundancy to support the merchandise replenishment system. These sites were selected because of their co-location with distribution region headquarters and because they are AAFES's largest distribution activities.

We evaluated studies made by the Exchange Service to support two of its largest recent computer procurements to determine whether sole-source procurement was justified and whether the computer hardware needs of the organization were being adequately and accurately defined. We analyzed the computer workload by applying statistical methods, based on regression analysis, to the computers' internally generated accounting data (discussed in detail in app. I). We also

measured current computer utilization to validate the capacity planning assumptions used by the Exchange Service in determining computer requirements. (See app. II.) To do this we used a computer software package to analyze utilization data recorded by IBM's Resource Measurement Facility which is an integral part of the computer's operating system software.

We examined the Exchange Service's computer procurements and judged their efficacy by reviewing contract files and associated correspondence, minutes of meetings, and audit and inspection reports. We then contrasted actual procurement activities to the requirements outlined in pertinent Department of Defense and AAFES directives.

As part of our analysis of software development practices, we compiled life-cycle management criteria from both Federal sources and private retailers and compared them to the Exchange Service's criteria and to its actual development practices. In doing this we evaluated the management of four software development projects:

--Warehouse Inventory Control and Replenishment System (WICRS).

--Repair Automotive Parts Improvement Delivery System (RAPIDS).

--Sales Promotion System (SPS).

--Food Plant Management System (FPMS).

We selected the WICRS project for review because it was the largest development at AAFES and had a substantial, direct impact on the Exchange Service's mission. We asked data processing managers to select for our review a second project that they felt best represented their systems development activities; they selected the Food Plant Management System. We selected the other two projects, SPS and RAPIDS, because they represented current development projects that were nearing completion.

We also reviewed the Exchange Service's point-of-sale (POS) project because it involves large expenditures for hardware and has a significant impact on operations. The purpose of the project is to produce a system in which electronic cash registers automatically record sales data for later computer processing for sales and inventory management purposes. We evaluated the project's hardware purchases as we did other acquisitions, and its overall management in consonance with methods we applied to other projects. We have treated the POS project as a separate entity in this report because of its significance, present status, and future impact on expenditures.

We also visited private retail establishments, the National Retail Merchants Association, and several computer vendors to gather information on software development practices, point-of-sale

systems, and computer hardware capabilities relevant to the retail industry and the Exchange Service's systems. As part of our evaluation of the point-of-sale data transmission needs, we gathered information on telecommunications systems planning and computerized data transmission at the Defense Communications Agency in Arlington, Virginia. We also contacted other public and private sector officials for background information, and reviewed published reports on retail systems such as point-of-sale and on computer resource management.

CHAPTER 2

NONCOMPETITIVE PROCUREMENT AND POOR REQUIREMENTS DEFINITIONS GENERATE EXCESSIVE COMPUTER COSTS

The Army and Air Force Exchange Service could have saved up to $4.5 million on its two largest recent computer procurements if AAFES managers had taken advantage of known opportunities for competitive computer acquisition and had functionally defined their actual computer needs. One procurement replaced the main computers at headquarters and the other provided 41 minicomputers to support an overseas credit sales program. Both procurements were sole-source and in each case the Exchange Service acquired more computer capacity than it either needed or could justify.

Department of Defense and AAFES procurement instructions direct the Exchange Service to obtain maximum practicable competition when procuring computer resources and to define and justify the need for such resources. AAFES, however, has circumvented this policy by utilizing a procedure that allows it to substitute a limited in house equipment assessment, or staff study, for an equipment requirements justification if the assessment concludes that (1) a specific make and model of equipment is required, (2) the acquisition is operationally necessary and (3) the expenditure is "minor." The Exchange Service's two largest recent procurements involved multimillion-dollar expenditures and were justified on this basis. In each case, the in-house assessment specified the brand and model of equipment without presenting a functional requirement to the marketplace.

SOLE-SOURCE COMPUTER PURCHASES WERE UNJUSTIFIED

Sole-source procurement of automatic data processing (ADP) equipment has been common practice at the Exchange Service for years. In 1977, the Army's Inspector General criticized AAFES's procurement practices, stating that sole-source procurement of data processing equipment was the rule rather than the exception at AAFES. Our review showed that AAFES is still acquiring its computer resources on a sole-source basis and failing to obtain competition. Between 1978 and 1980, AAFES made four major computer acquisitions, each on a sole-source basis, ranging in price from $245,000 to $6 million.

The in-house assessments for the two acquisitions we reviewed did not adequately justify the sole-source procurements. The assessments supporting the $6 million purchase of two large computers for the main computer facility and the $2.5 million purchase of 41 minicomputers were inadequate. Relying on one of these studies, AAFES unnecessarily spent $1.45 to $3.25 million by acquiring its main computers via sole-source procurement from the incumbent vendor even though fully compatible, comparably sized equipment was

available from another vendor. In both cases, the Exchange Service did not take advantage of additional cost reductions that could have been realized if its requirements had been submitted to industry for competitive bidding.

Sole-source justification for main computers favored incumbent and did not consider cost

The in-house assessment supporting the sole-source procurement of the $6 million main computers for the central facility was not adequate because

--equipment considerations favored the incumbent vendor and

--known lower costs for fully compatible, comparably sized equipment was not a factor in selecting the equipment.

The in-house study supporting the procurement was prepared when data processing managers determined that their existing computer was at or near saturation. The study, published in February 1980, concluded that AAFES should procure an IBM 3033 MP (Multiprocessor) computer to replace its IBM 370/158 and 3031 systems and meet its processing needs for 1981 through 1984. AAFES's top management proceeded with this sole-source procurement with full knowledge that at least one other vendor, Amdahl Corporation, could have provided the same computing capacity for as much as $3.25 million less.

Equipment selection favored incumbent

In its study, AAFES asserted a need for a dual computer processor capability to provide uninterrupted data processing in the event one processor is out of service. The Exchange Service contended that only IBM, with its multiprocessing hardware feature, could adequately provide this capability. We found that (1) the need for fully redundant computers was not adequately justified and (2) the contention that only IBM could meet such a need was inaccurate.

The AAFES desire for 100-percent processor redundancy was based largely on a perceived need to support daily warehouse operations for receiving and distributing merchandise sold in Exchange Service stores. AAFES's data systems personnel contended that daily warehouse processing was so critical that if it were interrupted for even a short time, the resulting overtime, canceled shipments, and lost retail sales would be unacceptably costly.

Our visits to the Exchange Service's two largest distribution facilities disclosed that, although the merchandise distribution system is heavily dependent on ADP support, it also has various contingency plans and built-in safeguards to mitigate the effects of data processing failures. Merchandise distribution data is batch processed at night and there are built-in time buffers between completion of processing and the actual need for the products. In

addition, the warehouse facilities we visited routinely began daily activities with work carried over from the previous day. They also had the ability to shift workers among various assignments to make up lost time on key shipments.

Records indicate that AAFES has a history of main computer reliability exceeding 99 percent and the average length of processor "down time" has been less than an hour. When we examined the effects of recent 5- and 12-hour delays in computer products reaching the warehouse (cases described to us as the worst in recent memory) we discovered that each facility had recovered with only minimal overtime expense, no missed shipments to main exchange stores, and no idling of any segment of the work force during the delays.

The need for a redundant capability was therefore not substantiated; however, even if it had been, AAFES's contention that only IBM could provide adequate dual processor capabilities is inaccurate. At least one other vendor--Amdahl--could have satisfied this requirement at approximately $1.45 million less cost.

A second pivotal factor in AAFES's decision to buy its main computer via sole-source procurement was its reluctance to introduce another vendor into its IBM-oriented data processing environment. The Exchange Service's data processing managers feared they would have problems obtaining satisfactory vendor support and maintenance of its computer hardware and systems software if they acquired processors from Amdahl and all other supporting equipment from IBM.

This concern was reflected in AAFES's technical evaluation of IBM and Amdahl. IBM was allowed to make a formal presentation to AAFES officials on its maintenance policies for multivendor environments. Amdahl, who had asked to be considered as a possible supplier, requested the same forum for a similar presentation but AAFES denied the request. AAFES decided it already knew enough about Amdahl's policies because Amdahl always operates in a multivendor environment.

After the IBM maintenance presentation, data processing personnel made a technical comparison of the two vendors and included it in their analysis. To make the comparison, AAFES devised a rating scale from information in a technical journal. Ratings were then based on information gained during informal meetings with vendor sales representatives. AAFES personnel neither visited sites using the equipment nor employed quantitative measures such as benchmarking. 1/ The chart below illustrates the AAFES rating for each vendor.

1/A procedure in which a set of computer programs and associated data tailored to represent a particular workload are used to evaluate system performance or cost.

