COMPUTER SCIENCE & TECHNOLOGY:

TECHNOLOGY ASSESSMENT: ADP INSTALLATION PERFORMANCE MEASUREMENT AND REPORTING

NBS Special Publication 500-53
U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress on March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau's technical work is performed by the National Measurement Laboratory, the National Engineering Laboratory, and the Institute for Computer Sciences and Technology.

THE NATIONAL MEASUREMENT LABORATORY provides the national system of physical and chemical and materials measurement; coordinates the system with measurement systems of other nations and furnishes essential services leading to accurate and uniform physical and chemical measurement throughout the Nation's scientific community, industry, and commerce; conducts materials research leading to improved methods of measurement, standards, and data on the properties of materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; develops, produces, and distributes Standard Reference Materials; and provides calibration services. The Laboratory consists of the following centers:

Absolute Physical Quantities[2] — Radiation Research — Thermodynamics and Molecular Science — Analytical Chemistry — Materials Science.

THE NATIONAL ENGINEERING LABORATORY provides technology and technical services to the public and private sectors to address national needs and to solve national problems; conducts research in engineering and applied science in support of these efforts; builds and maintains competence in the necessary disciplines required to carry out this research and technical service; develops engineering data and measurement capabilities; provides engineering measurement traceability services; develops test methods and proposes engineering standards and code changes; develops and proposes new engineering practices; and develops and improves mechanisms to transfer results of its research to the ultimate user. The Laboratory consists of the following centers:

Applied Mathematics — Electronics and Electrical Engineering[2] — Mechanical Engineering and Process Technology[2] — Building Technology — Fire Research — Consumer Product Technology — Field Methods.

THE INSTITUTE FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides scientific and technical services to aid Federal agencies in the selection, acquisition, application, and use of computer technology to improve effectiveness and economy in Government operations in accordance with Public Law 89-306 (40 U.S.C. 759), relevant Executive Orders, and other directives; carries out this mission by managing the Federal Information Processing Standards Program, developing Federal ADP standards guidelines, and managing Federal participation in ADP voluntary standardization activities; provides scientific and technological advisory services and assistance to Federal agencies; and provides the technical foundation for computer-related policies of the Federal Government. The Institute consists of the following centers:

Programming Science and Technology — Computer Systems Engineering.

[1]Headquarters and Laboratories at Gaithersburg, MD, unless otherwise noted; mailing address Washington, DC 20234.
[2]Some divisions within the center are located at Boulder, CO 80303.

COMPUTER SCIENCE & TECHNOLOGY:

TECHNOLOGY ASSESSMENT: ADP INSTALLATION PERFORMANCE MEASUREMENT AND REPORTING

Carol B. Wilson

Institute for Computer Sciences and Technology
National Bureau of Standards
Washington, DC 20234

U.S. DEPARTMENT OF COMMERCE, Juanita M. Kreps, Secretary
Luther H. Hodges, Jr., Under Secretary
Jordan J. Baruch, Assistant Secretary for Science and Technology
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, Director

Issued September 1979

Reports on Computer Science and Technology

The National Bureau of Standards has a special responsibility within the Federal Government for computer science and technology activities. The programs of the NBS Institute for Computer Sciences and Technology are designed to provide ADP standards, guidelines, and technical advisory services to improve the effectiveness of computer utilization in the Federal sector, and to perform appropriate research and development efforts as foundation for such activities and programs. This publication series will report these NBS efforts to the Federal computer community as well as to interested specialists in the academic and private sectors. Those wishing to receive notices of publications in this series should complete and return the form at the end of this publication.

National Bureau of Standards Special Publication 500-53
Nat. Bur. Stand. (U.S.) Spec. Publ. 500-53, 37 pages (Sept. 1979)
CODEN: XNBSAV

Library of Congress Catalog Card Number: 79-600154

U.S. GOVERNMENT PRINTING OFFICE
WASHINGTON: 1979

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
Stock No. 003-003-02123-7 Price $2.00
(Add 25 percent additional for other than U.S. mailing)

Technology Assessment:
ADP Installation Performance
Measurement and Reporting

Table of Contents

ACKNOWLEDGMENTS

The author wishes to thank Peter J. Calomeris and Wayne D. Bennett of the National Bureau of Standards for their contributions to this report. Mr. Calomeris performed the literature search, provided copies of all the references used in this report, and prepared the bibliography. Mr. Bennett performed the auditing agency site visits and contributed to the material in Appendix A.

Technology Assessment: ADP Installation Performance Measurement and Reporting

Carol B. Wilson

Abstract

This report compares the current status of ADP installation performance measurement and reporting in the Federal ADP community to the best practices as found in the Federal and private sectors and described in the literature. The comparison reveals that more effort could be expended by the Federal sites in the area of computer performance management. The principal obstacles to more and better performance programs are perceived to be the lack of needed measures on many systems and the magnitude of the effort involved in accessing and analyzing the measures which are available. The report discusses several underlying causes for these obstacles and makes three recommendations which could partially relieve the situation: (1) development of standard performance measures, (2) development of a Government-wide data base for normative performance ranges, and (3) development of statistical computer performance evaluation techniques.

Key words: Computer performance evaluation (CPE); computer performance management (CPM); installation management; installation performance management; performance measurement and reporting; resource management; standard performance measures.

1.0 Introduction

1.1 Overview

The purpose of this report is to examine the current status of ADP installation performance measurement and reporting in the Federal ADP community, to identify and discuss any current inadequacies in practice, and to make recommendations for the correction of those inadequacies. For purposes of this report, an ADP installation is considered to be the complete set of resources dedicated to meeting the automated processing needs of an agency. Typically, the ADP installation consists of the computer hardware itself along with the administrative, systems support, user support, and operational staff.

The major purpose of an ADP installation should be to meet the computing needs of its user population at the least cost. While this goal may be simply stated, the measurement of the degree of success in meeting this goal is a complex problem. Ideally we would like to be able to solve this problem by using precise quantitative measurements that are

objective and free of human biases and intuitive judgments. This is not possible because the performance we are trying to measure depends on complex human behavior and also on the complexities of modern computer system relationships which are not fully understood. In addition, randomly varying workloads, or even cyclical workloads, pose problems in optimizing service and cost.

Further, most of today's ADP installations must meet the demands of a multi-user, multi-application environment. The work handled by the installation is a composite of the computing needs of all of the users; each putting different demands on the installation. Because the demand for resources varies by user, improving the performance of some resources for the benefit of specific users may be at the expense of other users or may even have an overall detrimental effect on installation performance. Hence, the goal of an installation cannot be to provide optimal service to each user but to provide "good" service to all users with respect to organizational goals and priorities. It should be noted that state-of-the-art techniques, n-th generation machines and higher level languages do not necessarily result in a "good" installation but are only important in that they enhance the potential for better productivity, lower cost, or better user service.

To meet the goal of providing good service at the least cost, the installation manager must do capacity planning. Gilmore [GILMM 78-p1] defines capacity as "the workload that a well-tuned system can process without exceeding the limits of [defined by] user performance objectives." Capacity planning can thus be thought of as optimizing the installation resources (e.g., tuning the system) to the user workload at the least cost, for both the short and long terms. To be successful in this function, the ADP manager must undertake several tasks: (1) communicate with upper management, (2) serve and influence the user community, (3) manage his resources, and (4) maintain vendor relations. A Computer Performance Management (CPM) program supports the ADP manager in all of these functions by providing quantitative data for the decision-making process. We will discuss these tasks and how they relate to installation performance by introducing a model below.

1.2 ADP Installation Model

The model below represents a functional view of an ADP installation as seen from the perspective of the ADP installation manager.

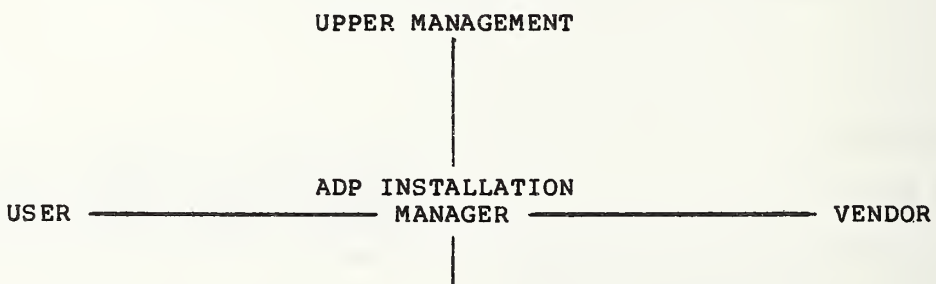

Figure 1: ADP Installation Model

We choose to place the installation manager in the center of the model because he/she controls or influences the factors which contribute to the success or failure of the ADP installation. Although the problems and responsibilities that the ADP manager must face are similar to those encountered by managers in other functional areas in an organization, it is becoming more widely recognized that there are extra dimensions to the control of the ADP installation. The ADP manager must be accountable to upper management for the economic operation of the installation. He is responsible to the users for providing an efficient and effective service. He must oversee the actions and obligations of the vendor. And finally, he must control the resources of his installation. However, the on-rushing technological changes and complexities of the computer field affect the ADP manager's ability to meet these responsibilities. For example, there is rarely a large set of precedents to aid him in making many of the short or long range decisions which often arise. Secondly, staffing is uncertain as new technologies require new skills. Further, the ADP manager is required to assume multiple roles, to manage a multi-million dollar facility upon which the success of many agency programs depends and to remain technically knowledgeable in a rapidly changing technology. And finally, he must also oversee the mundane activities which can so easily degrade installation performance if left unattended.

In Section 2 we briefly discuss each of the four areas of our model by describing the functions an ADP manager must undertake to fulfill his obligations with respect to each area: upper management, users, resources, and vendors. In Section 3 we discuss the current practices in the Federal sector. The discussion notes that few ADP installations fully address the four areas of concern. In particular, the upper management relationship is quite weak. Planning and managing of installation resources has typically digressed to a fire-fighting mode of operation at many sites.

Section 4 discusses possible underlying causes for this lack of good resource management. These causes include current inadequacies with respect to the measurability of computer systems, the lack of well-defined terms for performance and utilization measures, the lack of "good" values for installation performance, and the lack of statistical techniques which have been validated for use in the computer environment and which can be easily used by non-statisticians. The upper management problem is not addressed since its solution lies in the area of management science, not computer science. Section 5 recommends work which could be performed to increase installation performance measurement and reporting: development of standard performance measures, generation of a data base for normative performance, and the development of "cookbooks" for statistical techniques to be used in the evaluation of computer systems. The thrust of the three recommendations which are made is that more effort would be expended by Federal sites in the area of CPM if the task did not require so much personnel time and expertise.

