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# BY THE COMPTROLLER GENERAL

## Report To The Chairman, Committee On Science And Technology United States House Of Representatives

# OF THE UNITED STATES

RELEASED



# The National Science Foundation's Management Information System: A Status Report

The review of the current status of the National Science Foundation's management information system and its plans for making needed improvements focuses on identifying changes planned or in process, quality controls, user satisfaction, and cost.

Reliability problems, including inaccurate and incomplete data and slow response time at computer terminals, seriously impair the system's effectiveness and frustrate its users. Recommendations for management and technical improvements made by a Foundation consultant 3 years ago have not been carried out. A September 1979 study of system performance also pointed out the need for many system improvements.

The Foundation can increase system reliability by improving quality control, system response time, long-range planning, performance evaluation, and administrative management. The Foundation also should determine users' needs, and establish specific, quantified goals and target dates for correcting deficiencies.

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

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The Honorable Don Fuqua
Chairman, Committee on Science
and Technology
House of Representatives

Dear Mr. Chairman:

In accordance with your Committee's request and subsequent discussions with our representatives, we reviewed the current status of the National Science Foundation's management information system (MIS) and the Foundation's plans for making needed improvements. The review focused on identifying major changes planned or in process, quality controls, user satisfaction, and cost. As agreed, we did not conduct a major audit of MIS data quality because we found early indications of system and management problems that would likely result in unreliable data. Nor did we include in our audit scope a determination of how well actual MIS operations conformed to stated procedures. Such audit work would have been unproductive, in our view, because system documentation and procedures were not always available or current.

We reviewed a 1977 management consultant's study of MIS to determine how the system functioned then, and what improvements had been recommended. We then determined how the Foundation had acted on these recommendations. We used a General Accounting Office standardized format to assess reliability, determined user satisfaction from user questionnaires based on several MIS routine reports, interviewed a sampling of Foundation personnel who manage the system or use it regularly, and made test checks of data from several subsystems by comparing automated data with original documents. We also gathered system cost data from Foundation personnel. Finally, we reviewed a report on a system performance study conducted during 1979 by the Federal Computer Performance Evaluation and Simulation Center. At the request of your office, we delayed issuance of this report until we could evaluate the Center's study which was published after most of our work was done.

We obtained Foundation officials' views on our findings and recommendations, and their comments are considered in the report. Our findings are summarized below and discussed in more detail in the appendix.

## SYSTEM DESCRIPTION AND MANAGEMENT

The goal of MIS is to automate all the Foundation's administrative and program functions. MIS is made up of 5 major systems which are divided into 20 subsystems with specific Foundation functions. All the subsystems use data from a common data base (integrated data base) so that data must be entered only once into the system. A Honeywell computer system provides access to the data from 284 terminals throughout the Foundation's headquarters and annexes. Users of the system's data include Foundation management, the Congress, the Office of Management and Budget, and grantee institutions.

A staff of 128 Foundation and contractor personnel administer the system, which is managed by the Directorate for Administration through the Division of Information Systems (DIS). The Foundation began developing MIS in 1971 and has spent over $15 million on it through fiscal year 1979, excluding personnel costs.

## MANAGEMENT CONSULTANT'S EVALUATION

A management consultant assessed the system in 1976 and found that user objectives had not been met and that significant improvements in the system were needed. The consultant recommended changes and provided an action plan for future work. Since the consultant's study, systems and management changes made to improve the system include establishment of a steering committee, user representatives, directorate task groups, and a management controls branch; development of a financial accounting system implementation plan; and redesign and enhancements to several subsystems. The Foundation has not studied the impact of these changes, but system managers and users find these changes useful. However, some of the consultant's recommendations for changes in important areas such as data quality assessment, long-range planning, and system performance evaluation have not been implemented.

## THE SYSTEM AND ITS MANAGEMENT STILL NEED IMPROVEMENT

While MIS is not yet fully implemented, it is being used to supply data important to managing the Foundation. However, users still cite system reliability problems, particularly inaccurate and incomplete data, and slow response time at the computer terminals. To solve these and other problems, improvements are needed in five areas--quality control, system response time, long-range planning, performance evaluation, and administrative management. Each of these areas is discussed briefly below.

The Foundation does not have procedures to monitor data quality or identify system problems which cause poor data quality. The consultant recommended in his January 1977 report that the Foundation immediately conduct a data quality study to identify system weaknesses and develop data quality control procedures. However, the Foundation deferred the study because of higher priority work and because system managers believed the data was accurate despite the absence of formal quality control procedures.

Our reliability assessment revealed some system weaknesses that reduce reliability. The weaknesses include inadequate error correction procedures to insure the timely and accurate correction of data errors that are found in the data base, system design problems which make identifying and correcting data errors difficult, and inadequate system documentation which make identifying and correcting system design problems difficult.

System users complain that response time at MIS computer terminals is frequently slow. Reported delays of several minutes when numerous terminals are concurrently active indicate a probable system overload. Foundation officials are aware that this problem has existed for at least 2 years.

In February 1979, the Federal Computer Performance Evaluation and Simulation Center (FEDSIM) began assessing the design and performance of the Foundation's computer system including system response time. The study showed that occurrences of slow system response time were not primarily traceable to system hardware, but rather to the management of available computer resources. FEDSIM stated that improving operating procedures, workload scheduling, and software design could minimize the impact of heavy prime time user demand for computer resources and improve system response time. Also, the Foundation needs better system accountability data to improve its use of available computer resources. Meanwhile, the Foundation added 46 more terminals to the system in fiscal year 1979.

The Foundation's MIS management program lacks both a long-range plan and a planning process. The consultant cited the absence of effective long-range planning as adversely affecting system management and recommended that the Foundation pursue immediately a long-range plan and a planning process. The Foundation still has no firm plan for developing a long-range system plan, and consequently has no firm target date or projected cost for completing the system.

The system is now managed on a short-range basis, essentially reacting to daily problems. While numerous work projects for system improvements have been identified, there were often no detailed documented plans for the improvements nor funds to put them into effect.

The Foundation has no procedures for systematically assessing user needs and evaluating system performance and cost in meeting those needs. Since the MIS initial requirements study in 1971, the Division of Information Systems has assumed the task of determining the current needs of program users. In so doing, system managers have used feedback from program personnel through user representatives and task groups. The consultant's recommendations for performance evaluation and cost accounting programs have not been implemented.

We found that other aspects of overall system management need improving, such as system security, documentation, and training for users and managers. Also, the Foundation's internal audit staff, which should monitor the MIS operation, lacks the technical capability to evaluate the system effectively.

## CONCLUSIONS

Significant improvements in MIS and its management are needed if the system is to fulfill its intended purpose and achieve a degree of reliability satisfactory to its users. Although 3 years have passed since the consultant's evaluation study, the Foundation has not yet implemented major recommendations that the consultant said were needed immediately. As a result, serious technical and management problems threaten the successful operation of the system. System managers cite lack of resources as the main reason for not implementing important recommendations. However, we believe that the absence of long-range planning and a knowledge of system effectiveness has caused the Foundation to give low priority to areas such as data quality and system reliability which should have had the highest priority.

The Foundation is adding additional equipment to the system, which is already experiencing response time delays, without knowing what adverse impacts this equipment will have on the system's overall performance. Considering the absence of good system accountability data and FEDSIM's conclusion that system hardware is not a constraint to improved system performance, we believe the Foundation should carefully assess any further plans for adding terminals and associated equipment to the system. Better management of existing computer resources, as recommended by the consultant and FEDSIM, would seem to be a more desirable alternative at this time.

The value of MIS to the Foundation, and user acceptance of it, depends on high system reliability. Our reliability assessment shows the system to be of medium reliability, which means that users of system data should verify the accuracy of the data before using it for important decisions. In our view, system users within the Foundation, the Congress, the Office of Management and Budget and others will not, nor should they, be satisfied with data from a medium-reliability system.

While MIS is not yet fully implemented, it is already being depended upon to provide many essential services and data to Foundation management. Yet the system will be unable to provide highly reliable data until the technical and management problems that we identified in this report are addressed and remedied. In addressing these problems, we believe the Foundation should re-examine the purpose of MIS, clearly define its users and their needs, and establish specific, quantified goals and target dates for correcting deficiencies and completing the system.

AGENCY COMMENTS AND OUR EVALUATION

We proposed that the Foundation take several actions to improve MIS including actions to resolve the slow system response time problem, provide data quality control, and assess user needs. In a letter dated June 15, 1979, the Foundation advised that although it had concerns about our reliance on the use of questionnaires and interviews to assess user satisfaction with MIS, it generally agreed with most of our proposed recommendations. However, the Foundation did not agree that it had a slow system response time problem of the magnitude we described in the draft report. The Foundation referred to FEDSIM's study of MIS's user response time which, the Foundation said, showed response time to be in an acceptable range.

The Foundation suggested that our user satisfaction findings regarding two widely used reports produced by MIS could not be attributed solely to the quality of MIS's integrated data base, but rather may have been the result of differences in user perception of the reports. We believe our questionnaires and interviews identified a legitimate system problem--errors in the data base--which appears to adversely affect the accuracy of a widely used report produced from the data base. We selected two widely used reports produced by MIS, each of which is used by a different Foundation management group. Program managers use the Workload Status Report, whereas division directors use the Proposal Aging Report. We asked only program managers about the Workload Status Report, while only division directors were asked about the Proposal Aging Report. Our questionnaire showed that users of the Proposal Aging Report (division directors) were having problems with the report because of errors, and the Foundation confirmed this by noting that of the two reports we tested, more errors occur in the Proposal Aging Report.

The Foundation suggested in its letter that although errors are present in the Workload Status Report, the errors are not as easily recognized as in the Proposal Aging Report because of the larger volume of information present in the workload report. We believe errors in the data base are still errors, not just perceptions, no matter how unrecognizable they might be in some reports. The Foundation also suggested that the use of the Proposal Aging Report by management as an oversight tool over program managers may have caused the managers to resent the aging report, and judge the report more harshly in our user survey. However, we did not obtain program managers' views on their satisfaction with the Proposal Aging Report--program managers were not asked to judge this report. We asked only division directors --who are the primary users of the aging report--how satisfied they were with it.

The Foundation stated in its letter that the FEDSIM tests show system response time to be in an acceptable range and that the tests, as well as the agency's recent experience, do not support the implication in the GAO report that only 20 terminals can be concurrently active on the system. The Foundation's letter was dated June 15, 1979, prior to FEDSIM's final report. The final report, dated September, 1979, acknowledges the occurrence of slow system response times and does not characterize current system performance as being either acceptable or unacceptable. FEDSIM's report shows that hardware performance was generally good during the controlled testing and was not a constraint to improved system performance, but that better management of available computer resources would improve system performance.

We conclude from the FEDSIM report that there are times when system response time is poor. The study indicates that under controlled testing it is possible to have more than 20 terminals concurrently active. However, the day to day operations of the Foundation are a real world environment where the computer system must respond to uncontrolled demands which we believe can yield situations where only 20 terminals could be concurrently active, or slow system response times could occur.

Regardless of the cause, users will react negatively to slow response time at the terminals even if they are apprised of possible causes. The Foundation's task, as we see it, is to eliminate or minimize what Foundation personnel perceive as a system response time problem regardless of the exact number of terminals involved. We believe FEDSIM's recommendations should be helpful in doing so.

Although the Foundation states in its letter that it has taken steps to address user needs by establishing an advisory group, we believe the Foundation should insure that the group's actions will be adequate to provide for user needs assessment. As we have recommended, a performance evaluation program is also needed in addressing user needs.

## RECOMMENDATIONS

We recommend that the Director of the National Science Foundation improve MIS by taking actions in the following areas:

--System Response Time--Resolve expeditiously the slow system response time problem which is frustrating system users, and reassess the need for acquiring additional hardware.

--Data Quality Control--Assess MIS's data quality and establish procedures for periodically testing and maintaining data quality to insure high reliability.

--Long-Range Planning--Develop and maintain a long-range system and hardware planning process to insure orderly and systematic development of MIS. The planning process should include top management participation; provide a reasonable 5-year projection of system requirements and costs, which would include life-cycle cost analysis; establish quantified goals and priorities for work projects; and set milestone completion dates.

--Performance Evaluation--Develop and implement performance evaluation procedures to determine and control the efficiency of the system in meeting its goals. Such procedures should assess user needs and insure system cost effectiveness.

--Overall System Management--Assess MIS short- and mid-range management efforts to insure that areas such as general system security, system documentation, and training receive adequate attention. Also, the Director should strengthen the internal audit staff capability to monitor MIS's performance.

As agreed with your representatives, our office will limit initial distribution of this report to House Science and Technology Committee and National Science Foundation recipients. Subsequent distribution will be made to interested parties 1 week from the date of the report.

Sincerely yours,

Elmer B. Staats

Comptroller General
of the United States

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## ABBREVIATIONS

| | |
|---|---|
| MIS | Management Information System |
| FEDSIM | Federal Computer Performance Evaluation and Simulation Center |
| NSF | National Science Foundation |
| DIS | Division of Information Systems |
| ADP | Automatic Data Processing |
| PI/PD | Principal Investigator/Project Director |
| GAO | General Accounting Office |
| FY | Fiscal Year |

# THE NATIONAL SCIENCE FOUNDATION'S MANAGEMENT INFORMATION SYSTEM: A STATUS REPORT

## INTRODUCTION

On July 20, 1978, the Chairman of the House Committee on Science and Technology requested that we review the National Science Foundation's management information system (MIS). The Chairman was concerned with the system's data quality and reports from Foundation staff that the system had not been entirely satisfactory. He stated that an assessment of the current status of MIS and the Foundation's plans for making needed improvements would be useful to the Committee in carrying out its oversight of the Foundation. The Chairman asked that the assessment consider:

--identifying major changes planned and in process;

--identifying and testing quality controls for assuring data accuracy;

--determining the Foundation's efforts to identify the needs of the system's users and its plans to meet those needs; and

--identifying the cost of MIS and of any planned major purchases of hardware or software.

Pursuant to the Chairman's request and later agreements with our representatives, we:

--reviewed a 1977 consultant's study of MIS to understand how the system functioned then, what problems were identified and recommendations made; and what actions the Foundation had taken on these recommendaations;

--interviewed a cross section of Foundation personnel who manage the system and use it regularly to determine how the system functions today and how it is managed;

--performed a system reliability assessment using our "Audit Guide for Reliability Assessment of Controls In Computerized Systems";

--made limited test checks of data accuracy in three key subsystems by comparing automated data with original documents;

--determined user satisfaction from questionnaires based on several MIS routine reports;

--gathered system cost data; and

--reviewed a report on a system performance study conducted during 1979 by the Federal Computer Performance Evaluation and Simulation Center (FEDSIM).