Factor	Maximum possible rating	Ratings	
		IBM	Amdahl
Hardware maintenance	24	19.5	20.7
Hardware performance	23	18.5	22.4
Product reliability	18	16.0	15.2
Expansibility	10	5.0	10.0
Vendor reliability	10	10.0	6.3
Software maintenance	10	9.0	1.0
Intangibles	5	5.0	0.0
Total	100	83.0	75.6

The combined points on the first four factors gave Amdahl a clear edge; however, the points awarded for vendor reliability, software maintenance, and intangibles tipped the balance in favor of IBM. The IBM advantage under "vendor reliability" reflects AAFES's award of rating points for factors such as market position, reputation, and financial position. In software maintenance, AAFES gave a decided advantage to IBM on the basis of its judgment that IBM would provide better support of telecommunication, utility, and general application software; no points were awarded to either vendor for maintenance of the operating system software because both vendors use IBM's software. Finally, AAFES gave no points to Amdahl for "intangibles" because of its concern about operating a multivendor data processing installation.

AAFES's concern over multivendor operations and Amdahl's ability to provide adequate support are not consistent with the experiences of Amdahl users. In a 1980 user reaction survey conducted by DATAPRO Research Corporation, a noted computer technical information service, Amdahl was rated better or at least comparable to IBM for ease of operation, reliability of hardware, responsiveness and effectiveness of maintenance service, troubleshooting of technical problems, operating system and other support software, ease of programming, and overall satisfaction. DATAPRO's 1981 survey produced similar results.

Lower cost alternatives not adequately considered

Data processing managers at the Exchange Service were aware throughout the procurement process that at least one other vendor, Amdahl, could provide the same computing power for substantially less cost--$1.45 to $3.25 million less, depending on the hardware configuration needed. The sole-source justification did not mention this price difference and cost was not made a factor in selecting IBM over Amdahl. Because the procurement was noncompetitive, AAFES neither solicited nor received vendor price proposals. The computer was acquired at the GSA contract price with no price negotiations by AAFES.

As illustrated below, the computer configuration purchased by AAFES was the most expensive alternative under consideration. Additional price reductions might have resulted from competition.

Comparative Computer Costs

Alternative configurations (note a)	Estimated cost (note b)	Lost savings (note c)
	--------(millions)---------	
IBM 3033 MP (dual processor)	$6.55	
Amdahl V-7 (dual processor)	5.1	$1.45
Amdahl V-8 (single processor)	3.3.	3.25

a/Configurations limited, for comparison, to those offered by the two vendors AAFES considered. Each configuration offers approximately equal computing capacity.

b/Estimated costs are prices in effect at the time of processor selection, as determined from GSA schedules. Both vendors subsequently reduced GSA schedule prices. Figures do not include site preparation costs, which were significantly higher for the IBM equipment.

c/Potential savings derived by comparing decision price for each alternate configuration to the decision price for the IBM 3033 MP.

Exchange Service contracting personnel challenged the adequacy of the AAFES study when presented with it as justification for the sole-source procurement of the main computer. Procurement management concluded that the study did not support a sole-source award and challenged the rating system used to justify vendor selections as inconsistent with previously stated facts about the two vendors. Procurement questioned the ratings for "intangibles" and referred to the $1.45 to $3.25 million price difference between the two vendors.

In a subsequent memorandum the AAFES General Counsel noted that the same study did not address the price difference between vendors and did not consider the cost of phased implementation over a 3-year period. General Counsel recommended that the sole-source procurement be reconsidered. AAFES procured the IBM system despite these documented concerns.

Ambitious minicomputer purchase schedule did not justify ignoring competition

The Exchange Service's basis for using sole-source procurement for its $2.5 million purchase of minicomputers was not fully justified. In May 1979 the Exchange Service received congressional approval to extend a credit sales program to its patrons at all overseas locations, and it needed more computer resources to implement it. Because AAFES viewed credit sales as both a benefit to military personnel and a major sales generator, it established an ambitious implementation schedule--a schedule that it contended could be met only by acquiring the minicomputers from the incumbent vendor.

The Exchange Service had tried unsuccessfully for more than 20 years to obtain permission from the Department of Defense and the Congress to implement some form of credit sales. But in March 1978, AAFES, after consulting with the House Armed Services Committee, received permission from its Board of Directors to test credit sales in four stores in Germany. The Committee raised no objection but expressed concern about the wisdom of authorizing a program that would allow military personnel to go into debt to buy nonessential items. According to Committee staff members, however, the Committee's approval of the test and the later expansion to all overseas locations was spurred by the feeling that action was needed to increase the purchasing power of military personnel stationed in overseas areas where, at the time, the value of the dollar was rapidly eroding. On the other hand, the minutes of the Board of Directors meetings show that AAFES and the Board pushed for the program primarily because they saw it as a highly effective means of increasing sales.

When AAFES received approval from Defense and the Congress to expand credit buying to all overseas locations, it asserted a need to begin installing computers within 2 months to support the program at the remaining overseas bases. Because of this 2-month time frame, data processing personnel concluded that sole-source procurement was necessary: (1) hardware could be obtained quickly only from the incumbent vendor and (2) software could not be converted in time to accommodate any hardware other than that installed at the four test stores.

The equipment acquired for the four test stores and ultimately for all locations was selected by AAFES technical personnel. They reviewed publications and vendor brochures to preselect some specific computer vendors that they considered acceptable. They then selected the specific vendor's equipment they considered to be best. The equipment configurations evaluated were those the study team considered representative, rather than those specifically proposed by vendors responding to a functional requirement specification; costs were estimated from vendor price lists, rather than developed in the marketplace through bid or negotiation; and no opportunity was given to prospective vendors to present innovative solutions to AAFES's needs.

We could find no compelling reasons for the rapid expansion schedule that dictated the sole-source procurement. The Exchange Service did not document any specific rationale for immediate implementation of the program worldwide. In asking the Board of Directors for permission to expand the program in December 1978, the Commander of AAFES said it would be done selectively and gradually. Further, in authorizing the program, neither the Congress nor Defense mandated any fixed implementation schedule, let alone the rapid one chosen by AAFES. And finally, although there may have been a valid perception of urgency in granting credit to military personnel in some overseas locations, the need was not universally acute. In the Far East, for example, as AAFES was aware, the demand for credit sales was likely to be less because of Defense restrictions on selling certain items that are subject to resale on the black market.

In addition, AAFES's concern for its software investment was overstated. AAFES developed the programs for the credit accounting functions in COBOL, a standard computer language that facilitates conversion to other manufacturers' equipment. Actual development required only 3,200 staff-hours (a personnel expense of approximately $56,000) over a 7-month span. Therefore, in the absence of self-imposed time pressures, the programs could have been converted with only a short delay to program implementation. Further, any software conversion costs, which would have been only a fraction of AAFES's intended $2.5 million hardware expenditure, could have been incorporated as a contract requirement to any competitive solicitation.

AAFES BOUGHT EXCESS COMPUTER CAPACITY BECAUSE NEEDS WERE INADEQUATELY DEFINED

The studies prepared by the Exchange Service to support the two procurements we reviewed did not properly justify the computer capacity ultimately acquired. The studies

--did not functionally define computer needs, and

--used unvalidated or technically inaccurate assumptions which overstated expected computer workloads.

Computer needs not functionally defined

Expected computer workloads were not functionally defined for either of the procurements we reviewed. Instead, Exchange Service data processing personnel attempted to determine the capacity needed for the main computer by studying the historic growth in the number of hours the central processors of its computers were being utilized and assuming the growth would continue. For its minicomputer purchase, AAFES extrapolated estimated workloads for all overseas sites from portions of the workload data it had developed at the four test sites. After data processing managers had estimated computer capacity needs, they used technical information from data processing journals and industry publications to select the

make and model of equipment they believed would meet their needs without seeking a marketplace response to any specific requirements.

Determining computer requirements by describing the specific business functions the computer is expected to perform, and then acquiring hardware from the marketplace that will best perform those functions, is accepted practice in the data processing community. Other Defense and civil agencies are required by regulation to procure data processing equipment against such functional definitions, but AAFES--which is exempt from these regulations--has no requirement to functionally define its computer needs and has not done so.

Unvalidated or inaccurate assumptions overstated expected workloads

Because AAFES officials did not functionally define their data processing needs, each of their justification studies applied technical assumptions about workload requirements in an effort to quantify computer capacity needs. We found that these assumptions either had not been validated or were technically inaccurate. Each of these erroneous assumptions contributed significantly to the Exchange Service's overstatement of expected workload for both the main computer and the minicomputers, and to the subsequent purchase of excess computer capacity.

The assumptions regarding AAFES's main computer served to overstate main computer processing requirements. Using minicomputer sizing assumptions, AAFES purchased several computers with more capacity than needed. It bought minicomputers for six Pacific sites where its own initial projections of credit sales activity were low or for which they had additional information that such sales could be further reduced because of differences in the customer base and the possible effects of military ration control policies.

Main computer

In analyzing its past utilization, AAFES officials asserted that the rate of growth calculated from actual use hours was understated because the central processor hours needed to process its workload had been reduced by several enhancements AAFES had made to its computers since 1978. 1/ AAFES officials told us they had computed the growth on the basis of the central processor time that would have been needed if the enhancements to the system had not been made. On this basis, they concluded that growth was actually 32 to 34 percent per year. AAFES gave no details on how these figures were derived and it cited no technical authority for making the adjustments.

1/These included the addition of main memory and improved system software.