2.0 Installation Performance Management

Before we address the current state of installation performance practices in the Federal sector, we need to establish a basis for discussion. In this section we will describe the best practices as found in the Federal and private sectors and described in the literature. Section 6.0 (Bibliography) contains a list of literature references which were reviewed as part of this study. Each of the four relationships of concern -- upper management, user community, resources, and vendor -- and the corresponding functions will be discussed. These functions should be performed by the ADP manager to ensure that his installation is meeting its goal of providing good service to its users at the least cost. Then, having established this baseline for installation performance practices, we will be able (in Section 3) to compare current practices in the Federal sector with the baseline.

We will restrict our description to the more traditional ADP installation -- centralized batch with timesharing and remote batch. The question of informational needs for networks and other forms of distributed processing is beyond the scope of this report. However, within the best practices as set forth below, we will discuss functions which could be performed by the manager of any size ADP installation whether it is oriented toward data processing or toward research and development. Of course the size of the installation, its position in the organization, and its mission will cause variations in the details in carrying out the functions given below, although most of the tasks are necessary for any ADP installation to be well-managed and operated.

2.1 Upper Management

The ADP installation manager has a responsibility to report to his upper management on the status of requirements, performance, and finances of the ADP installation. It is best that the installation manager report to a person who has sufficient authority to ensure that the ADP installation will receive adequate support for its policies. It is necessary that the installation manager receive this support from upper management for the controls, procedures, and management policies which he establishes at the installation for the assignment of resources to the users. To help him in this task, he should present performance information to upper management that is at a level of abstraction which can be easily digested and understood, but is sufficient to support the upper management decision-making process.

To permit the ADP installation to fully support the goals and objectives of the organization, upper management must make the effort to include the ADP manager in the planning process, to recognize the impact that organizational plans will have on the ADP installation, and to know where the ADP installation fits into the plans. To aid in the planning process, upper management needs to know the costs of various levels of service and their effects on program schedules, personnel levels, and budget. The ADP manager must, therefore, relate the cost of providing service at various levels to the current configuration and, perhaps, to future configurations. The ADP manager should project the load which planned projects will place on installation resources. The ADP manager should encourage management to reconsider committing to ill-conceived or unrealistic ADP projects. If the ADP manager is successful in this task, he can save his installation from much of the busy work which has minimal payoff but which is a constant drain on resources.

The ADP manager should keep his upper management informed about the current operations and the performance of the ADP installation with respect to organizational goals and objectives. That is to say, reports should be concerned with the effectiveness of the installation; i.e., how well the installation is satisfying the user requirements for service. Depending upon the management style of the organization, upper management may be interested in regular reports or may

only be interested in the reporting of exceptions to the expected service levels. The exact content of the reports would also vary with management style but could address the amount of work being done by the various departments and the installation's ability to process the work in a timely manner. Reports should also be presented which are concerned with budget, revenue, actual cost, and financial tracking for the installation. Reports concerning component utilization, etc. are probably inappropriate for upper management, although certainly necessary for proper resource management.

2.2 User Community

The relationship between the ADP manager and the user community is of crucial importance to the success of the installation. The ADP installation exists to serve its users, but it must also influence their behavior if the installation is to be both effective and efficient. The ADP manager's most difficult task probably lies in working with and for the user community. The expertise in a typical user community often ranges from the very naive to the very sophisticated user. But even the most sophisticated users usually have only the vaguest concept of the overall installation operation and the functions which the ADP manager performs. The ADP manager must have rapport with his users and instill in them a sense of mutual cooperation and good will.

There are several general measures of installation performance which involve the user community. They are based upon the acceptance of the computer as reflected in the number of departments using the facility, the use each department makes of it, and how well the computer is accepted as an easy-to-use tool. But these measures only provide a rough estimation of user acceptance and do not indicate user satisfaction with the installation. For example, many departments may use the facility with ease but still not be satisfied with the installation because service is poor. User satisfaction can be one of the best general indicators of installation performance. An iterative plan for ensuring user satisfaction is detailed below. It calls for measuring the current level of user satisfaction, setting service levels, measuring the service, reporting to the users about the success or failure in meeting the service level goals, and taking corrective action for missed goals.

2.2.1 Measuring User Satisfaction

One of the accepted means of ascertaining user satisfaction is to use a well-designed survey. Developing a good survey may be hampered by two facts: (1) satisfaction is related to the user's expectation, which may rise or fall rapidly with the occurrence of a single event, and (2) satisfaction is not a single quantity but a blend of many factors. Hence the survey must allow many factors to be evaluated simultaneously and provide a means of ensuring reliability of the data, but must not be excessively long lest errors be introduced through fatigue. Pearson [PEARS 77] discusses the requirements for a survey designed to measure user satisfaction and the procedures he used to develop a comprehensive thirty-nine factor questionnaire which takes only thirty minutes to complete. He discusses the factors used in his questionnaire and why they are important to computer users.

2.2.2 Setting Service Levels

The typical user is principally concerned about the service he receives in meeting his project deadlines and the consistency of the service. If he is regularly receiving poor service he is little consoled by the fact that everyone else is more fortunate than he. It is unusual for one user to receive consistently poorer service than other users, but it is not unusual for him to remember only the reports that were late, the jobs that did not come back when he wanted them, or the day that time-sharing response was abysmal. With no defined levels of service there is no basis for the ADP manager or the users to judge the installation. Hence, in order to satisfy the users, it is essential that the ADP manager know what the users' service needs really

are. The ADP manager and the user community must together establish service levels for timeliness, availability, accuracy and cost which are acceptable to the users (or classes of users) and which are reasonable to the ADP manager. These service levels then provide one basis for measuring installation performance. Depending on the type of installation and users, the service levels may be categorized by class of job: batch, timesharing, etc.; by class of user: payroll, accounts, etc.; by resource class: requested and used; or by some other category. The categories should reflect the needs of the user community and provide a basis for the installation manager to understand more clearly their needs. Satisfactory performance at each service level is defined in terms of criteria that must be met by a specified percentage of jobs in each class.

2.2.3 Measuring Service

The measurement of service levels depends on both the categories of work and the types of service which the users demand. For example, measures of timeliness for batch jobs could be expressed as the number of jobs on-time (or late), average turnaround time, or average throughput. Measures of timeliness for interactive processing normally include the average times for responses, as well as the consistency of the responses for similar tasks [see FIPS 57]. Availability is measured for the total system, as well as for each subsystem. Reliability encompasses both hardware components and software modules. Finally, revenue data is usually a function of and obtained from the particular chargeback system being used.

Much of the batch service level measurement data may be collected from the accounting logs found on most vendor systems. However, most vendor systems do not provide the necessary data for interactive or remote batch measures. Special hardware devices, or modifications to the system software, may be necessary in these cases. Depending on the definitions of the service measures, manual logging procedures may even be necessary.

2.2.4 Reporting to Users

Many installations overlook the benefits that can be derived from organized reporting to the user community. Proper publicity can help both to accurately report on the service the users are receiving and to influence their behavior. The attitude of the user community toward the computer installation is a determining factor in the effectiveness of the installation. The installation may not be meeting its service level objectives, but may be performing its functions in the best way possible. That is, there are times when the causes of poor performance may actually lie in the practices of the users, and changes in these practices are needed to improve overall installation performance. However, dissatisfied users are often unlikely to be cooperative in making changes which would improve the efficiency and effectiveness of the facility as a whole.

Reports to the user community should indicate how effectively the installation has been meeting the service requirements of the user and what he can expect to receive in the future. Users are generally more interested in the number of reports which are on-time, the batch turnaround time, or the timesharing response time than in CPU utilization or any other measures of hardware performance. Other measures of effectiveness encompass the areas of reruns and aborts, user complaints, and the availability and reliability of the system as seen by the various user groups or classes of jobs. It is important that the definitions of turnaround time, availability, etc. be well-defined, well-understood and mutually acceptable to both the ADP manager and the user community. Examples have been given in the literature showing the wide disparities between how the user perceives (defines) a measure and what is actually measured by the installation (for example, see [STEVD 78]).

The reports to the users should display more than averages since a particular user's job is rarely "the average job." Reports showing distributions for the various measures can

demonstrate to the user what service he can expect to receive most of the time and that occasionally things are not as good as they should be. Of course, the reports may only serve to show him that service is not as good as he would like and that he should alter his expectations accordingly or seek to renegotiate the service levels and/or the cost for service. Reports displaying service measures by class over time can indicate to the user what to expect if he begins a different type of processing or if he changes the characteristics of his jobs. Reports by time of day, time of month, or some other cyclical period may indicate to the user that he may obtain better service by performing his work in the off-peak periods.

The reliability information used in vendor relations, although usually reported to the users in terms of availability, is also useful to the ADP manager in assessing the quality of service he is providing the user community. An unreliable system translates into a system which is unavailable when the user needs it and into a system which causes the user to have to repeat lost work. It is quite possible that an unreliable and sporadically available system causes more user frustration and hostility than a slow one. At least the user knows what to expect from a system giving poor service.

2.2.5 Correcting Poor Service

Poor service may be caused by a true lack of hardware capacity or may be the result of poor utilization of existing resources. Some remedies for poor utilization fall under resource management (see Section 2.3) but others lie in changing the manner in which the user community uses the installation. With respect to the users, increasing capacity may be accomplished by influencing the user community to limit their resource usage through charging practices, by workload management, or by increasing user proficiency. Each of these possible remedies is discussed below.

A method often used by ADP managers to limit resource usage is charging the users for the resources and services they receive. Without some type of fiscal responsibility, the workload at an installation may grow in an uncontrollable manner. Chargeback is more effective when the user of the installation computer and the person paying the bill are very closely associated. In installations where the user has little fiscal responsibility, or the budget cycle does not encourage economy of resources, the chargeback method alone produces little change in user behavior. However, charging users for their jobs is still often quite an effective means of controlling unreasonable requests and preventing uncontrolled growth. The charges should be directly related to the actual resource utilization and should be understandable to the user so that he can control his usage of resources. Further, the charges should be approximately repeatable when the identical job is run again on the system. Cost should be linked to the impact the job has on the installation's performance. The user who chooses resource demanding, high priority processing should be charged accordingly. Perhaps, such a user should be notified what extra cost he is incurring through his current mode of operations as compared to alternate methods, priorities, or times of execution. The chargeback system should provide economic incentives for the users to request only cost effective services.

Workload management is a tool of the ADP manager which is not used often, although it is well known that great gains can be made by eliminating little-needed work. In times of low usage and great capacity at an installation, the problem of resources consumed by non-essential workload is not so crucial. But, as excess capacity begins to dwindle, an audit of the existing workload should be performed and definite steps taken to eliminate unnecessary, and perhaps even marginal, workload from the computer. In reality, the audit of the existing workload for the installation should be an on-going project. Not only can work of limited worth be kept off the machine, but workload statistics can highlight the top users of resources who may then receive training or guidance by the ADP department to enhance their efficiency in using the system.