In assessing the status of MIS we limited our audit work to assessing the system through interviews, questionnaires, and spot testing of data. As agreed with the House Committee, we did not attempt the time-consuming effort to conduct a major audit of MIS data quality because we found early indications of system and management problems that would likely result in unreliable data. Nor did we include in our audit scope a determination of how well actual MIS operations conformed to stated procedures. Such audit work would have been unproductive, in our view, because system documentation and procedures were not always available or current.

System development

The Foundation, under the authority of the National Science Foundation Act of 1950, as amended (42 U.S.C. 1861 et seq.) supports scientific research in various disciplines (such as chemistry, physics, biology, and engineering) primarily by awarding grants to colleges and universities. The Foundation processes about 28,000 research proposals annually. Of these, approximately 24,000 are acted on and eventually about $900 million is paid out in grants.

To help process proposals and to provide current data for program management, the Foundation decided in 1970 to automate all administrative and program functions by using an MIS. The project began in 1971 with a major requirements study to identify all the functions the system would perform. This study was followed by a system design phase and the installation of the system. By 1975, all major subsystems had been installed although some were running parallel with older manual systems and some subsystems, such as the financial accounting subsystem, had serious operational problems. In 1977, an office automation project extended the system to include automated word processing.

While the Foundation had automated parts of its program before 1971, the parts had not been organized into a comprehensive information system. The new system design, on the other hand, used the concept of a single integrated data base --that is, data would be entered only once into the system for use in all subsystems, thus eliminating the need for duplicating data in numerous nonintegrated files. This data would be accessible directly from video terminals.

The Foundation chose to put all of the functional parts of the system into operation at the same time rather than implementing them in a series of time-phased steps. The latter approach would have provided better control of system development and quality. Since then, the system has experienced numerous technical and management problems as well as resistance from agency personnel.

In 1976, a management consultant firm, D. P. Management Corporation of Lexington, Massachusetts, was hired to assess the MIS project. The consultant compared MIS's performance with the Foundation's goals and concluded in January 1977 that the:

--MIS goals were ambitious but achievable over time;

--MIS had not yet met user objectives, although progress had been made;

--efforts to maintain the system's current program and to achieve its growth objectives concurrently had caused an imbalance;

--ADP administrative organization needed significant strengthening; and

--many management programs and procedures needed for the successful operation and administration of the MIS system did not exist.

The consultant recommended controlled, incremental development of MIS and provided an action plan with priorities for system development. Some of these recommendations have been fully or partially implemented; others have been deferred for lack of resources.

System description

MIS uses a Honeywell computer system which provides an integrated data base (JASON) accessible from 284 terminals throughout the Foundation's headquarters and annexes. MIS is made up of 5 major systems divided into 20 subsystems with specific Foundation functions (see attachment I).

The major MIS systems are the:

--Proposal/Award Administration System which supports the receipt, control and approval or rejection of grant and contract proposals, and the administration of active awards;

--Peer Review Administration System, which contains the names of 80,000 potential reviewers used by the Foundation to decide on grant proposals;

--Grantee/Contractor Information System, which maintains business and historical information about institutions and researchers having Foundation grants;

--Administrative Management System, which supports the Foundation's management and administration; and

--Local Management System, which gives services such as individualized data searches, specialized report formats, query of data bases outside the Foundation, and development of individual computer programs.

Users of the system include Foundation management, the Congress, the Office of Management and Budget, and grantee institutions. The primary user is the Foundation itself, where upper level managers use administrative and financial data for overall Foundation management. Increasingly, MIS is being used by other Foundation personnel, such as program managers and administrative staff, for monitoring grant funding levels and expenditures, tracking proposals through processing, and expediting letter writing.

System management

MIS is managed under the Directorate for Administration through the Division of Information Systems (DIS) which is comprised of five branches:

--Application Systems Branch--responsible for all MIS subsystems, software development and maintenance, requirements analysis, design specifications, and software.

--Computer Facility Management Branch--responsible for the computer facility including the terminals, operating system software, executive control, and management of the integrated data base.

--Customer Service Branch--responsible for office automation, directorate user representatives, user training, and technical writing.

--Systems Support Services Branch--responsible for input services, processing support, fund controls, and the documentation library.

--Management Controls Branch--responsible for data quality, system standards, security, system project management, and certification of new software.

The system is operated by a staff of 128, of which 80 are Foundation management and administrative personnel and 48 are contractor personnel who operate the computer hardware and develop system software.

Our audit found that MIS users continue to cite technical and management problems affecting system reliability including inaccurate and incomplete data, slow response time at the computer terminals, and lack of attention to the user's needs. To solve these and other problems, improvements are needed in five areas: quality control, system response time, long-range planning, performance evaluation, and system management. These areas are discussed in the following text.

## DATA QUALITY CONTROL PROCEDURES AND IMPROVED SYSTEM RELIABILITY NEEDED

The Foundation does not have procedures to monitor data quality and identify system problems that cause poor data quality. Furthermore, our assessment of system reliabilty identified other areas which need strengthening.

### Data quality is not monitored

The Foundation has no systematic process for monitoring data quality or statistically measuring the reliabilty of the system. Several one-time efforts have been made to correct selected portions of the data base where known errors existed. However, no formal and regular effort has been made to identify the causes and solutions of the problems to prevent recurrences. In addition, the system lacks documented error-correction procedures to insure timely and appropriate corrections to errors that are found.

The Foundation's consultant did not study data quality because he found problems in the system that could contribute to poor data quality. However, he recommended 3 years ago that the Foundation undertake such a study within 6 months. Nevertheless, the Foundation has not performed the recommended data quality study and has given it low priority because officials believe the data quality is generally good. In support of their view, system managers cite a 1976 internal study of the Proposal and Application Information Subsystem which examined that subsystem during its first full year of operation. A total of 9,539 observations were made on 41 data elements in a sample of 947 proposals from all Foundation directorates. 1/ The result was an overall accuracy of 95.1 percent, and 98.9 percent for critical data elements.

As part of our reliability assessment, we made spot checks of 152 critical data elements from six proposals and four awards to see if computerized data and original records agreed. Almost no errors were found. We also made a spot check of duplicate names in the principal investigator subsystem. Out of 2,176 entries in the alphabetical list of names for the letter J, 5 percent possible duplications were found. Further limited testing of seven data elements in the financial accounting subsystem data from four awards and three proposals showed no errors.

These spot checks do not represent the quality of data in the 28,000 proposals or 24,000 awards in process annually, but were done to determine the kinds and quantity of errors which might be anticipated in a full-scale quality audit. Both the Foundation's study of 1976 and our spot checks were concerned only with the value of basic data elements at a certain time, not with what happens to data during the running of individual programs or with the operation of all subsystems over time.

Through a user questionnaire we solicited comments from a selection of 27 Foundation division directors and program officers on the quality of data in two widely-used routine MIS reports and the usefulness of MIS in carrying out their work. Program officers commented on the Workload Status Report and division directors on the Proposal Aging Report. Respondents also provided numerous narrative comments on MIS. The results, which follow, are the opinions of a smaller selection of users, but are not necessarily representative of the opinions of users as a whole.

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1/The Foundation is organized around the Office of the Director, six program directorates, and one administration directorate. (See attachment II.)

## USER REACTION TO MIS REPORTS--RESPONSES TO KEY QUESTIONS

| Is the reported data: | Workload status report<br>Percent Yes | Proposal aging report<br>Percent Yes |
|---|---|---|
| --accurate and reliable? | 82 | 29 |
| --complete? | 73 | 86 |
| --available early enough? | 67 | 79 |
| --current? | 67 | 38 |
| --useful? | 67 | 92 |
| --understandable? | 100 | 100 |
| Can the report be used as is without further correcting, explanation, or analysis? | 69 | 57 |
| Do you maintain manual records to supplement computer produced information? 1/ | 69 | 71 |
| Does the report duplicate any information you now receive? 2/ | 25 | 71 |
| On a scale of 1 to 10: | | |
| In the work of your office or division, the report is: (not important at all = 1, very important = 10) | 5 | 5 |
| How useful is the MIS to you in carrying out your duties and responsibilities: (not useful at all = 1, very useful = 10) | 5 | 6 |

1/Some respondents said manual records were kept because automated records were unreliable, but others indicated that manual records might be kept anyway as a backup system.

2/Some respondents said duplication provided a useful cross-check of data and aided in error identification.

Representative respondent comments

--MIS seems to be a closed system and used primarily by DIS and upper managers. The needs of the program officials are secondary.

--MIS data are too unreliable to be of use, necessitating the maintenance of manual records to check the computer.

--The system is improving over time, but still has a long way to go.

--DIS should find out what programs personnel need before generating software.

--Too much time is required locating errors in the financial accounting system and identifying such for the Division of Financial and Administrative Management.

--The system will never be better than the accuracy and completeness of its data.

--Response time at the terminals is often unacceptable.

--Down time on the system is much too frequent and often comes at the end of the month when it is important to get actions processed.

--DIS staff are most helpful and courteous in responding to any questions we have.

The results of the questionnaire survey including the narrative comments strongly indicate the need for improved system reliability.

System reliability needs strengthening

Our reliability assessment is a judgment based on a structured analysis of organizational and computer operation controls and procedures including access controls, file controls, disaster recovery, teleprocessing, input and output controls, and user opinions. We obtained information necessary for our evaluation from system managers and users through interviews and questionnaires. (Time constraints did not allow verification of this information with actual Foundation procedures or system operations.) Reliability is evaluated in terms of risk (potential for error). High reliability indicates low risk, low reliability indicates high risk.

Our assessment revealed system strengths and weaknesses and resulted in a rating of medium reliability, which means that a user should audit any system data significant to critical decisionmaking. A discussion of these strengths and weaknesses follows:

Strengths

--Steering committee--Top management involvement, in the form of a steering committee, is essential to the development and operation of an information system. In July 1977, the Foundation established the MIS steering committee to provide top management participation in all phases of MIS planning and resource allocation. However, the committee, composed of assistant directors, was chaired by an assistant director until January 1979, when the Deputy Director was made chairman. The committee lacks full-time staff support needed to function effectively and has spent much of its effort thus far defining its role.

--Separation of duties--Separation of duties enhances system security and, by providing an effective check against losses from carelessness or fraudulent manipulation of data, promotes accuracy and reliability in data. Within DIS branches, we found different Foundation and contractor employees performing such duties as maintenance of the operating system and data management system, system design and programming, hardware operations, file maintenance, and data input.

--Security--Physical equipment, production programs and procedures, and data files should be adequately secured to prevent unauthorized access. We found access to the computer area and hardware is limited to necessary personnel through the use of key locks and visitor sign-in logs and badges. Account codes, authorization codes, and passwords are controlled to prevent unauthorized use of data files and procedures. Other DIS security measures prevent the unauthorized entry of program changes and data through the operator's console, detect attempts at unauthorized system intervention, and prevent unauthorized modifications to production programs. In addition, the MIS tape library is accessible only to authorized librarians.

--Disaster recovery--Disaster recovery controls are preventive processes that help protect critical data files, software, and systems documentation from fire and other hazards, allowing a continuation of data processing activities if such hazards occurred. DIS has established such procedures describing the action to be taken in the event of a disaster involving the data center, data files, and computer programs. Among these are provisions for copying and retaining master files. Sufficient generations of files are maintained to facilitate reconstruction of data records, and copies of operating and production programs are also maintained. These critical data files and software are stored in a vault outside the data center and at an offsite storage facility.

--Other controls present--Traditional control concepts are augmented by controls written into computer programs and other system software as well as controls built into the computer hardware. The MIS executive control is a collection of software modules which control access to the integrated data base and journalize all transactions which alter the data base. Journalization, the storage of before and after images of all altered pages in the data base, provides an audit trail for analysis of data base integrity and system restoration. In addition, computer programs include various types of edits and routines which are helpful in assuring that data is properly processed through the entire run.

Weaknesses

--Internal audit oversight--Internal audit oversight of data processing activities helps to insure that computer-produced information is accurate and reliable. However, the Foundation's audit office has had little involvement in DIS activities. Internal audit monitoring has consisted of minimal participation in MIS design and implementation, membership in DIS study team efforts, and verification of information on computer reports. Although an operational audit of MIS has been a part of the yearly audit plan since FY 1974, the internal audit staff has not been able to perform a detailed review due to limited funds, time, and technical expertise.

--System documentation--Internal control in an automatic data processing department requires adequate documentation describing both the system (including the application systems and programs) and the procedures used. However, DIS management has not encouraged the systems analysts/programmers to maintain and update systems documentation, feeling it would divert their limited resources from system/program maintenance and other more important functions. The amount of documentation varies for each system (subsystem). Original system documentation which was developed by the contractor and turned over to the Foundation during implementation has not been updated or, in some cases, retained. Although these systems/programs have undergone considerable testing, test plans and their results are not available. System descriptions and flowcharts are developed when needed for documents and briefings. In addition to the lack of systems documentation, we observed limited procedural documentation. For example, DIS could not provide documentation for ADP personnel duties and responsibilities, other than position descriptions. Although tape library procedures, disaster recovery procedures, and security procedures are documented, error correction procedures are not. This can result in standard procedures not being followed and errors not being corrected promptly and appropriately.

--<u>System utilization data</u>--Utilization data is essential to management for measuring the efficiency and effectiveness of the data-processing system. Available utilization data includes the names of individuals accessing MIS, the number of times they were on line per period, and total lapsed time for each individual per period; for batch processing, the number of jobs run daily. No data is gathered which could be used to determine the number of times each procedure was accessed per period, the number of job reruns, or total processing time for each program. Failure to obtain and analyze these types of information could result in inefficient utilization of MIS.

--<u>Internal controls</u>--Internal controls safeguard resources from waste, fraud, and inefficiency and promote accuracy and reliability in accounting and operating data. Although MIS functions appear to be secure, several procedures need to be improved. For example, tighter controls are needed over system and program documentation kept at the system analysts' and programmers' desks to prevent unauthorized access to such material. Also, sensitive output, such as personal information, is discarded along with nonsensitive information instead of being shredded or burned. There is no nonprinting/nondisplaying or obliteration facility incorporated in the terminals to prevent unauthorized persons from having access to accounting and authorization codes and passwords. These additional control procedures would help produce a more secure climate for data processing.

System design problems

In addition to the security and system control weaknesses, we learned about system design problems in the Principal Investigator/Project Director (PI/PD) Subsystem. The MIS integrated data base allows data to be strung out in chains, allowing records to be linked by pointers within each record and permitting the linkage of related files so that data need be entered only once. However, this chain linkage is absent between the PI/PD Subsystem and the integrated data base. Instead, this subsystem is linked by common data elements within the integrated data base. Any changes to the PI/PD data records must be made individually to each common data element. Errors could be made while making these changes or some common data elements could be overlooked, creating unsynchronized data within the data base. Another problem, the absence of a standard identifier within PI/PD records, can lead to duplicate entries in the data base. DIS is currently seeking solutions to both of these problems.

