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WASHINGTON, D.C. 20548

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JUN 20 1977

The Honorable Jack Brooks, Chairman
Committee on Government Operations
House of Representatives



Dear Mr. Chairman:

This report is in response to an informal request from your office for our assistance in resolving a dispute among the Department of Agriculture, the General Services Administration (GSA) and the ITEL Data Products Corporation. The dispute concerned an allegation by the Department that disk drives (Model 7330) acquired from ITEL through a GSA mandatory requirements contract were causing degradation of service at the Department's Washington Computer Center.

We had previously reviewed the Department's proposal to lease 44 double density disk drives to replace 80 IBM single density disk drives that had been leased on a sole-source basis for the Center. On April 16, 1976, we reported (LCD-76-120) that the Department had not justified the need for double density disk drives and that single density disk drives available from a GSA mandatory requirements contract would meet the Center's storage needs and save about \$339,000 annually. We proposed, and the Department agreed, that the IBM disk drives be replaced by those available from ITEL under the mandatory requirements contract.

We have reviewed the allegation, with technical assistance from the Federal Computer Performance Evaluation and Simulation Center (FEDSIM), and discussed our conclusions with your staff, GSA, and Agriculture officials. As a result, the Department has agreed to complete its contract with ITEL.

A summary of our work follows.

The GSA contract involved is GS-OOC-50022. It was competitively awarded to ITEL on February 5, 1974, and is renewable annually through fiscal year 1979. The contract is for ITEL Model 7330 disk drives that are replacements for IBM Model 3330 disk drives. Government agencies who have requirements for the

LCD-77-115

RELEASED

IBM type disk drives generally must use the ITEL contract as their source of supply. At the present time there are about 3,000 of the ITEL drives in use throughout the Government. These drives cost the Government about \$15 million annually.

< The Department ordered 80 ITEL disk drives from the requirements contract in April 1976 to replace 80 IBM drives that were being used with the Center's IBM 370/168 computer system. The order was for 10 lots of 8 disk drives each to be delivered in two-lot increments with initial delivery in May 1976. The Department accepted the first two lots in June 1976 and began testing lots 3 and 4. During that testing, the Center encountered problems with the drives and said that they caused degradation of service provided by the IBM system. Those problems were resolved by ITEL, but the Center did not contractually accept lots 3 and 4. The Department contended that they continued to degrade service.

On February 22, 1977, the Department notified ITEL that it was curtailing further installation of the ITEL drives because the drives were degrading service more than the IBM drives that the Center continued to use. The Department claimed that the degradation was in breach of the contract provision that required the ITEL drives to perform equal to or better than the IBM drives and provided ITEL with a study to support its claim. The study, which was made in December 1976 and amended in February 1977, compared the performance of the two types of drives using performance data compiled during the period June 1976 through January 1977.

The Department immediately brought the issue of a possible breach of contract to the attention of GSA for resolution. On March 4, 1977, the contracting officer issued his findings and determinations concerning the issue. He concluded that (1) ITEL was not in breach of the contract and (2) the continued refusal by the Department to replace its installed IBM disk drives with ITEL drives constituted a breach of the contract by the Government and a violation of Federal Procurement Regulations. The Department accepted the finding concerning ITEL's alleged breach of contract but refused to install the remaining ITEL drives because of its continuing contention that the drives degraded system performance.

As a result of the impasse reached between GSA, the Department, and ITEL, your office was asked by ITEL

officials to resolve the issue. Subsequently, we met with your staff and the parties involved to discuss how the issue should be resolved. The parties agreed that we should contact other users of the ITEL drives to ascertain their experience with them. They also agreed to our using FEDSIM to evaluate the Department's disk drive study and to abide by our findings and conclusions.

We contracted with FEDSIM to evaluate the Department's study. FEDSIM (1) reviewed the study to determine if its assumptions and methodology were valid, (2) verified the accuracy of the study data, (3) assessed the performance differences between the ITEL and IBM disk drives to determine if the alleged performance degradation existed and (4) prepared a final project report (see enclosure) summarizing its findings and conclusions. In brief, FEDSIM concluded:

(1) The conclusions in the study are based on the results of inappropriate statistical methods and therefore are invalid.

(2) The use of certain methods of averaging data to compare the IBM and ITEL disk drives is inappropriate and misleading.

(3) Although some of the performance measures were correctly reported, one was inconsistent with the Center's definition of that measure and others were (a) meaningless as performance measures, (b) inconsequential, (c) invalidly computed or (d) erroneous.

(4) Most of the failures attributed to ITEL disk drives occurred during the ITEL acceptance tests.