Such adjustments to AAFES's computer use statistics are without technical merit. The adjustments are not supported by the technical literature on computer performance measurement or by logic. To make such adjustments assumes that AAFES would not make future enhancements to its computer system in order to process its workload cost effectively. Prudent data processing managers do in fact enhance their systems by adding memory, when needed, and by using improved versions of operating system software provided by equipment manufacturers.

The study indicates, and AAFES officials confirmed, that the growth figures were developed from an analysis of an "average representative month" for each year, 1976 to 1979. AAFES defined the average representative month as the average of the computer use hours for September, October, and November of each year. The study did not contain the actual analysis and AAFES maintained no records or documentation to support its growth calculations. We attempted to validate AAFES's reported workload growth using both the data in the study itself and the computers' internally generated accounting data, but could not approximate the 32 to 34 percent annual growth through any reasonable series of calculations using either set of statistics. As the chart shows, the rate of growth in computer use reported in the AAFES study was much less than that.

Year	Average hours per representative month (note a)	Increase over preceding year	Percent increase
1976	628	-	-
1977	690	62	9.9
1978	790	100	14.5
1979	b/ 895	105	13.0

a/All figures are derived from the AAFES study, which expressed them in IBM 370-158 equivalent hours. 1976 and 1978 data cannot be verified because of incomplete source records.

b/The study itself cites contradictory figures: 850 hours and 895 hours. Source documents indicate a third figure: 873 hours. We elected to use the highest of these figures to give AAFES the benefit of any doubt.

To validate AAFES's workload projections, we made statistical analyses of its computer utilization data for the 27 months before installation of the new processors. These analyses (discussed in detail in app. I) revealed that actual growth was

considerably below AAFES's projections. In one analysis we adjusted the data for unusual, nonrecurring peaks and valleys after consulting with AAFES officials most knowledgeable about the data, and processed it through standard regression routines. This analysis showed that reasonable compound growth was only 18 percent per year, far less than the 32 to 34 percent projected by AAFES. We also processed the data without making any adjustments and found that the compound growth was only 23.9 percent--also significantly below the AAFES projection.

Another flaw in AAFES's study was its analysis of computer processor time needed by the system software to perform housekeeping functions in the computer--commonly referred to as system overhead. AAFES concluded that, in addition to time spent processing jobs, 42.5 percent of available processor time would be spent on system overhead functions. AAFES calculated the capacity of the new system using this overhead figure. We were told that the 42.5 percent figure was derived by having a system programmer periodically monitor the computer's processing activities from a terminal over a 31-day period and make random observations on the computer time necessary to process the AAFES job stream. We could not verify this because AAFES did not keep records of this analysis. Further, AAFES did not use the available software facilities on the old systems, which could collect detailed, precise statistics on system overhead.

As a final validation of this and other assumptions made by AAFES, we reviewed in depth the computer use data recorded for the present system for fiscal months April to September 1981. (See app. II.) We found that overhead on the current system averaged between 22.8 and 28.8 percent of processor busy time--a level consistent with expectations published by IBM for job streams similar to AAFES's, and far below the level projected by AAFES. 1/ We also found that total processor busy time--including system overhead--averaged between only 26 and 31 percent of total available time.

Because AAFES did not properly define its requirements it acquired more capacity than it could justify. Its own approach (analysis of historic growth in processor time), if applied properly, would have led AAFES to acquire a smaller system. If AAFES had acquired such capacity from the lower priced vendor, its total acquisition costs would have been reduced by an additional $750,000.

1/We have stated system overhead as a percentage of processor busy time because system overhead is influenced more by the jobs processed than by the time the processor is potentially available for work (i.e. total potential hours). If AAFES had shown its estimated overhead as a fraction of processor busy time, it would have been about 47.2 percent.

Minicomputers

The assessment used to support the acquisition of the 41 minicomputers was the one prepared originally to outline an interim solution for automating the customer credit sales accounts at four test stores in Europe. The study and related documents specified that the system would have a life expectancy of 1 year, and that further evaluation would be performed if the credit program were expanded. In spite of these understandings, AAFES spent 5 months preparing for the expansion of the credit program to all overseas exchanges using the original, very limited study to document equipment requirements systemwide, rather than further assessing equipment needs.

When the AAFES study planners proposed equipment size for the four-test-site interim system, they were automating an existing manual system. The planners knew the actual number of accounts and transaction records to be automated at each location. This was not the case when AAFES expanded the program to 40 sites worldwide.

Had AAFES functionally defined its computer needs when it received permission to expand the program, it would have studied each projected site and independently determined workload projections for each location. Instead, Exchange Service planners extrapolated worldwide workload estimates from the four-store test experience documented in the initial study. AAFES assumed, without formal analysis, that credit sales activity at the four test sites in Europe would be duplicated worldwide and, further, that the relationship between credit sales activity and customer strength at the four European sites could be used to project credit sales activity at all other sites. AAFES accepted these assumptions without determining if the relationships were valid and used the extrapolated workload estimates to determine the number and size of the minicomputers it would buy.

Because of these assumptions, more and larger computers were ordered than were needed. Six of the 41 minicomputers were not needed and most of the others were larger than needed. Within 3 to 9 months of installation, five of the six surplus minicomputers were demonstrably underused and the sixth was cannibalized temporarily for spare parts before it was ever installed. Ultimately, all six surplus computers were sent to other locations to perform unrelated work. In addition, 24 of the remaining computerized sites had less sales activity than was originally projected, and all of the computers still being used by the credit program proved to have enough available capacity to process other unrelated applications. Nine of the minicomputers were the largest of three models available from the vendor, but the actual account activity on each of these systems is within the capabilities of the next smaller model. Consequently, a proper definition of its minicomputer requirements would have led AAFES to acquire six fewer and several smaller minicomputers at a savings of more than $500,000.

VIEWS OF AAFES OFFICIALS

On December 28, 1981, we provided AAFES with a "Statement of Principal Facts" on the findings we developed during our audit. On January 15, 1982, AAFES provided us with unsolicited written comments on the statement. AAFES agreed with many of the facts but expressed several reservations about possible conclusions and opinions we might draw from them. We considered these views in our final analysis of the facts presented in this chapter.

Even though AAFES presented no additional documentary evidence to support its main computer or minicomputer procurements, it reasserted the adequacy and reasonableness of its actions in each instance. AAFES stated that it believed its main computer growth analysis was correct and ours was not. Nevertheless, we believe the errors we found in the AAFES analysis are sufficient to render it incorrect. In concluding that our analysis was in error, AAFES recalculated the growth with a different set of mathematical formulas and initially derived the same results we had obtained. However, AAFES continued to mathematically adjust the results through a series of inappropriate and logically inconsistent calculations rather than agree with the original results derived from accepted regression analysis techniques.

On the minicomputer procurement, AAFES stated that its assessment was reasonable and that the subsequent uses of surplus minicomputers illustrated good utilization of existing assets. We believe the facts presented in this chapter amply demonstrate the weaknesses in the procurement. The fact that the surplus minicomputers are now being used for other purposes does not absolve AAFES from the responsibility to acquire only those resources that it can properly define and justify.

On July 21, 1982, we provided the Department of Defense with a draft of this report. However, the Department did not provide official comments. The Department told us the report raises significant issues at the Exchange Service which need to be addressed fully by the Department before it can provide responsive comments.

CONCLUSIONS

Even though the Department of Defense has exempted AAFES from the instructions that normally govern the procurement and management of data processing resources, it has instructed nonappropriated funded activities to obtain maximum practical competition and to use Defense instructions as management guidelines. Acting under this exemption, AAFES has procured computer resources noncompetitively and inadequately defined its computer needs. These practices have resulted in excess computer hardware costs of up to $4.5 million in the past 2 years.

In our opinion, AAFES needs to more closely follow Defense policies governing maximum practical competition, and definition and justification of computer requirements. Otherwise, the

Exchange Service will continue to incur unnecessary equipment costs which are borne ultimately by military personnel. We believe greater involvement is needed by the executive management at AAFES and its Board of Directors to ensure that the data systems division properly and economically meets AAFES's data processing needs. This greater involvement must include more active participation in approving and monitoring ADP procurements.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

To increase competition and reduce costs, we recommend that the Secretary of Defense

- --direct the Exchange Service and its Board of Directors to comply with Defense policies governing competitive acquisition and proper definition of computer requirements; and

- --direct the AAFES Board of Directors to review and approve, as necessary, all major ADP procurements to ensure that Defense procurement policies are followed.

CHAPTER 3

SYSTEM DEVELOPMENT IS HAMPERED BY POOR PLANNING, MANAGEMENT OVERSIGHT, AND CONTROL

Software development projects we reviewed were inadequately planned and managed, resulting in substantial cost and schedule overruns and costly delays in providing needed support to data processing users. Top management did not have the common decision-making and accountability tools--such as a cost accounting system--that are necessary to monitor and control system development.

We found that the Exchange Service has some sound project management guidelines but has not complied with them fully. Projects lacked required documentation and users were not always involved in project design. In addition, top management at the Exchange Service

--was not involved at key decision points and

--lacked meaningful information on progress and cost.

If AAFES management does not aggressively manage its system development projects, inflated project costs and the costs associated with deferring needed operational benefits will continue.