Our data quality and reliability assessments were performed from October through November 1978 and apply only to that time frame. The results are not necessarily typical of the system over other time frames because the system is changing with respect to design, procedures, and management controls, and there is no ongoing data quality assessment process. The Foundation has system and computer program change control procedures that provide some control over, and a chronological history for, the modifications made to the system.

IMPROVEMENT IN SYSTEM RESPONSE TIME NEEDED

System users and managers reported experiencing excessive response times at the terminals, sometimes as long as 5 minutes. System managers want a response time of under 5 seconds. The problem was generally described as an overload problem arising when 20 or more of the Foundation's 238 (at the time of our study) MIS terminals were concurrently active. The Foundation's consultant noted in his report that response times of several minutes were common. We, too, experienced long delays in getting on the system and subsequently retrieving data during information gathering for our audit.

While system managers agreed that a response time problem had existed for at least 2 years, they had not defined the exact degree of the problem or identified its causes. Instead, they have been trying to work around the problem by requesting program personnel to use MIS at times when the computer center was not performing high volume data entry. System managers were looking to a study by the Federal Computer Performance Evaluation and Simulation Center (FEDSIM) to assess the problem further.

In February, 1979, FEDSIM began studying the Foundation's computer system analyzing workload characteristics, system response, system design, system utilization levels, and operational procedures. The study included two system loading experiments to determine the number of users that could be adequately serviced on the present computer, and to identify potential system bottlenecks during peak use periods. The principal conclusion of the FEDSIM study was that significant improvements in slow response times were not to be found by adding central system hardware. Rather, they would come from better management of existing computer resources.

The FEDSIM findings were qualified by the instrumentation available and the study methodology used. For example, JASON, one of the two major systems tested, lacked the software instrumentation necessary to collect terminal response times. Since response time delays had been observed using JASON, this limited the study's ability to identify and suggest specific solutions to response time problems. Other qualifications include a limited workload and operational environment measured under controlled conditions; no batch processing load applied during the system loading experiments; and Foundation staff and representative workloads used in the experiments were selected and coordinated by Foundation personnel, not FEDSIM. (See Agency Comments and Our Evaluation on page 23 for additional comments.)

FEDSIM reported that those system response times that were measured were generally good during the testing. (Most were in a range of 1 to 10 seconds.) However, some delays ranging from 6 seconds to 6 minutes and 15 seconds occurred. The tests also demonstrated that up to 71 users could access the system concurrently under the controlled conditions of the test.

The study reported that the Foundation does not have adequate system accountability data for assessing and managing the performance of its computer system under varying workloads. Improving this condition was FEDSIM's first recommendation to the Foundation. Additional FEDSIM findings affecting system performance and responsiveness include:

--Competition exists between data entry personnel and system users for computer resources.

--Formal response and turnaround time requirements for system users do not exist, together with lack of communication with users over what constitutes reasonable expectations of computer performance.

--Most batch workloads are processed during the day shift when users' demands are at a peak.

--Central processing unit and memory resources are almost fully used during the day shift.

--System resources are not a constraint to additional workload during evening, night, and weekend processing periods.

FEDSIM recommended many changes to the system including the following:

--Enhance the policies and procedures for system accounting to provide Foundation personnel with better information by which to manage computer resources.

--Establish performance goals for the system by identifying formal response and turnaround requirements for system users.

--Reevaluate the design of the Office (Local) Management System to meet user needs while reducing load on the system, and

--Improve guidance to users concerning the optimum use of the system.

Even though the Foundation has no continuing performance evaluation program, it has continued to expand the number of terminals accessing the system without knowing whether this expansion will further delay system response time. In 1977 the Foundation added a second communications control unit with 16 communications lines to the MIS computer, which already had 64 lines. The Foundation added 46 additional terminals in fiscal year 1979 to the 238 it already had.

## LONG-RANGE PLANNING NEEDED

The Foundation's MIS management program lacks both a long-range plan and a planning process to establish quantified goals, priorities, and target dates. As early as 1972, Foundation management recognized that past efforts to automate Foundation files had been too narrow in scope and had led to disappointing results. While development of MIS was based on a 5-year plan, the plan ended in 1976 with no continuing long-range planning process in existence. The Foundation then contracted for a system evaluation. The consultant cited the absence of effective long-range planning as adversely affecting system management and recommended that the Foundation immediately develop a long-range plan and a planning process. He emphasized the need for long-range hardware planning to control costs and efficiency of operations and recommended that a long-range hardware plan and a computer optimization study be done immediately. He also recommended the immediate implementation of a system development management program which would provide for the orderly development of system software.

After 3 years, the Foundation still has not developed these long-range plans, performed the optimization study, or implemented a system development management program. DIS officials said these projects have received low priority because daily operation and maintenance of the system was consuming the available resources. Furthermore, no firm plans exist for pursuing these projects.

Currently MIS is managed on a short-range basis, essentially reacting to daily demands and problems. While numerous work projects for system improvements have been identified, there were often no detailed documented plans for the improvements nor funds to put them into effect.

## IMPROVEMENT IN PERFORMANCE EVALUATION NEEDED

Forty-three Foundation personnel including upper-level managers, program officers, and administrative and financial personnel answered questionnaires. The users stated that MIS should perform better than it does and that greater attention is needed to determine and meet user information needs. These issues are discussed below.

### Users expect MIS to perform better

Most users criticized MIS for unreliability in data accuracy and completeness and, as previously discussed, for unsatisfactory delays in getting on the system and long waits at the terminals for data access. Because of such problems many users have kept in their offices manual records which are used for computerized data verification and for program management. Several users noted that DIS had asked program officers to review long computerized lists of proposals and awards for their divisions at the end of fiscal year 1978 to help correct errors, reconcile financial data, and find proposals and awards which had become lost in the system. One user criticized the system for not having established error correction procedures so users could clearly describe the error discovered and recommend how it should be corrected. Another user stated, however, that the computer was not to blame for all errors because some were caused by the program office staff's failing to identify and report errors.

<u>A better assessment of user needs is required</u>

We found no adequate process for evaluating and addressing user needs. Except for the initial requirements study of 1971, the Foundation has not systematically assessed user needs. In answering our questionnaires (see p. 7) users said that MIS is only moderately important and useful in helping them carry out their duties. They identified problems which indicate that MIS is not adequately addressing their needs. For example, users said that MIS reports required further correction, explanation, or analysis, that manual records were needed to supplement computer-produced information, and that some reports duplicated information already received.

Some program officers complained that some routine MIS reports were not useful and therefore not used. Instead, personnel used their own computer programs to develop special-format reports tailored to their specific needs. Other criticisms included heavy use of numerical codes for classifying data, which required frequent use of a code dictionary, the undesirable format of data, lack of effective training for use of the system, and inadequate communication on user needs between system users and system managers.

The Division of Information Systems has assumed the task of determining the current needs of program users. In doing so, system managers have used feedback from program personnel through user representatives (DIS personnel located within Foundation directorates) and the directorate task groups (committees that monitor MIS performance). These channels are still the main sources for identifying user needs, since the Foundation has not established a performance evaluation program to assess user needs and how well they are served. The consultant recommended such a program 3 years ago.

STATUS OF OVERALL SYSTEM MANAGEMENT

The consultant made 23 recommendations for system improvements in applications organization, and systems and resources management programs. Of these the Foundation has addressed 13 recommendations, partially addressed 2, and not addressed 8.

For those addressed we did not assess the extent to which the changes have effectively improved MIS performance. However, a description of the recommendations and the status of implementation is presented below. (See attachment III for additional details.)

Recommendations addressed

1. Establish a hierarchy of steering committees. Two committees were recommended: one, composed of upper level managers, would determine overall policy, funding, goals, and objectives; the second, composed of operational staff, would monitor policy and program implementation. The first committee was established (July 1977), but not the second. Instead directorate task groups were established in early 1978 to monitor MIS implementation.

2. Provide user representatives. Each directorate now has a program analyst from DIS located on-site to help program personnel use MIS. User reaction was favorable in GAO's questionnaire responses.

3. Establish a "quick response" service group. A staff of four has been established in DIS to expedite MIS response to external requests for data.

4. Develop an implementation plan for a financial accounting system. The consultant developed a plan which the Foundation is now implementing on a 5-year basis. Implementation is now in its third year.

5. Establish a DIS administrative staff. Quality control of MIS products and activities has been fragmented among numerous parties with none having authority to establish standards. As a remedy, DIS established a management controls branch (April 1977) responsible for quality control, system development, cost accounting, training, and security.

Thus far the branch's activities have been limited to organizing itself and performing ad hoc tasks. Resource limitations reportedly have prevented greater achievements.

6. Enhance award processing. The consultant stated that the Foundation could enhance its award processing by automating award letters and institutional indirect cost rates. Both capabilities have been added. Also, the financial accounting system now automatically reflects award actions.

7. Enhance award management. The consultant stated that control and monitoring of active awards was inefficient because of numerous manual operations which could be automated; for example, tickler files used to identify delinquent reports. The Foundation has made the recommended enhancement and is currently reviewing and redesigning, where necessary, the Awards Management System.

8. Conduct requirements study. The consultant performed a requirements study for the Foundation in early 1977 which assessed detailed work projects, priorities, and resources required. The study was to be the initial step in developing a long-range planning process. The study concluded that the MIS workload was well in excess of available resources, thus requiring critical management decisions.

9. Centralize ADP expenditures. Several directorates contract for supplementary data processing services tailored to specific needs (cost is approximately $500,000 annually). Previously these contracts were not coordinated with DIS. Now the steering committee reviews and approves these expenditures.

10. Implement certain office automation modules. Office automation is the use of computers to perform office processes otherwise done manually. MIS provides programs (modules) for such processes as letter writing, text editing, data base searches, and dictation services. Twenty percent of the Foundation's divisions have some modules installed.

11. Defer automation of general office functions. Conceivably office automation can result in using electronic media totally, instead of paper. The Foundation has limited office automation to word-processing applications and deferred automating

processes that would eliminate altogether the use of paper.

12. Develop a skills improvement program. The consultant noted that DIS needed to develop better managerial and ADP technical skills in its staff. Meanwhile, it recommended contracting for software until in-house skills could be improved. Since then, DIS has contracted for all major software. Formal training courses have been identified and made available to personnel.

13. Make miscellaneous enhancements. Numerous detailed and technical recommendations were made for strengthening major subsystems by 1980. The Foundation has followed up by identifying numerous subsystem projects, many of which were completed in FY '78. An additional 80 projects remain, 38 of which were scheduled for FY '79. The remaining 42 projects are unfunded and include such tasks as user documentation of system procedures, evaluation and enhancement of subsystems, providing report numbers on recurring reports, testing annual closing procedures for the financial accounting subsystem, and rewriting reports for optimization.

Recommendations partially addressed

1. Conduct a workload process study. The consultant said a study of workload processing procedures should be done within 6 months to streamline existing procedures. Subsequently the Foundation had the consultant perform such a study in one directorate (science education). Studies in the other directorates have been deferred.

2. Adopt a project management organization structure. MIS development efforts have been accomplished by numerous people working on specific tasks with no one individual responsible for overall coordination. The consultant said this approach was hindering effective management and recommended immediate adoption of a project manager approach where one person was responsible for specifically identified projects. DIS adopted the project management principle within its existing organizational units without changing its organizational structure, on the premise that most MIS work is now maintenance and not developmental. Also, limited resources did not permit a staff of the size project management requires.

Recommendations not addressed

1. Conduct data quality study. The consultant did not perform a data quality study but recommended that the Foundation perform one within 6 months. DIS analyzed and corrected errors in selected portions of the data base but did not perform a major study because data quality was considered good. In addition, resources were lacking. As we began our review DIS officials said they were reinstituting this study with newly acquired resources.

2. Develop and maintain a long-range systems plan. The consultant cited the absence of effective long-range planning as adversely affecting system management, and recommended that the Foundation pursue immediately a long-range plan and a planning process. No long-range planning process or plan has been developed. Currently DIS relies on the MIS steering committee and the Management Controls Branch for planning.

3. Prepare a long-range hardware plan. The consultant noted the necessity for effective long-range hardware planning in controlling costs and efficiency of operations and noted that the Foundation was not doing such planning. The consultant recommended that a long-range hardware plan and a computer optimization study be done immediately. To date, lack of resources and low priority have prevented such studies, according to agency officials.

4. Develop a performance management program. The consultant found need for a better ability to determine and control how well MIS is performing its mission An intermediate-level study was recommended using readily available data. DIS has not decided how it will act on this recommendation.

5. Develop a program-budgeting and cost-accounting system. The Foundation's efforts at ADP budgeting and cost accounting were judged as very rudimentary, and a more formal systematic approach was recommended. The Foundation has not pursued this recommendation and is undecided about its ultimate disposition.

6. Develop and install a systems development management program. DIS has lacked a systems development

management program and has relied on contractors to develop its software. The consultant recommended immediate development and installation of a formal program for this purpose. Subsequently, the Foundation had the consultant develop a program, but it has not been implemented and is not scheduled for implementation.

7. Reposition system analysts into the development process. The consultant noted the desirability of positioning system analysts between users and programmers to help insure that user needs were effectively met. DIS has not found it possible to do this because of manpower limitations. Therefore, it is seeking to develop system analyst skills within its programmer ranks.

8. Develop a new personnel system. The consultant found the agency's personnel system needed major improvements. The Foundation made several enhancements of the system pending a system requirements study.

SYSTEM COSTS

According to Foundation figures, MIS has cost over $15 million from fiscal year 1971 through fiscal year 1979, excluding personnel costs. Items of cost include equipment rentals and purchases, supplies, and software and system development contracts. Costs for fiscal years 1976-1979 including personnel are shown below. (See attachment IV for greater cost detail.)

| Fiscal Year | ADP Costs* | Personnel | Total |
|---|---|---|---|
| | ------------ | (millions) | ------------ |
| 1976 | $2.4 | $1.2 | $3.6 |
| 1977 | 2.0 | 1.4 | 3.4 |
| 1978 | 2.3 | 1.6 | 3.9 |
| 1979 | 3.8 | 1.8 | 5.6 |

*ADP costs include equipment rentals and purchases, supplies, and support contracts.

During fiscal year 1979, the Foundation purchased the second processor it had been renting, but shelved plans to add a third communications control unit. The Foundation added 46 more computer terminals.