Another way to reduce resource usage is by upgrading the proficiency of the user community through training programs, meetings, newsletters, technical support, documentation, etc. General areas for improvement can be determined by the examination of processing errors and their causes. If errors are further categorized by application or user, customized approaches can be used for the top offenders. If installation personnel are available, they should work with the users during their planning and design phases to provide guidance to better approaches to the solution. It is often beneficial to optimize the large production programs. Tools and packages exist to aid the installation in this task once problem programs have been identified. It should be noted that it is better and easier to optimize programs during the design phase than after development.

2.3 Resource Management

A systematic approach to resource management requires a non-trivial amount of time, effort, and money but may provide for better operations in a better accepted installation. Efficient operation of the installation is needed if the installation is to operate at least cost. Operational standards need to be set and tracked. Standards for hardware utilization need to be defined, monitored, and corrective action needs to be taken when necessary. Forecasting is required to ensure the continuation of good service in the future. Performance measurement for resource management may begin with observation and simple manual techniques and extend through use of sophisticated software and/or hardware monitors. The size and maturity of the installation should determine the degree of sophistication of the performance measurement program.

2.3.1 Operational Standards

Operational standards and procedures should be defined since without approved standards and procedures there is no basis for performance evaluation in the short term. They also provide the basis for long-range planning needed to meet new service criteria or simply to continue meeting the same service levels in an expanding workload environment. Operational standards might encompass such functions as reading cards, bursting output, handling media, such as mounting tapes, security measures, etc. Procedural standards would define procedures to follow for unscheduled restarts, cold starts, malfunctioning units, etc. These standards and procedures must not be rigid but should be adaptable to technological and environmental changes as they occur. For a rather comprehensive document on the subject, the reader is referred to Standards in Operations [RICKJ 75].

Operational procedures will work only as well as the people performing them. Without well-trained and motivated personnel, the effectiveness of the installation can be seriously degraded. The ADP manager should take steps to ensure that morale is and remains good at his installation. Low morale often leads to sloppy work which will show up as operator errors requiring reruns, delays in bursting output that inhibit meeting timeliness criteria, etc.

In order to compare the actual performance of the operational procedures to the standards, special logging procedures may need to be implemented in order to capture the exact information specified by the service level definitions. For example, the user may require turnaround time for local batch jobs to be defined as counter-to-bin time instead of the more prevalent and easily captured measure of cards-read to lines-printed. Typically in the operations spectrum, work flow studies are performed to measure times and volumes of work in critical areas such as dispatching. Another source of data is time records and the manual logging of events. As in hardware management, such historical data can then be used to set realistic goals and can also be used in planning by comparing future requirements to available personnel hours. Logs of errors and reruns can be studied to detect areas which require further operator training or a modification of software or procedures for easier use by the operators.

2.3.2 Resource Utilization Standards

Utilization measurements make up the primary data used in resource management. Utilization levels by themselves are not a valid measure of installation performance but are important only as they affect installation performance criteria, such as service to the user. High utilization levels may indicate congestion and consequent system degradation, but congestion and degradation are not necessarily related. It should be remembered that utilization levels are not only a function of internal computer system characteristics and configuration but are also strongly influenced by external factors such as scheduling policies, priority processing requirements, etc. The effects that changes in configuration, workload and application, or operating system have on utilization of components and subsystems should be examined for possible causal relationships. Information on such relationships could be used both in analysis and tuning in the operational environment and in the planning process. The inverse process of examining changes in trends of utilization to ascertain changes in the external environment is also helpful in the planning process and for optimizing operational procedures.

Bell [BELLT 75b] introduced the concept of using control limits to help the ADP manager to allocate and plan for computer resources by tracking resource consumption to know when to act and what action to take. Simply stated, a control limit is a value of a variable which should not be consistently exceeded if the installation is to continue to operate efficiently. If the control limit is exceeded some action should be taken to return the variable to its proper range; i.e., the controlled area. Control limits for hardware units and subsystems can be developed by determining the values at which the users begin to complain, by plotting service levels versus component utilizations, etc. Both resource usage and service levels must be tracked to ensure the acceptability of installation performance. When an installation is not meeting a particular service level, there can be many causes. By looking at resource consumption relative to the control limits set to keep service levels under control, the ADP manager can anticipate what corrective action to take and when to take it to ensure continuation of proper service.

Once control limits are set there is a need for a consistent set of management policies for both control limits and service levels. The level of response will not necessarily be the same for all control limit violations but should be commensurate with the significance of the violation. The ADP manager must ensure that enough time is allowed for the evaluation of variances and that corrective action is undertaken when there really is a consistent problem, but that no action is taken for random occurrences. The use of control limits can reduce costs due to excessive capacity and can enhance the ability to consistently provide good service by reducing the need for fire-fighting and hasty subjective judgments.

2.3.3 Forecasting

Forecasting should be done by the ADP manager so that his installation remains responsive as new work is added, the existing workload changes, or when changes in installation configuration could result in less cost. The goals of forecasting are to predict future workloads and their resource consumption; to anticipate problem areas, such as bottlenecks, in time to prevent them from occurring; and to predict performance changes that may result from changes in system configuration and workload. With the long procurement times in the Federal sector and difficulties in enhancing existing systems speedily, forecasting accurately over a several year span is necessary. However, even when the ADP manager can accurately forecast the future workload for his installation, he may be faced with the problem of forecasting in the face of a rapidly changing technology, which may affect the manner of processsing in the future. Examples in recent years include the shift from batch to online processing and the introduction of data base management systems.

The process of forecasting can not be performed by the ADP manager in isolation but must involve the users who are the source of information on the characteristics of new workload, new service requirements, or the expansion or contraction of existing workload. The obvious patterns in workload can be predicted from trend data, but the effect from the introduction of new applications, etc. must also be estimated and such information comes from the user community. The workload must be described in terms which can be understood by the user and can be used as the basis for the user to project his future requirements. But, the user description must also be translatable into terms used by the forecasting technique. The process of forecasting may also involve upper management, particularly if the installation must acquire capacity for future use and, hence, may require an interim subsidy.

The forecasting process begins with the characterization of the current and projected workload. There are many techniques for characterizing workloads which range from simple job stream analysis to determine the average job characteristics to sophisticated clustering algorithms which statistically categorize job classes. The degree to which the workload can be accurately described strongly influences the accuracy of any forecasting done by the ADP manager. However, sometimes the ADP manager needs only rough estimations and the simpler techniques suffice in such instances.

Job stream profiles are typically graphs displaying percentage of jobs versus: CPU time per job, number of tapes per job, elapsed time per job, memory used or required per job, etc. The graphs provide a visual means for the ADP manager to partition his installation's workload. Job stream profiles also provide rough estimations of workload changes and can indicate when the composition of the workload is staying steady. In most installations, whether production or not, the composition of the workload will remain steady for substantial periods of time. Hence, the average job, or jobs, for the installation may be defined by resource consumption characteristics. For example, the average compile-only job may use two seconds of CPU time and require twenty thousand units of memory. These average jobs can be used then as coarse measures of workload when measuring system productivity or doing "ball park" forecasting of workload. Workload statistics of this type can point to growth in specific applications or changes in the workload composition. Continuing workload monitoring can provide data to support benchmarking and simulation work used in the planning process. More sophisticated means of workload characterization -- for example, clustering -- also exist (for example, see [AGRAA 78], [DEVEE 78], [FERRD 72], [MEADR 78]).

The reason for forecasting usually determines the specific techniques which would be used (for example, see [ABERF 78], [AGRAA 78], [CANNR 75], [GILMM 78], [HERNE 76], [MEEHJ 78]). The specific techniques include benchmarking, regression analysis, time series analysis, response surfaces, analytical modelling, operational analysis, and many more. Of course, the workload characterization technique must provide the proper type of data for the forecasting technique being used. Unfortunately, some of the forecasting techniques are difficult to use or are inaccurate. Further clouding the issue is the question of how to forecast user adaptability to future changes in the system. Despite these problems, forecasting at some level of detail and accuracy must still be done.

2.4 Vendor

During the operational phase of the ADP life-cycle, the ADP manager must ensure that the vendor lives up to his obligations under the contract. Furthermore, the manager may need to enlist the vendor's support in the correction of persistent or increasing problems with system failure. The collection and review of concrete reliability data will foster mutual understanding of problems and cooperation between the ADP manager and the vendor in finding solutions. When the ADP manager must rely on supposition

and intuition for his arguments, antagonistic and non-cooperative relationships may evolve with the vendor.

When a system malfunctions, the problem is usually the result of hardware or software malfunction, but finding the culprit is not always a simple matter. The problem is difficult even when the installation has a single vendor supplying both the software and the hardware. In multi-vendor environments, the problem of assigning responsibility for the malfunction is compounded and the need for accurate information on the reliablity of each module or device is necessary for both pinpointing the specific problem and for ensuring solutions to recurring problems.

Information on error rates by device or software module should be collected, as well as information on downtimes for preventive (scheduled) maintenances and the frequency and duration of remedial (unscheduled) maintenance. Displaying this data as trends and peaks can assist the ADP manager in detecting declining performance and in identifying inadequate vendor support areas. Collection of reliability data may also allow the installation manager to make comparisons with installations of similar environment and configuration.

Time lost due to a computer system malfunction translates into loss of availability to the user community. The modularity of many computers today clouds the issue of availability since many systems can continue to operate in degraded mode. For example, the system may operate more slowly when a device is down and similar devices pick up the work for the malfunctioning unit. In other cases, jobs may not be scheduled which require devices for which there are no backup capabilities. Evaluation of availability of such systems can be extremely complex especially in the latter case where the system could be described as being "partially available;" i.e., it is unavailable for the user class requiring the malfunctioning device but available to all other users.

2.5 Summary

The sections above discussed many functions which the ADP manager should perform in fulfilling the goal of providing good service to the users at the least cost. The upper management and user relationships are extremely important to the proper management of the ADP installation. The ADP manager cannot plan well and provide the necessary service unless he has strong relationships in both of these two areas. In an installation where both the users and the ADP installation are under the same upper management structure the ADP manager should be able to exert strong influence on his user community and vice versa. These relationships are vital to the planning process if the needed installation capacity is to be available when new work arrives. When the users' upper management is not the same as that of the ADP installation, the user relationship becomes even more important in the areas of planning and workload management.

To support the ADP manager in performing the tasks for all four functional areas, the CPM program must supply him with the proper information. The data items making up this information come from many sources -- accounting logs, manual logs, financial statements, hardware and software monitors, surveys, etc. A single data item -- for example, CPU time -- may also support several informational needs and be used in multiple ways. Appendix A presents a model depicting the informational needs of the ADP manager. This model was developed by expanding the functions described above into the classes of information needed to support each function.