LATE AND OVERBUDGET PROJECTS DELAY EXPECTED OPERATIONAL BENEFITS

We reviewed four software development projects and found them, to varying degrees, both late and over budgeted costs. (See p. 3 for criteria used to select these projects.) As illustrated in the following table,

--the Warehouse Inventory Control and Replenishment System had overrun its schedule by 32 months and its cost estimates by 277 percent,

--the Repair Automotive Parts Improvement Delivery System was 6 months late and programming costs were 967 percent over estimates,

--the Sales Promotion System was 12 months late and had overrun cost estimates by 316 percent, and

--the Food Plant Management System was 13 months behind schedule and 24 percent over the budget.

Approved vs. Actual Cost and Time for
Four Selected Software Development Projects

	Cost (note a)		Time (note e)	
Project	Approved estimate	Actual	Approved estimate	Actual/scheduled as of 10/31/81
WICRS	$175,000	b/$660,000	12 mos.	44 mos.
RAPIDS	c/ 4,500	c/ 48,000	10 mos.	16 mos.
SPS	10,820	b/ 45,000	4 mos.	16 mos.
FPMS	84,888	d/ 105,000	7 mos.	20 mos.

a/Best characterized as "minimums" rather than true costs because of the absence of a cost accounting system for tracking and allocating all aspects of development costs.

b/Represents primarily estimated personnel costs for users and systems designers involved in development; in some instances includes identifiable hardware expense.

c/Represents program development costs only.

d/We believe user costs that AAFES provided for this estimate are understated but have included them as a "not less than" figure.

e/AAFES informed us that projects are sometimes delayed or interrupted because of changing priorities and reallocation of development resources. Total elapsed time is shown here because approved estimates were not updated and extenuating circumstances were not documented. Increases in actual development time over budgeted development time are reflected in cost figures. (See note b.)

WICRS--potential to avoid excessive inventories is delayed

The Warehouse Inventory Control and Replenishment System was designed to track and control AAFES's $700 million inventory. It will utilize data base technology to (1) minimize the maintenance of multiple inventory data files, (2) reduce manual posting of shipments in transit, (3) develop an automated procedure to control merchandise flow, and (4) provide management reports. When complete, WICRS should replace the Visual Rapid Reorder (VRR) system--an aging, automated merchandise control system originally designed to provide inventory replenishment in response to sales, inventory control, and simple ordering procedures.

AAFES officials informed us that critical problems have occurred in the merchandise replenishment system because VRR was not revised in response to AAFES's changing environment. Specifically, VRR cannot track purchases in transit during the long lead time

required for overseas shipment. As a result, orders are often duplicated and excess inventories accumulate. In addition, many VRR functions have, over time, become the responsibility of other systems, necessitating time-consuming, multiple file updates to accommodate changes in single data elements.

AAFES officials informed us that WICRS delays resulted largely from using an untried data base development package and from the fact that the project's enormous size was not anticipated. AAFES used the development tool on the WICRS project and discovered the package was faulty, which caused several months' delay. In addition, developers had to acquire knowledge of data base technology before proceeding with development.

Since the WICRS benefits are, at best, 2-1/2 years behind schedule, VRR's inefficient operations and attendant maintenance costs have continued. Moreover, the problems that WICRS was designed to eliminate were identified by AAFES officials as contributing to a $48 million excess inventory position overseas.

RAPIDS--costs escalated and benefits eroded

The Repair Automotive Parts Improvement Delivery System was designed to automate and increase the reliability of an existing manual system for ordering and tracking auto parts in Europe. It was intended to speed order processing, track auto parts orders, and reduce order processing costs by approximately $1,900 per month. The project was approved with an estimated development cost of $4,500 (roughly equivalent to 256 staff-hours of effort); it was later scheduled as a 1,000-hour project and at the time of our review actual completion was estimated to take 1,750 development hours. This accounted for almost $30,000 of the increased development costs we observed. Thus, the development costs alone outstripped the project's approved total cost. AAFES also changed its acquisition method for RAPIDS hardware from purchase to rental. This effectively reduced the system's projected monthly savings to $1,000.

SPS--AAFES's profitability retarded by delays

The new automated Sales Promotion System was expected to simplify the ordering process, improve markdown procedures, provide additional data, and decrease requisition times for an expected 49 to 52 sales promotions per year. AAFES considers these sales promotions necessary to maximize profits. By implementing the automated system, AAFES planned to double the number of its mandatory promotional events--an endeavor merchandising planners stated would be cost prohibitive using the manual system. Besides increasing the number of promotions, AAFES merchandisers also planned to increase the number of featured items in each promotion.

Development efforts were virtually complete before the system was presented to its actual users, who rejected segments of it as not meeting their needs. The rejected segments were redesigned

and reprogrammed, programming time increased, and the implementation schedule slipped. As a result, the merchandising division delayed any increase in its mandatory promotional events, deferring the project's potential benefits.

FPMS--benefits not identifiable

The Food Plant Management System was designed to automate bakery administrative operations, such as facility orders, total product demand, shipping, cost distribution, and invoicing, theoretically reducing required administrative support. AAFES currently has a manual system for managing these functions in three bakeries. FPMS is being developed concurrently with the consolidation of these bakeries into one new central facility. The documentation for FPMS states it will reduce the number of personnel necessary in the accounting, shipping, and stockroom function of the central bakery; however, AAFES officials could not differentiate between personnel reductions expected from consolidations and those, if any, resulting from the automated system.

Delays in developing FPMS can be tied, at least in part, to construction delays at the central bakery facility. As construction was delayed, software development for the project assumed a lower priority and was also delayed. The project's higher costs (illustrated on p. 19) are tied to understated estimates for hardware and implementation expenses.

AAFES SPECIFIES SOME SOUND PRINCIPLES FOR SOFTWARE DEVELOPMENT BUT DOES NOT MANAGE BY THEM

AAFES has developed planning directives which specify a five-phased, life-cycle approach to managing development projects. For proper management, each of these phases is critical. The directives, however, lack some key requirements necessary to manage development activities. Furthermore, the requirements that are specified are not being followed.

The five development phases specified in the AAFES planning directives are:

--Initiation.

--Definition.

--Design and programming.

--Testing and evaluation.

--Implementation.

The initiation and definition phases constitute initial planning. During the initiation phase, a project's objectives, justification, benefits, impact, and constraints should be specified.

The definition phase should (1) define the scope of the project; (2) determine costs, performance schedule, and resource requirements; and (3) specify how all project elements will fit together. Documents that provide a basis for the system's design and the computer programs should also be developed. During the design and programming phase, the actual system should be set up, software fabricated, project authority and responsibility allocated, and supporting documentation completed. By the time the system reaches the testing and evaluation phase, the system should have been proven economical, feasible, and practical. The project's life cycle is concluded with the implementation phase.

We compared AAFES's planning principles with those ascribed by private industry and the Federal Government and found that AAFES's initial planning did not require the detailed cost/benefit analyses and feasibility studies that are commonly required elsewhere. Further, we found AAFES's planning provided weak involvement by users and top management, and gave the project manager little authority. Even with these weaknesses, the AAFES planning system could provide some measure of development control if it were followed. However, this was not the case on the projects we reviewed.

Initial systems planning was superficial

Although the AAFES planning directives specify a life-cycle approach to managing development projects, the planning standards require no true cost/benefit analyses or feasibility studies. Further, the standards do not ensure that user needs are satisfied.

Basic planning documents--project proposals and functional descriptions--generally included elementary cost justifications. We found, however, that these documents contained (1) estimates with no backup, (2) underestimated costs, and (3) inflated benefits. Further, these documents were not updated when substantial overruns occurred.

Costs for all systems we reviewed were undocumented and underestimated and benefits could not be validated. For example, an AAFES study on bakery consolidation projected a personnel reduction from 387 to 178 as a direct result of consolidating operations at a central facility. In a separate study, AAFES projected a reduction of 50 additional personnel as a savings from FPMS implementation. The FPMS project manager could not show how the 50-position reduction would occur and could not identify the specific positions to be eliminated. Further, AAFES officials could not determine whether the positions cited for elimination under FPMS had already been assumed as a benefit from the consolidation. The RAPIDS project presented a similar situation. Documentation did not show how the project's approved $4,500 development cost estimate was derived and the systems analyst working on the project could only speculate that it must have been a mistake, in the face of the project's tenfold cost increase.

Certain costs are not included for any AAFES analyses. Cost elements such as site and facility preparation; clerical staff assistance; reviews and other technical and management overhead; involuntary retirement, severance, and relocation costs for displaced personnel; general overhead costs; space occupancy; supplies; and utilities are not recognized. Of the projects we reviewed only the FPMS included implementation cost estimates for travel and printing, and these were understated. Consequently, even the most accurate of AAFES's cost estimates did not reflect the true cost of development.

Because feasibility studies are not required, project feasibility is addressed only superficially, if at all. Typically, AAFES overemphasized the approach users and analysts wanted developed, ignored other feasible alternatives, and/or presented for comparison alternatives known at the time to be infeasible. The FPMS functional description, for example, listed two alternative approaches, both of which were described to us by AAFES officials as infeasible when they were presented. However, the functional description contained no consideration of (1) obtaining a commercial software package, an option suggested by an outside bakery consultant, or (2) implementing a revised manual system being used successfully in other food plants.