CONCLUSIONS

Significant improvements in MIS and its management are needed if the system is to fulfill its intended purpose and achieve a degree of reliability satisfactory to its users. Although 3 years have passed since the consultant's evaluation study, the Foundation has not yet implemented major recommendations which the consultant said were needed immediately. These recommendations addressed data quality assessment, long-range planning, performance management, and system management.

Serious technical and management problems threaten the successful operation of the system. While system managers cite lack of resources as the main reason for not implementing important recommendations, we believe that decisions made without long-range planning or knowledge of system effectiveness are also major causes. We believe the Foundation has given low priority to areas which should have had the highest priority. We found, for example, that the Foundation is giving higher priority to implementing office automation than to achieving a highly reliable system. Also, the Foundation has added equipment to the system's operating hardware, which is already experiencing response time delays, without knowing what adverse impact this equipment will have on the system's overall performance.

Additional equipment would serve to increase potential demand on the system during peak daytime hours. Considering the absence of good system accountability data and FEDSIM's conclusion that system hardware is not a constraint to improved system performance, we believe the Foundation should carefully assess any further plans for adding terminals and associated equipment to the system. Better management of existing computer resources, as recommended by the consultant and FEDSIM, would seem to be a more desirable alternative at this time. Any additional equipment should broaden the scope of services to users, yet the Foundation has not yet assessed how effective existing services are, or how such services can be improved.

In our view, MIS's value to the Foundation and user acceptance depend on high system reliabilty. Our reliability assessment shows the system to be of medium reliability, which means that users of system data should verify the accuracy of the data before using it for important decisions. System users within the Foundation, the Congress, the Office of Management and Budget, and others will not, nor should they, be satisfied with data from a medium-reliability system.

Some changes have been made to MIS as a result of the consultant's recommendations but the Foundation has not examined the impact of these changes on the system. So far, improvements are not obvious since users continue to cite system unreliability and slow response time at the terminals. They also report that manual records must be kept to verify and correct computerized data and that MIS reports are not effectively meeting their needs. In addition they report the absence of good training and documentation on using the system and correcting data errors.

While MIS is not yet fully implemented, Foundation management already depends on it to provide many essential services and data. Yet the system will be unable to provide highly reliable data until the technical and management problems identified in this report are addressed and remedied. In addressing these problems, we believe the Foundation should reexamine the purpose of MIS, clearly define its users and their needs, and establish specific, quantified goals and target dates to correct deficiencies and complete the system.

## AGENCY COMMENTS AND OUR EVALUATION

We proposed that the Foundation take the following actions to improve MIS: (1) resolve the slow system response time problem, (2) assess MIS's data quality and establish procedures to periodically test data quality, (3) develop and implement a long range system and hardware planning process, (4) conduct MIS performance evaluation to include assessing user needs, and (5) improve overall MIS management in areas such as security and training.

In a letter dated June 15, 1979 (see attachment V), the Foundation advised us that although it had concerns about our reliance on the use of questionnaires and interviews to assess user satisfaction with MIS, it generally agreed with most of our proposed recommendations. The Foundation stated that it was or will be taking actions to implement most of our recommendations to improve MIS. However, the Foundation did not agree that it had a slow system response time problem of the magnitude we described in the draft report. The Foundation referred to FEDSIM's study of MIS's user response time which, the Foundation said, showed response time to be in an acceptable range. The Foundation agreed, however, to conduct computer performance evaluations on a regular basis to maintain an optimized system. Our evaluation of the specific points the Foundation raised in its letter follows.

Audit methodology to assess user satisfaction

The Foundation stated it had concerns regarding our report's usefulness because of our reliance on interviews and questionnaire data to help assess user satisfaction with MIS. The Foundation noted that the use of such data could make it difficult to distinguish between legitimate system problems and other factors that influence user satisfaction. The Foundation suggested that our user satisfaction findings regarding two widely used reports produced by MIS could not be attributed solely to the quality of MIS's integrated data base, but rather may have been the result of "differences in user perception" of the reports.

Our questionnaires and interviews identified a legitimate system problem--errors in the data base--which appears to adversely affect the accuracy of a widely used report produced from the data base. We selected two widely used reports produced by MIS, each of which is used by a different Foundation management group. Program managers use the Workload Status Report, whereas division directors use the Proposal Aging Report. We asked only program managers about the Workload Status Report, while only division directors were asked about the Proposal Aging Report. The differences in user perception appear very much dependent on the data base errors since the Foundation states that, of the two reports we tested, errors tend to be concentrated in the report (Proposal Aging Report) our work showed had the lowest user satisfaction rate (29 percent). Our questionnaire showed that users of the Proposal Aging Report (division directors) were having problems with the report because of errors, and the Foundation confirmed this by noting that of the two reports we tested, errors are concentrated in the Proposal Aging Report.

The Foundation suggested in its letter that although errors are present in the Workload Status Report, the errors are not as easily recognized as in the Proposal Aging Report because of the larger volume of information present in the workload report. However, errors in the data base are still errors no matter how unrecognizable they might be in some reports. Errors are present in some data in the integrated data base that can adversely affect the accuracy, and thus the reliability, of a report produced from the data base. The extent to which the errors adversely impact report quality will depend on the specific data used to develop the report and the intended use of the report. Merely suggesting that errors in the data base are just perceptions because the errors are more recognizable in one report than another attempts to obscure the real point--that there are errors in the data base which have an adverse impact on user satisfaction with MIS-produced reports.

The Foundation also suggested that the use of the Proposal Aging Report by management as an oversight tool over program managers may have caused the managers to resent the aging report, and therefore judge the report more harshly in our user survey. However, we did not obtain program managers' views on their satisfaction with the Proposal Aging Report--program managers were not asked to judge this report. We asked only division directors--the primary users of the aging report--how satisfied they were with the report. As a result, our questionnaire could not have measured the resentment program managers might have regarding the aging report since they were not asked.

Foundation suggestion for GAO work scope qualification

The Foundation suggested that we include in the letter transmitting our report to the Congress a notation regarding the limitations that were placed on our work. We had already included a paragraph qualifying our work scope in the introductory section of the report (see paragraph 1 on page 2 of appendix I). We have also included this work scope qualification in the introductory section of the basic transmittal letter to the chairman.

Analysis of FEDSIM report on MIS response time

The Foundation stated that the FEDSIM tests show system response time to be in an acceptable range and that the tests, as well as the agency's recent experience, do not support the implication in the GAO report that only 20 terminals can be concurrently active on the system. The Foundation's letter was dated June 15, 1979, prior to FEDSIM's final report. The final report, dated September 1979, acknowledges the occurrence of slow system response times and makes many recommendations for improving overall system performance. The study does not characterize current system performance as being either acceptable or unacceptable. The study reports that hardware performance was generally good during the controlled testing and was not a constraint to improved system performance, but that better management of available computer resources would improve system performance.

GAO's reference to diminished system response time capability when 20 or more terminals are in use was based on information received by interviewing Foundation personnel. Our inquiry showed that system managers did not know the cause of the apparent slow response time problem and may have, in their speculation, attributed the problem to numerous related or unrelated causes. We conclude from the FEDSIM study that the number of terminals that can be concurrently active and the response time at those terminals is dependent on many variables, including the number of users and the difficulty of their procedures, the competition between data entry personnel and other users for computer resources, system scheduling procedures, and others. We also conclude from FEDSIM that there are times when system response time is poor. The study indicates that under controlled testing it is possible to have more than 20 terminals concurrently active. However, the day to day operations of the Foundation are a real world environment where the computer system must respond to uncontrolled demands which we believe can yield situations where only 20 terminals could be concurrently active. Improved system accountability data would be needed to show how frequently this condition actually occurs.

We believe it is important to note the FEDSIM study's qualification that its test results depended strongly on the workload and operational environment measured under qualified conditions. We observed that some of the qualifications may limit the study's conclusions with respect to the Foundation's actual daily operation. For example, JASON, one of the major systems tested, lacked the software instrumentation necessary to collect terminal response times. Also, the test methodology used in the system loading experiments excluded batch processing from the workload applied to the computer system. The combined effect of batch processing and normal user demands on limiting the number of terminals concurrently active is unknown.

In its discussion of available computer resources, the FEDSIM study generally assumes 24-hour system availability. If all the Foundation's procedures could be distributed over a 24-hour period, undoubtedly system overloads could be minimized. But in practice, the Foundation has a prime daytime peak loading period which is a period of great user demand to which the system must respond successfully. As the study notes, the central processing unit resources and memory resources are almost fully utilized during this day-time period.

We also observed that the system loading experiments used participants and representative workloads selected by Foundation personnel. Such an approach could introduce agency bias into the testing in that all aspects of a typical workload environment may not have been represented.

We believe that the FEDSIM study will be useful to the Foundation in strengthening the management of its system. Because of the limitations of the study, however, we believe it would not be surprising to find system users experiencing the same response time problems we reported, despite FEDSIM's conclusions that response time is generally good and that system hardware is adequate to handle the current workload. The difference lies in assessing system components under controlled conditions as FEDSIM did, and the results of the system operating in a normal work environment.

Regardless of the cause, users will react negatively to slow response time at the terminals even if they are apprised of possible causes. The Foundation's task, as we see it, is to eliminate or minimize what Foundation personnel perceive as a system response time problem regardless of the exact number of terminals involved. We believe FEDSIM's recommendations should be helpful in doing so. (See attachment VI for excerpts from the FEDSIM report showing report abstract and FEDSIM's conclusions and recommendations regarding the Foundation's MIS.)

## Assessing user needs

Although the Foundation states in its letter that it has taken steps to address user needs by establishing an advisory group, we believe the Foundation should insure that the group's actions will be adequate to provide for user needs assessment. As we have recommended, a performance evaluation program is also needed in addressing user needs. The importance of conducting user needs assessment cannot be overemphasized. It helps insure that the system is providing the services intended and that the services are accurate and reliable.

## RECOMMENDATIONS

We recommend that the Director of the National Science Foundation improve MIS by taking actions in the following areas:

--System Response Time--Resolve expeditiously the slow system response time problem which is frustrating system users, and reassess the need for acquiring additional hardware.

--Data Quality Control--Assess MIS's data quality and establish procedures for periodically testing and maintaining data quality to insure high reliability.

--Long-Range Planning--Develop and maintain a long-range system and hardware planning process to insure orderly and systematic development of MIS. The planning process should include top management participation; provide a reasonable 5-year projection of system requirements and costs, which would include life-cycle cost analysis; establish quantified goals and priorities for work projects; and set milestone completion dates.

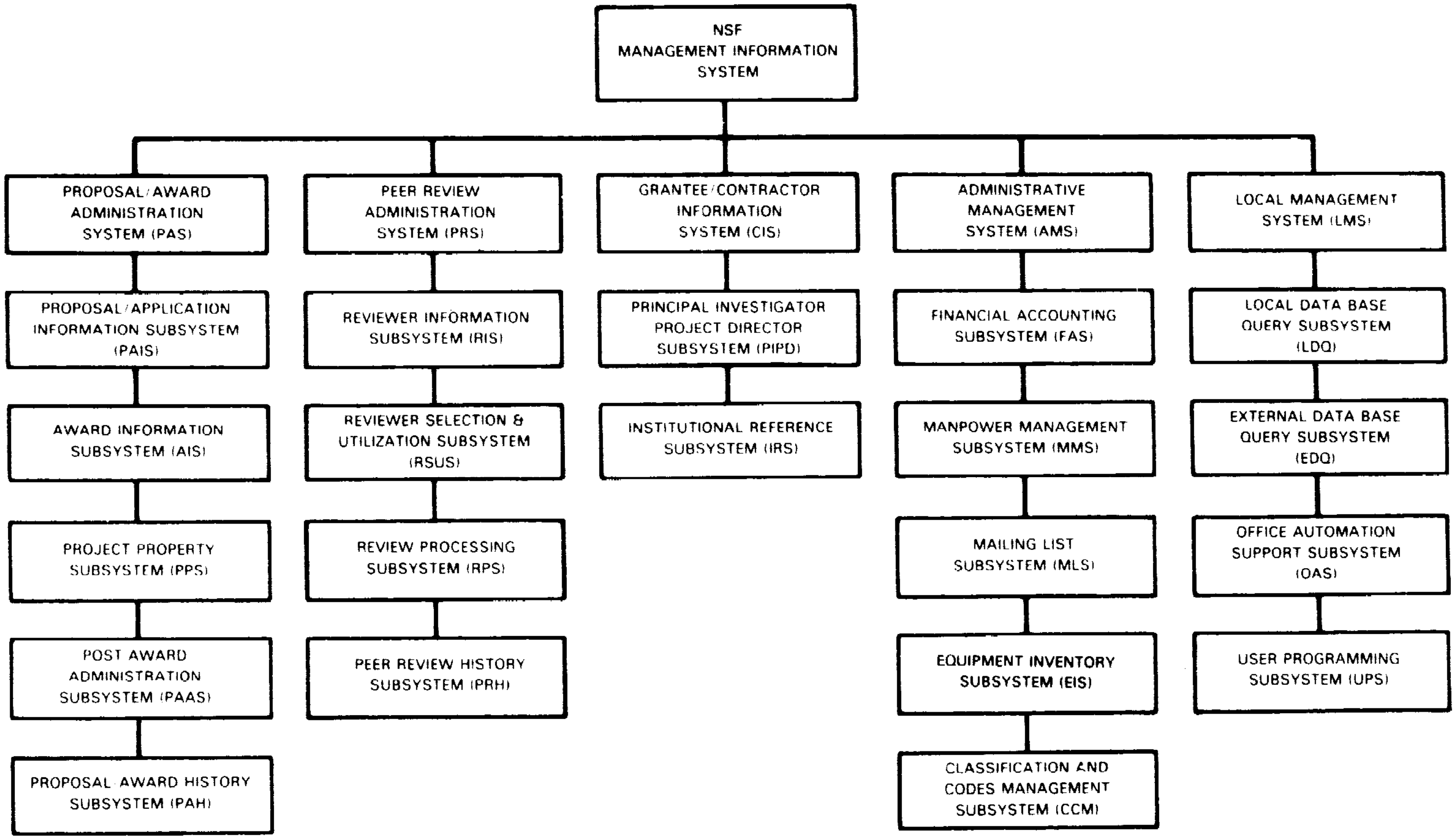
--Performance Evaluation--Develop and implement performance evaluation procedures to determine and control the efficiency of the system in meeting its goals. Such procedures should assess user needs and insure system cost effectiveness.

--Overall System Maintenance--Assess MIS short- and mid-range management efforts to insure that areas such as general system security, system documentation, and training receive adequate attention. Also, the Director should strengthen the internal audit staff capability to monitor MIS performance.