(5) Such factors as acceptance test procedures, the placement of system packs and the Center's air conditioning may have adversely affected ITEL disk drives' performance.

(6) Neither the study nor the Center's manual logs support the conclusion that ITEL disk drives' performance is inferior to that of IBM disk drives.

We contacted a number of other Government users of ITEL disk drives and were told by some that performance problems existed. However, they felt that their problems

may have been caused by the unique environmental characteristics of their installations. Other users were pleased with the ITEL performance and some stated that the ITEL drives performed as well as, if not better than, the IBM disk drives. The consensus of the users contacted was that the operating environment greatly impacts on the performance of disk drives and that a side-by-side comparison of the ITEL drives with the IBM drives using identical workloads and operating conditions would be needed to measure their respective performance.

On June 6, 1977, we met with your staff and the parties involved to discuss our findings and conclusions. At that meeting the Department admitted that its study was invalid. It agreed to contractually accept the disk drives delivered as lots 3 and 4, which the Center was using on a conditional basis, and to install the remaining ITEL drives that were ordered. The Department and ITEL also agreed to negotiate any payments due ITEL as a result of this dispute. These agreements should resolve the issue to the satisfaction of ITEL and the Government.

We will be pleased to assist you further in this matter if you so desire.

Sincerely yours,

DEPUTY

R. J. Keller
Comptroller General
of the United States

Enclosure

ENCLOSURE

FEDSIM REPORT

AY-057-062-GAO

TECHNICAL EVALUATION OF A
US DEPARTMENT OF AGRICULTURE
WASHINGTON COMPUTER CENTER REPORT

MAY 1977

FEDERAL COMPUTER PERFORMANCE
EVALUATION AND SIMULATION CENTER

Washington, D. C.

AY-057-062-GAO

TECHNICAL EVALUATION OF A
US DEPARTMENT OF AGRICULTURE
WASHINGTON COMPUTER CENTER REPORT

MAY 1977

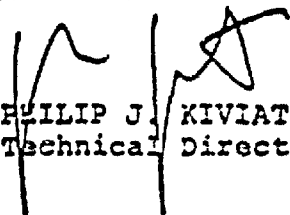
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PREFACE

This Report is based on the Federal Computer Performance Evaluation and Simulation Center's (FEDSIM's) detailed analysis of a report and data provided by the Washington Computer Center (WCC), US Department of Agriculture. The results address FEDSIM's technical evaluation of the WCC report for the US General Accounting Office (GAO). Because the nature of the analysis strongly depends on the report and the data provided by WCC, generalizing the recommendations beyond the system described or extracting conclusions without their respective qualifying conditions is not possible. Questions related to the subject of this Report or to the possibility of extending the stated conclusions or recommendations should be addressed to the Report's authors at FEDSIM.

ABSTRACT

In response to a GAO request, FEDSIM performed a technical evaluation of a US Department of Agriculture Washington Computer Center (WCC) report. The WCC report compared the performance of 32 ITEL disk drives with 64 IBM disk drives from June 1976 through January 1977. The WCC report concluded (1) that the ITEL disk drives' performance was inferior to that of the IBM disk drives and (2) that ITEL disk drives degraded performance of the Washington Computer Center.

FEDSIM reached the following conclusions about the WCC report:

(1) The conclusions in the WCC report are based on the results of inappropriate statistical methods and therefore are invalid.

(2) The use of "per drive per month" average data to compare the IBM and ITEL disk drives is inappropriate and misleading.

(3) Although some of the performance measures were correctly reported, one was inconsistent with WCC's definition of that measure, and others (1) were meaningless as performance measures, (2) were inconsequential, (3) were invalidly computed, or (4) were erroneous.

(4) Most of the hard fails attributed to ITEL disk drives occurred during the ITEL acceptance tests.

(5) Such factors as acceptance test procedures, the placement of system packs, and WCC air conditioning may have adversely affected ITEL disk drive performance.

(6) Neither the WCC report nor the WCC manual logs support the conclusion that ITEL disk drives' performance is inferior to that of IBM disk drives.

FEDSIM recommends that the US General Accounting Office request the WCC to reevaluate the performance of IBM and ITEL disk drives. This reevaluation should proceed only if WCC still believes that ITEL disk drive performance is inferior to that of IBM disk drives. FEDSIM further recommends that any reevaluation include such performance advantages as access time performance and that it exclude acceptance test data.

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FIGURE

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I. INTRODUCTION

A. BACKGROUND

The US Department of Agriculture Washington Computer Center (WCC) installed 80 IBM single density disk drives in mid-1974. The General Services Administration (GSA) authorized the installation of these disk drives on an emergency sole source basis in order to help alleviate the problems WCC was experiencing with its IBM System/370 (Model 168) computer system.

