BY THE COMPTROLLER GENERAL

Report To The Congress

OF THE UNITED STATES

Data Base Management Systems--Without Careful Planning There Can Be Problems

Computers and related resources are used throughout the Government for highly complex applications--from payroll to energy, from space to weather systems. Data base management systems have been developed to improve the management and control of data maintained in computer-based systems.

GAO studied Federal agencies' use of these systems to determine what problems agencies encounter in acquiring and using the systems and what impact data base management system technology has had on agency operations.

GAO recommends that the General Services Administration establish clear and concise procurement policy and procedures. GAO also recommends that the National Bureau of Standards develop standards and technical guidelines to help Federal agencies determine when to use a data base management system and how to acquire the system that will best suit their needs.

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Software package	Software, in the form of a prepared "package," which is often sold by a vendor and which consists of the program(s) itself and documentation, such as flowcharts and users' manuals.
Transaction - oriented system	A system that is controlled by application programs and permits a user only to input and receive data.

GLOSSARY

Application program	A set of instructions designed for a computer to accomplish a specific job or application, such as payroll computation, inventory control, and accounting. It is also called application software.
Audit trail	A means of identifying and tracing actions taken in processing data. It encompasses the logging of selected events as they occur at specified points within a system.
Batch processing	A data processing technique in which jobs are collected and grouped before processing.
Data base	A repository for an organization's pertinent data. It can be correlated, cross-referenced, and processed by one or more application programs.
Data base loading	The initial placement of formatted data into the data base. This is a data base management system (DBMS) function.
Data base management system	A computer software package that can facilitate the management, manipulation, and control of data.
Data base recovery	Correction of errors due to system or data base failures by returning the data base to its condition before the failure.
Data model	The logical organization of the data for processing without regard for the physical ordering required for storage.
Direct access	The process of storing data or selecting stored data without scanning surrounding data.
File access method	Moving data between the central processing unit of a computer and its peripheral storage devices.

Hardware	The physical equipment of a computer system, e.g., mechanical, magnetic, electrical, or electronic devices; contrasts with software.
Higher level language	A computer programming language which is independent of a particular computer's limitations. Such languages adapt the computer to the needs of the programmer.
Main memory	The storage component that is considered integral, internal, and primary to the computer system.
Minicomputer	A small-scale computer for which the manufacturers may furnish only limited software support products and services.
On-line processing	Pertains to fast response computer processing. It obtains data from an activity or process, performs computations, and returns a response rapidly enough to control, direct or influence the outcome of the activity or process.
Operating system	A group of computer programs that monitors and controls the operation of a computer system while the application programs are running.
Pointer	A symbol that identifies the physical location of a data item.
Query language	A computer programming language which allows ad hoc inquiries to be entered, or allows a nonprogrammer user to extract data from the data base and produce reports from it.
Software	A set of computer programs, procedures, and associated documentation concerned with the operation of a data processing system. Three categories of software are (1) application software, (2) operating system software, and (3) utility software.
Software conversion	The act of making computer programs run on a computer system other than the one for which they were originally devised.

ABBREVIATIONS

ADP	automatic data processing
COBOL	Common Business Oriented Language
CODASYL	Conference on Data Systems Languages
DBA	data base administrator
DBMS	data base management system
FIPS	Federal Information Processing Standard
GSA	General Services Administration
NBS	National Bureau of Standards
OMB	Office of Management and Budget
OPM	Office of Personnel Management

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--develop a family of data base management system standards that recognizes diverse user needs.

Several agencies provided written comments on this report. They generally agreed with the conclusions and recommendations. (See p. 43.)

assistance from the National Bureau of Standards. Technical guidelines should be formulated as soon as possible to help the agencies determine when to use a data base management system and how best to evaluate and select the right one in the competitive procurement environment. (See p. 25.)

Increasing efforts by Federal agencies to use the data base management system technology without adequate procurement policies and procedures are creating data base management system acquisition problems. (See pp. 17 and 21.)

The lack of data base management system standards could cause a Federal agency to invest in data base applications that would lock it in to one vendor. (See p. 26.)

RECOMMENDATIONS

To improve the acquisition of data base management system software, the Administrator of General Services should establish clear and concise procurement policy and procedures that

--recognize the importance of data base management system software when an agency needs both the computer equipment and a data base management system and

--deal with data base management system application software conversion costs in evaluating competing vendor proposals in the computer system acquisition process.

To insure that data base management system technology is properly applied and Federal agency investment in data base applications is protected from being locked in to any one vendor, the Department of Commerce, through its National Bureau of Standards, should

--develop technical guidelines in collaboration with GSA to help Federal agencies (1) determine when to use a data base management system and (2) evaluate and select a data base management system on a competitive procurement basis; and

--Ability to better respond to changing information needs.

--Effective support of on-line access to a data base from remote terminals for data retrieval or processing.

--Ability to develop programs in response to ad hoc requests for information.

--Reduction in redundant data. (See pp. 3 and 33.)

PLANNING IS CRITICAL

Experience has shown clearly that efficient and successful implementation of a data base mangement system requires careful planning. The process should begin with a comprehensive evaluation of users' information processing requirements. Defining user needs is critical to determining a system's appropriateness and also critical to its successful selection.

The implementation of a data base management system can be complex, time-consuming, and costly, and it can affect every information handling aspect of an organization. A data base management system allows many diverse user groups to share data, but successful implementation requires careful planning to anticipate and counteract any adverse impact on the user, the data processing organization, other computer resources, the internal audit function, and the organization as a whole. Since "going data base" is such a serious decision, the implementation planning should include a comprehensive evaluation of commercial data base management system packages to ensure that the most appropriate one is selected for the job. (See p. 10.)

CENTRAL AGENCY GUIDANCE NEEDED

The need for good technical guidance to help in this technical and demanding process is obvious; but, unfortunately, Federal agencies have not received adequate technical

COMPTROLLER GENERAL'S REPORT TO THE CONGRESS

DATA BASE MANAGEMENT SYSTEMS--WITHOUT CAREFUL PLANNING THERE CAN BE PROBLEMS

D I G E S T

Data base management systems are computer software packages--computer programs, documentation, users' manuals, etc.--which can help organizations manage, manipulate, and retrieve data from computer-based systems. If properly planned and controlled, the systems can provide Federal agencies with an effective and efficient management tool to better organize and access data and to improve the accuracy and timeliness of information available for decisionmaking. If not properly planned and controlled, the systems can be complicated and costly, providing management with more problems than solutions or benefits.

Most agencies ~~GAO~~ visited by GAO did not adequately plan before acquiring a data base management system; consequently, they may have spent substantial amounts for automatic data processing resources that they did not need. Fed...
(See p. 5.)

The costs of acquiring data base management systems are generally insignificant compared with the costs involved in using them in what is technically known as a "true data base environment." This requires a long-term management commitment to application software, computer hardware, communications, procedures, training, and support which will cost far more than the system itself. In most instances, organizations do not save data processing dollars by integrating files and implementing a data base management system, primarily because of increased costs associated with a more complex system.

The systems do offer potential advantages to offset their cost. Most system packages provide the following:

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

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

Data base management systems can be an effective and efficient tool to improve the management and control of data maintained in a computer-based system. However, the effectiveness of the data base system depends on proper planning and control.

This report discusses the problems that Federal agencies have encountered in acquiring and using data base management system technology.

We are sending copies of this report to the Secretary of Commerce and to the Administrator of General Services.

ACTING Comptroller General
of the United States

CHAPTER 1

INTRODUCTION

Automatic data processing (ADP) has had an enormous impact on the way the Federal Government conducts its operations. Computers and related resources, such as personnel, supplies, and communications, are now used extensively throughout the Government for highly complex applications--from payroll to energy, from space to weapons to weather systems. Over the years, the acquisition of hardware, software, and data has grown into a multibillion dollar investment. Some agencies would find it impractical, if not impossible, to accomplish their missions without computers.

In recent years, new technologies and concepts have evolved which can provide for more efficient and effective data processing operations. One of these, the data base management system (DBMS), was developed to improve the management and control of data maintained in computer-based systems. A DBMS is a computer software package 1/ which can significantly improve the management, manipulation, and retrieval of data.

DBMS technology is one of the most rapidly growing areas of computer and information science. DBMS acquisitions in both the Federal and private sectors have been increasing as the systems become more available. To illustrate, in February 1974, 925 data processing installations had acquired one of the six major DBMS software packages; by October 1977 that number had increased to 3,720. We made this study to determine the problems that agencies encountered in acquiring and using DBMS technology and what impact DBMS technology has had on agency operations.

THE DATA BASE APPROACH

The effective operation and management of any organization requires data that is both timely and accurate. As with other resources, data should be efficiently managed and controlled. The concept of data as a basic organizational resource is gaining acceptance and is the cornerstone of the data base approach. The decision to implement a data base environment involves a significantly different approach to data processing than that used previously.

1/See glossary.

The data base approach facilitates the sharing of data through a common data base. In its simplest form, a data base is a repository for an organization's pertinent data that can be correlated and cross-referenced. Specifically, the term data base implies

--an automated pool of accurate and timely data;

--data that can be easily accessed, manipulated, and retrieved by a community of users; and

--data that is stored so it remains independent of the application programs 1/ which use the data.

The data base approach emphasizes that data can be managed as an organizational resource separate from the operating uses for which it is acquired; data is no longer the property of a single person, function, or application program. To illustrate, consider the separate functions of payroll processing and personnel management. These functions have data common to both; but traditionally, separate files were developed and maintained for each. These files contained duplicate data, and maintaining the accuracy of these files involved duplicative processing. Under the data base approach, all data would be captured and processed only once. Both the personnel and payroll offices could then, through their individual application programs, draw the information from the system for their own use. Appendix II shows the benefits associated with the data base approach as compared with traditional file-oriented data processing techniques.