ATTACHMENT I

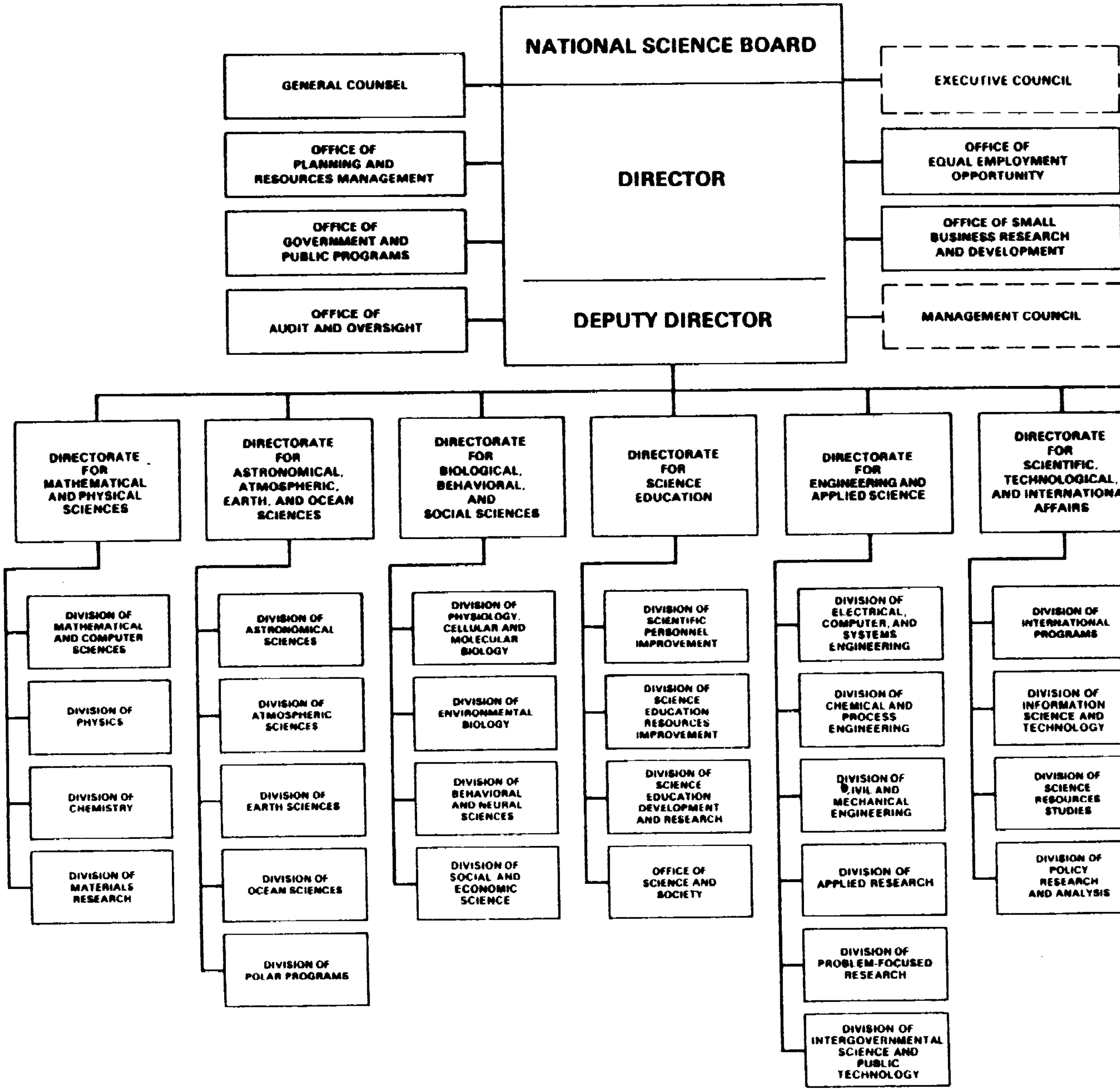
# ORGANIZATION OF THE NATIONAL SCIENCE FOUNDATION

# MANAGEMENT INFORMATION SYSTEM




ATTACHMENT I

ATTACHMENT II




Richard C. Atkinson, Director

Date JUL 27 1979

ATTACHMENT II

SUMMARY OF NATIONAL SCIENCE FOUNDATION/MANAGEMENT INFORMATION SYSTEM
CHANGES SINCE 1/77

| Problem area | Consultant's recommended action | Timeframe after 1/77 to begin | NSF reaction | NSF action to date | NSF planned action |
|---|---|---|---|---|---|
| A. MIS APPLICATIONS | | | | | |
| 1. User needs identification. | Provide MIS user representatives in each directorate and certain divisions and offices. | Within 6 months. | Partially agreed. | User representatives provided in each program directorate but not all identified divisions and offices. | Continue as present. |
| 2. Users ad hoc information requests. | Establish quick response service group. | Within 2 years. | Agreed. | Group established with staff of four. | Develop ad hoc reports for individual users. |
| 3. Automation of select office functions. | Implement office automation modules including conventional word processing applications. | Within 2 years. | Agreed. | Office automation project established 6/77. Nineteen modules identified. First few now being installed with user representative assistance. | Develop remaining modules. Continue installation. |
| 4. Automation of general office functions requiring long-term effort. | Defer automation of general office functions beyond conventional word processing applications. | Within 5 years. | Agreed. | Deferment in effect. | None at present. |
| 5. Workload processing efficiencies in addition to automation. | Conduct a policy and process study directed at reducing effort necessary to process workload. | Within 6 months. | Agreed. | Conducted for one directorate only. Remainder of NSF deferred due to unavailable resources. | None at present. |



ATTACHMENT III

| | Problem area | Consultant's recommended action | Timeframes after 1/77 to begin | NSF reaction | NSF action to date | NSF planned action |
|---|---|---|---|---|---|---|
| 6. | Unsuccessful attempts to implement MIS financial system since 1973. | Develop and execute implementation plan for financial accounting system. | Immediately. | Agreed. | Plan developed 8/77, execution on schedule. | Plan extends through FY 81. Reassess remainder of plan during FY 79. |
| 7. | Potential productivity gains in award generation. | Enhance award generation: automate award letters, provide video access to institution cost rate data. | Within 2 years. | Agreed. | Done. | |
| 8. | Inefficient post-award operations. | Enhance award management: control, monitoring, and close out. | Within 2 years. | Agreed. | Some control enhancment. | Indepth review scheduled 2/79. |
| 9. | Inadequate automation of personnel system. | Develop new automated personnel system. | Within 2 years. | Agreed. | Some interim enhancement. | Personnel system requirements study scheduled for FY 79. |
| 10. | Weaknesses in current MIS applications. | Make miscellaneous enhancements. | Within 2 years. | Agreed. | FY 78: 59 projects completed. | FY 79: 38 projects funded. FY 79: 42 projects remaining to be funded. |
| 11. | Data handling procedures and controls suspect. | Conduct data quality study: procedures and controls. | Within 6 months. | Agreed. | Some interim data clean up. Procedures and controls study deferred. | Study scheduled for FY 79. |
| 12. | Implementation of previous recommendations. | Conduct study of requirements needed to accomplish recommended applications development and as initial step to completing long range systems and hardware plans. | Immediately. | Agreed. | Requirements study performend by contractor early 1977. | |

ATTACHMENT III

| Problem area | Consultant's recommended action | Timeframes after 1/77 to begin | NSF reaction | NSF action to date | NSF planned action |
|---|---|---|---|---|---|
| B. ADMINISTRATIVE SYSTEMS | | | | | |
| 1. Top management and user involvement lacking in MIS decision-making. | Establish hierarchy of steering committees involving top management and users in MIS system planning, implementation, and review. | Immediately. | Agreed. | Steering committee established 7/77. Directorate task groups established early 1978. | |
| 2. Independent spending by directorates for outside ADP services. | Centralize coordination of all ADP expenditures. | Immediately. | Agreed. | Steering committee approves all ADP expenditures. | |
| 3. Ineffective organization for developing MIS system. | Adopt project management organization structure to encompass all aspects of project. | Immediately. | Disagreed due to lack of resources and current emphasis on system maintenance. | Adopted project management approach in developing software. | |
| 4. Inadequate quality assurance of MIS products and activities. | Establish DIS administrative staff to develop and operate management control programs. | Immediately. | Agreed. | Established Management Controls Branch, 4/77, responsible for establishing and operating management programs in DIS. | No documented plans. |
| C. SYSTEM AND RESOURCE MANAGEMENT PROGRAMS | | | | | |
| 1. ADP strategy reactive to problems. Applications planning informal. Tactical plans unlinked to resource availability. | Develop and maintain long-range MIS plan. | Immediately. | Agreed. | Responsibilities assigned to MIS steering committee and Management Controls Branch. | No documented plans. |



ATTACHMENT III

| | Problem area | Consultant's recommended action | Timeframes after 1/77 to begin | NSF reaction | NSF action to date | NSF planned action |
|---|---|---|---|---|---|---|
| 2. | Ineffective MIS development methodology yielding fragmented systems. | Develop and install system development management program. | Immediately. | Agreed. | Document describing the program tailored to NSF developed by contractor. | No documented plans. |
| 3. | Limited ADP financial planning and budget control. | Develop program budgeting and cost accounting system. | Within 8 months. | Undecided. | None. | No documented plans. |
| 4. | Ineffective determination and control of how well MIS is serving its NSF mission. | Develop an effective performance management program. | Immediate interim effort. Formal program within 8 months. | Undecided. | None. | No documented plans. |
| 5. | Ineffective equipment requirements planning and procurement. | Prepare and continuously update long-range hardware plan as part of long-range MIS plan. Conduct computer program optimization study in support of this. | Immediately. Study within 3 months. | Agreed. | Deferred. Awaiting resources. | No documented plans. |
| 6. | System analyst skills lacking in development process. | Reposition system analysts in the development process. | Immediately. | Disagreed due to lack of resources. | Currently seeking to develop system analyst skills within programmer ranks. | Continue present strategy. |
| 7. | DIS managerial and technical skills needing lengthy upgrade before being capable of development efforts needed immediately. | Establish program to improve skills including installation and operation of recommended management programs as training vehicle. Meanwhile use contractors to provide the expertise to build major recommended applications immediately. | Immediately. | Agreed. | All application development and enhancement contracted out. DIS personnel act as development managers learning from contractors. Formal training courses identified and made available. | Continue present strategy. |

ATTACHMENT III

## ANALYSIS OF DATA PROCESSING COSTS
## FY 1971 - FY 1979

| FY | ADP rentals costs | ADP supplies totals | ADP contracts | ADP equipment | MIS development contractors | Office automation development | Fiscal year |
|---|---|---|---|---|---|---|---|
| FY 1971 | $ 194,042 | $ 36,072 | $ 56,430 | $ 300 | $ 85,000 | $ - | $ 371,844 |
| FY 1972 | 296,375 | 41,013 | 69,136 | 4,990 | 654,000 | - | 1,065,514 |
| FY 1973 | 539,722 | 81,888 | 124,649 | 34,634 | 150,000 | - | 930,893 |
| FY 1974 | 607,458 | 75,462 | 66,415 | 80,878 | 246,000 | - | 1,076,213 |
| FY 1975 | 772,617 | 81,500 | 352,297 | 43,083 | - | - | 1,249,497 |
| FY 1976 | 875,342 | 81,945 | 356,964 | 1,093,492 | - | - | 2,407,743 |
| FY 1977 | 615,998 | 121,927 | 633,142 | 661,863 | - | - | 2,032,930 |
| FY 1978 | 1,023,970 | 98,470 | 456,059 | 412,700 | - | 357,000 | 2,348,199 |
| FY 1979 | 1,422,388 | 110,076 | 920,611 | 1,103,545 | - | 250,000 | 3,806,620 |
| TOTAL | $6,347,912 | $728,353 | $3,035,703 | $3,435,485 | $1,135,000 | $607,000 | $15,289,453 |

## PERSONNEL COSTS

## FY 1976 - FY 1979

| | |
|---|---|
| FY 1976 | $1,219,180 |
| FY 1977 | $1,433,480 |
| FY 1978 | $1,604,237 |
| FY 1979 | $1,787,800 |

Data supplied by the National Science Foundation and not verified by GAO.



ATTACHMENT IV

ATTACHMENT V

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

nsf

OFFICE OF THE
DIRECTOR

June 15, 1979

Mr. Harry S. Havens
Director
Program Analysis Division
U. S. Government Accounting Office
Washington, D.C. 20548

Dear Mr. Havens:

I appreciate the opportunity to comment on your office's proposed report on the National Science Foundation's Management Information System (MIS). We appreciate the importance of a responsive, accurate MIS and are determined to continue improving our system's effectiveness for both the NSF staff and the Congress. Your report will be useful to us as we develop plans for future improvements in this important resource.

However, I am concerned that the report's usefulness may be diminished by the audit team's frequent reliance on anecdotal evidence rather than empirical data. Interviews and questionnaires help assess user satisfaction, of course, but they also can make it difficult for an audit team to distinguish between legitimate system problems and other factors that influence user satisfaction. An example of this effect is the user survey conducted by your audit team. The survey revealed that 82% of the respondents are "satisfied" with the accuracy and reliability of the "Workload Status Report," while only 29% are "satisfied" with the "Proposal Aging Report." In fact, both reports are derived simultaneously from the same integrated data base. Thus, the differences in user perception for these two reports cannot be attributed solely to the quality of our integrated data base. The "Workload Status Report" contains information on all proposals received by the Foundation during the current fiscal year. The "Proposal Aging Report" contains proposals received, less those on which an action has been entered correctly in the MIS. Thus, overall data base errors tend to be concentrated in this report simply as a result of the nature of the report.

(See GAO response in Appendix I, pp. 24, 25.)

These same proposals and errors also are present in the "Workload Status Report" but, because of the larger volume of information present, they are not as easily recognized. Moreover, the aging report is used by top management to ensure the prompt processing of all proposals submitted to the Foundation. The report serves as a valuable tool for identifying "old" proposals and bottlenecks in the proposal processing stream. This use of the report as a management oversight tool may be resented on occasion as an intrusion into the responsibility of program managers, and therefore may be judged more harshly in user attitude surveys than less sensitive reports.
(See GAO response in Appendix I, pp. 24, 25.)
I recognize that the audit team did not have time for an exhaustive study of the NSF system and had to rely on less time-consuming techniques for data gathering. I do believe, however, that this limitation should be acknowledged explicitly in the letter transmitting the report to Congress and in the conclusion of the repoı (See GAO note below.)

I also would like to comment briefly on the report's specific recommendations.