The US General Accounting Office (GAO) reviewed WCC's requirements and, in January 1976, recommended that WCC replace the 80 IBM disk drives with functionally equivalent disk drives from ITEL Corporation. (GSA had previously awarded ITEL a Mandatory Requirements Contract [Number GS-00C-50022] that stated that the ITEL disk drives were functionally equivalent to the IBM single density disk drives installed at WCC and specified ITEL as the sole source of supply for these disk drives.) GAO estimated that replacing the IBM disk drives with ITEL disk drives would save approximately \$339,000 per year.

The WCC replaced 32 IBM disk drives with 32 ITEL disk drives in mid-1976. The WCC configuration thus included 64 IBM disk drives and 32 ITEL disk drives. In December 1976, the WCC prepared a report that compared the performance of the 64 IBM disk drives with that of the 32 ITEL disk drives. This report was based on data for June through November 1976. On 10 February 1977, WCC prepared an addendum to the report that addendum reflected additional data for December 1976 and January 1977.¹ The Chief, Procurement Division, Central Services, USDA forwarded a copy of the WCC report to ITEL on 22 February 1977. The forwarding letter advised ITEL that the WCC was curtailing further installation of ITEL disk drives.

The WCC report defines five measures of performance (see Table I-1) and uses them to evaluate the disk drives. The addendum defines an additional measure of performance (see Table I-2) and uses it, along with the original five measures, to evaluate the disk drives. The WCC report asserts that the ITEL equipment degraded the WCC computer system more than IBM equipment and that this degradation was a breach of the Mandatory Requirements Contract Number GS-00C-50022.

¹Both the basic report and the addendum are subsequently referred to as the WCC report.

PERFORMANCE
MEASURE

WCC REPORT DEFINITION

IPL	This unscheduled loss of the operating system affects the entire "signed-on" community of users. In the case of WCC, an average IPL requires 20 minutes recovery time.
Hard Fail	This error on a drive results in the user's job abnormally terminating. If a hard fail occurs on a system pack, the system will be brought down and an IPL will be required.
Soft Fail	This error on a drive is ultimately recovered either by software or hardware. The system attempts to complete the read or write activity that generated the soft fail before terminating the job under a hard fail condition. When such termination occurs, the soft fail counter reverts to the number it held before the activity was first attempted, and the hard fail counter is incremented by one.
Incidents	These are all the errors recorded in LOGREC that can be traced to a single cause and recorded as one incident from the time of the first error occurrence until remedial action has been taken. Any error that occurs after the vendor's customer engineer informs WCC that the drive is available for use is recorded as a new incident.
Downtime Hours	These are downtime hours attributable to a given component. Time begins accumulating when the device has an error condition. The device is then varied off-line, and the responsible customer engineer is notified. Downtime ends when the component is declared "fixed" by the responsible customer engineer.

WCC REPORT PERFORMANCE MEASURES DEFINITIONS

TABLE I-1

PERFORMANCE
MEASURE

WCC REPORT ADDENDUM DEFINITION

System Availability	This performance measure is computed by dividing Actual Drive Uptime by Scheduled Drive Uptime. Actual Drive Uptime is computed by subtracting Drive Downtime from Scheduled Drive Uptime.
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WCC REPORT ADDENDUM PERFORMANCE MEASURE DEFINITION

TABLE I-2

On 4 March 1977, the GSA Contracting Officer, ADP Procurement Division, issued his findings and determination about the WCC report. He concluded (1) that ITEL was not in breach of Contract Number CS-00C-50022 and (2) that the continued refusal of USDA to replace their installed IBM equipment with ITEL equipment constituted a breach of Contract Number CS-00C-50022, and a violation of FPR 1-4.1107-7 and FPMR 101-32.403-1.

After GAO was asked to review the situation, GAO requested that FEDSIM provide technical assistance to the review process.

B. PROJECT OBJECTIVES

The objectives of the FEDSIM project were (1) to evaluate the validity of the WCC report, (2) to verify the accuracy of the data contained in the WCC report, and (3) to attempt to identify the performance differences between the ITEL and IBM disk drives (in only the performance areas identified by the WCC report) and determine the reasons for such differences.

Although the GSA Contracting Officer, ADP Procurement Division, had determined that ITEL was not in breach of contract, GAO requested that FEDSIM evaluate the validity of the WCC report. WCC had documented their belief that ITEL

was degrading the performance of the WCC computer system. GAO wished to determine whether the methods used in the report were valid. If the methods were valid, relief might be obtained even though ITEL was not held in breach of contract.