Data base management systems

Essential to the organization, access, and control of a data base is a DBMS. It is a software tool which handles the data--creates, stores, retrieves, deletes, and modifies it--and provides for the capability to share data resources among many users. The DBMS allows an organization to structure its data in a manner that best suits its information processing needs. How that is accomplished depends on the DBMS used.

Several potential advantages of DBMS can offset its cost. Based on user interviews and industry studies, we found that most DBMS packages offered the user the following advantages:

1/See glossary.

--Ability to better respond to changing information needs.

--Effective support of on-line 1/access to a data base from remote terminals for data retrieval or processing.

--Ability to develop programs in response to ad hoc requests for information.

--Reduction in redundant data.

Appendix I discusses the advantages of DBMS in greater depth as well as describes the disadvantages and the general characteristics of the various DBMS software packages and how the DBMS interacts with the application programs.

A DBMS may be either developed by the organization or acquired from a vendor. As is true with most custom designing, however, a custom DBMS can cost much more than a commercially available DBMS software package. In addition, an extended delay usually occurs before the custom DBMS is ready for use, and its tailoring to a specific set of requirements may lessen its adaptability to changes in an organization's information processing needs. This contrasts with the flexible, adaptive characteristics of commercial DBMS packages, which have been available for over 9 years. A recent market survey listed 41 DBMS packages--27 available from independent software vendors and 14 from computer hardware manufacturers.

Nonetheless, whether developed by the organization or acquired commercially, the initial cost of a DBMS is generally insignificant when compared to the long-term commitment agency management must make to develop application software, computer hardware, communications, procedures, training, and support should it decide to implement the data base approach. In most instances, organizations do not save data processing costs by integrating files and implementing a DBMS primarily because a more complex system leads to increased costs.

While essential to the data base approach, merely using a DBMS does not constitute establishing a data base environment. Some Federal agencies that we visited have acquired a DBMS to improve programmer productivity. However, because a DBMS requires extra computer resources, other methods of improving programmer productivity may be more appropriate.

1/See glossary.

RESPONSIBILITY FOR FEDERAL ADP MANAGEMENT

The Brooks Act (Public Law 89-306), which was passed in October 1965, provides for the economic and efficient purchase, lease, maintenance, operation, and use of ADP equipment. The responsibilities under the Act are disbursed to several agencies. The General Services Administration (GSA) is responsible for developing, implementing, and monitoring Government-wide policy for the acquisition, use, and management of ADP resources. The Department of Commerce, primarily through the National Bureau of Standards (NBS), is responsible for providing scientific and technological advisory services and for developing Federal Information Processing Standards (FIPS). 1/ The Office of Management and Budget (OMB) is responsible for fiscal and policy control. In addition, each Federal agency has certain responsibilities for managing its own ADP resources.

SCOPE OF REVIEW

We reviewed the legislative history of the Brooks Act, OMB circulars and guidelines, GSA regulations and procedures, and NBS publications. We analyzed selected agency procedures pertaining to the acquisition and use of a commercially available DBMS package. We also interviewed officials of OMB, GSA, NBS, and 18 selected civil and defense agencies who have acquired, or are in the process of acquiring, a DBMS. In addition, we talked with representatives of the computer industry and academia. We also researched computer industry trade journals, technical documents, and other publications for information relative to the evaluation, selection, implementation, and use of a DBMS.

1/FIPS has three major goals--(1) improved competition among the vendors providing ADP resources and services to the Government, (2) improved procurement procedures, and (3) improved interchange of data and programs within the Government. NBS pursues these goals by issuing FIBS publications, which may be either standards or guidelines. A standard requires action while a guideline advises and suggests action.

CHAPTER 2

PLANNING IS CRITICAL

IN THE DATA BASE ENVIRONMENT

A data base management system can serve as an effective management tool to better organize and access data and to improve the accuracy and timeliness of available information. A DBMS also presents new risks that can be successfully handled only with very careful attention from management. To minimize the risks of DBMS and to avoid as many of its potential pitfalls as possible, Federal agency managers must carefully plan for the data base environment. The planning process should include comprehensive studies of user requirements, feasibility, cost-benefit analysis, and detailed implementation planning to minimize the adverse impact that the data base approach can have on an organization.

STUDIES NEEDED BEFORE ACQUIRING ADP RESOURCES

OMB policies and guidelines and Federal Property Management Regulations require that well-documented general systems or feasibility studies precede decisions to acquire any ADP resources. These studies should include a comprehensive evaluation of user requirements, technical feasibility, and costs and benefits of alternative approaches. Such studies can establish whether

--a valid need exists for ADP resources,

--a proposed approach is technically feasible,

--a high degree of effectiveness will be achieved both efficiently and economically.

Need to determine user requirements

Before acquiring a new computer system, user requirements must be determined. To do this, the agency's information needs are matched with the ADP resources necessary to meet those needs. If a DBMS is determined to be appropriate, the user's needs, as defined, will point toward the most appropriate DBMS to be selected.

Many of the 18 agencies that we visited used similar criteria to justify acquiring a DBMS. Agency justifications cited the need to

--integrate data/files, reduce data redundancy, and/or support complex data relationships;

--support on-line access to a data base from remote terminals for data retrieval or processing;

--improve programmer productivity by reducing the time it takes to develop application programs or to develop programs in response to ad hoc requests for information;

--better respond to changing information requirements;

--improve the management and control of data; and/or

--reduce hard copy output.

Most of the agencies used one or more of the first three criteria to justify acquiring a DBMS. Of the agencies that did not use the criteria, two considered the flexibility offered by a DBMS sufficient justification, while another acquired a DBMS because it was available without charge from the computer manufacturer. While the six criteria listed above appear valid, only 6 of the 16 agencies we visited that had already acquired a DBMS surveyed user requirements before the acquisition. 1/ As a result, substantial amounts of money may have been spent for ADP resources that were not needed.

The experience of one agency we visited illustrates the need for users and ADP specialists to work together to define user information processing requirements before acquiring a DBMS. The agency's data processing center justified the acquisition of a DBMS based on the need for

--a user-oriented query language, 2/

--an integrated data base, and

--support of on-line data retrieval and processing. 2/

However, the DBMS acquisition justification was not based on a survey of user requirements, but rather on the data processing center director's desire to offer users the latest ADP technology.

1/Two agencies that we visited were in the process of acquiring a DBMS.

2/See glossary.

This agency acquired the DBMS in February 1973 and established a DBMS project team to develop a hypothetical application for training and testing purposes. The project team determined that it would need technical assistance to use DBMS capabilities effectively. The agency contracted with two management consulting firms at a cost of about $400,000. One was to provide assistance in implementing DBMS applications, and the other was to develop internal standards, procedures, and techniques to minimize the adverse impact of the DBMS on the data processing center and its users. In addition, the agency spent about $20,000 in tuition fees to train its programmers in DBMS concepts.

The first and largest DBMS application developed by the agency did not become operational until June 1977, more than 4 years after the DBMS was acquired. This application does not make full use of DBMS capabilities and could readily have been accomplished far more economically by using traditional file processing techniques. Because the DBMS saw only limited use at the center, in late 1975 the data processing center conducted a user survey which was intended to promote use of the DBMS. The user survey showed that use of the DBMS, which now accounts for about 5 percent of the processing workload, would not increase significantly in the future.

By January 1978, this agency had spent more than $1.2 million for the DBMS and related support services (exclusive of application program development costs) but had little to show for its investment. None of the criteria used to justify the DBMS acquisition was valid; there has been no integration of data, or on-line processing, and the user-oriented query language has not been used. In our view, expenditures of at least $1.2 million could have been avoided if a user requirement study had been performed before spending all the money on what has been essentially a nonproductive area.

Other preacquisition studies needed

An agency's ADP staff can help users and top-level managers determine whether a DBMS will improve the effectiveness of the agency's data processing operations. In addition to determining user requirements, an agency should also evaluate the technical feasibility and analyze the comparative costs and benefits of existing and proposed alternative approaches. In the absence of such studies, the acquisition of a DBMS can be a costly error for the organization. Properly completed, the studies should provide a sound basis for selecting the alternative that satisfies user needs with a high degree of effectiveness, efficiency, and economy. However, only one of the agencies we visited

had conducted both a feasibility study and a cost-benefit analysis before deciding to acquire a DBMS. Four other agencies performed feasibility studies (in varying degrees of detail), while two others had contracted for such studies.

The experience of one agency we visited illustrates the need to perform a comprehensive feasibility study before acquiring a DBMS. The agency acquired the DBMS and the computer equipment jointly and did not perform a feasibility study because it felt that its previous experience with data management software adequately demonstrated the technical feasibility. Before acquiring its present computer system, the agency had developed a software tool that provided several capabilities commonly associated with a DBMS and which was tailored to the agency's applications.

After contract award, but before the computer equipment was installed in August 1973, agency officials determined that potential problems could arise concerning the DBMS software capabilities. The agency's concerns were realized when system testing began in September 1973. The first problem encountered was the excessive time it took to load the first of two data bases. The initial data base loading 1/ test took more than 3 days of computer processing time for one data base and 12 days for the other. Later (still during system testing) one data base took 5 days to load and the other more than 3 weeks. Data base updating also became a problem during the test phase; the first update test required 44 hours of computer time to process 93,000 transactions against 800,000 data base records. In a later test, it took 7-1/2 hours to process 15,000 transactions. Since, at that rate, the weekly average of 100,000 transactions would take about 50 hours of computer time to process, the agency considered this unacceptable.

The agency implemented the data base processing system a year later than scheduled. The problems that were encountered during system testing remained, and new ones surfaced. It took 6 weeks to accomplish the intial update of one of the data bases, whereas the agency had initially planned to update daily. Other problems included

--excessive inquiry response time,

--excessive computer processing time to delete data base records,

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1/See glossary.