3.0 Installation Performance Activities in the Federal Sector

The functions described in Section 2 above constitute best practices for managing installation performance. These functions define a baseline for comparison with common practices in the Federal sector. As a result of previous communication with personnel at Federal and private sector ADP installations, attendance at computer performance conferences, and discussions with computer performance consultants, certain hypotheses were formed concerning the current state of installation performance and measurement activities in the Federal and private sectors. In order to verify these hypotheses, site visits were made to nine Federal ADP installations and the various computer performance auditing organizations within the Federal government. At the installations, the discussion included the question of how the installation evaluates itself, what information is used or needed by the ADP manager and, if more performance activities could be done at their site, what prevents them from being attempted. In the interviews with the auditing agencies, the topics of discussion were what types of and how many audit functions they perform, the state of installation performance from their perspective, and what could be done to improve the situation. The views on CPM practices expressed by the Federal ADP performance auditor and the ADP installation managers will be discussed in turn below. The perceptions of the interviewees concerning the reasons why more activity is not present are included in Section 4.

We do not directly address the question of how the Federal sector compares with private industry. The situation with respect to installation performance work appears to be similar in both sectors although the emphasis may be different. For example, the private sector may not have the requirement for competitive procurement or upgrade and, hence, may limit its planning and forecasting to various machine sizes within a single vendor line.

3.1 Auditor Perspective

In order to verify the hypotheses which were made concerning the current state of installation performance activities, it was decided that computer performance audit groups within the Federal government should be interviewed. Each of these agencies does performance audits at many Federal ADP sites each year. Hence, they would be quite knowledgeable about the status of CPM activities. Below we briefly discuss the activities of the agencies which were interviewed and summarize the remarks and points which they made concerning their view of installation performance activities in the Federal government.

Six individuals from all four of the known performance auditing agencies were interviewed. One of the agencies is a true audit agency and the others do performance audits in conjunction with their role as invited advisors on installation performance problems. The first agency, the General Accounting Office (GAO), performs audits to establish how much capacity exists at an installation and how much of that capacity is being used. The major thrust of their effort is to encourage installations to plan more effectively. The other agencies see as their goal the encouragement of good computer management practices at installations. All of these latter agencies are a part of the Department of Defense (DOD), although one serves more than DOD installations.

Each of the agencies had reviewed dozens of sites but from different perspectives. The less experienced agencies concerned themselves primarily with utilization measurements while the more experienced agency had moved from an emphasis on utilization statistics to the need for measurement of user attitudes as a starting point in the performance analysis process.

The problems with installation performance activities which were most often cited during the interviews were: (1) failure to assign personnel and to allocate funds to a CPM program, (2) lack of upper management support, (3) failure of ADP managers to consider service levels and their attainment as one of the primary

measures of installation performance, (4) failure to institute a chargeback system as a means of influencing user behavior, and (5) a general lack of knowledge and training in CPM. Each of these problem areas is discussed in more detail below.

The agencies indicated that one of their primary objectives was to convince the ADP manager that CPM is necessary and useful and that CPM can supply information to support more of his functions than is commonly thought. Few of the sites reviewed by the agencies had comprehensive CPM programs as outlined in Section 2 above. The initial entry into a CPM program was indicated to be the tuning efforts of the installation. The sites mentioned as having good CPM programs tended to use a mix of commercial accounting packages, locally developed monitors, and chargeback systems.

One agency indicated that it rarely found sites where the ADP manager regularly reported to his upper management. And at the sites which did report, the reports themselves were usually not appropriate but were composites or summaries of resource management reports. They pointed out that the lack of reporting to and the observed lack of support by upper management are probably related.

The agencies noted that a difference in installations having good CPM programs and in sites having poor CPM programs could be observed in the attitudes of the installation managers. At the good sites there appeared to be a genuine concern about meeting service levels. Those installations viewed their mission as one of providing service which must be measured and planned for in order to meet realistic levels of service. At other installations, the agencies perceived several reasons for the failure of ADP managers to consider service levels with respect to installation performance: (1) poor user relations or lack of concern for the users by the ADP manager, (2) negative incentives for the ADP manager, (3) lack of appropriate measuring tools, and (4) lack of adequate forecasting tools. In most such sites, poor user relations seem to arise from the lack of both service goals or standards of performance and well-defined user reporting procedures. With no performance goals the ADP manager has no means of evaluating user complaints and with no reporting system the users tend to complain frequently. Eventually the ADP manager begins to believe that his installation is performing poorly and this attitude becomes a negative incentive for establishing a CPM program for fear that it will reflect poorly on his work as a manager. When early attempts at measuring or forecasting are inaccurate, the fear of failing again leads the ADP manager to search for infallible tools. Failing in his search, the ADP manager moves further away from implementing a CPM program that could help him solve perceived installation performance problems.

Chargeback is viewed by the agencies as more than simple cost recovery. They view it as another measure of accountability and a means of controlling user behavior. The key elements were defined to be high visibility among the users -- not just their managers -- coupled with actual low-level fiscal responsibility. Under these circumstances the agencies believed that the users would be encouraged to exercise more care in the development and implementation of programs and would be more likely to demand reasonable service and resource levels. Unfortunately, they reported finding few sites with good chargeback systems.

Lack of knowledge and training had been observed by the agencies with respect to both the user and the ADP installation personnel. On the user side are found users who are not aware of efficient ways to program nor otherwise utilize the full capabilities of the system. Additionally they are rarely aware of the problems of the ADP manager or the demands being made by other users which could affect their own use of the installation. On the installation side are found managers who often lack even a rudimentary knowledge of the CPM process or its benefits. Lacking such knowledge and facing turnovers and training expenses, the ADP manager is hesitant to invest the necessary funds

and personnel in CPM training.

3.2 Installation Perspective

Although the NBS staff is in frequent contact with many Federal ADP installations, it was decided that a formalized interview procedure should be undertaken to ascertain the types of installation performance measurement and reporting procedures which are used in the Federal government. Site visits were conducted to interview nine ADP managers, or the CPM managers if the ADP manager was unavailable, for installations in the greater Washington metropolitan area. The selection criteria was not formal but attempted to include sites from many of the major Federal departments, sites that supported central agency functions, sites that are "field installations," sites that were known to have at least some computer performance program, and sites about which nothing was known concerning their installation performance work.

The sites visited included installations from the Departments of Defense, Agriculture, Commerce, and Health, Education and Welfare. In addition, information from a previously conducted NBS review [CONTD 79] of the U.S. Postal Service CPM program was used. We will not attempt to generalize on the amount of CPM work which is performed at Federal sites throughout the country but will restrict our comments to what we found at these sites. Of the nine sites, three could be characterized as having good, though not complete, programs; one as having a fair CPM program; three as having poor efforts; and two as having their programs in various stages of development and specification, but little implementation.

During the interviews the discussion centered on the four areas of ADP manager responsibility which are given in the model above (Figure 1). The intent was to find out what the installation was currently doing in those areas, what the ADP manager thought they should be doing in those areas, and what types of information he needed to perform his job. It might be of interest to note that the ADP managers of sites with good CPM programs were more aware of the inadequacies in their programs than the managers whose programs were somewhat less than adequate. In fact, during the interviews it was evident that the latter managers were often unaware of other practices or functions which could be performed or the benefits which could result from such practices.

The relation to upper management was found to be the least developed of all the areas. Very few of the sites did any reporting to upper management and only one site presented information which was management oriented. A few other sites sent various types of utilization reports to their management. Often these reports were nothing more than "management reports" produced from commercially-available software packages (for example, accounting log analyzers, software monitors). In fact, these reports would be more appropriately classified as condensed resource management reports. At several sites the ADP manager expressed surprise at our inquiry and even questioned the need for such a relationship with upper management.

The user relationship area was the best developed area and all of the sites had some type of user community liaison effort. The most popular mechanisms were the use of regular, usually monthly, meetings of user groups; user liaison personnel; newsletters; and trouble desks for answering questions. Few of the sites had formal user reporting. The installations with strong user support groups, who believed their function to be user service, seemed to have overcome the problem of user dissatisfaction. In addition, such sites usually had good user training programs. Only one site actually negotiated service levels and charges with their users. Few of the sites had a chargeback system which caused funds to be transferred from the user project to the ADP installation, and those chargeback systems were oriented toward cost recovery with little emphasis on influencing user behavior.

All of the sites did some performance tuning in the area of resource management but many were restricted to one-time, isolated projects. The three sites with good CPM programs all kept historical data for trends and analysis and to help them in setting control limits. One of these three, however, was prohibited from openly setting control limits for fear that the installation's performance would become more visible. The other six sites appeared not to use control limits but the ADP managers were satisfied with a fire-fighting mode of operation. Workload statistics were commonly reported to the users in addition to some information in terms of responsiveness and availability. Capacity planning and forecasting were a rare occurrence and, when attempted at all, were usually restricted to projections based on the utilization of one component -- normally the CPU.

In the area of vendor relations the sites varied according to the formality of the arrangement but all did some tracking of equipment reliability. Several sites used commercially-available packages to track the performance of their equipment versus other sites with the same equipment. Most of those sites believed that such information gave them more leverage with the vendor. Most of the sites used their trouble reports in a fire-fighting mode -- if a problem seemed to persist, the ADP manager went to the files and looked back through the paper console logs and trouble forms for any trends. One site had its own automated system which it ran regularly to try to detect any equipment which might be degrading and to use this information in its dealings with its vendors.

3.3 Summary

None of the findings of the interviews were surprising, although they tended to confirm previous hypotheses concerning the quantity and quality of installation performance work being done in the Federal government. There is a general lack of CPM programs in the Federal sector. At the sites doing any performance work, the important upper management path is quite weak while the strength usually lies in the user community relationship, although this area could also be enhanced with better reporting practices. Dealing with the vendors was the most uniform across sites while the amount of resource management performed varied the most between sites.

As is noted above, it does not appear that the Federal government practices are any better or worse than would be found in the private sector. However, there would appear to be ample room for improvement in all of the four areas described in Section 2 above. In Section 4 we will discuss possible underlying causes for these inadequacies.

4.0 Current Inadequacies in Installation Performance Practices

How do the current practices in the Federal government compare to state-of-the-art possibilities? In Section 2 above we discussed a number of functions which could be performed by an ADP manager in relating to his upper management, to users, and to vendors and in managing his installation resources. Section 3 outlined the practices at a small number of Federal sites which were visited and the collaborating views expressed by personnel in several Federal computer performance auditing agencies. The site visits and the interviews confirmed the hypotheses which had been made concerning current practices. A gap exists between what is practiced and what could be done. In particular, the upper management relation rarely exists; fire-fighting is the prevalent mode of operation instead of managed performance; little user reporting is done; and very few sites negotiate service levels.

This lack of well-developed and widely-used CPM programs is the result of the magnitude of the effort currently required to have a CPM program at an installation. This conclusion is supported by the literature, by conversations with computer performance conference attendees, by observation, and by remarks made during the site visits. CPM programs can require substantial personnel time to develop and operate. The nature of the work further requires that the personnel who do the work be experienced and quite knowledgeable about the system being measured. In this section we will discuss several possible underlying reasons for the stringent requirements of installation performance activities: (1) lack of measurability, (2) lack of well-defined terms, (3) lack of "good" values, and (4) lack of statistical Computer Performance Evaluation (CPE) techniques. Section 5 will outline a few initial steps which could be undertaken to alleviate some of these problems.