GAO requested that FEDSIM provide technical support to verify the accuracy of the data in the WCC report. There had been much controversy over the report and, even if FEDSIM determined that the methods used in the report were valid, there might still be doubt that the actual data in the report were valid. GAO therefore wanted an unbiased review of the source data from which the WCC report data were obtained.

GAO requested that FEDSIM determine the performance differences between ITEL and IBM at the WCC. Since WCC personnel believed that performance differences existed between IBM and ITEL disk drives, GAO wished to determine the basis for this belief--regardless of the validity of the WCC report. ITEL disk drives are installed at many other Federal computer sites, and GAO was aware of no other computer site that had issued a report asserting that ITEL equipment performed less well than IBM. GAO therefore reasoned that, even if ITEL equipment performed worse than IBM equipment at WCC, conditions unique to WCC might be responsible for the poor performance. GAO wished to identify such conditions if any existed. GAO and FEDSIM realized that this objective might not be met because of the short time allowed for the project and that the objective would not be met unless all relevant WCC data were made available to FEDSIM in a timely manner.

C. STATEMENT OF WORK

To accomplish the objectives of this project, FEDSIM identified four separate tasks. These tasks are summarized below and detailed in Section II, METHODOLOGY.

Task 1 - WCC Report Review. FEDSIM was to review the results of the WCC report in order to determine its validity and was to determine (1) if the data presented were justifiable and relevant, (2) if the analysis methods were appropriate, and (3) if the correct conclusions were derived from the data and methods.

Task 2 - Verify Accuracy of WCC Report Data. FEDSIM was to review the accuracy of the data in the WCC report both by analyzing the actual data presented and by reviewing the source documents from which the WCC report data were obtained.

Task 3 - Performance Comparison. FEDSIM was to analyze the source data provided by WCC, attempt to assess the performance differences between the ITEL and IBM disk drives, and attempt to determine the reasons for whatever performance differences were found.

Task 4 - Project Report and Briefing. FEDSIM was to prepare a Final Project Report that summarized the results of the study. This document is the result of Task 4. FEDSIM has also prepared a briefing that will be presented to GAO management after the final project report is delivered.

D. TIME SCHEDULE

FEDSIM began this project on 9 May 1977 at the first GAO/FEDSIM Meeting. The weeks of 9 May and 16 May were spent reviewing the WCC report, meeting with ITEL and WCC personnel, and reviewing WCC source documents. FEDSIM documented the results of this project by writing this Final Report the week of 23 May 1977.

E. PRIMARY PROJECT CONTACTS

During this project, FEDSIM dealt with personnel from three separate organizations (see Table I-3).

F. ACKNOWLEDGEMENT

FEDSIM thanks Mr Kurt Matlock (GAO) for the outstanding support he provided during this project. Mr Matlock arranged meetings, acted as liaison between the four organizations involved, and provided FEDSIM most of the project background information. Since this project was very short and involved four separate organizations, the potential for serious problems was great. FEDSIM credits Mr Matlock's outstanding coordination with preventing such problems.

ORGANIZATION	PERSONNEL
US General Accounting Office	Mr D. Eirich Mr K. Matlock
US Department of Agriculture Washington Computer Center	Mr T. Kuhn Mr A. Borough Mr D. Flynn Dr D. Bearfoot
ITEL Corporation	Mr W. Topercer Mr J. White Mr M. Nebel

PRIMARY PROJECT CONTACTS

TABLE I-3

II. METHODOLOGY

The basic purpose of this project was to review whether ITEL disk drives degrade the WCC computer when compared to IBM disk drives. The WCC report was crucial to the WCC assertion that ITEL disk drives degraded performance. FEDSIM therefore reviewed both the validity of the methods and the accuracy of the data in the WCC report; but, because FEDSIM did not wish to be constrained to consulting only the report, it met with both ITEL and WCC personnel. The purpose of these meetings was to gain additional insight into background and detail that might not be covered in the report. FEDSIM also reviewed many of the source documents from which the WCC report had been prepared. WCC planned to provide FEDSIM summary reports from EREP and output from the Reliability Plus software. (EREP is the report provided from the IBM SYS1.LOGREC file of error records. Reliability Plus--software provided by Reliability Research, Inc.--analyzes SYS1.LOGREC data.) FEDSIM was to use these summaries so that it would understand better the effects of ITEL and IBM disk drives on the WCC's performance.