--severe limitation on the number of concurrent users of the data base for on-line inquiries, and

--inadequate data base security.

The magnitude of the problems has since been reduced by enhancements to the DBMS software, by procedural changes, and through use of additional hardware. However, the agency still experiences lengthy computer processing times for data base updating and for record deletion. We estimate that the agency has incurred costs of at least $2.6 million for DBMS-related activities. Much of these costs and many of the problems could have been avoided had the agency performed a comprehensive study of the technical feasibility of using a DBMS for its applications before acquiring its computer system.

Cost-benefit study

Only 1 of the 18 agencies we visited had performed a cost-benefit analysis before deciding to acquire a DBMS and that agency did not consider all costs associated with implementing and operating a data base processing system. Reasons given by the agencies for not performing a cost-benefit analysis before acquiring a DBMS included the following:

--The relatively low cost of a DBMS precluded the need for a formal analysis.

--Informal analysis showed that a DBMS could result in more effective operations.

--The data base approach was the only way to go.

--The DBMS was provided at no charge by the computer manufacturer.

--Quantifying the benefits of a data base environment was difficult.

The acquisition cost of a DBMS appears to be relatively insignificant when compared to the long-term commitment that an agency must make to application software, computer hardware, communications, procedures, training, and support should it decide to acquire a DBMS and implement the data base approach. For this reason, we believe that an analysis considering all the costs and possible benefits of alternative approaches is an absolutely indispensable prerequisite to acquiring a DBMS. Without such an analysis being made which promises net benefits, agency management is asked to approve a long-range, high-cost project on the basis of incomplete

information or spurious justification and therefore cannot be assured that the most appropriate economical and effective ADP resources will be obtained.

NEED TO DEVELOP DATA BASE IMPLEMENTATION PLAN

The implementation of a DBMS can be complex, time consuming, and costly, and it can affect every information handling aspect of an organization. A DBMS allows the sharing of data by many diverse users; however, successful implementation requires careful planning to minimize any adverse impact that the data base approach can have on an organization. A DBMS can have an impact on the user, the ADP organization, other computer resources, the internal audit function, and the organization as a whole. The implementation planning should include the careful evaluation of commercial DBMS packages to ensure that the most appropriate one is selected.

DBMS evaluation and selection

Some agencies have failed to recognize the importance of following a systematic evaluation process for DBMS selection. Successful selection is dependent on matching the characteristics of an agency's data and its users with the capabilities provided by the DBMS. The comprehensiveness of the DBMS evaluation and selection studies varied greatly among the agencies we visited. Most agencies established evaluation criteria (although not always based on a study of user requirements) and reviewed computer industry literature on the capabilities and features provided by the various DBMS packages to determine which would satisfy all or most of the criteria. Two agencies tested one or more DBMS packages to determine their suitability for the agency's applications before acquiring the DBMS and committing the agency to a data base environment. Eight agencies considered the capability of the DBMS to operate on the computer equipment of more than one manufacturer a factor in the selection decision.

One agency's experience illustrates the need to carefully evaluate the functional capabilities of each DBMS that is considered before one is acquired to ensure that the selected DBMS will meet user needs. The agency found that the DBMS it acquired, at a cost of about $120,000, could not provide the functional capabilities needed for its planned use. It then contracted with the DBMS vendor to enhance the DBMS software to provide the needed capabilities. Contractor costs for the enhancements amounted to about $263,000 and

took 28 months to complete. In our view, had the agency thoroughly evaluated the functional capabilities of the DBMS before it was acquired, it could have identified that particular DBMS's shortcomings in advance and avoided the need for costly enhancements.

Data base plan can minimize any adverse impacts

Developing and implementing a data base processing system can be a very lengthy operation. Because of the complexity and the agencywide implications of the data base approach, detailed planning and tight project control are needed to minimize potential problems. With the availability of data for multiple users, there is a great need for close coordination, for agencywide standard procedures, and for a careful approach to application programming changes.

Of the 16 agencies we visited that had acquired a DBMS, only 5 had implemented or were in the process of implementing a true data base processing system; that is, one where the data is integrated across functional lines and shared by multiple users. The other agencies continued to operate using traditional file-oriented processing techniques and used the DBMS primarily as an improved file access method. 1/ At many of the agencies, the DBMS accounted for only a small portion of the total data processing workload. The five agencies which have adopted the data base approach did develop data base implementation plans; however, not all the plans were as comprehensive as they should be.

One agency we visited had adopted the data base approach because of the interdependence of mission and functions of its component organizations. All of the agency's three major functions shared many of the same data elements, but each was collecting, defining, and maintaining the data separately for its own use. The agency found inconsistencies among the data maintained in separate files and experienced time-consuming and wasteful reformatting when data had to be exchanged. In July 1975 the agency developed a data base implementation plan which covered the acquisition of the DBMS and the data base design. Each of its component organizations prepared plans to develop application programs. The data base processing system became operational in December 1977 with a slippage of only 2 months.

1/See glossary.

Data base administration

After the data base project was underway, it became apparent that the agency needed to establish a data base administrator (DBA) function. The function was established in June 1977 to provide effective management of the development, creation, and use of automated data. The DBA establishes and enforces policy and procedures concerning automated data and its users. 1/ Agency officials felt that had the function been established at the outset of the project, implementation would have been much smoother. Such matters as who could create, update, and have access to the data had to be resolved, since several groups within the agency were involved. Also, which organizational component would be responsible for a particular data element and how the data base would be designed had to be resolved since the data was shared among several user groups.

Most agencies we visited had established a DBA function with a staff size ranging from one to seven. Because most agencies did not establish a true data base environment but continued the traditional file-oriented approach, the DBA was usually a computer system technician concerned with the operational efficiency of the DBMS applications; the DBA did not have the authority, responsibility, or need to resolve user conflicts.

DBMS affects other areas

In addition to the establishment of the DBA function, an agency should anticipate--through the planning process--the impact that a DBMS can have on the ADP and user organizations, and on other ADP resources. The implementation plan must provide for ADP staff training and user education.

ADP and user personnel must be adequately trained to use DBMS capabilities effectively. DBMS vendors provide training in data base design and use; some charge for training and others include a number of training seminars in the price of the DBMS package. DBMS training in the form of 3- to 5-day seminars is offered by several management consulting firms and universities. Some agencies have hired consultants to provide DBMS training for their staffs. User training was generally limited to a relatively short session on data base concepts and procedures for using the system while ADP

1/For additional discussion of the DBA function see NBS Special Publication 500-28, "Data Base Administration: Concepts, Tools, Experiences, and Problems," March 1978.

specialists generally received much more extensive training. The following two cases illustrate the need for DBMS training. One agency we visited provided inadequate training to its ADP staff and later experienced extensive delays in recovering the data base after the failure of a disk storage device because the ADP staff was not trained in data base recovery 1/ procedures. Another agency found that it had to educate users as to what type of inquiries could be made on-line after the users had experienced excessive delays receiving responses to inquiries. These delays could have been avoided by adequate advance training of users.

A DBMS can adversely affect the operation of other ADP resources such as direct access storage devices, 1/ the computer's main memory, 1/ and in some cases additional processing power may be required. Many systems using traditional file processing techniques have been built around data files that use inexpensive magnetic tape to store data. One agency we visited had implemented a data base processing system and as a result had to change from magnetic tape to magnetic disk storage. Annual lease cost for the tape was $600 while annual lease cost for the disks amounts to $96,000. Another agency had to double its main memory capacity to accommodate the data base processing system. Annual lease cost for the additional main memory amounts to $43,200. Two other agencies experienced the need for additional computer processing power.

One agency had to shift part of its data base processing system workload onto a computer intended to be used for other purposes because the computers that were intended to handle the DBMS work did not have sufficient processing capacity. The shift was made to improve turnaround time and this work now accounts for more than half the processing on the other computer which cost about $2.3 million when purchased.

The second agency would not allow the on-line use of its DBMS because it would consume too much of the computer's resources. The agency estimated that support of the on-line DBMS capabilities would require additional main memory, additional disk storage devices, and two tape drives to log transactions for recovery purposes. Because of the existing data processing workload, additional computer equipment costing more than $2 million would have had to be acquired.

1/See glossary.

Internal auditor involvement needed

The potential advantages of computer processing have encouraged Federal agencies to automate many program activities. The resulting Government-wide, multibillion dollar computer investment and its impact on agency functions necessitate effective control over computer applications. While Federal agency management is responsible for controlling its organization's resources, responsibility for assuring agency management that proper controls both exist and function, rests, in part, with the internal auditor.

One approach to help assure agency management that proper controls exist and function is for the internal audit staff to participate in the design phase of the DBMS applications as a normal audit function. Because of the complexity of data base processing systems, adequate controls must be designed into a system before it becomes operational. At one agency, the participation of the internal auditor in the design phase helped assure (1) adequate control over transactions entering the system, (2) design and maintenance of audit trails in the system, and (3) appropriate data validation procedures. However, most agencies we visited had given little consideration to the special challenges associated with auditing a data base processing system. We believe that success or failure in responding to those challenges can have significant implications for agency programs.

The reliability of the information generated and the resultant management decisions based on such information depend on effective ADP systems. To provide an adequate evaluation of a particular function, the internal auditor must ascertain the system's reliability. Internal auditors should review computer application systems to assess whether

- --accurate and timely data is entered into the computer and data is kept updated;
- --adequate controls exist over the input and processing of data;
- --the user receives timely, accurate, and useful output; and
- --adequate documentation of all aspects of the application exists.

To assess whether adequate controls exist over the input and processing of data, the internal auditor must be able to

--understand the flow of data throughout the application system(s),

--follow specific events and intermediate steps in the processing, and

--independently access and manipulate stored data.