4.1 Lack of Measurability

Before the ADP manager can manage the performance of his installation, he must have access to certain information. Unfortunately, most of the computer systems in use today were not designed to be measured and do not supply all of the needed information. The common measures which are provided by most vendors were originally for accounting purposes and not performance management. Additionally, most vendors supply only a small fraction of the information needed by the ADP manager in ensuring good installation performance.

Many of the measures needed in the performance area are not readily accessible but are buried in the system. Hardware and software monitors are necessary to retrieve the needed information but the monitors themselves may cause degradation of system performance. All software monitors consume resources to a greater or lesser degree depending upon the architecture of the system and its operating system. In addition, the use of hardware monitors requires specialized expertise.

Even when installations go to the expense and time of installing monitors, measurement is not ensured. Some measurements are prohibitively expensive with respect to the substantial computer resources consumed during the measurement, data collection, and analysis process. Other measurements are not possible without substantial system alterations and may still consume many computer resources when put in place.

From observation and from the interviews, it would appear that the lack of measurability contributes greatly to the lack of performance programs at Federal ADP installations. Many of the measures are not directly provided by the vendors and collecting and analyzing measurement data require the time and effort of a highly trained staff. Many installations cannot afford the drain on their resources which would be required for an installation performance program. Designing system hardware and software with performance measurement in mind and providing easy access to the data

would reduce the effort required to do performance management at individual installations.

4.2 Lack of Well-Defined Terms

Stevens [STEVB75b-p1] summed up the terminology problem in the performance area when he stated:

> As an industry we suffer from a complete absence of both standard units of measure and standard metrics. With standard units we could make direct comparisons among equipment types available to service the same workload, and identify the precise configuration having the absolute minimum amount of capacity necessary to do the job. ... Failing that, we could utilize standard metrics to at least describe to each other the selection and evaluation processes we use to assure ourselves that we are producing the best possible result.

The lack of commonality of well-defined terms hinders communication between practitioners. The computer performance field is one of the few "professional fields" which lacks standard nomenclature and, as a result, has probably not progressed as rapidly as it might have. It is not that the various systems collect vastly different information which prevents the sharing of ideas and techniques. The problem lies in the fact that although different vendor systems collect essentially the same basic set of data, they mean slightly different things and are recorded in different formats. Hence, there is little completely common ground.

Further compounding the problem, is the lack of common names for the same measures. Some measures from system A may be identical to those on system B, although different names are used. A performance problem on system A may be identical to a performance problem on system B which has been solved on system A. But, the analysts on system B do not recognize that the problems are the same because the terms are different. Hence, they can not avail themselves of an approach to the solution or the solution itself.

The two problems -- measuring different things and measuring the same thing but naming it differently -- combine to force much of the development work in CPM to be repeated at each installation. The lack of well-defined and common terms seriously limits the ability of small installations with limited resources and installations new to CPM to use an established base of techniques, problem approaches, and solutions developed by other sites and verified by repeated use. As a consequence, many sites do not use CPM to as great a degree as they could or they do not start up any program at all. The establishment of common and well-defined measures used in installation performance work would also allow greater communication among installations working on various performance problems. Common terminology would allow work to begin toward establishing standards of "good" performance and ranges of normative values for operating levels.

4.3 Lack of "Good" Values

One of the difficulties of an ADP manager is knowing what constitutes "good" performance. When a system is meeting its service goals and no problems are visible in its operation, how can the ADP manager know if his system is well-tuned? Before this question is summarily dismissed as not being germane to installation performance, the following should be considered. An installation may be operating close to its performance levels but still have capacity to process additional work. When new work is presented to an installation, the ADP manager needs to know whether sufficient excess capacity exists in his system to accommodate the new work through a performance enhancement effort instead of an upgrade or procurement. Such delays of upgrades or procurements could save the installation money. The arguments that the upgrade would be cheaper than the performance enhancement effort (since hardware is cheaper than personnel) indeed have merit in an environment

where procurements or upgrades are easily justified and do not take long periods of time. However, such an environment is rarely found in the Federal sector.

Hence, the ability to compare installations (i.e., to determine if a particular system is well-tuned) could be beneficial in the Federal ADP environment. The lack of industry-wide standards of "good" performance even prohibit the comparison of performance levels among installations with like configurations and workload. Such standards could provide a starting point for setting goals for a particular installation and provide a basis for the ADP manager to compare the performance of his installation with respect to a large number of other "similar" installations. Such normative values could assist the ADP manager in assessing how well his system is operating and how much capacity could be obtained for new work coming to his installation. Furthermore, the installations which are just starting performance programs would have a baseline for setting initial performance goals.

4.4 Lack of Statistical CPE Techniques

It would be of benefit to the ADP manager if he had a means of determining what effects various components of the system and workload have on the service that his installation is providing. How does one bridge the gap between measures of effectiveness in meeting service goals and efficiency measures in resource management? How does the performance of certain hardware components affect service levels? The ability to correlate the effects of computer configuration, operating system parameters, etc. with the attainment of user service requirements has not been fully studied because of the complexity of the interrelationships and also because of the general shortage of data which would help in the evaluation. Instead of bridging the gap, the ADP manager often picks one goal by deciding what is more important to him -- for the computer to run efficiently or for the computer to serve its users by meeting their goals. Since efficiency is often easier to attain than effectiveness, the emphasis has been historically on efficiency. However, efficiency of the system may not produce the service desired by the users. In recent years, more emphasis has been placed on user service level definition and attainment. But, little work has been done in bridging the gap between the two alternatives and little work has been done on statistical techniques for either area.

There are many reasons for specific CPE studies but they all have a common goal: to improve the performance of the installation. This goal may be accomplished by making the system more responsive to the user requirements, or by reducing the cost while maintaining the same service levels, or both. The problems studied may be simple with simple solutions or may be extremely complex involving workload characteristics and their effects on a system which has many interdependencies and interrelationships. Simple problems may be attacked by simple graphical methods while others may require more rigorous and precise techniques. The latter studies, however, are often done without the rigor and preciseness which comes with statistically based techniques. Instead the "eyeball" approach is used where practitioners subjectively decide whether differences in a measure are significant when a change was made or whether a change actually had the desired effect. Furthermore, with a non-statistical approach nothing can be said about how much confidence may be placed in the conclusions.

There are two basic approaches to analyzing CPE data: graphical and mathematical. Graphical techniques are quite straightforward and provide a visual means of detecting patterns and trends. Graphical techniques include scatter plots for detecting possible relationships, plots of time versus service and resource measurement on the same graph for correlations or maximums, and plots for trend analysis. Graphs will often indicate where experimental studies should be performed by visually pointing to possible causal relationships between

system and service variables over time. There are many mathematical techniques which are applied to CPE: correlation analysis, cluster analysis, multiple regression, analytical models, operational analysis, curve fitting, time series analysis, and response surfaces. Currently there are several problems with using any of these techniques.

The major problem is that these techniques are usually based on underlying assumptions and the exact nature -- statistical or otherwise -- of computer systems and workloads is not well understood. For example, regression analysis assumes a linear relationship between the dependent variable and the independent variables, equal variances, and an assumption that the independent variables are additive. These properties, however, have not been totally verified in the general computer system environment. A second problem is that future performance is often of interest. Modelling techniques are the most often used methods for predicting performance in growth situations where the predicted values may exceed the current operating levels. But analytical modelling has very stringent assumptions and is still fairly limited in modelling the true complexity of modern computer systems. The most stringent assumptions for analytical modelling are removed by operational analysis techniques but many of the queueing parameters needed are currently unavailable from most operating systems. The techniques discussed above are not exhaustive but are described to illustrate the difficulties and problems associated with the application of statistical analysis to CPE.

With all of the problems associated with good CPE studies, it is no wonder that so little work is being done at installations. The more complex techniques are statistically based and often not understood or known by the typical analyst. Little study has been done to assess the nature of the computer environment vis-a-vis the statistical techniques being used today. Furthermore, "cookbooks" of procedures have not been developed for the non-statistician analyst.

5.0 Proposed Remedial Work

The previous section discussed four areas which were seen as inhibiting more wide-spread use of installation performance programs. The inadequacies increase the effort needed to develop and operate computer performance management programs at individual ADP installations. If these inadequacies could be somewhat relieved, less installation personnel and fiscal resources would be required for a CPM program. Thus the use of performance programs in the Federal sector might increase and the benefits from such programs could be realized. In this section, we will discuss some remedial work which could be started to alleviate at least partially the problems mentioned above: lack of measurability, lack of well-defined terms, lack of "good" values, and lack of statistical CPE techniques. The proposed remedies involve the development of standard performance measures, development of a data base of normative standards for performance, and development of statistical techniques to be used in the CPE area.

5.1 Standard Performance Measures

Work should be undertaken to develop a list of standard performance measures and definitions for these measures. The list of metrics should satisfy a minimal set of informational requirements of the ADP manager in assessing installation performance and should be vendor independent.

Since the establishment of a set of performance metrics does not ensure their accessibility, standard reporting formats should also be developed. Depending upon the type and use of the data item, the format might take the form of a record on a file or, maybe, a special hardware register which could be monitored. Most measures which are needed by the ADP manager could probably be written to a special file whose format would be standard across vendor lines. However, there are some types of data which are needed but which would cause an excessive drain on the system if collected in that way. For these measures, an alternate method of capturing and recording would need to be specified which would also be common across vendor lines.

The metrics should be grouped according to purpose and use. There are two reasons for considering multiple groups. First, some measures do not warrant continuous monitoring and collection but are needed for specialized studies. The overhead in collecting some measurements is higher than for others and the installation may not be able to tolerate the drain on resources. Second, depending on the sophistication and needs of a particular installation, not all measures would be of interest to all installations. Thus, the use of multiple groups would allow the installation to tailor the collection of performance data to its own needs.

5.2 Data Base for Normative Performance

Work should be instituted to determine the feasibility of developing a Government-wide data base which would contain measures of installation performance classified by type of installation (configuration) and type of workload. The measures would have to be quantitative if automatic comparison of performance is to be made across installation types and workloads. The problems associated with quantitatively describing workloads, installation configurations, and organizational objectives have not yet been solved. Without such quantitative descriptions, the utility of the data base would be somewhat limited. Some types of measures like hardware reliability, for example, are readily quantifiable and normative values would be useful. By examining averages and ranges using the performance data in the data base, optimum values or ranges could be established which would provide the basis for setting individual ADP installation performance goals. These values would be based on a large number of installations and would therefore provide an additional means for the ADP manager to assess his installation's performance.

Of course, if such a system is to be workable it must help the ADP installations and require little in return. It must have a well-designed collection mechanism which would not place a large burden on the individual installations. The system must also ensure the proper feedback of information to the ADP installations. Last, if the data is to be useful, it must be accurate. It is anticipated that installations which perceive such a data base as a threat will not provide accurate data and the establishment of normative data values will fail. Hence, the system must be designed to eliminate, or at least reduce, the possibility that the information supplied by the individual installations might be used against them.