A. REVIEW OF WCC REPORT

FEDSIM reviewed the WCC report to determine (1) whether the statistical methods used were appropriate and correct, (2) if the method of uniformly applying the selected performance measures on a "per drives per month" basis was valid, and (3) the magnitude and actual significance of the performance values shown. The WCC report was also carefully reviewed to determine (1) whether the computations in the report were accurate and (2) if the data elements within the report correlated with one another and with data obtained from other WCC sources. FEDSIM reviewed the WCC report during the weeks of 9 May and 16 May 1977. The FEDSIM personnel who reviewed the WCC report included experts in management reviews of data processing installations and experts in computer performance evaluation. The report's statistical methods were reviewed by two FEDSIM personnel with doctoral degrees in probability and statistics, and in operations research.

B. MEETINGS WITH ITEL AND WCC PERSONNEL

FEDSIM met with ITEL and WCC personnel (see Table II-1) (1) to discuss the background of the WCC report, (2) to solicit opinions and clarification of the methods and validity of the WCC report, and (3) to gather reports from those who

had personally observed the performance of ITEL and IBM disk drives and might have noted reasons for performance differences between the two. FEDSIM felt that the last purpose of these meeting was particularly important, because the real issue was whether ITEL disk drives performed less well than IBM disk drives. This issue should not necessarily be decided solely on the basis of a potentially deficient report. If performance differences existed between ITEL and IBM disk drives, WCC might not have documented these differences with a technically sound method, but the differences would nonetheless exist. FEDSIM hoped that the meetings would provide additional insight about the daily operational use of ITEL versus IBM disk drives and about daily observations of such use.

DATE	PERSONNEL IN ATTENDANCE
12 May 1977	FEDSIM: D. Deese, T. Fasso GAO: K. Matlock ITEL: B. Topercer, J. White
13 May 1977	FEDSIM: D. Deese, T. Fasso, B. McKenzie GAO: K. Matlock WCC: T. Kuhn, A. Borough, D. Bearfoot, D. Flynn
16 May 1977	FEDSIM: D. Deese, T. Fasso, B. McKenzie ITEL: M. Nebel
18 May 1977	FEDSIM: B. McKenzie WCC: T. Kuhn, A. Borough, D. Flynn
20 May 1977	FEDSIM: B. McKenzie WCC: A. Borough, D. Flynn

MEETINGS WITH ITEL AND WCC PERSONNEL

TABLE II-1

C. REVIEW OF WCC SOURCE DOCUMENTS

FEDSIM reviewed the source documents available at WCC in order to verify the reported data for IPL's, incidents, and downtime hours. These reviews were conducted at WCC on 18 and 20 May 1977. WCC also provided FEDSIM manual error logs that were compiled from daily EREP reports.

D. ANALYSIS OF EREP SUMMARIES AND RELIABILITY PLUS OUTPUT

WCC was to provide FEDSIM monthly summaries from EREP and from Reliability Plus software. These summaries were to be provided for the period covered by the WCC report (June 1976 through January 1977). WCC planned to provide these summaries on 16 May 1977 so that FEDSIM could properly analyze the data during that week. WCC was not able to provide the summaries as planned; operating system problems and data errors in the EREP tapes prevented the timely delivery of the summaries. These problems are discussed further in Section III, CONSTRAINTS.

III. CONSTRAINTS

A. TIME SCHEDULE

The major constraint to this project was the short time from the project's inception to its completion. The schedule in Table III-1 shows the project's key dates. This schedule necessarily limited the project's scope and detail.

DATE	PROJECT ACTIVITY
9 May 1977	First FEDSIM/GAO meeting
12 May 1977	First FEDSIM/GAO meeting with ITEL
13 May 1977	First FEDSIM/GAO meeting with USDA
19 May 1977	FEDSIM received EREP Summaries
27 May 1977	FEDSIM delivered Final Report to GAO

KEY PROJECT DATES

TABLE III-1

B. PROJECT SCOPE

The scope of this project was limited to the WCC. No attempt was made to expand the project so that it would include data from other IBM System/370 computer sites that had IBM and ITEL disk drives. This constraint was reasonable considering (1) the limited time schedule and (2) that the issues had been formally raised only by WCC.

C. PERFORMANCE AREAS

This project examined only those measures of performance advanced by WCC (i.e., IPL's, Hard Fails, Soft Fails, Incidents, Downtime Hours, and System Availability). Although FEDSIM recognizes that many other areas could have been addressed, time considerations precluded exhaustive analysis, and the areas advanced by WCC were actually the only ones at issue. Performance considerations other than these are briefly discussed in Section V, CONCLUSIONS AND RECOMMENDATIONS.