Traditional files, which allow an auditor to do each of these tasks, do not exist in a data base environment. Instead, a DBMS merges data that was once maintained in separate files into an integrated data base. Because an integrated data base links previously separate records for use by multiple applications, the auditor can no longer focus attention solely on a single application in developing an understanding of the flow and use of data throughout the system. Finally, the complexity and diversity of DBMS data structures have complicated the development of generalized audit software packages and made many existing packages nearly useless in the data base environment. 1/

1/Generalized audit software packages provide the auditor with independent access to data and permit selection and manipulation of data based on a variety of criteria specified by the auditor.

CHAPTER 3

CENTRAL AGENCY GUIDANCE NEEDED

Data base management system technology is a relatively recent development. While agencies are very interested in taking advantage of the potential capabilities of this technology to improve their operations, their efforts in this complicated field have been hampered by a lack of Federal policy and guidance. Each agency has had to shift for itself in an uncharted area, and many avoidable and costly problems have arisen. In our view, if Federal agencies are to acquire and use DBMS technology effectively, the central agencies--OMB, GSA, and NBS--must develop clear procurement policy, promulgate procedures, and provide technical guidance.

PROCUREMENT POLICY IS NEEDED

Increasing use of DBMS technology and the potentially high costs involved in its use emphasize the need for GSA to establish appropriate procurement policies and issue procurement regulations. Current policies and regulations are general and do not adequately cover DBMS-related issues. We believe that the present lack of clear and concise procurement policy and procedures must be overcome if future problems are to be avoided. Such procedures should address (1) acquiring DBMS software when both the computer hardware and the DBMS software are involved and (2) treating DBMS application software conversion costs in the computer system acquisition process. Although adequate procurement procedures currently exist for acquiring a DBMS when an agency already has a computer, we found that they have not always been followed.

Acquiring DBMS for use with existing ADP systems

An agency can acquire a DBMS in one of three ways. The agency can issue a request for proposal to industry, it can use GSA's ADP Schedule Contracts--the most common method--or it can obtain the system directly from the computer manufacturer. 1/ The ADP Schedule enables Federal agencies to

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1/For some brands of computer equipment, if a DBMS is needed, the agency has little choice but to acquire the DBMS offered by the computer manufacturer. For example, one agency that we visited was limited to the computer hardware manufacturer's DBMS package because it was the only DBMS that was compatible with the agency's computer system.

acquire ADP goods and services at prearranged terms, conditions, and prices. The major DBMS packages are available from the ADP Schedule. An agency cannot use the ADP Schedule unless it has determined that the Schedule provides the lowest overall cost.

While acquiring a DBMS for an existing computer system is relatively simple, putting it to good use can be difficult. The DBMS should not be acquired unless user requirements, feasibility, cost-benefits, and implementation planning have been comprehensively studied to prepare for the many effects the data base approach can have on the organization. In addition to the impact on current operations, a DBMS can significantly affect the transition to future computer systems.

DBMS can constrain future computer system acquisitions

Converting application software 1/ for replacement computer systems is a recurring, frequent, and costly activity in the Federal Government. A DBMS can significantly affect the costs and time needed to convert an agency's application programs. Federal procurement policy and procedures should be established regarding the uniform treatment of DBMS software conversion costs in the computer system acquisition process.

Contributing to the difficulty of application software conversion is the proliferation of (1) methods to describe the data model, 2/ (2) methods of DBMS interface, (3) internal data representation, and (4) computer equipment architecture. In addition, computer manufacturers and software vendors have developed unique features to make their products more attractive. However, these features inevitably lock the agency into a particular way of doing things. Application programs developed for a specific DBMS and a particular data model can be used for that DBMS alone and can result in a "lock-in" to a particular manufacturer of computer hardware for an extended period.

We were not able to obtain adequate cost information associated with converting application software from one DBMS to another, because DBMS technology is relatively new and Federal agencies are just beginning to use it. We did

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1/See glossary.

2/See glossary and app. I.

find two cases where the application programs that interfaced with a DBMS had to be converted and another case where an agency is planning to replace its computer equipment and now uses a DBMS for most of its processing.

The first case involved converting a personnel application from one DBMS to another with no change in computer equipment. The conversion was undertaken because the agency decided to have a "standard" DBMS for all applications. The conversion took about 6 months to accomplish by one programmer, who was thoroughly familiar with the application and experienced in using DBMS technology.

The second case involved an agency which converted from the computer equipment of one manufacturer to the equipment of another while simultaneously changing the DBMS. The conversion was undertaken as part of the agency's effort to standardize and modernize computer equipment in its data processing centers. The agency has contracted with a software vendor to convert its application programs. The conversion involves both DBMS and non-DBMS applications and will take an estimated 20 months to complete. We estimate that costs directly related to converting the data base applications will amount to more than $6.4 million. Other costs, such as facility alterations, project management, and computer operator training that would benefit both DBMS and non-DBMS applications will amount to more than $1.3 million. We calculate that the cost of converting one line of program code for the DBMS applications is about $6.50. By comparison, at another of this agency's data processing centers which provided only file-oriented batch processing 1/ support to its users, we calculate that the cost of converting one line of program code is about $1.60; that is, about one-fourth the cost to convert the DBMS application. (The cost per line of program code includes only the cost to convert the software.) This case clearly demonstrates the magnitude of the data base conversion problem.

In the last case, the agency has implemented the data base approach using a commercial DBMS software package and standard COBOL 2/ for its application programs. A significant factor in the DBMS selection process, which took place

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1/See glossary.

2/Common Business Oriented Language (COBOL) is the only application programming language for which a Federal standard now exists.

in 1975, was the requirement that the selected DBMS be able to operate on the equipment, including minicomputers, 1/ of several computer manufacturers. This was a factor because the agency planned to replace its hardware in a few years and wanted to assure competition when the procurement took place.

Beginning in 1980, this agency plans to evolve, over a 4- to 5- year period, a data processing system using minicomputer technology. The agency's plan calls for several minicomputers, each assigned to a particular user application and all sharing the integrated data base which the agency has already designed and is using for its current operations. However, the agency may not, as planned, be able to acquire a minicomputer that supports its existing DBMS.

According to GSA officials, the agency will not be allowed to specify that the hardware must support its existing DBMS and cannot consider future DBMS conversion costs when evaluating competing vendor proposals. Agency officials believe that a request for proposal that specifies compatibility with an existing DBMS as a mandatory requirement would still be a competitive procurement because several computer systems on the market can support it. According to a GSA official, however, such a mandatory requirement could be considered highly restrictive and therefore would be questioned by GSA. If this happens, agency officials feel that conversion costs and associated problems may prevent the planned procurement.

Currently, there is no written procurement policy or regulation dealing with the treatment of DBMS software conversion costs in the evaluation of vendor proposals during the computer system acquisition process. Federal Property Management Regulation 101-35.2 (formerly Federal Management Circular 74-5), which establishes policies for the management, acquisition, and utilization of ADP equipment, recognizes conversion as a cost factor but, in our view, provides only general guidance which is unclear and subject to misinterpretation.

Much of the existing policy on the treatment of software conversion costs is based on recommendations arising from 1976 hearings of the House Committee on Government

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1/See glossary.

Operations 1/ and from correspondence between the Committee and GSA. The Committee's position is that software conversion costs should not be considered when evaluating computer equipment bids until the agency has converted to standardized higher level programming languages 2/. A different position has been taken by the House Committee on Appropriations, which directed the Defense Department and the Veterans Administration to consider conversion costs when evaluating costs of new computer systems.

In September 1977, GSA and the Defense Department formed a joint work group to revise the Federal procurement regulations to include policy regarding the uniform treatment of software conversion costs when evaluating vendor proposals during the computer system acquisition process. The objective of the proposed revision, dated February 23, 1978, is to balance the public goal of full competition with the equally important goal of lowest overall cost to the Government. The proposed revision addresses the DBMS software conversion problem. It allows an agency to include DBMS software conversion costs if the DBMS is available on the computer equipment of multiple manufacturers (excluding plug-to-plug compatible computer equipment 3/), and at least three vendors may reasonably be expected to offer the same DBMS or a functionally equivalent DBMS. However, GSA has yet to issue the revision to the Federal Procurement Regulations.

The subject of conversion costs generally has been under active consideration for some time, and will eventually be resolved, but this specific area--treatment of DBMS software conversion costs in the computer system acquisition process--needs early direction. DBMS software conversion problems will continue until DBMS standards are developed and enforced. Until that time, interim Federal procurement policy and procedures must be established for the treatment of DBMS application software conversion costs in the computer system acquisition process. (Progress toward DBMS standards is discussed on page 26.)

1/House Committee on Government Operations, "Administration of Public Law 89-306, Procurement of ADP Resources by the Federal Government," House Report 94-1746, Oct. 1, 1976.

2/See glossary.

3/Several computer equipment manufacturers offer computers which are compatible with the equipment of International Business Machines Corporation.

Acquiring DBMS with the computer equipment

One of the keys to the successful development of an agency's computer system applications is acquiring both the appropriate computer equipment and the software necessary to make that equipment operate effectively. Jointly acquiring DBMS software and computer equipment that fulfills an agency's information processing requirements can be a difficult undertaking. Clear and concise procurement policy and procedures that recognize the importance of DBMS software when the acquisition involves both computer hardware and DBMS software must be developed.

Present procedures focus on the competitive procurement of computer hardware. This is even though recent computer industry studies and the experiences of various Government agencies indicate that the cost of developing application software generally exceeds the hardware cost. One such study shows that equipment costs represent less than 25 percent of the total costs incurred to design, develop, and operate a new computer system. When a Federal agency has a valid need for a DBMS, the successful development of its application software is dependent upon acquiring a DBMS that fulfills its information processing requirements. Because of the emphasis GSA has placed on computer hardware in the competitive procurement process, an agency may, under existing policies, end up with a computer system that is less well suited to meet its information processing requirements than other available alternatives.