Users were not adequately involved

A basic tenet of systems development generally accepted by the data processing community is that users should be involved at the earliest stages of systems planning and participate in development throughout the various life-cycle phases. The AAFES planning directives echo this requirement but two of the four AAFES projects we reviewed did not effectively involve users.

As previously discussed, because the actual users were not involved in the Sales Promotion System until virtually the end of development, the project was not acceptably defined. Users were also not effectively involved in the development of RAPIDS. Although AAFES directives specify user representatives as project managers, no readily identifiable project manager was assigned to RAPIDS. During our review we were referred to four different individuals from two different AAFES divisions in our search for a user representative involved in project management; each one said he was not involved with the project. AAFES officials finally informed us that an individual located in Europe was the project manager, but the analyst developing the system did not know who he was and had not had any contact with him.

Top management was ineffective in monitoring and controlling development projects

AAFES top management was not involved during project development and did not enforce compliance with the existing planning standards, which are less encompassing than those prescribed by private industry or the Federal Government. Further, had top

management sought more involvement, weaknesses in AAFES's (1) management review process, (2) status reporting, (3) development plans, and (4) postimplementation evaluations would have hindered management's attempts to obtain the information necessary to track development projects.

We have observed, through extensive analysis of Federal systems development, that an essential element in developing effective automated systems is the early and continuing involvement and commitment of top management. 1/ We have found that effective, stage-by-stage, top management involvement--from project initiation to system implementation--minimizes problems, helps ensure effective and efficient use of resources, and increases the probability of developing successful systems. These observations are reinforced by similar findings in the private sector and by the degree of top management involvement called for by commercial systems developers.

Management review process

The four projects we reviewed each had low visibility to top management because of the structure of AAFES's project management system. Each weakness in the life-cycle management process served to further reduce project visibility and to undermine the phased approach to systems development that both government and commercial managers see as essential.

At AAFES the top management elements--the Board of Directors and executive management--are involved in broad policy formulation but have no formally prescribed role in project management or systems development. As the chart illustrates, management involvement in the systems development life cycle is generally prescribed at staff levels below the Master Planning Board--a group comprising selected division directors.

1/See: "Government-wide Guidelines and Management Assistance Center Needed to Improve ADP Systems Development," AFMD-81-20, Feb. 20, 1981.

AAFES Management Participation
In Systems Development Life Cycle

Level of management	Life-cycle phase				
	Initiation	Definition	Design and programming	Test and evaluation	Implementation
AAFES Board of Directors					
AAFES executive management group					
Master Planning Board	a/X				c/X
Development Planning Committee	X	X		b/X	
Functional divisions/ offices	X	X	X	X	X

a/Initial approval for projects costing more than $75,000.

b/Analysis report only. Test plan approval authority is vested at the functional level.

c/May request a postimplementation evaluation (discretionary). The implementation plan is a functional responsibility.

AAFES planning directives provide milestone decision points at each development stage. Although an AAFES management group--either the Master Planning Board or the Development Planning Committee--provided initial approval for each project we reviewed, management was not involved after development began. We found no documentation to indicate that management had revalidated project goals during a cycle or tracked schedules and budgets, as required by AAFES directives. Several AAFES officials informed us that once a project is approved it is perceived as an organizational need and is eventually completed regardless of cost.

We found that key project management decision points, specified in AAFES directives, were often bypassed or approved out of sequence, negating their value to a step-by-step management approach. For instance, on the WICRS project--the largest software development project recently undertaken at AAFES--a definitive project description, the second phase of development, was prepared and approved by the Committee before the project was initially authorized by management. The technical documents specified as a basis for system design were either never prepared or not approved. The project proposal, described by AAFES planning directives as the

initial management decisionmaking document for all new development, was never prepared for either the Sales Promotion System or the RAPIDS projects. The technical documents used as a basis for systems design were also not prepared for either project.

Although three of the projects we reviewed underwent at least one significant change, no required change documentation was prepared or submitted to management for approval. Further, although each project we reviewed was late and over the budget, the cost elements of the functional descriptions were never changed or submitted to the Development Planning Committee for approval as required by AAFES planning directives. The WICRS project is a classic illustration of this. At the time we reviewed the project, it was estimated to be 32 months behind schedule, was still in development, and was approximately $500,000 over the initial budget, yet no changes to the functional description had been made for presentation to an AAFES planning group.

Periodic status reporting

Many companies in the private sector require periodic project status reporting to management during the system development process. At AAFES it is provided at the discretion of the program manager, as needed. Only one of the projects we reviewed was providing status reports. These reports provided information about the project team's accomplishments, but lacked essential information for comparing progress with planned development.

Development plans

Further, we found that project task lists (called development plans), which formally established the plan of action for systems development, were either not prepared or lacked detail. Only two projects had detailed task lists and these were not updated to reflect schedule slippages, nor could they be related to the actual development tasks being performed. The chief systems analyst for one of these projects acknowledged that because actual design and programming activities did not relate to the development plan, it was impossible to use it to track the system's progress.

Postimplementation

Finally, the AAFES planning manual directs that postimplementation evaluations be performed at the request of the Master Planning Board. However, we were informed that in practice such requests are seldom made. The projects we reviewed were not to this stage of development, but we found no indication in planning documents for three of these projects that such an evaluation would be made.

Project managers lack authority to manage

At AAFES we found that project managers had no direct authority for managing the development process. Our experience has shown that the absence of this authority leads to development problems.

Each system under development should have a project manager as the central authority to provide daily direction, coordination, and control. The project manager needs the authority from management to decide on personnel allocations, establish project plans, schedules, and budgets; and conduct most technical activities. The manager should be the key person in assessing and negotiating tradeoffs.

AAFES project management directives establish a monitoring role rather than a managing role for this position. The AAFES project manager is assigned to arrange administrative support and prepare management reports but he is authorized only to monitor team effort, personnel allocations, and budgets. The functional divisions involved with the project retain management authority over the application of resources. The project manager is required to pursue AAFES organizational goals by working through others; he has no official authority to enable him to develop and maintain schedules or control costs and resources.

LACK OF COST ACCOUNTING AND CHARGEBACK MECHANISMS HAMPERS DECISIONMAKING AND ACCOUNTABILITY

Federal policy requires cost accounting as a tool for management control of the development process. Commercial data processing activities view cost accounting as an important element in each step of a system's life cycle. We found that AAFES has no system to track, account for, or report systems development costs and no mechanism to charge user divisions' operating budgets for the costs of specific development efforts.

By ignoring cost accounting, AAFES officials have deprived themselves of a basic accountability and decisionmaking tool. Without cost reporting, management cannot (1) evaluate project progress and performance, (2) decide if system benefits warrant continued development, or (3) plan future development efforts accurately. By avoiding chargebacks, management gives users little incentive to avoid unnecessary development costs.

After we questioned the absence of a cost accounting system for data processing at AAFES and the grossly underestimated project costs for WICRS, the Master Planning Board chairman directed better documentation for project costs, but did not advocate instituting a cost accounting system. AAFES managers informed us that they believe the expense of instituting a cost accounting system would be excessive and they would get no significant return from a user chargeback system. We strongly disagree with this opinion.

In a 1978 report on the inadequate cost accounting procedures of the Federal sector, 1/ we surveyed the cost accounting practices of private industry. The surveyed firms cited large benefits from accounting for ADP costs. One firm claimed over $1 million in savings. Other companies stated that they canceled or reconsidered large system investments, kept costs within limits, and eliminated submarginal applications by using cost data to make decisions. We concluded that cost accounting and user chargeback mechanisms were important to ADP management decisionmaking in Federal organizations. Six cabinet agencies, the Veterans Administration, the General Services Administration, and the Office of Management and Budget concurred in this conclusion, and subsequent guidelines for ADP cost accounting have been adopted Government-wide. We are not aware of any aspect of AAFES's data processing operations that would make them unique among government and industry in this regard; to the contrary, the problems we have observed at AAFES support a need for greater cost consciousness.

VIEWS OF AAFES OFFICIALS

In its written comments on our "Statement of Principal Facts" AAFES agreed that its software development directives could be strengthened and compliance improved but, as we have discussed, AAFES officials see no value in a cost accounting system. Again, we disagree.

CONCLUSIONS

The software development projects we reviewed at AAFES were consistently late and over budgeted costs and, consequently, were delinquent in providing intended service to users. The software projects were inadequately planned and managed. Top management neither monitored nor controlled development efforts and did not have the decisionmaking and accountability tools, such as a cost accounting system, necessary to do so. We believe that the delays and overruns we observed were symptomatic of AAFES's inadequate management of its software projects, and that the lack of a cost accounting and chargeback system deprived management of basic accountability and decisionmaking tools.

In our opinion, greater involvement is needed by the executive management at AAFES and its Board of Directors to ensure that the managers and operating divisions at AAFES, who depend heavily upon ADP resources, will not continue to wait unnecessarily for the benefits that can be realized through the sound management and use of these resources.