D. UTILITY OF WCC-PROVIDED DATA

FEDSIM initially examined Reliability Plus software reports and EREP reports at the 13 May 1977 meeting with GAO and WCC. This examination revealed inconsistencies between the data in the WCC report, Reliability Plus software reports, and the EREP reports. WCC personnel were unable to reconcile these differences, but they felt that the EREP and Reliability Plus data perhaps did not cover the exact periods represented in the WCC report. WCC personnel also felt that the EREP and Reliability Plus data might be fragmentary, since they were extracted from tapes that contained a number of errors. These errors would have caused tape records to have been rejected or otherwise improperly processed.

WCC proposed to reprocess the tapes in order to provide monthly summary EREP reports and Reliability Plus software reports. This would be done by (1) using identical input, (2) covering the eight-month period represented by the WCC report, and (3) providing the reports in exact monthly increments. These data were to be provided to FEDSIM for analysis on 16 May 1977.

WCC did not provide FEDSIM the data on 16 May as planned. The historical data tapes apparently contained many errors, and the WCC operating system had been changed since the tapes were created. These two factors caused considerable delay in the planned delivery of EREP summaries and Reliability Plus software reports.

When WCC finally did provide the summaries on 19 and 20 May, FEDSIM found no correlation between the EREP summaries, the Reliability Plus software, and the WCC report. Data that supposedly covered the same periods were inconsistent. Close examination revealed (1) that the data were not always for the same periods, (2) that the data were fragmentary (in that several months were represented by only 6 to 10 days of data), and (3) that Reliability Plus software reports printed the Reliability Plus execution date rather than the dates represented by the reported data. These problems rendered the reports and summaries useless for FEDSIM's analysis.

The hard-fail and soft-fail data in the WCC report had been compiled from manual logs prepared from daily EREP reports. Since the EREP summaries provided FEDSIM were of no value, FEDSIM was unable to verify the accuracy of the

manual logs. FDSIM did find, however, (1) that the method of recording hard fails was inconsistent with the WCC report hard fail definition and (2) that the soft fails were inconsequential as a performance measure. These findings are discussed in Section IV, RESULTS.

IV. RESULTS

A. VALIDITY OF STATISTICAL METHODS

The statistical analyses in the WCC study fail to meet standard practices in two significant ways. First, the use of a paired-data t test is unjustified. The use of the paired t test must have a basis for pairing and there must be a set of coupled observations. There is no basis for pairing the data on the IBM and ITEL disk drives, because each unit's workload is unique, because each device is unique, and because the units have certainly not undergone any "common treatment." The only observations in the report that are statistically related are the common monthly time periods. Since the sample sizes are different and the resultant data points are averages, the use of the paired-data t test is invalid.

The report's second nonstandard practice, which is not as severe as the first, concerns the statement of a null hypothesis without an alternative hypothesis. It is well known that, in a null hypothesis analysis, an alternative hypothesis is mandatory for establishing the acceptance and rejection regions for inferential statistics. The information in the WCC study does not indicate what alternative hypothesis was used.

FEDSIM discusses separately in this document its objection to the use of average "per drive per month" data. However, if the averaging technique were valid, a pooled variance t test appears to be the most appropriate test. The required assumptions for this test are sample independence, normal populations, and unknown but equal variances. Unknown but equal variances might require testing, but the basic data should provide the vehicle for validation. The other two assumptions are reasonable and were required for the paired t test as well.

Under the assumption that the variances are equal ($\sigma_1^2 = \sigma_2^2$), the appropriate test would be

$$H_0: \mu_1 = \mu_2$$

$$H_1: \mu_1 \neq \mu_2$$

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

$$\text{where } s^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

and degrees of freedom:

$$r = n_1 + n_2 - 2$$

The critical region is

$$t < -t_{\alpha/2} \text{ and } t > t_{\alpha/2}$$

FEDSIM also objects to (1) the "per drive per month" assumption used as the basis for the comparing IBM and ITEL disk drives and (2) the method of evaluating the rejected hypotheses that treated all performance measures equally. The "per drive per month" objection is discussed separately in this document. The equal treatment of all performance measures is clearly inappropriate. For example, an IPL causes significantly more degradation than a soft fail. In fact, according to data presented in the WCC report, an IPL degrades the system more than 3.5×10^4 times the degradation caused by a soft fail. The method of evaluating rejected hypotheses nonetheless considers IPL's equal to soft fails in terms of system performance degradation.