Office of Personnel Management

The Office of Personnel Management (OPM) 1/ has acquired a computer system that does not adequately fulfill its information processing requirements because the DBMS software needed to operate on its computer equipment is not commercially available. According to OPM officials, the Office was not authorized to include the need for availablity of a DBMS that supports an inverted file structure in its request for proposal for computer equipment. GSA contended that the requirement would unduly restrict competition. (See App. I for a description of characteristics of a DBMS that supports an inverted file structure.)

OPM has major responsibilities for assuring that the Federal Government has qualified people to do its work, for serving the public by providing accurate information

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1/Formerly the Civil Service Commission.

on Federal job opportunities, and for assuring that applicants are matched with jobs on the basis of merit, fitness and equality of opportunity. OPM decided that with regard to its information processing requirements to meet these responsibilities, the data base approach was the best alternative. Their system design concept provides for the integration of seven major applications of the OPM recruiting and examining operations into a single system. Analysis of OPM's information processing requirements showed that a DBMS which supports an inverted file structure was needed to efficiently match the requirements of available jobs with the qualifications of the applicants.

Prior to issuing a request for proposal, OPM asked GSA to determine whether, under procurement regulations, the Office could specify, as a mandatory feature of the computer system to be acquired, a DBMS that supported an inverted file structure. 1/ At that time, February - March 1975, DBMS software packages that supported an inverted file structure were commercially available on the equipment of three manufacturers. One of these manufacturers could not satisfy another OPM requirement (in support of the data entry function). This narrowed the field to only two manufacturers that could provide equipment that satisfied all of OPM's requirements. GSA's position was to make the computer hardware acquisition as competitive as possible and would not allow OPM to specify in the request for proposal the need for a DBMS that supported an inverted file structure. Instead, it was classified a desirable feature.

Only two equipment manufacturers responded to the request for proposal; one proposed its list prices from the ADP Schedule Contracts while the other manufacturer proposed some discount and substantial rental credits toward the purchase price. The contract was awarded in June 1975 based on acceptance of the proposal with the lowest hardware cost. However, a DBMS that supports the inverted file structure was not available for the computer hardware acquired.

OPM then had several alternatives to obtain the needed DBMS software:

--Develop the DBMS using in-house resources.

--Have a software vendor develop a DBMS especially for OPM.

1/OPM officials could not locate any written records of the discussions held with GSA.

--Have an existing DBMS recoded to operate on the acquired equipment.

--Use a "backend" minicomputer to perform the data base management functions. 1/

In August 1975, OPM solicited industry comments on the best approach to satisfy its DBMS software needs. Four software vendors and one equipment manufacturer replied to the solicitation. Discussions were held with the vendors during late 1975 and early 1976. Two were considered not responsive, one software vendor proposed the recoding of an existing commercial DBMS to operate on OPM's computer equipment, and two others proposed the backend approach.

OPM decided to pursue the backend approach, as it appeared to be the most cost effective and quickest to implement. OPM was to find out that the vendors were too optimistic during their discussions. OPM issued a request for proposal for a backend DBMS in April 1977, but no vendors responded. Reasons given for the lack of response included the following:

--The manufacturer of the acquired computer would not cooperate in providing information needed for the interface between the host computer and the backend minicomputer.

--The implementation timeframes could not be met.

--Not all desired DBMS capabilities could be provided.

During the summer of 1977, OPM discussed with another vendor whether the company was still interested in recoding its DBMS to operate on the acquired equipment. The firm was interested, but it had meanwhile entered into a licensing agreement with another firm, whereby that firm has exclusive rights to recode the DBMS to operate on other computer equipment.

1/The "backend" minicomputer is electronically connected to the host computer and performs data base management functions for the host. The backend approach is a relatively new technology that has not been widely implemented and is currently undergoing prototype testing in the Defense Department. Defense officials believe the backend approach is a promising alternative and may be commercially available in the near future.

After discussions with the licensee, OPM issued a sole source request for proposal in November 1977; a contract agreement was completed on June 15, 1978. The contract provides for the licensee to recode the DBMS to operate on OPM's computer hardware within 12-1/2 months at a cost of $100,000. The contract amount reflects only about 25 percent of the licensee's estimated cost to perform the conversion. Once the conversion is completed, the licensee will have the rights to market the DBMS to other users (both Government and private) of this manufacturer's hardware.

Given that the conversion is successfully completed on schedule, OPM will have had the computer equipment installed for more than 3-1/2 years without the DBMS software needed to develop its applications. Because of the lack of that software, six of OPM's seven major applications have not been implemented. The application programs that were in operation on OPM's previous computer equipment were converted to operate on the new hardware without being redesigned and with little enhancement. OPM officials were not able to place a dollar value on the time they were unable to implement the proposed data base system but believe that it is substantial.

The problems that the Office of Personnel Management has encountered in acquiring a computer system that meets its information processing requirements clearly illustrate the need to develop Federal procurement policy and procedures that recognize the importance of considering DBMS software in the computer system acquisition process. GSA officials state that their policy calls for the maximum practical competition, but what constitutes the maximum pratical competition is not well defined. GSA needs to establish procurement policy and procedures that properly consider both the public goal of full competition and an agency's need to satisfy its information processing requirements.

DBMS GUIDELINES AND STANDARDS ARE NEEDED

Federal agencies use computer systems to process a wide variety of applications that affect all levels of Federal, State, and local government, as well as commercial organizations and individual citizens. As Federal use of data base systems grows in importance and pervasiveness, there is a need to ensure that DBMS technology is properly applied and that a Federal agency does not invest in data base applications which would lock it in to any one vendor. DBMS guidelines and standards must be developed to reduce future costs of application software and to facilitate competition among vendors.

Technical guidance needed

The problems that we encountered during our visits to various Federal agencies illustrate the need for Government-wide guidelines which provide technical assistance to managers considering the use of DBMS technology. Such guidelines could help managers avoid such problems in the future by providing information on sound management practices drawn from industry experience and tailored to the special needs of Federal agencies.

Discussions with various Federal agency officials indicated that guidelines that address when to use a DBMS, and what the DBMS evaluation and selection process should be in light of the Federal competitive procurement environment, are sorely needed. Some agency officials felt that a considerable amount of their time and resources could have been saved if DBMS guidelines had been available. Literature on how to evaluate and select DBMS software is available from computer industry trade journals and data processing management textbooks, but none address the process within the framework of Federal competitive procurements.

For example, one small agency we visited would benefit greatly if DBMS evaluation and selection guidelines were available now. Analysis has shown that the data base approach would be the best method to satisfy the agency's information processing requirements; however, the agency found it necessary to hire a management consulting firm to make that analysis. The agency currently plans to include the DBMS software requirements in the request for proposal along with the computer equipment requirements and will again contract with a consulting firm--one that specializes in Federal ADP procurement--to prepare the request because the agency does not have the expertise in-house, and technical guidelines are not yet available.

In its 5-year program plan (1979-1983), the National Bureau of Standards recognized the need for DBMS guidelines. The need for the guidelines was recognized earlier in a 1975 workshop sponsored jointly by NBS and the Association for Computing Machinery. The results of the workshop are contained in NBS Special Publication 451, "Data Base Directions: The Next Steps." The publication states, in part, that

> "* * * management does need DBMS guidelines, that management has needed them for some time, that it is impossible to overemphasize the importance of DBM to the management process * * *."

The Federal Information Processing Standard (FIPS) Task Group 24 on Data Base Management Systems 1/ was initiated to study the need for DBMS standards. In its report of November 16, 1978, the task group recommended to NBS that FIPS guidelines be developed in several management categories including the DBMS analysis, evaluation, and selection process.

In addition to Special Publication 451, NBS has published several informative documents that cover various aspects of data base management technology. Despite all this recognition of the problem, little positive action has been taken. These documents do not provide Federal managers with the technical guidance needed to assist them in making decisions concerning DBMS technology. FIPS guidelines that address all aspects of DBMS technology management should be developed by NBS. Moreover, we believe that guidelines should be formulated as soon as possible that address the criteria for when an agency should use a DBMS and for the DBMS evaluation and selection process in the competitive procurement environment.

DBMS standards needed

Federal agencies have made and plan to continue making significant investments in applications supported by DBMS software. The number of commercial DBMS packages offered by software vendors and computer manufacturers continues to increase. Because of the absence of standards, each DBMS is unique. DBMS standards are needed to protect a Federal agency from investing in data base applications which would lock it in to any one vendor.

The Congress and Federal agencies have long recognized the important role of standards. In general, the goals of standards are to:

--Ensure the ability to maximize competition among the largest pool of vendors, thus obtaining the lowest overall price and avoiding being locked in to any one vendor.

--Facilitate the comparison and selection of offered products.

1/To assist NBS in its consideration of FIPS standards, FIPS task groups are established to address specific subject areas. These task groups are advisory bodies made up of volunteer participants from Federal agencies interested in the subject.

--Conduct efficient and informed procurement actions by establishing explicitly what is to be purchased, thereby reducing negotiation before and after the purchase.

--Ensure the maximum interchangeability of data, programs, and personnel skills.

With specific regard to DBMS software, standards are needed to reduce application software conversion costs.

We recently reported on the progress of the Federal standards program. 1/ In conjunction with that report, we developed a questionnaire that dealt with the impact of the Federal standards program on Federal agency ADP operations, staffing, and funding and sent it to 251 data processing management officials. One question addressed the general need for FIPS standards; 70 percent of the respondents to that question indicated an urgent or moderate need for DBMS standards. Discussions with various Federal agency officials during our study indicated that DBMS standards were generally needed and that a single standard DBMS would be too restrictive to satisfy the information processing requirements of all users. Some agency officials felt that it would be beneficial to standardize on an agencywide basis by selecting a DBMS that operates on the computer equipment of several manufacturers. Some agency officials were against DBMS standards because they would inhibit technological advances and because industry is not far enough along with DBMS technology to develop the standards. However, we believe that DBMS standards work should not be delayed or inhibited by arguments of restrictiveness.