5.3 Development of Statistical CPE Techniques

Work should be started to develop and validate techniques for bridging the gap between measures of effectiveness and resource consumption measures. The environment of the computer installation and its interrelationships need to be studied to determine which techniques used in other control environments (such as production lines) are applicable to the computer performance area. When such techniques have been validated for use in the computer environment, guides need to be prepared for the non-statistician analyst in terms that he can relate to and understand.

Work should be continued to develop techniques to model computer systems, workloads, and service levels. Such work is needed to help the ADP manager in forecasting his future work and the ability of his installation to handle increased or different workloads. Techniques and tools are needed which are relatively easy to use and which use data which is available to the installation.

5.4 Summmary

We believe that many Federal ADP installations perform little or no work in installation performance because they lack the expertise in their staff or the staff is not large enough to spend the required time and because there can be rather substantial costs involved. The benefits from the three proposals above come about largely because of their potential for reducing the effort to implement installation performance programs. The standardization of performance measures and their reporting format would allow greater communication between installation practitioners and could result in better solutions to common problems being developed in shorter time periods. The approaches to solutions would be more widely known and available. Further, the standardization of the reporting format would allow greater portability of packages and programs which are currently rather expensive to develop both in terms of time and money. The benefits of performance programs vary from installation to installation, but no benefits can be realized if no such activity is being done. By reducing the effort to start and participate in performance programs at installations, it is hoped that more ADP managers will be willing to institute such programs at their sites.

6.0 Bibliography

[ABERF 78] Abernathy, Frances S. Communicating Capacity Plans to Management. Wright, Linda S.;Buzen, Jeffery P., eds. Proceedings of CMG IX International Conference on Management and Evaluation of Computer Performance; 1978 December 5-8: San Francisco, California. c1978. Bethesda, Maryland; Computer Measurement Group, Inc.: 17-34.

[AGRAA 78] Agrawala, A.K. and Mohr, J.M. Predicting the Workload of a Computer System. AFIPS Conference Proceedings; 1978 National Computer Conference (NCC); 1978 June 5-8: Anaheim, California. Montvale, New Jersey: AFIPS Press; c1978: [v47]: 465-471.

[ANDEH 75] Anderson, H.A.,Jr., Reiser, M. and Galati, G.L. Tuning a Virtual Storage System. IBM Systems Journal. 1975; 14(3): 246-263.

[AXELC 79] Axelrod, C. Warren. How Effective Is Your Computer?. Infosystems. 1979 February; 26(2): 50,52-53.

[BATTV 72] Battaglia, Vincent J. Cutting Computer Costs. Financial Executive. 1972 August: no data (n.d.): 26-30.

[BAZEM 77] Bazewicz, Mieczyslaw and Petersiel, Adam. Use of Modelling in Performance Evaluation of Computer Systems -- A Case of Installations in the Technical University of Wroclaw. Performance Evaluation Review. 1977 Fall; 6(4): 22-26.

[BELLT 72] Bell, T.E., Boehm, B.W. and Watson, R.A. Framework and Initial Phases for Computer Performance Improvement. AFIPS Conference Proceedings (FJCC); 1972 Fall Joint Computer Conference ; 1972 December 5-7. Montvale, New Jersey: AFIPS Press; c1972: [v41 part 2]: 1141-1154.

[BELLT 73] Bell, T.E., Boehm, B.W. and Watson, R.A. How to Get Started on Performance Improvement. Computer Decisions. 1973 March; 5(3): 30-34.

[BELLT 75a] Bell, Thomas E. Set Limits to Control Performance Measurement. Computer Decisions. 1975 September; 7(9): 35-38.

[BELLT 75b] Bell, Thomas E. Managing Computer Performance with Control Limits. Proceedings of the Ninth, Tenth, and Eleventh Meetings of the Computer Performance Evaluation Users Group (CPEUG); 1974 May 21-23; Atlantic, Georgia; 1974 October 23-25; Columbus, Ohio; 1975 September 23-26; Oklahoma City, Oklahoma. Springfield, Virginia: NTIS; PB 252-174: 169-172.

[BELLT 76] Bell, Thomas E. Computer Performance Management Through Control Limits. Transactions of the CMG. 1976 March. 11: 3-2 to 3-5.

[BEMER 73] Bemer, R.W. Standards in Performance Evaluation & Measurement. Computer Performance Evaluation: Report of the 1973 NBS/ACM Workshop. 1973 March 27-30: San Diego, California. NBS SP 406 (Issued August 1975):141-149.

[BENTT 76] Bentley, Trevor John. Defining Management's Information Needs. AFIPS Conference Proceedings; 1976 National Computer Conference (NCC); 1976 June 7-10; New York City, New York. Montvale, New Jersey: AFIPS Press; c1976: [v45]: 869-876.

[BROTD 75] Brotherton, Dale E. and Harder, Donald C. Computer Performance Measurement. Data Management. 1975 January; 13(1): 12-15.

[BROWS 77] Brown, Shellman H.,Jr. EDP Capacity Management. Proceedings of the 1977 SIGMETRICS/ CMG VIII; Conference on Computer Performance: Modelling, Measurement, and Management; 1977 November 29 to December 2: Washington, D.C.. New York City, New York: ACM Order Dept. Camp Springs, Maryland; Computer Measurement Group, Inc.: 301-305.

[BUZEJ 78] Buzen, J.P., Goldberg, R.P., Langer, A.M., Lentz, E., Schwenk, H.S., Sheetz, D.A. and Shum, A.. BEST/1 - Design of a Tool for Computer System Capacity Planning. AFIPS Conference Proceedings; 1978 NCC; 1978 June 5-8; Anaheim, California. Montvale, New Jersey: AFIPS Press; c1978: [v47]: 447-455.

[CICA 70] The Canadian Institute of Chartered Accountants. Computer Control Guidelines. c1970; The Canadian Institute of Chartered Accountants; Toronto, Canada: 135p.

[CANNR 75] Canning, Richard G. (editor). Do We Have the Right Resources?. EDP Analyzer. 1975 July; 13(7): 12p.

[CHANJ 76] Chandler, John S., and DeLutis, Dr. Thomas G. A Methodology for the Performance Evaluation of Information Systems under Multiple Criteria. CMG VII Proceedings of the Seventh International Conference of the Computer Measurement Group, Inc.; 1976 November 16-19: Atlanta, Georgia. Camp Springs, Maryland; Computer Measurement Group, Inc.: 221-229.

[CHANJ 77] Chandler, John S., and DeLutis, Thomas G. A Methodology for Multi-Criteria Information System Design. AFIPS Conference Proceedings; 1977 NCC; 1977 June 13-16: Dallas, Texas. Montvale, New Jersey: AFIPS Press; c1977: [v46] : 895-905.

[CHASD 73] Chastain, Dennis R. Guidelines for Planning and Organizing a Performance Improvement Project. Proceedings of ACM 73: Annual Conference of the Association for Computing Machinery; 1973 August; Atlanta, Georgia. New York City, New York: ACM Order Dept.; c1973: 332-335.

[CONTD 79] Conti, Dennis M. Review of the U.S. Postal Service Computer Performance Management (CPM) Program: Task II Final Report. Washington, D.C.: MIS-USPS; 1979 July 30. Washington,D.C.: Center for Programming Science and Technology, ICST, NBS. 35p.

[DEARJ 73] Dearden, John, and Nolan, Richard L. How to Control the Computer Resource. Harvard Business Review. 1973 November/December; 5(6): 68-78.

[DEVEE 78] Deventer, E. N. van, and Roode, J. D. Computer Resource Performance Management - A Total Data Centre Approach. Wright, Linda S., and Buzen, Jeffrey P.,eds. Proceedings of the CMG IX International Conference on Management and Evaluation of Computer Performance; 1978 December 4-8; San Francisco, California. c1978. Bethesda, Maryland; Computer Measurement Group, Inc.: 67-79.

[DIEBG 74] Diebold Group, Inc. Computer Performance Appraisal - A Top Priority for Top Management. Automatic Data Processing Newsletter; 1974 December 9; XVIII(25): 4p.

[DIESJ 79] Diesem, John L. Data Centers Need Fair Management. Computerworld. 1979 March 12; XIII(11): 59 & 62.

[DODSP 74] Dodson, Philip O. Control Data Corporation's Cyber 70: Procedures for Performance Evaluation. 1974 May. Springfield, Virginia: NTIS; AD 785129: 104p.

[DRUMM 69] Drummond, M.E., Jr. A Perspective on System Performance Evaluation. IBM Systems Journal. 1969; 8(4): 252-263.

[DUNLR 78] Dunlavey, Richard F. Workload Management. EDP Performance Review. 1978 May; 6(5): 1-4.

[FERRD 72] Ferrari, Domenico. Workload Characterization and Selection in Computer Performance Measurements. Computer. 1972 July/August; 5(4): 18-24.

[FIPS 49] Federal Information Processing Standard Publication 49. Guideline on Computer Performance Management: An Introduction. 1977 May 1; FIPS PUB 49: 14p. Available from: National Technical Information Service, Springfield, Virginia; NBS-FIPS-PUB-49.

[FIPS 57] Federal Information Processing Standards 57. Guidelines for the Measurement of Interactive Computer Service Response Time and Turnaround Time. 1978 August 1; FIPS PUB 57: 26p. Available from: National Technical Information Service, Springfield, Virginia; NBS-FIPS-PUB-57.

[FIPS xx] Federal Information Processing Standards Publication xx. Guidelines for Evaluation of Remote Batch Computer Service. (Publication is in process as of September 4, 1979); (n.d.).

[FORER 78] Forest, Robert B. Perspective: What are we measuring?. Infosystems. 1978 May; 25(5): 92 & 94.

[FRIEH 75] Friedman, H.P. and Waldbaum, G. Evaluating System Changes Under Uncontrolled Workloads: A Case Study. IBM Systems Journal. 1975; 14(4): 340-352.

[FRIEL 72] Fried, Louis. Making Data Processing Pay Its Way. Computer Decisions. 1972 March; 4(3): 24-27.

[GELLH 75] Gellman, Harvey S. Evaluation of the Effectiveness of EDP Facilities. Cost and Management. 1975 November/December; 49: 16-19.

[GILMM 78] Gilmore, Martha R. Capacity Management: A Definition and Implementation Guide. Proceedings of CMG IX International Conference on Management and Evaluation of Computer Performance; 1978 December 4-8; San Francisco, California. c1978. Bethesda, Maryland; Computer Measurement Group, Inc.: 1-11.

[GROCJ 72] Grochow, J.M. Utility Functions for Time-Sharing System Performance Evaluation. Computer. 1972 September/October; 5(5): 16-19.

[GSA 77] General Services Administration: Automated Data and Telecommunications Service. Management Guidance for Developing and Installing an ADP Performance Management Program. Washington, D.C.: GSA; 1977 July. 252p. CS 77-5.