B. VALIDITY OF "PER DRIVE PER MONTH" ANALYSIS METHOD

The degradation measures are presented as "per drive per month" values throughout the WCC report. The monthly totals for each measure were divided by the appropriate number of installed drives to obtain a "per drive" average. Except for the month of June 1976, the WCC computer center had 32 ITEL drives and 64 IBM drives; during June, there were 16 ITEL and 80 IBM drives. * Such events as IPL's have equivalent effects on system performance, regardless of what type of drive cause them. However, the fact that there are unequal numbers of ITEL and IBM drives results in unequal "per drive" average values. For example, one IPL caused by

IBM disk equipment results in a 0.016 (1+64) "per drive per month" average value, whereas one IPL caused by ITEL disk equipment results in a 0.031 (1+32) "per drive per month" average value. These average data, which are used to compare degradation, are thus biased in favor of IBM. The "per drive per month" method of comparing data makes ITEL performance appear far worse for events that equivalently degrade system performance.

The WCC report assumes (1) that degradation caused by errors can be uniformly distributed among all the disk drives and (2) that errors can be evaluated independently of the usage of the device. FEDSIM believes that neither assumption is correct.

The first assumption could obviously be misleading if it were used as a basis for calculating total system degradation. The effect on total system performance of a large number of errors on one disk drive might be significantly different than the effect on system performance of the same number of errors uniformly distributed among all disk drives. To illustrate this difference, FEDSIM found that 761 of the 840 ITEL hard fails² in August 1976 occurred on one drive during a 40-minute period. The inference in the WCC report that each of the 32 ITEL drives averaged 26.25 hard fails in August 1976 is a completely misleading conclusion about total system degradation.

The second objectionable assumption in the WCC report is that device errors are unrelated to device usage. FEDSIM disagrees with this assumption. Two examples illustrate why usage cannot be ignored when evaluating device errors. First, consider a device that has little or no usage; few, if any, errors would be associated with this device because it was used very little. Very low usage will therefore result in a low error rate. (This usage characteristic is common in computer installations with many disk drives.) Second, consider a device that computer operators know has errors. An operator's natural tendency is to put active files on more reliable drives and, if possible, to avoid using the failing drive. Known error conditions can therefore result in very low usage. These two examples illustrate FEDSIM's belief that both usage and errors must be analyzed on a per component basis--not on the basis of a uniform distribution.

²FEDSIM also found this count inconsistent with the WCC report definition of hard fails.

C. MAGNITUDE AND ACTUAL SIGNIFICANCE OF DATA

The WCC report showed selected performance measures distributed uniformly over all drives and presented statistical results to either three or four decimal places. FEDSIM has already documented its objection to the basic "per drive per month" approach to analysis. Not only is the analysis approach invalid, but the data display technique used tended to confuse readers about the accuracy (or actual magnitude) of the values shown. No one FEDSIM interviewed had questioned the data. Everyone assumed that they were correct since they were presented with four-decimal-place precision. Few even questioned whether the data values were large enough to be significant or were too large to be reasonable.

FEDSIM multiplied the WCC report values by the appropriate number of IBM and ITEL disk drives installed at WCC in order to compute the actual values (see Table IV-1 and Table IV-2). These tables are referred to later in this report, where it is shown that several of the actual values in the WCC report are so large they are unreasonable (and inconsistent with WCC's definition) or so small they are inconsequential and should be ignored.

D. ACCURACY AND CORRELATION OF PERFORMANCE MEASURES

1. Initial Program Loads (IPL's)

The IPL's caused by ITEL and IBM disk drives were manually recorded and used by WCC as one measure of the effectiveness of the installed equipment. FEDSIM reviewed the source data that were used to develop the WCC report. The data showed that ITEL had been charged with 32 IPL's and IBM had been charged with 13. No problems or inconsistencies were observed in the manner in which IPL's were resolved and charged to each vendor.

The source data revealed that 16 of the IPL's charged to ITEL occurred during a two-week period in late September and early October and that they were caused by a failing controller. This controller was subsequently replaced by ITEL. Since that replacement, the numbers of IPL's charged to ITEL and IBM equipment have been comparable.

MONTH	IPL's	HARD FAILS	SOFT FAILS	INCIDENTS	DOWNTIME HOURS
Jun	2	1	809	29	26
Jul	0	2	9	10	27
Aug	2	4	7	8	29
Sep	1	3	219	47	28
Oct	5	0	13	17	24
Nov	2	120	23	22	99
Dec	1	1	61	2	12
Jan	0	0	107	5	19

ACTUAL PERFORMANCE MEASURES, IBM DISK DRIVES

TABLE IV-1

MONTH	IPL's	HARD FAILS	SOFT FAILS	INCIDENTS	DOWNTIME* HOURS
Jun	4	0	237	12	5
Jul	3	186	755	64	31
Aug	3	840	50	53	122
Sep	9	97	187	196	33
Oct	8	37	137	72	25
Nov	1	10	143	136	16
Dec	2	7	65	12	18
Jan	4	1	1059	15	20

*ITEL Downtime Hours have been corrected for December and January.