The standardization process can be quite involved, taking a number of years. Perhaps the best DBMS candidate and the only one proposed for standardization is the set of DBMS specifications developed by the CODASYL 2/ Data Base Task Group. Two of the agencies we visited considered

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1/"The Federal Information Processing Standards Program: Many Potential Benefits, Little Progress, and Many Problems," FGMSD-78-23, Apr. 19, 1978.

2/The Conference on Data Systems Languages (CODASYL), established in 1959, is a voluntary group which includes a broad spectrum of both users and manufacturers. Its recommendations are not binding and it receives no funds from any source. Instead it has relied upon people and organizations to volunteer time and resources. CODASYL developed the COBOL programming language and guided that language's evolutionary development.

the conformance to the CODASYL specifications as a factor in the DBMS evaluation and selection process. Several commercial DBMS packages were designed to conform to the CODASYL specifications; however, there is not a high degree of compatibility among them. The discrepancies result from vendors interpreting the complex specifications differently and from implementing different versions of the CODASYL specifications.

Since 1971 the CODASYL Data Base Task Group and its successors have made numerous improvements to the technical specifications both clarifying and extending the capabilities. The 1978 CODASYL DBMS specifications are now being considered as a candidate for standardization by the American National Standards Institute. Some industry experts believe that existing implementations of the CODASYL DBMS specifications can be modified to accommodate the recent improvements. While the current implementations of CODASYL DBMS specifications are well suited to transaction-oriented data processing environments, they do not, in our opinion, adequately address the information processing needs of all users. For this reason, we believe a family of DBMS standards must be developed which recognize diverse user needs.

NBS recognizes the need for DBMS standards in its 5-year program plan (1979-1983). Present plans are to begin developing DBMS software and languages in 1980 and continue through 1983. The need for DBMS standards was also recognized in the 1975 workshop on data base directions previously discussed (p. 25). The working panel on standards concluded that DBMS standardization would be highly profitable and standards efforts should not be delayed or inhibited by arguments of restrictiveness. In its November 1978 report, FIPS Task Group 24 recommended to NBS that specifications for a family of DBMS standards be developed, and it should adopt the CODASYL DBMS specifications as a FIPS standard. The family of DBMS standards as proposed by Task Group 24 includes the network, hierarchical, and relational data models 1/ with each data model being able to support three higher level programming languages 2/: COBOL, FORTRAN, and PL/1. For example, the existing CODASYL DBMS specifications would satisfy only the network data model and support only the COBOL programming language.

1/See glossary and app. I for discussion of the data models.

2/See glossary.

We believe that a family of FIPS standards for DBMS should be developed by NBS to reduce application software conversion costs and to facilitate competition among vendors. We endorse the Task Group 24 recommendation that NBS adopt the most recent CODASYL DBMS specifications as a FIPS standard because the specifications are freely available, have general user acceptance, and have been subjected to a fairly broad review.

CHAPTER 4

CONCLUSIONS, RECOMMENDATIONS, AND AGENCY COMMENTS

CONCLUSIONS

Properly planned and controlled, a data base management system can provide Federal agencies with an effective and efficient management tool to better organize and access data and to improve the accuracy and timeliness of information available for decisionmaking. If not properly planned and controlled, a DBMS can be a complicated and costly addition to an agency's data processing budget, providing management with more problems and costs than solutions or benefits. Most agencies we visited did not adequately plan before acquiring a DBMS and as a result may have spent substantial amounts for ADP resources that were not really needed. The agency planning process should include comprehensive user requirement, feasibility, and cost-benefit studies as well as detailed implementation planning to minimize any adverse impact that the data base approach can have on an organization.

To ensure that DBMS technology is properly applied, FIPS guidelines need to be formulated as soon as possible to help Federal agencies determine when to use a DBMS and how to evaluate and select a DBMS on a competitive basis. Such guidelines can help managers avoid potential problems by providing information on sound management practices drawn from industry experience and tailored to the special needs of Federal agencies.

Increasing use of DBMS technology by Federal agencies makes it critical that GSA establish procurement policy and procedures pertinent to DBMS software. Current policies and regulations are too general and do not adequately cover DBMS-related issues. Present procedures focus on the competitive procurement of computer hardware, even though recent computer industry studies and the experiences of various Government agencies indicate that the cost of developing application software generally exceeds the hardware cost. When a Federal agency has a valid need for a DBMS, the successful development of its application software is dependent upon acquiring a DBMS that fulfills its information processing requirements. Because of the emphasis that GSA has placed on acquiring the computer hardware, an agency may, under existing policies, end up with a computer system that is less well suited to its information processing requirements than are other available alternatives.

Clear and concise procurement policy and procedures must be established that address DBMS acquisition when the computer equipment and the DBMS software are jointly acquired. This policy should balance the public goal of full competition with an agency's need to satisfy its information processing requirements. In addition, clear and concise procurement policy and procedures must be established that address the treatment of DBMS application software conversion costs. A joint GSA Defense Department work group has addressed this problem in a draft revision to the Federal procurement regulations. However, application software conversion problems will continue until DBMS standards are developed and enforced. Standards are needed to protect a Federal agency from investing in data base applications which would lock the agency in to any one vendor.

RECOMMENDATIONS

To improve the acquisition of DBMS software, we recommend that the Administrator of General Services establish clear and concise procurement policy and procedures that

- --recognize the importance of DBMS software when an agency needs both the computer equipment and a DBMS and

- --deal with DBMS application software conversion costs in evaluating competing vendor proposals in the computer system acquisition process.

In addition, to ensure that DBMS technology is properly applied and that Federal agency investment in data base applications is protected from being locked in to any one vendor, we recommend that the Secretary of Commerce

- --develop technical guidelines in collaboration with GSA to help Federal agencies (1) determine when to use a DBMS and (2) evaluate and select a DBMS on a competitive procurement basis and

- --develop a family of DBMS standards that recognizes diverse user needs.

AGENCY COMMENTS

We asked GSA, the Commerce Department, the Defense Department, and OPM to comment on our draft report. Their replies, which indicated general agreement, are included as appendix III to this report and are discussed below.

The Acting Deputy Administrator of GSA concurred with our recommendations and agreed to work with NBS as required to carry them out. He stated that our draft report accurately reflects the problems that agencies may encounter when acquiring and using DBMS technology and believes that the report deserves wide distribution.

The Assistant Secretary of Commerce for Science and Technology, generally agreed with the analysis and conclusions of our draft report and concurred as well in the importance of including appropriate conversion costs in a cost-benefit analysis to assess the true impact of the acquisition of a DBMS. He stated, however, that the inclusion of conversion costs should not be used to support a sole-source procurement decision when a competitive process is justified. He also stated that under the increased funding for the ADP standards program beginning in fiscal 1979, NBS has begun developing the DBMS software standards. While those standards are being developed, as recommeded in our report, NBS will give high priority to providing planning guidelines to agencies to assist them in their decisionmaking.

The Assistant Secretary of Defense (Comptroller) said that the draft report represents an indepth analysis of a large number of case studies involving data base management systems and a valuable synthesis of lessons learned for ADP system managers. He also said that a definite need exists for planning and evaluation guidelines as well as for standards in the DBMS area. These guidelines and standards should be structured in such a way that the planning and procurement of DBMS support as a well-integrated component of an overall automated information system is promoted.

The Director of the Office of Personnel Management agreed with our conclusions and supports our recommendations. He believes that GSA should establish procurement policy and procedures which take into account the importance of DBMS software during the computer system acquisition process. He noted that OPM had tried unsuccessfully to locate written records of reported conversations between the OPM and GSA staffs about including a requirement for an inverted file structure DBMS in the request for proposal. We have footnoted our report to show that no written records are available.

ADVANTAGES, DISADVANTAGES, AND GENERAL CHARACTERISTICS OF DATA BASE MANAGEMENT SYSTEMS

A Federal agency which has decided that the data base approach is the best method for satisfying its data processing requirements can choose from a wide variety of data base management system software packages. Each package has a unique set of features and methods for describing the data base and manipulating the data. Because each package provides a general, yet different, set of data management functions, a particular DBMS cannot operate equally effectively in all data processing environments.

DBMS advantages

A DBMS offers several potential advantages to offset its cost. Based on user interviews and industry studies, we found that most DBMS packages provide the user with the following advantages:

--Ability to better respond to changing information needs.

--Effective support of on-line 1/ access to a data base from remote terminals for data retrieval or processing.

--Ability to develop programs in response to ad hoc requests for information.

--Reduction in redundant data.

A DBMS can respond to changing information needs more readily than traditional file processing techniques because the data is isolated from the application programs that use it. Thus, changes to the data base can be made with minimal impact on existing programs. This capability is called data independence, and the degree to which the data is independent of the application program varies among the commercial DBMS packages. The higher the degree of data independence provided by the DBMS, the greater the ability to respond to change. However, no commercially available DBMS can now provide complete data independence.

The DBMS advantage most often cited by officials we interviewed was the effective support of on-line access to

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1/See glossary.

a data base from remote terminals for data retrieval or processing. However, the DBMS does not provide the telecommunication functions directly to the user but provides convenient interconnections to other software packages that handle that function. Thus, the DBMS makes application program development in an on-line environment easier.

A DBMS provides an organization with a better environment for developing programs in response to new requests for information. However, the ability of the DBMS to respond to new requests for information depends on how well the data base is designed.

A by-product of an integrated data base and another frequently cited advantage is the reduction of redundant data, which

--eliminates inconsistencies that can occur when multiple files containing duplicate data are used, thus improving the integrity of the data;

--reduces costs associated with maintaining and referencing data stored in separate files;

--eliminates duplication of costly data collection and puts responsibility for accuracy at the point of entry;

--facilitates management and control of data resources; and

--conserves costly data storage space.