1/See: "Accounting For Automatic Data Processing Costs Needs Improvement," FGMSD-78-14, Feb. 7, 1978.

This involvement must include more active participation in approving and monitoring system development projects. A properly designed and implemented cost accounting and user chargeback system will give top managers one of the key decisionmaking and accountability tools necessary to effectively perform this role. Only through strong management oversight and control by AAFES executive management and Board of Directors can Army and Air Force military personnel their dependents be assured of effective service at minimum cost.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

To strengthen software development practices and reduce costs we recommend that the Secretary of Defense

--direct AAFES and its Board of Directors to comply with the Defense policies governing the management of data processing resources, and

--direct the AAFES Board of Directors to approve and monitor all software development projects or major modifications that (1) are essential to the AAFES mission or (2) involve significant costs.

To further strengthen software development practices, we recommend that the Secretary direct the Commander, AAFES to

--assume an active role in project management to ensure that projects either proceed according to cost and time estimates and meet objectives or are resubmitted to the Master Planning Board for revalidation;

--establish a system for accounting and charging the costs of system development and operations to major users; and

--revise AAFES planning guidelines to comply with Federal Information Processing Standards and accepted practices in private industry.

CHAPTER 4

AAFES'S POINT-OF-SALE PROJECT: A LENGTHY, EXPENSIVE PAST AND AN UNCERTAIN FUTURE

The procurement and project management control weaknesses at AAFES have also constrained severely its ongoing, 9-year, multi-million-dollar effort to install a nationwide, point-of-sale system. POS systems became an integral part of general merchandise retailing in the early 1970s. In these systems, data on sales transactions are recorded automatically in machine readable form by electronic cash registers and sent electronically to a computer or network of computers. There they are processed and used for sales and inventory management.

At the time of our review, the AAFES POS project was at least 4 years behind schedule and had missed three implementation deadlines while AAFES managers repeatedly changed the specifics of the system's hardware configuration. As a result, AAFES spent more than $2.7 million on POS equipment for 156 of its main stores; however, the equipment is being used at only 34 stores. The equipment for the other 122 stores has either been installed but not used, or simply placed in storage. Whether all of it will ever be used is still in question. Further, AAFES has not adequately evaluated the results of its experience at the 34 stores, yet it is testing another, more sophisticated concept that could cost an additional $20 million.

AAFES HAS BEEN UNABLE TO SOLIDIFY AND IMPLEMENT A POS CONCEPT

The point-of-sale project is at least 4 years behind schedule in part because AAFES managers have been unable to settle on a single POS concept and implement it. In January 1973, AAFES determined that POS data were needed and for the last 9 years has pursued acquisition of a system to furnish the data. AAFES views POS as a means of improving store-level inventory control, reducing personnel costs, and increasing the quality of operating information for management. The chart on the following page depicts AAFES's pursuit of these goals.

POINT-OF-SALE PROJECT HISTORY

Jan. 1973 -- Master Planning Board approved POS concept

Nov. 1973 -- POS Task Group recommended acquiring specially modified NCR-280 cash registers as central component of an AAFES POS system

Jul. 1974 -- AAFES began acquiring, via sole-source procurement, the first of 2,563 NCR-280 cash registers

1974-1976 -- AAFES delayed POS testing while price ticket reading technology was improved

Jul. 1976 -- Commander established a goal for worldwide POS implementation by March 1977

-- Original POS test sites identified

** -- AAFES began studying "cluster" computer support for POS processing

Aug. 1976 -- POS testing approved for seven stores

Dec. 1978 -- National Cash Register (NCR) notified AAFES it was discontinuing the 280-series cash register and related equipment

Jan.-Aug. 1979 -- AAFES purchased cash register upgrades, communications equipment, and peripheral items for a total POS system to beat NCR discontinuation deadline

-- AAFES committed to total POS implementation in U.S. main stores by June 1981, using cluster computers and a telecommunications network

Nov. 1979 -- POS test expanded to 16 main stores

Dec. 1979 -- Procurement initiated for cluster computers and telecommunications network

Sept.1980 -- Procurement canceled

** -- In-store computer concept replaced cluster computer concept for POS processing

-- Further expansion reduced to 20 stores and delayed until 1981

-- In-store computer test approved to start in May 1981, with evaluation/expansion decision in January 1982

Mar. 1981 -- In-store computer test slipped to February 1982 and implementation decision delayed to January 1983

-- POS test expanded to 34 stores

** Major shift in POS approach

In 1974, AAFES approved the point-of-sale project based on a concept of cash registers communicating with in-store computers. This interactive communication was initially viewed as a method of handling on-line inquiries, such as check verification. To facilitate its move to POS, AAFES combined its need for normal cash register replacements with its desire for electronic point-of-sale data capture capability and contracted with National Cash Register to produce a specially modified electronic cash register with POS data collection capabilities. Beginning in late 1974 with initial prototype registers, AAFES procured and installed 2,563 POS cash registers at a cost of approximately $7.8 million.

AAFES initially projected full implementation of POS by the end of fiscal 1977, assuming a payback in 5 years, largely from inventory control savings. But, beyond the acquisition of cash registers, AAFES did not pursue POS until 1976 because of slow development in price ticket reading technology. In July 1976, the AAFES commander directed a push to implement POS and established a goal of total implementation by March 1977.

By 1976, however, AAFES planners began studying an alternative concept in which several stores within a common geographic area would be linked by telephone lines to a single computer, and these regional computers would be linked to the headquarters main computer. They called this the "cluster" concept. In 1979, AAFES officials decided to implement it nationwide because they felt the cost of a POS system using in-store computers could not be justified. Unlike its commercial counterparts, AAFES does not grant consumer credit within the United States and cannot realize a credit management benefit from POS.

AAFES worked until August 1980 to procure a cluster network covering the continental United States. In December 1979, AAFES issued a multiple source solicitation for the communications equipment and computers necessary to establish its intended cluster network and support a POS implementation goal then stated as June 1981. AAFES received and evaluated vendor proposals but was unable to effect an award. In attempting to select a computer supplier, AAFES data processing officials disqualified NCR because it could not provide an IBM-specific communications protocol. AAFES had failed to specify this protocol in the original solicitation. In addition, AAFES allowed another bidder, IBM, to offer a computer that did not meet the upgradability requirements specified in the solicitation while requiring still another offeror, National Advanced Systems, to offer a central processor four times more powerful than IBM's to meet the same requirements. As a result, National Advanced Systems filed a formal bid protest and NCR wrote a letter expressing dissatisfaction with the evaluation process. Within 60 days of the protest, AAFES canceled its procurement and abandoned the cluster concept in favor, once again, of in-store computers.

It is impossible to determine the extent of AAFES's investment in the point-of-sale project because, as discussed earlier, AAFES lacks an effective cost tracking system. Nevertheless, its commitment to POS is substantial.

In addition to the $7.8 million investment in POS-configured cash registers, and $2.7 million in POS-related hardware, AAFES has had a project team assigned to work on the POS project for more than 9 years; data processing personnel have spent more than 4 staff-years on system planning and software development; contracting personnel have managed six major POS procurements; and retail management has been incurring personnel, training, and operating costs at test sites since 1976.

We recognize that major retailers consider point-of-sale data a necessity and in a previous report 1/ we commented on AAFES's need to develop and use such data, but POS is no closer to reality at AAFES today than it was in 1976. Each concept shift has resulted in one or more slips in the project's implementation goals and AAFES cannot say (1) how they will use their present equipment, (2) what their POS network will look like, or (3) when POS will actually be implemented.

AAFES IS UNDERUTILIZING ITS POS CAPACITY

As mentioned, AAFES has already purchased cash register upgrades, store wiring, data concentrators, and various pieces of peripheral equipment to implement POS at 156 stores, but only 34 stores are using the capability. The remaining equipment is either installed but unused, or in storage, and it is questionable whether some will ever be used. Exchange Service merchandisers have long desired to maximize the use of their present equipment by expanding this system but data systems planners have consistently maintained that they lack the central computer capacity to support the processing for a 156-store POS system--a contention we believe unfounded. As described in appendix II, our studies show that AAFES is using only 26 to 31 percent of its main computer capacity. Moreover, only 3 percent of that use is attributable to the POS data being generated by the 34-store system.

Although both computer capacity and data capture equipment are available now and have been available for more than a year, AAFES has chosen not to capitalize on this capability but rather to pursue new technology. Most of AAFES's cash registers, its oldest system component, were installed in 1977, and both the manufacturer and commercial users of this equipment report useful product lives in excess of 10 years. In addition, even a significant increase in POS data processing by the main computer would not greatly affect available capacity for several years.

1/"More Effective Internal Controls Needed to Prevent Fraud and Waste in Military Exchanges," FPCD-81-19, Dec. 31, 1980.

AAFES has no immediate plan to fully implement its current system. At present, it is procuring a sophisticated test system utilizing new cash registers, an in-store computer, and electronic price ticket scanning. The test is scheduled to run for a year at a cost of $140,000 and the new concept, if implemented as a nationwide in-store computer system, could cost as much as $20 million more than has already been spent.