[GUDEE 75] Gudes, Ehud, and Sechler, Charles. Measures for Workload and their Relation to Performance Evaluation. Proceedings of the Ninth, Tenth, and Eleventh Meetings of the Computer Performance Evaluation Users Group; 1974 May 21-23; Atlanta, Georgia; 1974 October 23-25; Columbus, Ohio; 1975 September 23-26; Oklahoma City, Oklahoma. Springfield, Virginia; NTIS; PB 252-174: 115-121.

[GUIDI 76] Guide International Corporation. Data Center Management 1975-1985. Transactions of the CMG. 1976 June; 12: 3-2 to 3-15.

[HALLS 75] Hallam, Stephen F. An Empirical Investigation of the Objectives and Constraints of Electronic Data Processing Departments. Academy of Management Journal. 1975 March; 18(1): 55-62.

[HANSJ 78] Hansen, John R. Getting A Handle On Computer Performance. Infosystems. 1978 June; 25(6): 82 & 87-88.

[HERNE 76] Herndon, Edwin S. Computer Systems Planning - Tools and Techniques. ACM 76 Proceedings: Annual Conference of the Association for Computing Machinery; 1976 October 20-22; Houston, Texas. New York City, New York: ACM Order Dept.; c1976: 203-207.

[HOPKR 75] Hopkins, Robert H. It Pays to Evaluate Your Systems Department. Canadian Chartered Accountant. 1975 February; 106: 22-25.

[HOWAP 74] Howard, Phillip C. (editor). What Management Should Know About Performance. EDP Performance Review. 1974 January; 2(1): 1-6.

[HOWAP 75] Howard, Phillip. Performance Reporting for Management - Theory vs. Practice. 1975 BBUG/ CMG VI Proceedings; 1975 October 7-10; San Francisco, California. Long Beach, California: Ian Roome (Treasurer, CMG): Computer Measurement Group, Inc.: 253-267.

[HOWAP 76] Howard, Phillip C. Performance Reporting and Management Responsibilities. Supplement Proceedings of Computer Performance Evaluation Users Group: 12th Meeting; 1976 November 8-12; San Diego, California. Springfield, Virginia: NTIS; PB 290-700: 65-60.

[HOWAP 77a] Howard, Phillip C. (editor). Performance Management Information Systems: State of the Art. EDP Performance Review. 1977 July: 5(7): 1-7.

[HOWAP 77b] Howard, Phillip C.; Stevens, Barry A., eds. The EDP Performance Management Handbook: Volume 1: Audit and Control and Volume 2: Tools and Techniques. c1977 (reference handbook is updated periodically.). Phoenix, Arizona: Applied Computer Research.

[HUNTH 70] Hunt, Holman. Is Your Computer a Success? Part 1. Data Systems. 1970 February; n.d.: 44-46.

[HURTC 72] Hurtado, Corydon D. A System to Measure EDP. Journal of Systems Management. 1972 January; 23(1): 32-35.

[IGERR 76] Igersheim, Roy H. Managerial Response to a Information System. AFIPS Conference Proceedings: 1976 NCC; 1976 June 7-10; New York City, New York. Montvale, New Jersey: AFIPS Press; c1976: [v45]: 877-882.

[JOSLE 74] Joslin, Dr. Edward O. Nine Alternatives to a New Computer. Journal of Systems Management. 1974 November; n.d.: 38-41.

[LEAVD 78] Leavitt, Don. Performance Measures Not Good Enough. Computerworld. 1978 May 29; XII(22): 27.

[LYBRR 73] Lybrand, Ross Bros., and Montgomery. Recognition of EDP Operational Problems. Management Advisor. 1973 January/February; 10(1): 55-57.

[McFAF 73] McFarlan, F. Warren. Management Audit of the EDP Department. Harvard Business Review. 1973 May/June; 51(3): 131-142.

[McKEL 79] McKell, Lynn J.; Hansen, James V.; Heitger, Lester E. Charging for Computing Resources. Computing Surveys. 1979 June; 11(2): 105-120.

[McLEE 73] McLean, Ephraim R. How Effective is Your Data Processing?. California Management Review. 1973 Fall; XVI(1): 95-100.

[MAMRS 79] Mamrak, Sandra A.; Amer, Paul D. Computer Science & Technology: A Methodology for the Selection of Interactive Computer Service. Washington, D.C.: National Bureau of Standards (NBS); Institute for Computer Sciences & Technology (ICST). 1979 January; NBS Special Publication 500-44. 77p.

[MATHJ 75] Mathews, J.R. A Survey of EDP Performance Measurement for Local Government. 1975 September. Springfield, Virginia: NTIS; PB 254-351: 20p.

[MATHJ 78] Mathews, Joseph R. A Survey of EDP Performance Measures. Government Data Systems. 1978 July/August; 7(4): 29-32.

[MEADR 78] Mead, Robert L., and Schwetman, Herbert D. Job Scripts - A Workload Description Based on System Event Data. AFIPS Conference Proceedings: 1978 NCC; 1978 June 5-8; Anaheim, California. Montvale, New Jersey: AFIPS Press; c1978: [v47]: 457-464.

[MEEHJ 78] Meehan, James C. Computer Capacity Planning: Evolution and Implementation. Proceedings of CMG IX International Conference on Management and Evaluation of Computer Performance; 1978 December 5-8; San Francisco, California. c1978. Bethesda, Maryland; Computer Measurement Group, Inc.: 17-34.

[MILLV 71] Miller, Victor E. Responsibility Time Reporting for Management Control Over EDP. Arthur Anderson Chronicle. 1971 June; n.d.: 8-11.

[NIELN 70] Nielsen, Norman R. The Allocation of Computer Resources - Is Pricing the Answer?. Communications of the ACM. 1970 August; 13(8): 467-474.

[PALMC 76] Palmer, Carl R. A Brief Review of the GAO Task Group's Recommendations on Management Guidelines for Resource Utilization Measurement of Data Processing in the Federal Government. Transactions of the CMG. 1976 June; 12: 3-16 to 3-22.

[PEARW 77] Pearson, Sammy W. Measurement of Computer User Satisfaction. (PhD dissertation) Arizona State University. 1977 August. Springfield, Virginia; NTIS: AD/A-046549: 315p.

[PEEPD 78] Peeples, Donald E. Measure for Productivity. Datamation. 1978 May; 24(5): 222-230.

[RAUPA 72] Rau, Paul. Evaluating the DP Function. Datamation. 1972 September; 18(9): 72-73.

[RICKJ 75] Rickerby, J. G.; Mellor, G.; Coan, D.R.A.,(eds). NCC Standards in Operations: Guideline for DP Management. United Kingdom of Great Britain and Northern Ireland: The National Computing Centre (NCC) Limited; 1975 November. (Distributed in USA and Canada by Hayden Book Co. Inc., 50 Essex Street, Rochelle Park, New Jersey 07662). ISBN 0850121523.

[SCHUD 74] Schumacher, David. A Graphical Computer Performance Report for Management. Proceedings of BBUG V; 1974 September 30 - October 3; Montreal Quebec, Canada. Camp Springs, Maryland: Computer Measurement Group, Inc.; c1974: 200-216.

[SHEMJ 72] Shemer, Jack E., and Roberston, John B. Instrumentation in Time-Shared Systems. Computer. 1972 July/August; 5(4): 39-47.

[SHIVR 72] Shively, Richard R. Performance Evaluation. Computer. 1972 September/October; 5(5): 12-15.

[STEVB 75a] Stevens, Barry A. Data Center Optimization. 1975 BBUG/CMG VI Proceedings; 1975 October 7-10; San Francisco, California. Long Beach, California: Ian Roome (Treasurer, CMG): Computer Measurement Group, Inc.: 268-300.

[STEVB 75b] Stevens, Barry A. Data Center Optimization and Performance Management. EDP Performance Review. 1975 November; 3(11): 1-4.

[STEVB 76a] Stevens, Barry A. CPE Measurement Activities for Data Processing. EDP Performance Review. 1976 May; 4(5): 1-7.

[STEVB 76b] Stevens, Barry A. Elements of a Performance Management Systems. EDP Performance Review. 1976 November; 4(11): 1-7.

[STEVB 78a] Stevens, Barry. Service Levels and the Service Level Matrix. Transactions of the CMG. 1978 March; 19: 3-1 to 3-18.

[STEVB 78b] Stevens, Barry A. Audit and Control of Performance in Data Processing. EDP Performance Review. 1978 January; 6(1): 1-8.

[STEVD 78] Stevens, David F. How To Improve Your Performance Through Obfuscatory Measurement. AFIPS Conference Proceedings: 1978 NCC; 1978 June 5-8; Anaheim, California. Montvale, New Jersey: AFIPS Press; c1978: [v47]: 425-431.

[STRAJ 72] Strauss, J.C. A Benchmark Study. AFIPS Conference Proceedings 1972 Fall Joint Computer Conference (FJCC); 1972 December 5-7; Anaheim, California. Montvale, New Jersey: AFIPS Press; c1972: [v41 part II]: 1225-1233.

[STRED 75] Streeter, D.N. Productivity of Computer-Dependent Workers. IBM Systems Journal. 1975; 14(3): 292-305.

[SVOBL 76] Svobodova, Liba. Computer System Measurability. Computer. 1976 June; 9(6): 9-17.

[WOSFM 73] Wosfey, Marvin M. Management of ADP Systems. Philadelphia, Pennsylvania; Auerbach Publishers, Inc.; c1973: 197-218.

Appendix A - Informational Model

Based on the functions discussed in Section 2, the following informational model is presented. There is no attempt to make this model complete, or uniformly detailed, but the intent is to illustrate the magnitude and variety of information used in supporting the installation performance program. Usually the detail levels are not given since the exact detail information would depend on the objective of the function; for example, the type of optimization in workload management - program, file handling, etc. - determines the exact measures to be made.