In some cases, not all redundant data should be eliminated. Some agencies have found it necessary to maintain some redundancy and establish interfile links to avoid excessively long processing times. There is a tradeoff between the elimination of redundant data and the efficient use of a computer system.

DBMS disadvantages

There are several valid reasons for not using a DBMS, depending upon an organization's information processing needs and financial resources. Users have identified several disadvantages of using DBMS technology and instances when DBMS use is not appropriate. For example, installation of a DBMS can be a costly addition to the data processing budget because it:

--affects other computer resources, such as the computer's main memory and direct access storage devices;

--requires an organization to either hire data processing personnel skilled in its use or provide costly training to its own personnel; and

--costs between $34,000 and $120,000 depending on which DBMS and what options are purchased. 1/

Users have identified circumstances when traditional file processing techniques may be more appropriate than a DBMS in satisfying an organization's data processing needs. These circumstances include when

--an organization does not have a need for or does not want to share data among multiple user groups,

--a relatively large portion of the records in a file are accessed each time the file is processed, and

--an organization does not need an on-line data processing environment.

The data base

An organization's data base is composed of well-defined groupings called files--for example, a master inventory file or a customer backorder file. Each file is composed of logically related records--for example, an inventory record for an item carried in stock. In turn, each record is composed of logically related data elements (also called data fields or data items). A data element cannot be further subdivided and still have meaning (e.g., stock number, item name, or reorder point).

The data in the data base is in two parts--a logical data structure and a physical storage structure. A DBMS provides the bridge between these two structures. The logical data structure describes the way that the data is viewed by the user and is often called the data model because it "models" an organization's data in terms of its logical relationships. The physical storage structure determines

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1/At least two computer equipment manufacturers provide their DBMS at no charge.

how the data is actually accessed and maintained on computer storage devices such as magnetic disk or drum. Different physical storage structures can be used to implement the same data model.

Data models

The two most prominent data models are the hierarchical and network models. The major commercially available DBMS packages primarily support one or the other. Another data model, called the relational model, is under development. The relational model has few implementations, but some industry advocates believe that it will be the primary model used in the future.

The hierarchical data model supports a logical data relationship commonly referred to as a 'tree structure' and allows the development of a hierarchy. The following diagram illustrates the hierarchical data model.

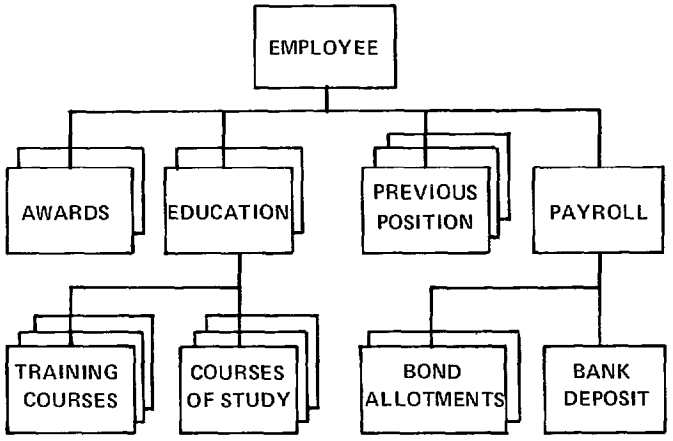

FIGURE 1. HIERARCHICAL DATA MODEL

Each record (a record may consist of only a single data element) may be related to any number of data records at any level below it, but only one record above it in the hierarchy. The data records are called nodes and the node at the top is called the root. Every node except the root has a "parent," which is the node immediately above it. Thus, in the above diagram, EMPLOYEE is the root node and parent node of AWARDS, EDUCATION, PREVIOUS POSITION, and PAYROLL. The hierarchical data model differs from other data models in that each record has only one parent and therefore has only one logical access path.

The network data model supports a logical data relationship--also referred to as a "plex structure"--and can represent complex data structures more readily than the hierarchical data model. The following diagram illustrates the network data model.

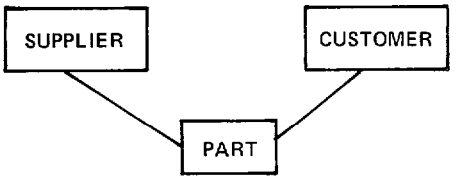

FIGURE 2. NETWORK MODEL

In a network model any given record can be logically related to any other. The network mode differs from the hierarchical model in that every node can have more than one parent, thus allowing multiple access paths through the data base. In the above diagram PART has two parent nodes. More than one CUSTOMER can order the same PART and the same PART can be obtained from more than one SUPPLIER.

Physical storage structures

The data in the data base is organized into a physical storage structure which determines the method of placement of and access to the data on the computer storage device. The types of storage structure include: sequential, random, index sequential, chain, and inverted. Some DBMS packages can support more than one physical storage structure. User information processing requirements are the most important and overriding consideration when choosing which storage structure to use. By knowing user requirements, the potential mismatch of requirements and improper storage structure can be eliminated.

In the sequential structure, records are stored according to some specified sequence. To order the records in a sequence, one common attribute--called a "key"--is chosen. The key is a data element or set of data elements which have unique values for each record within the data base. For example, records in an employees file could be stored in numerical order by social security number. In this instance, the employee's social security number would be the key. Sequential access implies data storage where access to the next record is by association to a previous record in sequence. The next logical record is also the next physical record. The sequential structure is simple to understand and can provide for fast retrieval for the next record in the file. However, it is not possible to add records, and generally not possible to delete or modify records, without rewriting the file.

The index sequential storage structure is simply a sequential storage structure with an index. Records can be accessed either by using indexes or in a sequential fashion. Each index contains the address of a record in the data base. If a record is to be retrieved by its index, the indexes are searched until the desired key is found, and the pointer 1/ from that index to the record is used as a direct address to retrieve the desired record. Record retrieval by index is much faster than in a sequential storage structure because the index is much smaller and therefore can be searched more quickly. However, additions, deletions, and modification (called maintenance) of records is more time consuming for the whole file than in the sequential structure because both the sequential order and the index must be maintained.

In the random storage structure, records are stored and retrieved based on a predictable relationship between the key of a record and the record's physical location on the storage device (called the address). The address is usually determined by an arithmetic operation on the value of the record's key. For example, records in an employee file could be randomly accessed based on the conversion of the last four digits of an employee's social security number to an address on the storage device. Random access means that access to a given record in the data base is not related to the access of other data base records. The random storage structure can provide very fast retrieval on a single key value; it is good if every key value yielded a unique physical location because then only one physical access is required for the desired record. However, different record key values could generate the same address on the computer storage device, which results in a "collision." The techniques for resolving the collision increase both retrieval and maintenance processing times. Random accessing does not readily allow for complex query processing. This storage structure is best suited for applications requiring fast retrieval on a single key value and is often used in conjunction with other storage structures.

A chain storage structure is one in which the records are linked together by pointers which are physically a part of the record. Several techniques can be used to link records in a data base, but the principle of having the pointer physically part of the record does not change. The basic concept of the chain structure is that pointers are used to separate the

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1/See glossary.

logical structure from the physical structure. To link records together, one of the records must be accessed by a key which is relevant to all of the linked records, and then use the pointers to access all subsequent records in the chain. The records in a chain are logically related.

To illustrate, it may be desirable to link the records contained in a personnel file of all employees who work in the organization's finance and accounting department. By accessing the personnel file in the data base by department, it would be possible to retrieve the personnel record of the first employee in the department which would contain a pointer to other employees in the same department. Since any data element in a record may be treated as a key, it is possible to have many chains passing through a single record. For example, in addition to linking all employees within a particular department, it may also be desirable to link employees who have special job skills, such as a foreign language proficiency. Record retrieval is normally slower in this structure because the search is sequential through the chain. However, file maintenance can be efficient because record additions and deletions are made simply by changing the pointers. A disadvantage of the chain storage structure is that it requires additional storage space to store the pointers. This structure is often used in conjunction with other storage structures.

The inverted storage structure can make every data element in a record available as a key. With this approach, a key value is stored in a directory which contains the addresses of all like-valued records. The directory is physically separated from the data and can be as large or larger than the data itself. (This approach is in contrast to the chain storage structure in which the pointer to the next logical record is physically a part of the record.) If every data element in a data base record is used as a key, then the data base is considered to be fully inverted.

A request for information is first processed against the directory to obtain the addresses of the data base records that satisfy the request. Once that has been accomplished, the data is retrieved from the data base to satisfy the inquiry. By maintaining the data addresses in a directory, information requests can be satisfied without having to search through the entire data base. The inverted structure allows for quick retrieval of complex inquiries. All data elements can be accessed with equal ease; therefore, it is better

APPENDIX I

suited for situations where the data retrieval requirements are less predictable than it would be for specific processing functions.

Although the inverted structure provides for easy retrieval, storing and updating can be difficult because of the maintenance of the directory. The directory must be updated whenever a record is added or deleted. Because the fully inverted structure more than doubles the storage requirement and increases maintenance time, it is often used in conjunction with other storage structures. Records can be partially inverted on only a few keys rather than on all the keys. Directories thus become smaller and easier to manage.

DBMS user environment

In addition to how the DBMS supports the logical and physical data structures, another way to classify DBMS packages is by the language used to initiate data management functions. There are two types of DBMS software--the host language system and the self-contained system. Host language DBMS packages provide extensions to programming languages that aid the application programmer. Such DBMS capabilities are accessible only to programs written in a higher level programming language, such as COBOL. The host language of the DBMS, in effect, enhances the capabilities of the programming language, thus making it easier for the application programmer to access and manipulate the data. Self-contained DBMS packages typically provide all essential capabilities for data creation, update, retrieval, and report formatting. The class of user who directly interacts with the data base can be the determining factor as to which type of DBMS to acquire. Those who interact with the data base can be grouped into two major categories--end users and data processing support personnel. The end users include those who work with specific predetermined transactions which are repetitive, such as a stock control clerk, and those who use the data base in response to unanticipated requests for information.