The managers of the NSF system are aware of the importance of system response time as a measure of system reliability. The users of our MIS, as noted in the report, would like a response time of under 5 seconds, and our system management agrees that this is a desirable goal. During the past three years, the Federal Simulation Center (FEDSIM) has conducted two computer performance evaluations at NSF, the latest commencing in January, 1979. A major portion of the most recent study was designed to assess the interaction between our MIS executive and the timesharing subsystem. Controlled tests consisting of adding sequentially up to 75 user terminals were conducted several times to assess the impact on the system, including response time. Response time during these tests was considered by FEDSIM to be in an acceptable range. These quantitative tests, as well as our own recent experience, do not support the implication in the GAO report that only 20 terminals can be concurrently active on the NSF system. The final FEDSIM report will be published in June, 1979 and will provide detailed data on system response capabilities.
(See GAO response in Appendix I, pp. 25, 26, and 27.)

GAO Note: Qualification statement included on page 1 of the letter to the Chairman. Our conclusions are based on our audit work which is qualified.

We intend in the future to conduct computer performance evaluations on a regular basis so that we maintain an optimized system.

Data quality is of continual concern to us, since our MIS is founded on the premise of supplying accurate and timely information to all levels of users. We will initiate a data quality assessment program in the near future. This program will identify problem areas, and also may involve adding controls to individual application software as warranted.

We recognize long range planning as an area needing more attention in the future. We also recognize the need for close coordination of ADP plans with overall NSF plans. Indeed, in order to determine user's needs, an advisory group was established in January, 1979 to assist in bringing user's requirements to the attention of MIS management. This advisory group has recommended the creation of a planning team comprised of computer specialists, user representatives and management. This recommendation is being adopted, and I expect it to lead to greatly improved planning, both for the next fiscal year as well as the longer term.

Performance evaluation is a difficult art. It has rarely been successfully implemented in federal agencies. Nevertheless, we recognize the need to evaluate system performance and assess the costs of meeting user needs. Thus, beginning in July, 1979 we will begin experimenting with a new project management software system. This software tool should help us collect data and produce reports on the costs of data processing and use of our resources. In addition, we plan to implement a computer accounting system. Thus, in the future, cost data should be available for software development, maintenance, and computer time.

Computer security is an important issue, and we have submitted our security plans in response to OMB directives. Moreover, in response to a previous GAO report, we recently appointed a computer security administrator in the office of the Assistant Director for Administration. The administrator is responsible for developing a security plan that will involve users, computer technicians, and

 ATTACHMENT V

internal audit staff. In addition, the NSF Audit Office recently hired a computer specialist who will work on ADP audits. A software certification program also has been established to improve the quality of computer products. This program will define technical documentation standards, and then analyze all software products to ensure compliance with these standards.

Again, I wish to express my appreciation for the efforts of GAO and to assure you that they will assist us in improving the Foundation's computer system. I look forward to seeing the final report.

Sincerely yours,

Richard C. Atkinson
Director

ATTACHMENT VI

AY-088-072-NSF

HONEYWELL 6060 MEASUREMENT
AND EVALUATION STUDY

SEPTEMBER 1979

PREPARED FOR:

NATIONAL SCIENCE FOUNDATION
WASHINGTON, DC 20230

PROJECT PERSONNEL

Capt Gary W. Richard

APPROVED:

RICHARD L. BLAIR
Colonel, USAF
Commander

FEDERAL COMPUTER PERFORMANCE
EVALUATION AND SIMULATION CENTER
WASHINGTON, DC 20330

## PREFACE

This report is based on the analysis of a large volume of data. The results address the measurement of the National Science Foundation's Honeywell 6060 computer system. Because the results depend strongly on the workload and operational environment measured, generalizing the recommendations beyond the system described or extracting conclusions without their respective qualifying conditions is not possible. Questions related to this report or to the possibility of extending the stated conclusions or recommendations should be addressed to the study's author at the Federal Computer Performance Evaluation and Simulation Center (FEDSIM).

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## ABSTRACT

From 12 February to 13 April 1979, the Federal Computer Performance Evaluation and Simulation Center (FEDSIM) conducted a computer performance evaluation study of the Honeywell 6060 computer system operated by the National Science Foundation (NSF). This project report presents the objectives, methodology, findings, conclusions, and recommendations of the study. This Abstract contains the most important conclusions and recommendations based on NSF's (1) workload characteristics, (2) system response, (3) system design, (4) system utilization levels, and (5) operational procedures.

### WORKLOAD CHARACTERISTICS

(1) NSF should establish formal response and turnaround time requirements for system users.

(2) Much batch workload is processed during the day shift when on-line systems are also demanding system resources. NSF should evaluate the requirement for most batch activities to process during the day shift.

(3) Programmers should make more use of system loadable files and libraries to reduce the overhead required to reload programs each time they are used.

(4) The use of BASIC programs on the TSS system should be re-evaluated to see if these programs could be more efficiently coded into loadable TSS subsystems.

### SYSTEM RESPONSE

(1) TSS response times are good. Longer response times experienced by TSS users are a result of non-trivial requests to TSS and problems (disk errors, etc.) that stop TSS from responding to all users.

(2) JASON response times are more a function of JASON user activity (or the interaction of JASON subsystems with the database) that a function of hardware resource availability.

ATTACHMENT VI

SYSTEM DESIGN

(1) NSF should re-evaluate the design of the Office Management System to more closely meet the needs of system users and to reduce the system's load on TSS.

(2) NSF should remove JASON data entry functions from competition with other JASON users to provide data entry personnel with more consistent response.

(3) JASON should be instrumented to provide the necessary information to better evaluate JASON response time and the interaction between user-written JASON subsystems.

SYSTEM UTILIZATION LEVELS

(1) Few additional CPU resources exist during the day shift. However, CPU resources are not considered to be a constraint to system performance because (1) excess CPU resources exist during non-prime processing periods which may be used by jobs now executing during the day shift and (2) response times are generally good or if poor, they are not a direct function of CPU availability.

(2) Memory is almost fully used during the day shift causing some jobs to move in and out of memory repeatedly. However, memory is not considered to be an overall constraint to system performance because excess memory resources exist during non-prime processing periods.

(3) Disk and tape channel utilization are not a constraint to improved system performance.

(4) The Datanet 355 front processor and memory utilization are not constraints to improved system performance.

OPERATIONAL PROCEDURES

(1) NSF should improve the collection and retention of system accounting data. Improved reporting procedures using these data should be implemented to provide NSF management with information to better manage computer resources.

(2) NSF should examine disk configuration, use of NOFMS disk options, and system file placement to improve disk efficiency.

(3) BASIC users should use the "RUN = filename" option whenever possible to reduce the resources required by the BASIC compiler.

(4) NSF should improve communications with system users to (1) notify them of system malfunctions, etc. and (2) provide guidance to improve awareness of how a user's activity impacts response times and system resource use.

ATTACHMENT VI

## E. SUMMARY OF CONCLUSIONS

The following summary of conclusions restate conclusions presented throughout the Findings (Section IV) and contain information based on the methodology, findings, and conclusions of the system loading experiments. FEDSIM suggests that Appendix D be read before proceeding with this Section. Each conclusion is a result of the analysis of NSF's (1) operational procedures, (2) workload characteristics, or (3) system component utilization levels.

1. More accurate accounting data and improved methods for their collection and retention would benefit management and evaluation of the NSF system.

2. Although system scheduling procedures were good, some factors and procedures in the current scheduling design could constrain system performance.

3. System availability was good. The TSS system was available for most of its scheduled periods. However, the JASON on-line system was unavailable to users a greater percentage of the time which intensified JASON workload when the JASON system was available.

4. More detailed information should be collected and reported concerning system, subsystem, and component availability and the reason for periods of unavailability.

5. The Office Automation System does not meet the needs of all divisions that use it. Centralized planning and control for this system does not exist, resulting in operational problems and potential constraints to future system performance.

6. Tape management procedures were generally adequate, but certain occurrences of data losses due to the inadvertent scratching of tapes indicated that some small changes are needed in this area.

7. Most batch activities are executed during day shift processing periods when resource consumption of on-line systems is greatest.

8. Most activities executed require small amounts of processor, memory, and I/O resources.

ATTACHMENT VI

9. Activities requiring two tapes imposed a significantly higher load on the tape subsystem than did activities requesting other amounts of tape drive resources.

10. The number of aborted activities is not a major problem on the H-6060 system. However, almost 6% of processing resources and over 10% of memory resources are lost to aborted activities.

11. Most NSF users load (link-edit) production programs each time they are executed, instead of using load modules (H* or ** files) and production libraries.

12. TSS response loads were moderate. Most NSF users executed TSS subsystems that were fewer than 21K words in size.

13. The largest amount of TSS processor use was consumed by users of the BASIC subsystem. Users compiled programs each time they were used instead of using more efficient processing techniques.

14. Text editor functions of the TSS system are largely used for document processing. The Text Editor subsystem and the RUNY subsystem (under which Office Automation programs were run) accounted for almost 45% of all characters transmitted by the TSS system.

15. Peak demand for system resources by the JASON on-line system and the TSS system occur concurrently.

16. System resources are not a constraint to additional workload during evening, night, and weekend processing periods.

17. CPU resources are almost fully used during day shift processing periods. These levels do not pose a significant constraint to response levels of on-line systems at current user activity levels.

18. Memory resources are almost fully used during day shift processing periods. This level of utilization is not a constraint to system throughput for most batch jobs. However, some jobs exhibit significant swap activity which adds to job elongation and system overhead use of processing and disk resources.

19. Disk channel availability is not a constraint to system performance.

20. Disk controller utilization is not a constraint to system performance.

21. System file placement was not a major constraint to system performance. However, some small changes in the way system files are allocated to disk devices could yield some performance improvements.

22. Seek activity on some JASON disk packs may vary enough to degrade response times of the JASON system.

23. System overhead can be reduced by placing system modules .MFS03 and .MFS09 permanently in memory and implementing SSA Cache Memory to reduce system module loads from disk.

24. Tape channel configuration is not a constraint to system performance.

25. The present tape controller is not a constraint to system performance.

26. The number of tape drives configured on the system is generally adequate for processing the current NSF workload. However, a constant demand exists for additional tape resources. This demand may be reduced somewhat by changes in memory swap rates and job control language procedures to reduce the number of tapes allocated but idle.

27. The Datanet-355 front-end processor is not a constraint to on-line response times.

28. JASON on-line response times, at current activity levels, are more a function of the interaction of JASON procedures than hardware resource availability.

29. TSS response times are good. Comments about slow TSS response seem to be more a factor of the type of function the user is doing than overall TSS performance. Occasions when system processing is interrupted (disk errors, accounting file problems, line problems, etc.) are being interpreted by users as poor TSS or JASON response because these users are not made aware of the occurrance of system problems. Conversely, users experiencing problems are not always making computer operations personnel aware of these problems.

## V. RECOMMENDATIONS

### A. OPERATIONAL PROCEDURES

FEDSIM recommends that the policies and procedures for system accounting be enhanced to provide NSF personnel with better information with which to manage computer and manpower resources. FEDSIM identified three main areas where system accounting could be improved:

a. Accounting for User Activity. FEDSIM recommends that the $IDENT card format be modified and expanded to include detailed information on the submitting agency, project code, test or production status, and type of system (JASON, TSS, or normal batch, etc). Figure V-1 outlines a sample $IDENT card format.

---

```
$ IDENT   AAAAAABBBB/CD/EEEEEE/,FFFFFFFFF,GGG...

      AAAAAA    = Office Identification
      BBBB      = Employee Number
      C         = System Code
                    J=JASON
                    L=TSS
                    B=BATCH, etc.
      D         = Production Code
                    P=Production
                    T=Test
                    S=Special (one time runs, etc.)
      EEEEEE    = Program Identification (JASON MODULE, etc.)
      FFFFFFFFF = Batch Distribution Banner
      GGG...    = Free Field for Remainder of Card
```

---

SAMPLE $ IDENT CARD FORMAT

FIGURE V-1

FEDSIM also recommends that the "ACCOUNT?" question be implemented for TSS users and Fields A through E of Figure V-1 be required of all workload submitted under TSS. The .MGNAT module (system input validity check), the .MSCAN (user scheduling), and .MSCN1 (control card examination) modules should be used in conjunction with each other to cross-reference the office identification, program identification, and user identification of each batch program and TSS user to ensure valid data are being collected by the accounting system. This cross-reference check with the user identification (which is used in conjunction with a password) will provide security for codes used on the $IDENT card yet will not require important data on the $IDENT card to be overlayed and lost for later accounting. FEDSIM recommends that, once enhanced system accounting has been implemented, users and their management be made aware of their own activity levels and resource consumption on a monthly basis. The knowledge gained from monthly reports provides management with the ability to track workload growth, aid capacity planning, identify candidates for program optimization, and "police" the use of accounting codes and parameters.

b. Accounting for System Availability. FEDSIM recommends that the current method of tracking system, TSS, and JASON availability be expanded to include specific times when outages are experienced, to account for component availability (front-end processors, etc.), and to trace the causes for these outages. FEDSIM recommends that NSF personnel design and implement a form (preferably with sequence numbers for accountability) for computer operations personnel to use when problems arise. This form will provide a record of system problems and serve as a tracer for subsequent disposition of problems. Figure V-2 is a sample of the type of form recommended.

Expanded accountability will ensure that each problem is noted and will allow NSF management to commit personnel and computer resources more effectively to solve those problems identified as causing significant inconvenience to users.

FEDSIM also recommends that NSF personnel closely evaluate data provided by test and diagnostic software to trace problems on tape and disk devices and monitor if and when these devices are becoming significant constraints to system performance.

FEDSIM also recommends that information concerning system problems be made available to users so that they may possibly relate their experiences (bad response, bad turnaround, etc.) to system malfunctions.