POS BENEFITS HAVE NOT BEEN VALIDATED

AAFES has increased its experience with the POS concept considerably over the past 5 years but, in spite of the project's substantial cost, management has never validated its benefits. AAFES implemented its first 7 POS test stores in 1976, expanded to 16 stores by 1979, and then to the present 34 stores in early 1981, but it has never quantified any benefits actually received from POS.

Project documents consistently state that AAFES hopes to benefit from POS by reducing inventory costs and store-level personnel costs. Yet, the project manager informed us that AAFES has been unable to reduce store personnel and has not studied comparative inventory costs at POS test sites.

Even though AAFES has a use for POS data and a desire for current technology to obtain it, it cannot ignore management's responsibility for ensuring the cost effectiveness of whatever program it implements. AAFES has neither made maximum use of its present POS capabilities nor validated the tangible benefits of the POS project--steps that obviously should precede and become part of a feasibility study of any future system.

Our discussions with major retailers and private consultants, identified as experts in the POS field, indicate that such validation could be accomplished through a controlled comparison of similar POS and non-POS stores. Such a comparison should focus on the questions that bear directly on AAFES's POS goals:

--Is inventory more/less in POS stores?

--Are markdowns and price changes better controlled?

--Are there comparatively fewer/more employees in POS stores? In what positions? At what cost/savings?

--Is customer checkout faster/slower in POS stores? By how much?

--Do POS stores have a higher/lower gross margin or net profit because of POS? By how much? Can this margin be projected to similar stores with similar customer profiles?

VIEWS OF AAFES OFFICIALS

In its written comments on our "Statement of Principal Facts," Exchange Service officials reasserted their belief that they do not have the central computer capacity needed to process point-of-sale data for a 156-store system. They further stated that the current 34-store test was achieving their inventory management goals and that the in-store computer test was designed to improve efficiency and responsiveness in the system by taking advantage of newly developed technology.

As we have explained, AAFES has plenty of unused capacity in its main computer systems (see app. II). Furthermore, AAFES's only support for its statements that the current POS system is meeting its goals is three trip reports from 2-day store visits by top executives in 1979 and 1980. As we pointed out, no quantitative study of POS benefits has been done.

CONCLUSIONS

AAFES has had extensive experience with the point-of-sale project and has spent a considerable amount of money to gain that experience. However, AAFES has neither made maximum use of its POS capabilities nor validated the tangible benefits of the POS project. We found that, although AAFES has the capability to implement a full point-of-sale system, it has not done so. Further, AAFES is prepared to spend as much as $20 million on new technology without fully implementing its existing system and with no validation of the benefits anticipated from either present or planned POS concepts.

We believe the Exchange Service is pursuing the latest technology in a desire to be at the leading edge of retail systems development. In this chase AAFES has essentially set aside its primary objectives of using POS concepts to reduce cost and increase service to its customers.

RECOMMENDATIONS TO THE SECRETARY OF DEFENSE

We recommend that the Secretary of Defense direct the Exchange Service and its Board of Directors to defer pending procurement efforts for the point-of-sale project and validate the POS concept by thoroughly documenting the costs and benefits of AAFES's present POS system. If such a study supports proceeding further with the POS project, AAFES should first consider using existing equipment and excess computer capacity for the life of that equipment before developing more sophisticated and costly follow-on systems.

APPENDIX I

AAFES COMPUTER WORKLOAD

AND GROWTH RATE PROJECTIONS

When AAFES replaced its central computer in late 1980, it based its capacity requirement on an in-house study which showed a 32 to 34 percent annual growth rate in computer workload. We identified several shortcomings in the AAFES workload analysis that caused us to believe the growth figures were overstated. To determine AAFES's actual growth in computer applications we conducted our own analysis based on commonly accepted statistical forecasting techniques. We determined AAFES's computer workload, its growth rate over 27 months, and its future capacity requirements, and concluded that its actual computer workload growth rate was only 18 percent per year.

SCOPE OF ANALYSIS

We analyzed computer utilization data captured and reported by AAFES's System Management Facility (SMF) during the 27 months from July 1978 to September 1980, when AAFES's basic computer configuration--an IBM 370-158 MP and an IBM 3031--remained constant. Our analysis covered both total Central Processing Unit (CPU) hours and a breakdown into 14 major application areas, identified by AAFES as making up 80 percent of total CPU use, and an "other" category covering the remaining applications. We also interviewed cognizant AAFES officials regarding utilization patterns and future program expectations for each applications area.

Statistical information was extracted from hardcopy SMF reports provided by AAFES. Source computer tapes of this data were available for only 12 months; however, since we successfully verified data reliability for 3 of these months, we believe the data for other months to be reliable.

PROCEDURES AND ANALYTICAL TECHNIQUES

We based our computer workload estimates, in part, on regression analysis. Definitions applicable to the analysis are contained in chart 1 and the step-by-step procedure used in the analysis is detailed in chart 2. The Statistical Package for the Social Sciences (SPSS), a software system of computer programs, was used to perform actual calculations for each regression analysis.

CHART 1

DEFINITIONS

Regression analysis--A general statistical technique used to analyze the relationship between a single dependent variable and one or more independent variables.

Intercept--The value of the Y axis where the line defined by the equation $y = a+bx$ crosses the axis ("a" is the intercept for this line).

Residual (or error)--The deviation of an observed value from its estimated value. We assume the residuals are normally distributed with a zero mean and uncorrelated with the explanatory variable, have a constant variance, and are uncorrelated with each other.

Coefficient of determination (R^2)--Measures the proportion of the variation of the dependent variable around its mean that is "explained" by the set of independent variables.

Dummy variable--A dichotomous independent variable used to account for certain nonquantitative values that may have an effect on a given dependent variable.

Linearity--Used to express the concept that the model possesses the properties of additivity and homogeneity.

Zero slope--A horizontal line indicating that the dependent variable does not vary with the independent variable.

Regression coefficient--The numerical value of any parameter estimate that is directly associated with an independent variable. (In the equation $y = a+bx$, the value of b is the regression coefficient for its corresponding variable x. If x changes by one unit, then y changes by b times one unit, ceteris paribus.)

F-value--A measure of the strength of an independent variable/regression equation in explaining variations in the dependent variable.

CHART 2

GAO'S WORKLOAD GROWTH ANALYSIS FOR AAFES

Step 1. Data collection: CPU hours for each application area and the total, as extracted from AAFES-supplied SMF data.

Step 2. Data research: Interviews with the responsible officials and/or systems analysts for each of the 14 major application areas. Central points of discussion were: utilization peaks and troughs, expectations regarding the application area's future, past CPU usage, major programs within each application area, and identification of major rewrites or revisions.

Step 3. Regression analysis: (a) CPU use by application area over time, using dummy variables for recurring peaks and treating nonrecurring peaks as "missing data" points; 1/ (b) CPU use by application area over time, using a semilogarithmic transformation and data adjustments, and (c) CPU use by application area over time after data adjustments, but without semilogarithmic transformation.

Step 4. Data research: Interviews with responsible officials, systems analysts, and users for major CPU application areas, regarding growth projections determined in the above analysis.

Step 5. Regression analysis: Total CPU use over time, using a semilogarithmic transformation after the data adjustments determined in the above steps. 2/

1/Recurring peaks were handled using dummy variables, whereas nonrecurring peaks identified by AAFES analysts were treated as "missing data" points, which instruct the SPSS program to move from the last known point to the next known point in calculating the regression equation.

2/Analysis and data adjustments are discussed on pp. 39-41.

In regression analysis, one variable may be dependent on one or more independent variables. The "best" fitting line is mathematically determined, maximizing the model's explanatory power by minimizing the sum of the squared residuals for a given set of data.

An intercept and a regression coefficient for each of the "n" independent variables are determined. The generalized equation for regression analysis is expressed as:

$$Y = a+b_1x_1+..+b_n\ x_n\ +u_i$$

where Y = the dependent variable,

$x_1,...,x_n$ = the independent variables,

a = the vertical intercept,

$b_1,...,b_n$ = the regression coefficients for each corresponding independent variable, and

u_i = the error term.

AAFES GROWTH RATE FOR COMPUTER APPLICATIONS IS 18 PERCENT

We utilized a semilogarithmic transformation and regression analysis to determine the rate of growth for the 27-month analysis period. The following equation postulates a relationship that CPU hours grew at a constant annual rate with minor variations that were a result of random events:

$$CPU_t = a(1+g)^t\ e^{u}t \quad , \text{ for } t = 1, 2, ..., n,$$

where CPU_t = total CPU hours used in month t,

a = a parameter (CPU hours at the beginning of the period),

g = a parameter that is the compound rate of growth of CPU_t,

u_t = the disturbance term, and

e = natural logarithm (or a unique number equal to approximately 2.718 such that ln e^x= x).

The equation above can be transformed into a linear relationship by logarithmic transformation:

APPENDIX I

$$\ln CPU_t = \ln a + t\ln(1+g)+u_t$$

If we let (1) $CPU_t^* = \ln CPU_t$,

(2) $a^* = \ln a$, and

(3) $b^* = \ln (1+g)$,

then we obtain

$$CPU_t^* = a^*+b^* t+u_t$$

The third equation converts the second into a linear relationship, not between CPU_t and t, but rather between $\ln CPU_t$ and t.