I. Upper Management
  A. Planning
    1. Configuration alternatives
    2. Pricing strategy
      * workload forecast
      * budget projection
      * new service levels
    3. Organization objectives
      * type of processing
      * priority
      * schedule
  B. Operations
    1. Fiscal Accounting
      * revenue
        * project
        * resources
      * budget
      * expenditures
        * salaries
        * supplies
        * equipment
        * packages
        * maintenance
        * space/utilities
      * pricing strategy
        * recovery
        * behavior modification
    2. Resources
      * total system capacity
      * personnel
    3. Workload
      * organizational unit
      * trends
    4. Service levels
      * timeliness
      * reliability
      * availability
      * cost when level not met

II. User Community

A. User Satisfaction
   1. Survey
   2. Suggestion forms

B. Setting Service Levels and Pricing Strategy
   1. Workload forecast (resource units)
   2. Revenue projection

C. Workload Management
   1. Audit (delete or reschedule)
      * project(s) supported
      * dependencies
      * age of application
      * age of version
      * run frequency
      * time of day
      * resources requested
      * resources consumed
   2. Optimize
      * execution characteristics
   3. Quality assurance

D. User Proficiency
   1. Trouble desk
      * reliability
      * availability (system)
      * availability (personnel)
      * types of problems
      * utilities needed
   2. User groups
      * service level tracking
      * workload statistics
   3. Technical support
      * modules being developed
         * use
         * schedule
         * revenue
      * staff time expended
         * user
         * utility
         * system
   4. Communication
      * service level tracking
      * cost (chargeback) information
      * new packages, upgrades, etc.
      * system schedule changes
      * training notices
      * efficiencies suggestions
   5. Training
      * workload statistics
      * reliability (user errors)
         * rates
         * type
         * jobs affected
      * new procedures, packages

E. Planning
    1. Service requirements
    2. Conversion impact areas
        * allocatable devices
            * magnetic tapes
            * disk packs
        * data files
            * data base management systems
            * internal formatted
        * programs
            * non-standard features
            * non-standard languages
    3. Workload forecast
        * functional
        * resource

III. Resource Management

A. Operational and Procedural
    1. Dispatching functions
        * staff time
        * volumes
            * cards handled
            * pages handled
        * poor quality output
    2. Schedules
        * availability of staff and system
        * schedule versus actual
    3. Errors (system and personnel)
        * number by type
        * time to fix or restore
        * fatal to system or subsystem
        * which jobs affected
            * direct
            * indirect
        * cost to projects
            * wasted processing time
            * wasted staff time
        * cost to installation
            * effect of user practices
                * file save rate
                * backup/restore activity
    4. Backup/restore
        * schedule
        * frequency
        * resources required
    5. Training (operators)
        * errors

B. Computer System
    1. Control limits
        * utilization
        * total system
            * device
            * time periods
            * subsystems
        * availability
            * time
                * down
                    * scheduled
                    * unscheduled
                    * diagnostic
                    * waiting for repair
                    * repair
                * up
                    * completely available
                    * subsystem down
                    * unstaffed
            * total system
            * hardware groups
            * software modules
            * responsiveness
                * turnaround time
                * time-sharing response
                * number of jobs ontime/late
                * throughput
        * file
            * space
            * distribution
        * allocatable device
            * number busy
            * time busy
        * contention and overlaps
    2. Tuning
        * utilization
            * by component
            * by device
        * productivity
        * subsystem activity
        * communication activity
            * timesharing
            * remote batch
            * transaction
            * line speeds
            * profiles
            * port activity
        * service
        * system queues
            * user requested
            * input
            * output
            * allocatable device
            * processor
            * misc. internal
        * file
            * organization
            * placement

(2. Tuning continued)
- * allocatable device
- * service - utilization relationship
- * system interrelations
    - * contention
    - * overlaps
    - * concurrency

3. Forecasting
- * workload characterization
    - * function
    - * batch (over-the-counter)
        - * arrival distribution
        - * priority
        - * dependency
    - * remote batch (job entry)
        - * origination
        - * priority
        - * dependency
    - * timesharing
        - * number sessions
        - * functions
        - * order of functions
        - * volume of characters
    - * transaction
        - * number and type
        - * volume of characters
    - * language
- * file storage
    - * permanent or scratch
    - * resources required
- * workload - service relationship
- * workload - utilization relationship
- * service - utilization relationship
- * system interrelations
    - * queue
    - * contention
    - * overlaps

IV. Vendor

- A. Hardware Reliability
  - 1. Error
    - * jobs affected
      - * which
      - * cost to project
      - * cost to installation
    - * rates
    - * intervals
  - 2. Retry
    - * rates
    - * intervals
  - 3. Maintenance
    - * schedule
    - * unscheduled
      - * response
      - * delays
    - * error profile
- B. Software Reliability
  - 1. Error
    - * jobs affected
      - * which
      - * cost to project
      - * cost to installation
    - * rates
    - * intervals
      - * time to fix
      - * release/version
      - * between errors
  - 2. Retry
    - * rates
    - * intervals
  - 3. Maintenance
    - * time between releases
    - * event profile
    - * regression

NBS-114A (REV. 9-78)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. SP 500-53	3. Recipient's Accession No.

4. TITLE AND SUBTITLE COMPUTER SCIENCE & TECHNOLOGY:

Technology Assessment: ADP Installation Performance Measurement and Reporting

5. Publication Date September 1979

6. Performing Organization Code

7. AUTHOR(S) Carol B. Wilson

8. Performing Organ. Report No.

9. PERFORMING ORGANIZATION NAME AND ADDRESS

NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, DC 20234

10. Project/Task/Work Unit No.

11. Contract/Grant No.

12. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS *(Street, City, State, ZIP)*

same as number 9.

13. Type of Report & Period Covered Final

14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

Library of Congress Catalog Card Number: 79-600154

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report compares the current status of ADP installation performance measurement and reporting in the Federal ADP community with the best practices as found in the Federal and private sectors and described in the literature. The comparison reveals that more effort could be expended by Federal sites in the area of computer performance management. The principal obstacles to more and better performance programs are perceived to be the lack of needed measures on many systems and the magnitude of the effort involved in accessing and analyzing the measures which are available. The report discusses several underlying causes for these obstacles and makes three recommendations which could partially relieve the situation: (1) development of standard performance measures, (2) development of a Government-wide data base for normative performance ranges, and (3) development of statistical computer performance evaluation techniques.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Computer performance evaluation (CPE), computer performance management (CPM), installation management, installation performance management, performance measurement and reporting, resource management, standard performance measures.

18. AVAILABILITY ☒ Unlimited

☐ For Official Distribution. Do Not Release to NTIS

☒ Order From Sup. of Doc., U.S. Government Printing Office, Washington, DC 20402, SD Stock No. SN003-003-02123-7

☐ Order From National Technical Information Service (NTIS), Springfield, VA. 22161

19. SECURITY CLASS (THIS REPORT) UNCLASSIFIED

21. NO. OF PRINTED PAGES 37

20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED

22. Price $2.00

USCOMM-DC

☆ U.S. GOVERNMENT PRINTING OFFICE : 1979—O-281-067

ANNOUNCEMENT OF NEW PUBLICATIONS ON COMPUTER SCIENCE & TECHNOLOGY

Superintendent of Documents,
Government Printing Office,
Washington, D. C. 20402

Dear Sir:

Please add my name to the announcement list of new publications to be issued in the series: National Bureau of Standards Special Publication 500-.

Name _____

Company _____

Address _____

City _____ State _____ Zip Code _____

(Notification key N-503)

NBS TECHNICAL PUBLICATIONS

PERIODICALS

JOURNAL OF RESEARCH—The Journal of Research of the National Bureau of Standards reports NBS research and development in those disciplines of the physical and engineering sciences in which the Bureau is active. These include physics, chemistry, engineering, mathematics, and computer sciences. Papers cover a broad range of subjects, with major emphasis on measurement methodology, and the basic technology underlying standardization. Also included from time to time are survey articles on topics closely related to the Bureau's technical and scientific programs. As a special service to subscribers each issue contains complete citations to all recent NBS publications in NBS and non-NBS media. Issued six times a year. Annual subscription: domestic $17.00; foreign $21.25. Single copy, $3.00 domestic; $3.75 foreign.

Note: The Journal was formerly published in two sections: Section A "Physics and Chemistry" and Section B "Mathematical Sciences."

DIMENSIONS/NBS

This monthly magazine is published to inform scientists, engineers, businessmen, industry, teachers, students, and consumers of the latest advances in science and technology, with primary emphasis on the work at NBS. The magazine highlights and reviews such issues as energy research, fire protection, building technology, metric conversion, pollution abatement, health and safety, and consumer product performance. In addition, it reports the results of Bureau programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

Annual subscription: Domestic, $11.00; Foreign $13.75

NONPERIODICALS

Monographs—Major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

Handbooks—Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

Special Publications—Include proceedings of conferences sponsored by NBS, NBS annual reports, and other special publications appropriate to this grouping such as wall charts, pocket cards, and bibliographies.

Applied Mathematics Series—Mathematical tables, manuals, and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computer programmers, and others engaged in scientific and technical work.

National Standard Reference Data Series—Provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a world-wide program coordinated by NBS. Program under authority of National Standard Data Act (Public Law 90-396).

NOTE: At present the principal publication outlet for these data is the Journal of Physical and Chemical Reference Data (JPCRD) published quarterly for NBS by the American Chemical Society (ACS) and the American Institute of Physics (AIP). Subscriptions, reprints, and supplements available from ACS, 1155 Sixteenth St. N.W., Wash., D.C. 20056.

Building Science Series—Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

Technical Notes—Studies or reports which are complete in themselves but restrictive in their treatment of a subject. Analogous to monographs but not so comprehensive in scope or definitive in treatment of the subject area. Often serve as a vehicle for final reports of work performed at NBS under the sponsorship of other government agencies.

Voluntary Product Standards—Developed under procedures published by the Department of Commerce in Part 10, Title 15, of the Code of Federal Regulations. The purpose of the standards is to establish nationally recognized requirements for products, and to provide all concerned interests with a basis for common understanding of the characteristics of the products. NBS administers this program as a supplement to the activities of the private sector standardizing organizations.

Consumer Information Series—Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

Order **above** *NBS publications from: Superintendent of Documents, Government Printing Office, Washington, D.C. 20402.*

Order **following** *NBS publications—NBSIR's and FIPS from the National Technical Information Services, Springfield, Va. 22161.*

Federal Information Processing Standards Publications (FIPS PUB)—Publications in this series collectively constitute the Federal Information Processing Standards Register. Register serves as the official source of information in the Federal Government regarding standards issued by NBS pursuant to the Federal Property and Administrative Services Act of 1949 as amended, Public Law 89-306 (79 Stat. 1127), and as implemented by Executive Order 11717 (38 FR 12315, dated May 11, 1973) and Part 6 of Title 15 CFR (Code of Federal Regulations).

NBS Interagency Reports (NBSIR)—A special series of interim or final reports on work performed by NBS for outside sponsors (both government and non-government). In general, initial distribution is handled by the sponsor; public distribution is by the National Technical Information Services (Springfield, Va. 22161) in paper copy or microfiche form.

BIBLIOGRAPHIC SUBSCRIPTION SERVICES

The following current-awareness and literature-survey bibliographies are issued periodically by the Bureau:

Cryogenic Data Center Current Awareness Service. A literature survey issued biweekly. Annual subscription: Domestic, $25.00; Foreign, $30.00.

Liquefied Natural Gas. A literature survey issued quarterly. Annual subscription: $20.00.

Superconducting Devices and Materials. A literature survey issued quarterly. Annual subscription: $30.00. Send subscription orders and remittances for the preceding bibliographic services to National Bureau of Standards, Cryogenic Data Center (736.00) Boulder, Colorado 80303.

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Washington, D.C. 20234

OFFICIAL BUSINESS

Penalty for Private Use, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE
COM-215

SPECIAL FOURTH-CLASS RATE
BOOK