ATTACHMENT VI

DATE ________ TIME UP ________ TIME DOWN ________

OPERATOR ______________________ LOG NUMBER ______

MAJOR PROBLEM AREA

/_/ H-6060 /_/ D-355 /_/ MCS-30

/_/ DISK ______ /_/ TAPE ______ /_/ MEMORY

/_/ JASON /_/ TSS /_/ ACCOUNTING

/_/ OTHER ______________________________

DISK PACK OR TAPE REEL # ____________________

SYMPTOMS: ______________________________________

________________________________________________

________________________________________________

DUMP? /_/ YES /_/ NO TAPE # __________

PRINTED? /_/ YES /_/ NO

ANALYSIS: ______________________________________

________________________________________________

________________________________________________

DISPOSITION: ___________________________________

________________________________________________

________________________________________________

SAMPLE SYSTEM PROBLEM TRACKING FORM

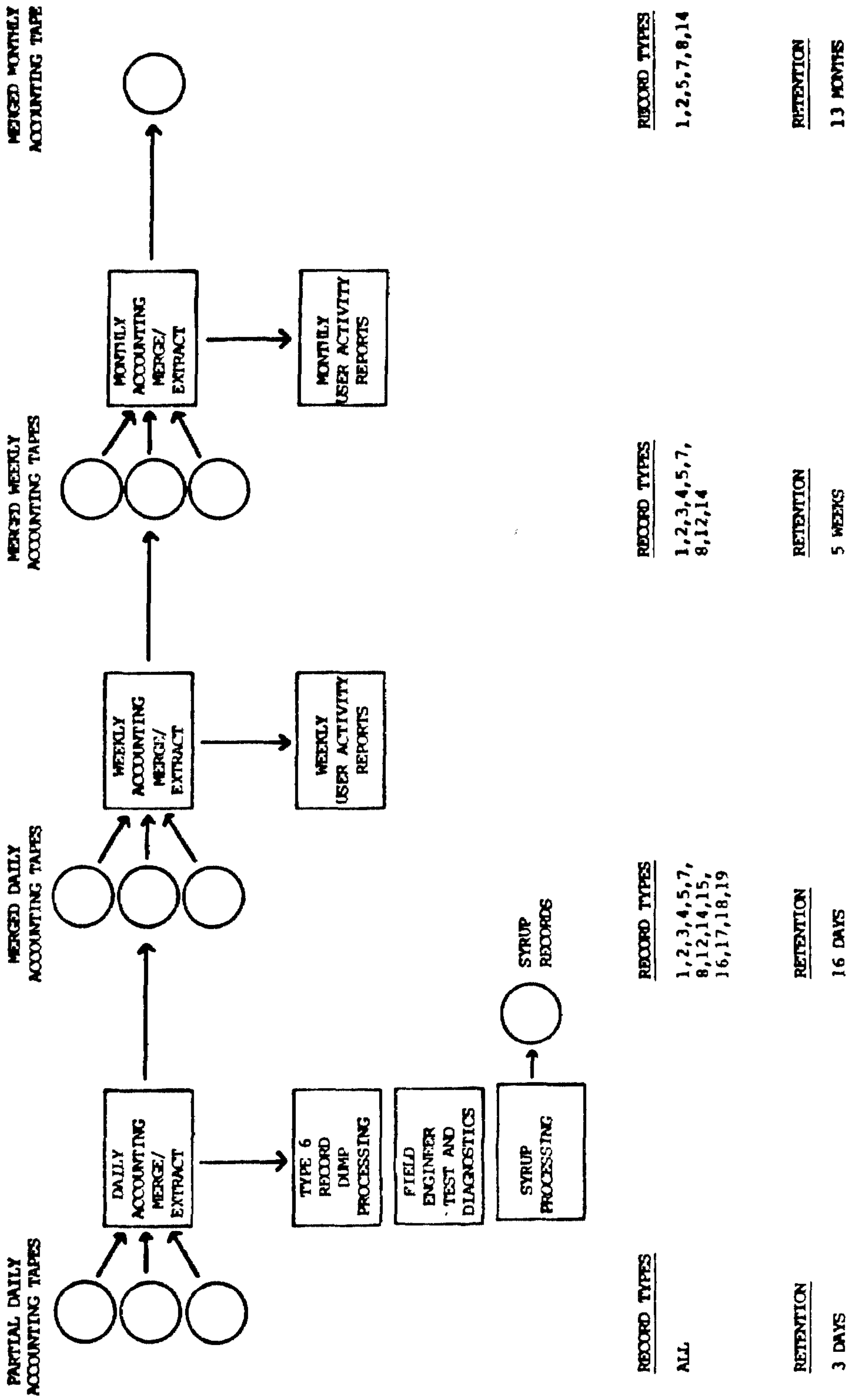
FIGURE V-2

c. Collection and Retention of Accounting Data. FEDSIM recommends that NSF personnel implement a procedure to ensure that accounting data are properly collected and maintained. Table V-1 shows the accounting record types normally produced by GCOS. Figure V-3 presents a sample accounting merge procedure designed to collect and retain accounting data. This procedure will retain certain record types only as long as necessary to meet the information needs of NSF computer operations. For example, accounting records such as Type 6 (system dump records) are important for the analysis of TSS failures, etc., but are not needed for workload purposes. These

| RECORD TYPE | RECORD DESCRIPTION |
|---|---|
| 1 | Activity Accounting Record |
| 2 | SYSOUT Report Writer Accounting Record |
| 3 | I/O Error Accounting Record |
| 4 | TOLTS Statistical Record |
| 5 | System Input Accounting Record |
| 6 | Program Dump or Operator SNAP Accounting Record |
| 7 | Time Sharing System Accounting Record |
| 8 | Activity Accounting Record Overflow |
| 9 | Restart Accounting Record |
| 10 | Transaction Processing System Statistical Record |
| 11 | Reserved |
| 12 | Operator-initiated Record |
| 13 | Reserved |
| 14 | Time Sharing Resource Data Record |
| 15 | File Management Supervisor Accounting Record |
| 16 | FMS Master Function Audit Record |
| 17 | FMS User Function Audit Record |
| 18 | FMS Allocate/Deallocate of Secured File Audit Record |
| 19 | Time Sharing Test and Measurement Record |
| 20-100 | Reserved for GCOS |
| 101-OVER | User-Defined Record Types |

GCOS ACCOUNTING RECORDS

TABLE V-1




SAMPLE ACCOUNTING MERGE/EXTRACT PROCEDURE

FIGURE V-3

records are not merged into the accounting data but are processed at the same time the daily merge is done. Data such as FMS audit records (Types 16, 17, and 18) are merged into daily accounting tapes so that questions concerning file security and access may be answered; yet, these records are deleted by the weekly accounting merge when they are no longer needed. Retention cycles outlined in Figure V-3 are designed to provide adequate backup capability and ensure that data are available to answer ad hoc inquiries for a reasonable time after data have been merged into more generalized formats. The weekly and monthly accounting merge tapes contain only those data needed for user accounting and capacity management functions, thereby condensing the volume of data on these tapes. FEDSIM has provided NSF personnel with an accounting merge/extract program that may be tailored to accomplish this recommendation.

FEDSIM recommends that the current system scheduling philosophy on the NSF computer system be altered to reflect priorities in batch workload and to eliminate possible performance problems.

a. Establishment of Operations Class. FEDSIM recommends that NSF establish an operations scheduler queue for all jobs spawned by computer operations personnel (VIDEO, HEALS, etc.). This class will provide a separate pathway into the system for operations jobs, thus eliminating them from competing with normal batch workload in the system scheduler queues. Also, the operations queue will ensure that jobs required by the operator can become candidates for execution quickly. Disk accounting purge programs should also be scheduled through this queue to ensure their prompt execution.

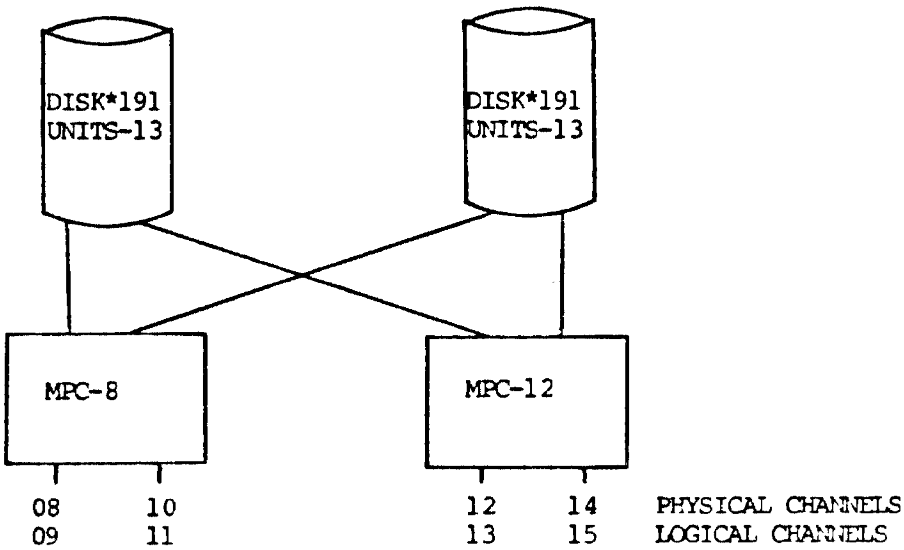
b. Use of JORDER, JCLASS. FEDSIM recommends that system operators alter their procedures for extracting jobs from scheduler queues. The computer operator often used the console verb JSCHED to manually start workload from other scheduler queues. Jobs that required significant amounts of resources were rescheduled into the express queue and occupied program numbers normally reserved for short, quick jobs. FEDSIM recommends that computer operators use the JCLASS console verb to raise and lower the number of jobs allowed from each class. This procedure will ensure that jobs will run from the class to which they were assigned. If it is necessary to run a particular job first, the computer operator should use the JORDER verb to reorder the system scheduler file class before allowing a job to execute from that class.

c. Design of System Scheduler Classes. FEDSIM recommends that NSF personnel modify the system scheduling philosophy to more closely reflect workload characteristics as outlined in the findings section (Section IV) of this report. Those findings have shown that most NSF batch activities were of short duration and required small amounts of memory. Additionally, jobs requesting one tape made little demand on tape channel resources, whereas jobs requesting two tape drives showed significantly more tape channel activity. FEDSIM recommends that a differentiation be made between jobs that request one tape drive and those that request more tape resources.

FEDSIM recommends that the current configuration of the H-6060 be modifed slightly to balance MPC utilization and to reduce the chance of disk errors incapacitating the entire disk subsystem. Currently, all 26 disk drives are defined on Channel 8 of the IOM with Channels 10, 12, and 14 acting as alternate paths to the disk drives. Although this configuration is not a significant performance contraint, GCOS builds one linked list for all I/O activity to disk devices. When disk errors occur, they are linked to the front of this list and constrain I/O activity for all other programs and disk devices. Figure V-4 shows a suggested configuration to reduce this contention. Since most disk activity is evenly balanced, NSF personnel should determine what devices should be on each disk string. One possiblity would be to segregate TSS swap files from JASON removable packs to reduce the possibility that these two on-line systems could conflict with each other if disk errors occurred. The configuration change outlined in Figure V-4 is a logical change to GCOS and does not require hardware modifications.

FEDSIM recommends that the use of the NOFMS option be re-evaluated at NSF. Disk packs DP5 and DP8 were defined to not contain permanent files. Interviews with NSF personnel indicated that this NOFMS option was used to identify more temporary file space for system users. GCOS system loading algorithims do not take NOFMS options into consideration when spreading files among disk devices. The NOFMS option may restrict the number of disk packs available to permanent

ATTACHMENT VI




CONFIGURATION

```
$       IOM-0    PUB-08,DISK*191,UNITS-13...
$       IOM-0    PUB-12,DISK*191,UNITS-13...

$       XBAR     IOM-0,PUB-8,PUB-14,PUB-9,PUB-15
$       XBAR     IOM-0,PUB12,PUB-10,PUB13,PUB-11
```

SAMPLE DISK CONFIGURATION

FIGURE V-4

disk files, thus increasing permanent file contention, but without guaranteeing that space will be effectively used on the NOFMS packs. NSF personnel should evaluate whether a significant number of jobs require the large contiguous disk areas provided by NOFMS packs (for sorting, etc.). If large temporary disk storage areas are needed infrequently, NSF personnel should consider using removable packs for these jobs. If these areas are not needed, the NOFMS options should be removed to further balance permanent and temporary file placement.

FEDSIM recommends that NSF personnel periodically check to ensure that four-way interlacing is being used for memory accesses on the H-6060 computer system. FEDSIM noted that after new hardware had been installed on the system, interlacing had been turned off. FEDSIM has found in various computer studies, including the previous study at NSF, that four-way interlacing makes a significant improvement in the CPU's capability to quickly access memory locations.

FEDSIM recommends that the placement of TSS program and swap files be examined with each software release to ensure that these files reside on separate disk devices.

FEDSIM noted that NSF, because of its relationships with educational institutions, has a rapid turnover of personnel. FEDSIM recommends that seminars concerning the proper use of the system be given to new personnel to ensure that they are cognizant of how their activity will affect system resource consumption and availability. Instruction should include operational procedures, proper use of JASON and/or TSS, reasonable programming standards, and where to seek assistance for programming and/or procedural problems.

FEDSIM noted that NSF operational procedures require a SAVE SINCE of the permanent file system to be run three times a day. This save processing copies to tape all files that have been created or altered since the last SAVE SINCE. FEDSIM regarded this procedure as a possible constraint to on-line performance since, during SAVE processing, the File Management Supervisor (FMS) hash bits are closed for the user master catalog being saved. With only 31 FMS bits, many different USERIDS may use the same hash bit. When these bits are "closed," the ability for users to sign-on to TSS or access files is delayed. FEDSIM recommends that NSF personnel track how often a SAVE SINCE is actually used to restore files and consider SAVE SINCE processing once a day after prime shift processing periods. If additional SAVE SINCE processing is necessary, NSF personnel should evaluate the need to save user files on an individual user basis.

FEDSIM recommends that tape management procedures be modified to reduce the possibility of inadvertent misuse of tape reels. FEDSIM noted that some tape reels were accidentally scratched before their release date, although this is not a major problem. This problem may be reduced by expressing the retention period on the external tape label as a date rather than the number of days in the retention cycle. This change would reduce the possibility of mathematical error when deciding whether or not a tape volume should be scratched. As an additional precaution for JASON journal tapes, a brightly colored label, identifying current JASON journals, could reduce the possibility of inadvertently deleting important JASON data. After the retention period on JASON volumes expires, these colored indicators should be removed before releasing JASON tapes. Additionally, FEDSIM recommends that tapes should be periodically cleaned and recertified. The use rates of tapes may be found from SCF accounting data. Each time a tape is used an entry is created in the activity accounting record. These data may be reduced to record the frequency of use and the user of each tape. Cleaning and recertification of tapes minimizes tape errors.

FEDSIM recommends that NSF management establish a computer management reporting and performance evaluation section. This section should be responsible for (1) the collection and maintenance of accounting and software monitor data and (2) management reporting concerning system use and availability. Additional functions that could be included within this section are JASON data base administration functions and approval of software design of batch and on-line applications. Prior approval of application design will ensure that these applications do not needlessly impact system turnaround, respose times, and the availability of system resources.

FEDSIM noted that NSF management expressed great interest in enhanced information with which to manage personnel and computer resources. Much of this information currently exists in accounting data and software monitor output. Personnel in the management reporting section, with appropriate guidance from NSF management, should use these data to create a management reporting system tailored to NSF needs.