To estimate the parameters, a* and b*, we must have observations on $\ln CPU_t$ for each month in the period we are considering. The value of $\ln CPU_t$ is derived by taking the natural logarithm of CPU_t.

The SPSS regression procedure will calculate $\hat{b}^*$ and $\hat{a}^*$ which are estimated values for b* and a*, respectively.

Since $\ln (1+g) = b^*$,

then $(1+g) = e^{b^*}$

and $g = (e^{b^*} - 1)$.

We therefore estimate the rate of growth, g, by $\hat{g} = e^{\hat{b}^*} - 1$. By substituting e which is a constant, approximately 2.718, we get

$$g = 2.718^{\hat{b}^*} - 1$$

where $\hat{b}^*$ predicts the value for b*.

Before the above regression was performed, the figures for total CPU hours in month t were extracted from SMF reports and adjusted for nonrecurring peak periods. The adjustment comprised the following steps:

1. Nonrecurring peaks or "abnormal" levels for each application area were identified through discussions with the responsible systems analyst for that area. As an example, one of the application areas contained a peak period which was double its mean value. After discussions with the responsible systems analyst and the primary user, this peak

was identified as a printout of the entire data base which was required to support a written report. Neither the analyst nor the user expects a similar report at any point in the future.

2. a. For small peak periods 1/ (for example, a printout of an entire data base in 1 month) points on each side of the peak were averaged to determine "normal" CPU for that month(s).

   b. For large peak periods 2/ (for example, implementation of a data base resulting in excessive testing, parallel runs, fine-tuning, etc.) the "normal" and "abnormal" ranges were independently averaged and the difference between the two averages determined.

3. The difference between

   a. the actual peak CPU and the derived "normal" CPU (for small peak periods), or

   b. the two averages (for large peak periods)

   was used to adjust actual total CPU. Using this adjusted data, the SPSS regression procedure, and a semilogarithmic transformation, the results were:

   $\hat{b}^* = 0.0138$ and $\hat{g} = 1.39$ percent per month 3/ or a growth rate of 18.0 percent per year.

The R^2 is .788 and statistically significant at the 99.5-percent level of confidence. 4/

SUMMARY

When total CPU was regressed against a single variable, time, we found this variable was statistically significant at the

---

1/Most peaks were either one or two periods in duration, yet there was one 3-month, one 4-month, and one 5-month period. A further exception was the catalog sales application area which had a 13-month period adjusted in this manner due to special circumstances.

2/Adjustments were made for four periods of eight or more continuous months.

3/This growth rate was confirmed using a base 10 semilogarithmic transformation.

4/The F-value associated with this R^2 is 92.973.

APPENDIX I

95-percent level of confidence and explained 83.0 percent of the variations in the dependent variable. This indicates that time did an excellent job in explaining the variations in total CPU hours.

CONCLUSION

A constant data processing workload growth rate of 32 to 34 percent was assumed by AAFES when the actual growth rate was 18 percent.

ANALYSIS OF AAFES

CENTRAL PROCESSOR UTILIZATION

As discussed in chapter 2, we identified several shortcomings with the AAFES in-house analysis used to justify acquisition of its current computer. In this appendix, we describe our analysis of AAFES's current computer utilization and related system overhead. The analysis shows that AAFES is using less than one-third of its computer capacity and has substantially overestimated system overhead.

SCOPE OF ANALYSIS AND ANALYTICAL TECHNIQUES

We analyzed central processor utilization data for the 6 months beginning Friday, March 27, 1981, and running through Thursday, September 24, 1981--a period corresponding to AAFES's fiscal months April through September. This time was chosen because it starts when AAFES's central processors were first configured as multiprocessors 1/ and ends at the completion of our audit field work.

We obtained the utilization data from magnetic tapes supplied to us by AAFES. These tapes contained utilization data recorded on the AAFES computer system by IBM's System Management Facility, a part of the computer's operating system. Integral to the System Management Facility is an IBM software monitor known as the Resource Measurement Facility, which makes possible an accurate calculation of processor utilization.

UTILIZATION ANALYSIS

During the 6-month period, total utilization of the AAFES computer ranged between 25.8 and 30.8 percent of available processor time. The highest level of processor utilization, 30.8 percent, was achieved in September 1981 (September has historically been AAFES's busiest processing month). Table I reports the total number of hours the AAFES computer was actually available for application processing. Table II reports the amount of time the computer was busy. Busy time and the resulting utilization percentage include both application processing and system overhead time.

1/Processors were first configured as multiprocessors on March 22, 1981. The period covered by our analysis actually begins on March 27, 1981, the first day of the first complete fiscal month following the start of multiprocessing operations.

TABLE I

Computer Availability

Fiscal month	Total potential time	Total available time	Percentage
	(hours)		
April	1,440	1,359	94.4
May	1,488	1,347	90.5
June	1,440	1,313	91.2
July	1,440	1,386	96.3
August	1,488	1,450	97.4
September	1,440	1,352	93.9
Total	8,736	8,207	93.9

TABLE II

Computer Utilization

Fiscal month	Total available time	Processor busy	Percentage
	(hours)		
April	1,359	351	25.8
May	1,347	364	27.0
June	1,313	351	26.7
July	1,386	376	27.1
August	1,450	408	28.1
September	1,352	417	30.8
Total	8,207	2267	27.6

APPENDIX II

AAFES's computer workload is predominantly batch processing (83 percent during September 1981), and approximately half of this is related to merchandise resupply applications which are normally processed overnight. AAFES officials informed us that, because of this, the most realistic picture of their processing requirements would be obtained by (1) disregarding weekends and (2) looking at peak workloads during particular periods of the day. In this regard, AAFES personnel suggested that we break their day into 6-hour intervals or shifts. They also informed us that the most critical of these shifts is the one from 6 p.m. to midnight.

Accordingly, we analyzed AAFES's workload for the 6 p.m. to midnight shift on weekdays only (see table III). Over the 128 weekdays for which we had data, the processors were available to users 97.9 percent of the potential fourth-shift time. The processors were busy 31.8 percent of this available time.

TABLE III

Processor Availability and Utilization

(6 p.m. to midnight, weekdays only)

Fiscal month	Potential time	Available time	Busy time	Processors busy as percentage of available time
	--------(hours:minutes)--------			
Apr.	252:00	249:44	74:30	29.8
May	252:00	247:21	82:32	33.4
June	264:00	246:31	76:53	31.2
July	240:00	239:30	72:18	30.2
Aug.	264:00	263:33	83:52	31.8
Sept.	264:00	257:30	87:42	34.0
Total	1,536:00	1,504:09	477:47	31.8

In 95 percent of these critical weekday shifts, processor utilization was less than or equal to 46 percent of the available time. Maximum processor utilization for 99, 95, 90, and 50 percent of these workshifts was:

APPENDIX II

Percentage of fourth shifts	Maximum processor busy (percentage of available time)
99	58
95	46
90	41
50	31

OVERHEAD ANALYSIS

In determining its need for the IBM 3033 Multiprocessor system, AAFES estimated that the CPUs would spend about 42.5 percent of total potential time performing system overhead functions. System overhead is the amount of processor busy time spent on housekeeping functions within the computer as opposed to the time spent actually processing applications.

To make our analysis we used the Resource Measurement Facility, which provides an extremely accurate record of system overhead time. Even though AAFES had this facility available on its old systems, we were told AAFES had not activated it to capture overhead measurements. We were told that AAFES determined the 42.5 percent by having a system programmer periodically monitor the computer's processing activities from a terminal for 31 days and make random observations on the computer time necessary to process the AAFES job stream.

In our analysis we calculated system overhead as a percentage of processor busy time because system overhead is influenced more by the jobs processed than by the time the processor is potentially available for work (total potential hours). If AAFES had shown its estimated overhead as a fraction of processor busy time, it would have shown about 47.2 percent. Our analysis, however, revealed that actual system overhead was averaging 25.8 percent of processor busy time, within a range of 22.8 to 28.8 percent. (See table IV.) This range is consistent with IBM's published expectations for batch processing workloads, such as AAFES's, run in a processing environment similar to that of AAFES's.

APPENDIX II

Table IV

System Overhead Analysis

Fiscal month	Processor busy	System overhead	Percentage
	---------(hours)---------		
April	351	101	28.8
May	364	83	22.8
June	351	90	25.6
July	376	102	27.1
August	408	100	24.5
September	417	109	26.1
Total	2,267	585	25.8

CONCLUSION

AAFES has a significant amount of unused capacity on its present processors and is experiencing system overhead rates far less than it estimated in its justification for acquiring the processors.

(913668)

*U.S. GOVERNMENT P RINTING OFFICE : 19820- 281-843/5

23824

AN EQUAL OPPORTUNITY EMPLOYER

UNITED STATES
GENERAL ACCOUNTING OFFICE
WASHINGTON, D.C. 20548

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE,$300

POSTAGE AND FEES PAID
U. S. GENERAL ACCOUNTING OFFICE

THIRD CLASS