The self-contained DBMS packages are better suited for users who work in a data processing environment where requests for information are generally ad hoc in nature. These packages minimize the need for application programmers by providing easy-to-use programming capabilities. The user does not need to write a program in a conventional programming language to access the DBMS capabilities. A host language DBMS is usually more flexible in its processing capabilities than a self-contained system and is better suited to support transaction-oriented users. Some host language DBMS packages also provide easy-to-use data retrieval capabilities.

How the DBMS interacts with the application program

An organization develops its application programs for a specific DBMS software package. The DBMS translates the data requirements of the application program and performs the data management functions for the program. These functions include record storage, update, deletion, retrieval, and storage space management. When an application program needs to read a data base record, the following sequence of events typically occurs:

(1) The application program issues a request to the DBMS to obtain a logical record. The program states the name of the record key and gives the value of the key for the record in question.

(2) The DBMS obtains the data description that is used by the application program and looks up the description of the data in question.

(3) The DBMS obtains and examines the logical data description and determines which physical records are needed.

(4) The DBMS instructs the operating system 1/ to retrieve the requisite record(s) from the physical storage device.

(5) The DBMS provides the application program with the data and indicates any errors that may have occurred.

(6) The application program then processes the data.

If the application program were to update a data base record, a step would be added to instruct the DBMS to write back the modified data.

1/See glossary.

APPENDIX II

BENEFITS OF THE DATA BASE APPROACH COMPARED TO TRADITIONAL FILE PROCESSING TECHNIQUES 1/

The Benefits Associated with Data Base Organization

Benefit	Data Base Organization	Traditional Organization
Reduce general data redundancy across application files.	The DBMS creates and maintains interfile access paths automatically so that the same data may be used by multiple applications.	Each application typically has its own master file, which contains data duplicated in files of related systems.
Reduce the programming effort required for file updating.	A program updates data in a single shared data base. The new data is immediately available for all applications.	Each physical file containing the data to be updated must be processed separately. This is usually done at different times, causing discrepancies in various reports.
Reduce the program modification brought about by changes in data definition.	Data description is segregated from application programs. Only those programs actually referencing the changed data type need be modified.	Changes in record definition, or expansion of record sizes must be reflected in every program accessing the data.
Increase the accessibility of data, by providing multiple access paths and retrieval sequences.	DBMS provide automatic generation and maintenance of secondary indexes and logical relationships, which allows tailoring of access to meet the requirements of application systems.	Most traditional file systems support a single access path, so that additional retrieval requirements must be satisfied by search and sort procedures.
Encourage the use of standardized data naming conventions.	For many retrieval operations, the applications programmer must use names known to the DBMS. Central data definitions are often maintained in a data dictionery system	Application programmers often supply their own data names.
Provide Data Security	Control blocks are generated that specify which data elements an individual application program can access. Control information and undesignated data is not available to the program.	Security systems must be coded as an independent task. Such systems are difficult to write, especially in COBOL.
Provide recoverability.	Recoverability is an automatic feature of DBMS. Once processing errors are detected, the system can restore the data base files to the last intact file copy. All transactions against the data base are logged on tape, from which is possible quick file restoration.	No automatic facility is provided; therefore, each application system must program its own recoverability. Standardized recovery procedures are difficult to define and implement.
Reduces operator intervention and associated production errors.	Data base files reside on disk	Tape handling is a major activity in production runs.
Promote data communications services.	Most DBMS have integrated, or interfaced communications monitor programs.	Application systems and data communications are sometimes difficult to integrate within acceptable standards of performance.

1/ Reprinted from Government Data Systems, Dec. 1975/Jan. 1976

General
Services
Administration Washington, DC 20405

MAY 16 1979

Honorable Elmer B. Staats
Comptroller General of the United States
General Accounting Office
Washington, DC 20548

Dear Mr. Staats:

We have reviewed the draft report, "Data Base Management Systems (DBMS) - Without Careful Planning There Can Be Problems," transmitted by Mr. Gutmann's letter dated March 19, 1979.

We consider that this document accurately reflects the problems that agencies may encounter when acquiring and using data base management technology. In particular, Appendix I provides a very effective summary of the general characteristics of such systems, and the advantages and disadvantages of utilizing a DBMS approach in the design of automatic data processing systems. For these reasons, we believe that the report deserves wide distribution.

We agree with the recommendations of this report and will work with NBS as required to carry them out.

Sincerely,

Clarence A. Lee Jr.

CLARENCE A. LEE, JR.

Acting Deputy Administrator

APPENDIX III

APR 20 1979

UNITED STATES DEPARTMENT OF COMMERCE
The Assistant Secretary for Science and Technology
Washington, D.C. 20230
(202) 377-3111

Mr. Henry Eschwege
Director, Community and Economic
Development Division
U.S. General Accounting Office
Washington, D.C. 20548

Dear Mr. Eschwege:

These are comments of the National Bureau of Standards Institute for Computer Sciences and Technology on the draft report, "Data Base Management Systems -- Without Careful Planning There Can Be Problems."

We generally agree with the analysis and conclusions of the report concerning Data Base Management Systems (DBMS) and the need for a thorough study of an agency's requirements prior to procuring one. We concur as well in the importance of including appropriate conversion costs in a cost-benefit analysis to assess the true impact of the acquisition of a DBMS. However, the inclusion of these costs should not be used to support a sole-source procurement decision when a competitive process is justified.

The report takes note of selected reports published by NBS to assist agencies in this problem area. It is evident also that more must be done. Under increased funding for the ADP standards program beginning in FY 1979, the Institute for Computer Sciences and Technology has begun the development of the DBMS guidelines and standards to which the report makes reference. These standards will be developed so that Federal users will be able to select standard software facilities from an array of functional levels to match application needs. Compatibility among standard systems and application conversion aids will be emphasized, in order to accelerate transition to standard systems and to enhance competitive procurement. While software standards are being developed, NBS will be giving high priority to providing planning guidelines to assist agency decisions to prepare for the use of the standards and to undertake cost and benefit analyses as recommended in the GAO report.

Sincerely,

for Jordan J. Baruch

APPENDIX III

COMPTROLLER

ASSISTANT SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

9 MAY 1979

Mr. D. L. Scantlebury
Director, Financial and General
Management Studies Division
United States General Accounting
Office
Washington, D.C. 20548

Dear Mr. Scantlebury:

This is in reply to your letter to the Secretary of Defense regarding your draft report dated March 15, 1979, on "Data Base Management Systems--Without Careful Planning There Can Be Problems," (OSD Case #5119) (Code 91326).

This review and evaluation of the subject report have been completed. The document represents an in-depth analysis of a large number of case studies involving Data Base Management Systems (DBMS) and a valuable synthesis of lessons learned for ADP system managers.

Program managers involved in enhancing ADP support by upgrade or replacement are faced with difficult trade-off analyses with respect to conversion costs and emulation. General Accounting Office involvement in software conversion cost over the total system life cycle is welcomed and encouraged. This report provides guidelines and cautions that will be of considerable assistance to the manager directing such activities.

The main value of the report for the operational manager will accrue from the discussion of the following:

a. the decision criteria for determining DBMS requirements,

b. the long range planning that must precede implementation, and

c. the nature of the management commitment necessary for successful operation.

APPENDIX III

There is a definite need for planning and evaluation guidelines. The recommendations on this topic should prove helpful. Standards in the DBMS area need the support of the entire ADP community. Hopefully, they will emanate from the activities of the National Standards program as have the major higher order programming languages.

The development of National and Federal level standards and the availability of appropriate planning and evaluation guidelines should have an immediate positive effect on the acquisition and implementation of properly designed DBMS capabilities. These guidelines and standards should be structured in a way which promotes the planning and procurement of DBMS support as a well integrated component of an overall automated information system.

Sincerely,

Fred P. Wacker

Fred P. Wacker
Assistant Secretary of Defense

APPENDIX III

United States of America
Office of Personnel Management
Washington, D.C. 20415

In Reply Refer To

MAY 15 1979

Mr. Donald L. Scantlebury
Director, Financial and General
Management Studies Division
United States General Accounting Office
441 G Street, N.W., Room 6001
Washington, D.C. 20548

Dear Mr. Scantlebury:

We appreciate the opportunity to review and comment on your draft report to the Congress entitled "Data Base Management Systems -- Without Careful Planning There Can Be Problems." We think it is an excellent report.

We concur with your conclusions and support your recommendations. GSA should establish procurement policy and procedures which do take into account the importance of Data Base Management System (DBMS) software during the computer system acquisition process. Technical guidelines to use during the evaluation and selection process of DBMS software would be most welcome. Management guidelines that address when to use a DBMS, or not use a DBMS, would be of great value to both management and the technical staff.

A family of DBMS standards is much needed. As your report states, this must be a family of standards which recognizes diverse user needs. We wholeheartedly support this family approach. A single standard would do more harm than help.

We do have one comment related to the description of the DBMS acquisition problems encountered by OPM. We have attempted to locate in our files, written records of the reported conversations (PP31-33) between our staff and the GSA staff about the inclusion of a requirement for an inverted-file-structure data base management system in our RFP, and have been unable to find any. The balance of your description of our problem appears to be accurate.

APPENDIX III

Again, thank you for the opportunity to review and comment on the draft report. Additionally, we compliment your staff on an exceptionally well written document, easy to read, and professionally done. Appendix I is an excellent tutorial on DBMS characteristics.

Sincerely yours,

Alan K. Campbell

(913260)

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