B. WORKLOAD

FEDSIM recommends that NSF personnel establish response and turnaround requirements for production users of the H-6060 computer system. These response and turnaround requirements can be used to measure the performance and capacity of the system and to select certain workloads for execution during non-peak processing periods. Findings indicated that much batch workload ran during the day shift when on-line systems were active. Identification of batch workloads that may be deferred to non-prime processing periods would free day shift processing resources. Findings have shown that the NSF computer system has excess capacity during evening and night shift processing periods to process additional workloads. FEDSIM does not recommend that NSF stop processing batch workloads during the day shift. Findings have shown that peaks and valleys exist in both CPU and memory utilization. Background batch activity serves to "fill in" the valleys in machine utilization, resulting in greater throughput with little or no degredation in response times. Turnaround and response requirements serve to measure the amount and type of batch workload that could be applied during the day shift before degradation occurs. NSF personnel should design day shift system scheduling around the primary philosophy of running priority workloads. Since most workload required small amounts of resources, NSF personnel should only consider scheduling based on resource utilization for activities that require unusual resource requirements. Long-running, low priority workloads that require little operating system support may prove to be better suited to run with on-line systems then many small, short activities that require more operating system activity for scheduling, allocation, and termination.

FEDSIM recommends that the Office Management System be placed under centralized control and be modified to more closely reflect the activity, response, and turnaround requirements of system users. Four main points were identified in interviews with Office Management System users: (1) users were required to group Office Management System input because of limitations imposed on the number of proposals that could be processed by the system, (2) some users were limited in Office Management System applications because the number of reviewers required per proposal was more than that allowed by the system, (3) users were apprehensive about using the Office Management System for a large number of proposals since no restart capability was provided, and (4) most Office Management System users favored the ability to quickly enter and validate proposal and reviewer numbers, but noted that the letter and form output printed by the system was not needed by users until the next day.

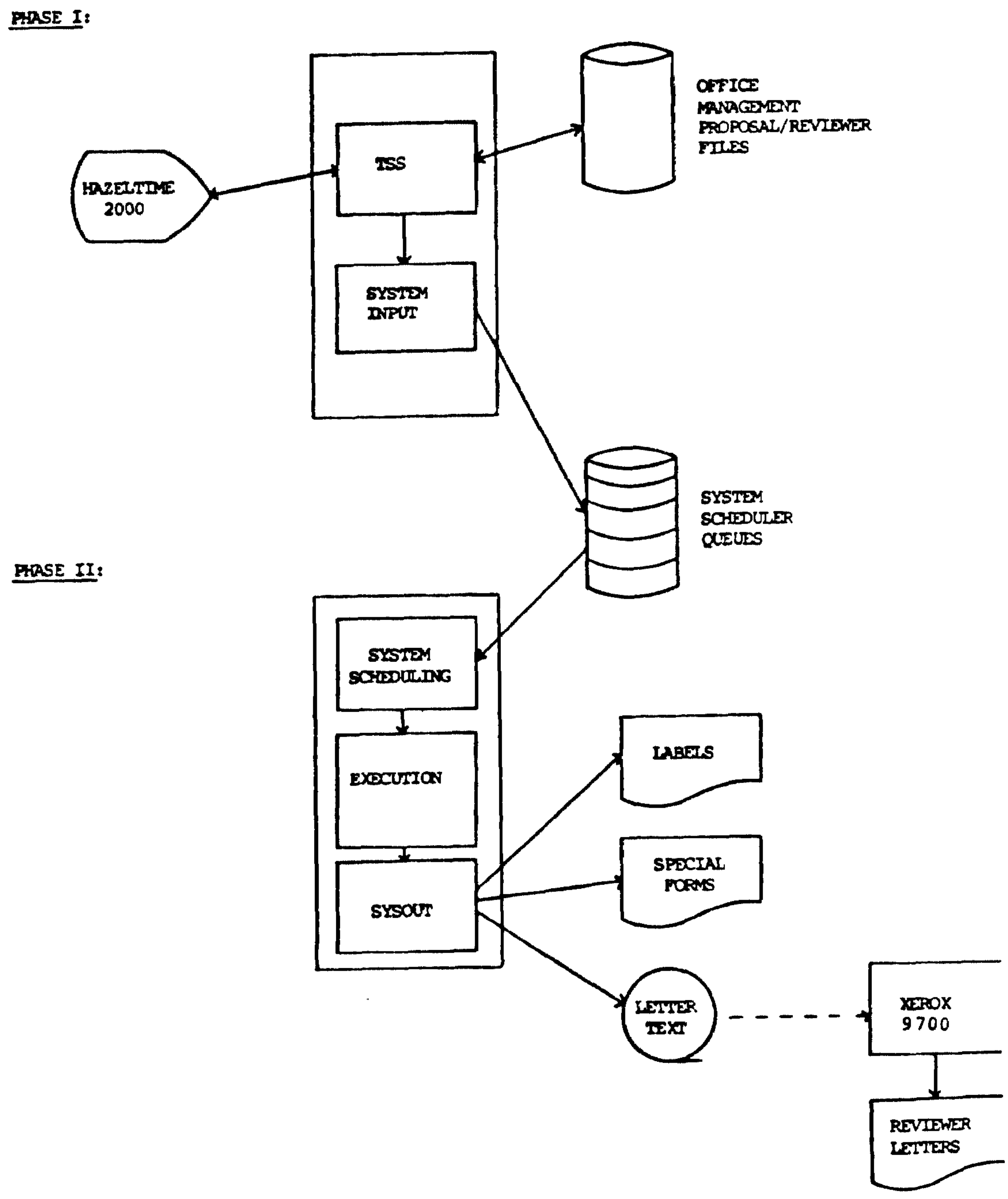
FEDSIM noted from workload findings that the Office Management System also contributed significantly to the number of characters transmitted by the TSS system.

FEDSIM recommends that the Office Management System be redesigned into two subsystems. One subsystem would operate on-line under TSS in much the same way as the present system and would provide on-line entry and validation of proposal numbers and reviewers. The other subsystem would replace the current on-line function of printing large volume output at low-speed terminals with a batch oriented subsystem. This batch subsystem would remove much Office Management System workload from TSS and direct it to high-speed printing devices with full restart capability.

Figure V-5 shows a suggested implementation of the Office Management System. Users interface with a TSS subsystem to enter proposal and reviewer information and direct the type of forms to be produced. This TSS subsystem then generates batch jobs for printing each type of form and notifies the user of the identification of each job. The batch system input program examines these jobs (via .MSCAN and .MSCN1 to identify special $IDENT card identifiers or a special $ FORMS card) and places them on system scheduler queues corresponding to the type of output desired (labels, special forms, etc.).

During non-prime processing periods, the computer operator can mount special printer forms and then run jobs from these special scheduler queues. Alternately, since the Job Control Language for these jobs is pre-determined with the TSS subsystem, output from these programs may be assigned to fictitious terminal identification codes corresponding to the type of output desired. The operator may then (1) redirect output for these station codes to on-line printers for labels and forms and (2) purge reviewer letter output to tape for printing on the XEROX high-speed printer. Under software control, this printer is capable of supplying letterheads, selectable printing fonts, and extremely high-quality output. This design of the Office Management System places responsibility for system output within computer

ATTACHMENT VI




SAMPLE OFFICE MANAGEMENT SYSTEM IMPLEMENTATION

FIGURE V-5

operations instead of with the computer user. Also, this design significantly reduces the printing load on the TSS system. FEDSIM feels that implementation of this recommendation would allow significant increases in Office Management System use, as requested by NSF personnel, without serious response and turnaround degradations to on-line system users.

FEDSIM recommends that batch users maintain production programs on system loadable user libraries instead of on object form. Findings have shown that almost all program executions are accomplished through GELOAD, the system loader. Loading requires extra processing resources each time programs are run to link-edit each program. Additionally, new operating system releases may cause problems with program executions, since a source module compiled under one release (kept in object form) and then link-edited with a system library from a new release may yield unpredictable results. Use of user libraries would also enhance system accounting since the activity identification would not be GELOAD but rather the actual name of the production program. Care in assigning unique production program names could allow the resource use and run frequency of individual programs to be monitored.

FEDSIM recommends that NSF personnel investigate the large number of BASIC programs run under the TSS system. If these programs are used repeatedly, they should be re-coded (e.g., into FORTRAN), and be made into loadable TSS subsystems. Currently, FEDSIM feels that much CPU and I/O time is being used by the TSS system to compile BASIC programs each time they are run. As a minimum, BASIC users should use RUN=filename to save the object module generated from BASIC compilations. Subsequent executions of the program will require only loading.

FEDSIM recommends that NSF personnel investigate the use of word processing equipment in lieu of using the TSS Text Editor for the creation and maintenance of large document files. Text Editor functions such as "Find String," which require character-by-character searches of large data files, impose a significant load on TSS processing and I/O resources. When large data files are edited on the H-6060, FEDSIM recommends that TSS users use "Line" mode to position file pointers close to the page or paragraph to be searched, then use "String" mode to find the required word or phrase.

FEDSIM recommends that NSF personnel examine the possibility of removing large-volume data-entry functions from competing with other JASON users. Although NSF has implemented a form of this recommendation by placing certain data in staging areas within the JASON database, data entry users must still compete for memory, CPU, and I/O resources within the JASON executive. Through user interviews, FEDSIM found that most data are not needed for processing the same day they are entered into the system. FEDSIM recommends that data entry functions be implemented under TSS (requiring little or no change to user interface) and be stored in a non-JASON file for later rapid update of the JASON database after the day shift. The JASON data base would then be available for processing by batch programs later in the evening and for on-line inquiries the following day. Implementation of this recommendation would provide a quicker and more consistent response time for data-entry functions.

FEDSIM recommends that the JASON system be modified to provide better accountability for resources used and system response times. FEDSIM feels that the current information reported by the JASON system concerning user activity (user identification, procedure name, terminal identification, date, start time, and stop time) is an excellent start for tracking JASON activity but should be expanded to include the accumulated processor time, number and type of data base calls, number of terminal characters sent or received, amount of memory used, and, if possible, keywords used within the procedure. The information can be used to identify procedures that use large amounts of system resources for possible re-evaluation and optimization. FEDSIM also recommends that a special accounting record be implemented within JASON to track system response time. This accounting record would be written each time a response request was received by the JASON Executive and each time a response was transmitted back to the user. Figure V-6 presents a sample accounting record format. Since this accountability generates extra overhead, the record should be optional so that it may be turned on or off as needed to trace JASON response. Data reduction software should be written to sort records based on transaction numbers and to determine response time on a transaction-by-transaction basis. Additionally, when response degradations do occur, this record provides detailed data about what transactions were in process at the time of the degradation and can help NSF personnel identify functions that adversely affect JASON response.

ATTACHMENT VI

| | | |
|---|---|---|
| 0 | RECORD LENGTH | RECORD TYPE |
| 1 | DATE | |
| 2 | TIME | |
| 3 | TRANSACTION NUMBER | |
| 4 | ACCOUNT CODE | |
| 5 | PROCEDURE | TERMINAL |
| 6 | USER IDENTIFICATION | |
| 7 | | |
| 8 | KEYWORDS, ETC. | |
| 9 | ACCUMULATED DATA BASE CALLS, RESOURCES, ETC. | |
| 10 | | |

SAMPLE JASON RESPONSE TIME ACCOUNTING RECORD

FIGURE V-6

ATTACHMENT VI

C. EFFECTS OF WORKLOAD ON SYSTEM RESOURCES

FEDSIM recommends that NSF personnel periodically add the MCOUNT patch to the dispatcher to count module loads. Highly used re-entrant modules should be placed in the Hard Core Monitor, thus eliminating large amounts of disk activity. FEDSIM also recommends that the SSA Cache Memory be maintained on the H-6060 computer system to further reduce the need for acquiring system modules from disk.

FEDSIM recommends that the current patches concerning Priority B dispatching be maintained. These patches give the JASON on-line system first priority with a Priority B dispatch interval of 224 milliseconds and TSS second priority with a dispatch interval of 96 milliseconds. FEDSIM noted that, at current user activity levels, JASON response is more a function of the interaction between JASON procedures than of CPU resource availability. System loading experiment #2 showed that overall JASON response could be adversely affected by dispatching parameters. FEDSIM identifies certain changes within the dispatcher that would ensure priority dispatching to JASON when needed. The following patch to the GCOS dispatcher will allow Priority B programs to accumulate more time in Priority B status than is usually allowed through normal system parameter settings:

```
10132  OCTAL  000013735200  ALS  11  .MDISP
```

This patch will reduce the time quantum subtracted from the amount of Priority B dispatch time alloted to Priority B programs. NSF personnel may want to alter the contents of this patch. Each bit shifted left less than 12 bits divides the current quantum used by one-half. This patch will ensure that the JASON on-line system receives adequate Priority B status before relinquishing to non-Priority B programs.

FEDSIM identified that under release 3/I, TSS subsystems are dispatched ahead of Priority B programs. Depending on the savings realized by recommendations concerning TSS subsystem activity, the following patch to the TSS executive can increase the amount of CPU resources available to the JASON system, yet not seriously degrade TSS response:

```
2626  OCTAL  000001000000  1  PROC  SUBDISPATCH  .MTIMS
```

This patch restricts TSS subsystem execution to only one processor instead of allowing TSS subsystems to consume the resources of both processors simultaneously. With some minor differences imposed by system release 3/I, this patch will cause the GCOS dispatcher to allocate processing resources to programs in a similar manner as release 2/H.

These patches were developed for the GCOS 3/I operating system in use at NSF during the measurement study and as such are considered to be correct. NSF personnel should follow good patch implementation procedures when installing these patches. Use of these patches on subsequent operating system releases should be verified by NSF personnel.

FEDSIM recommends that the system trace routine be turned off, except when these traces are necessary to analyze recurring system failures. FEDSIM has found through previous Honeywell studies that running with full trace capability subtracts significant processing resources from user workloads. (Each trace requires an average of 200 microseconds to process.) System traces may be turned on when system problems occur, although examination of the first failure will lack necessary system traces. Alternately, FEDSIM has identified certain traces that are normally used when system problems occur yet result in minimum impact on CPU resources. These trace tapes are 0, 1, 2, 4, 6, 7, 10, 11, 13, 14, 15, 16, 20, 21, 22, 23, 32, 33, 37, 46, 50, 51, 52, 61, 65, 70, 74, and 77.

FEDSIM recommends that the activity during test versions of JASON be monitored to see if the time periods required for JASON testing can be consolidated. Currently, test versions of JASON execute twice daily. FEDSIM observed on numerous occasions that very little activity occured during these test periods, yet the test versions of JASON imposed a significant bottleneck on memory resources, sometimes for periods of over one hour.

Consolidation of test times would make more productive use of test versions of JASON and free significant system resources at other times for normal batch workload.

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