ACTUAL PERFORMANCE MEASURES, ITEL DISK DRIVES

TABLE IV-2

2. Hard Fails

The hard fail data reported in the WCC report are not consistent with that report's definition of a hard fail. The hard fail data that are presented therefore cannot be used to determine whether ITEL disk drives perform less well than IBM.

The WCC report defines a hard fail as a device error that has the effect of causing a user job on the system to be cancelled. A count of hard fails, as defined, would be one measure of the number of jobs aborted because of device errors. If the device having errors was a system pack, a hard fail would result in the loss of all jobs in the system when the system was cancelled; an IPL would then be required to reinitialize the system, and some number of jobs would have to be restarted. A large count of hard fails, as defined, would represent a serious problem.

Tables IV-1 and IV-2 show the actual performance measures for IBM and ITEL disk drives. For some of the months shown, the count of hard fails for both IBM and ITEL is extremely large (IBM: Nov=120; ITEL: Jul=186, Aug=840, Sep=97). FEDSIM questioned the reasonableness of these counts of hard fails; the ITEL August value of 840 translates to over 27 hard fails per average day. After examining the EREP summary reports WCC provided, FEDSIM could not find 840 hard fails in August; in fact, FEDSIM could find only two ITEL hard fails in the incomplete EREP summaries and 36 ITEL hard fails in a report from Reliability Plus software that executed 7 September 1976 (and presumably processed August data). After checking detailed, daily EREP reports, WCC personnel located 761 hard fails that occurred during one 40-minute period and were associated with a system spool pack. Clearly, the system was not cancelled 761 times in one 40-minute period. (The WCC report indicates that an average IPL after the system is cancelled requires 20 minutes to recover the system.) The WCC report listed 761 "hard fails" when only one (by the report's definition) should have been included.

After some discussion with FEDSIM, WCC indicated their belief that the computer system would attempt to recover from permanent device errors associated with system packs (for some unknown number of attempts) until either a successful

I/O operation was completed or the system was cancelled. These attempts would obviously be made regardless of whether the system pack was on IBM or ITEL.

WCC did not identify the conditions under which large "hard fail" counts were attributed to IBM or ITEL. However, since (1) the months cited earlier are credited with unreasonably large counts and (2) it has been demonstrated that, in August, ITEL was erroneously credited with 761 "hard fails," FEDSIM discounted the WCC report hard fail data and reviewed the manual logs WCC had prepared from daily EREP reports. This review is discussed elsewhere in this document.

3. Soft Fails

A soft fail results from an uncompleted I/O operation; the I/O operation must be retried. A soft fail therefore essentially requires another I/O access. The worst case time for both IBM and ITEL disk drives to perform this I/O operation is approximately 33.3 milliseconds (assuming one complete rotation to position the read/write head and a full-track read). The software overhead necessary for the I/O retry on the WCC computer is potentially 0.5 milliseconds. Each soft fail thus "degrades performance" by as much as 33.8 milliseconds. Table IV-3 shows the maximum total monthly "overhead" caused by the number of IBM and ITEL soft fails reported in the WCC report. As Table IV-3 shows, the monthly total soft fails for all IBM and ITEL drives averages 5.27 and 11.12 seconds, respectively! These values are so small that it is not clear why WCC selected soft fails as a performance measure.

Clearly, any number of measures could be used in an evaluation of performance. The selection of specific measures depends on such variables as environment (e.g., weight of a device is relatively unimportant to most data processing installations but becomes critical with, for example, airborne computers) and the magnitude of the measure³ (e.g., soft fails are unimportant as a performance measure³ when they occur infrequently but become an important performance measure when the frequency is large).

³ However, soft fails may be important as an aid to customer engineers regardless of their magnitude.

MONTH	<u>64 IBM DISK DRIVES</u>		<u>32 ITTEL DISK DRIVES</u>	
	NUMBER OF SOFT FAILS	SECONDS OF "OVERHEAD"	NUMBER OF SOFT FAILS	SECONDS OF "OVERHEAD"
Jun 76	809	27.34	237	8.01
Jul 76	9	0.30	755	25.52
Aug 76	7	0.23	50	1.69
Sep 76	219	7.40	187	6.32
Oct 76	13	0.44	137	4.63
Nov 76	23	0.78	143	4.83
Dec 76	61	2.06	65	2.20
Jan 77	107	3.62	1059	35.79
Average	156	5.27	329	11.12

MAXIMUM TOTAL MONTHLY "OVERHEAD" CAUSED BY SOFT FAILS

TABLE IV-3

The number of soft fails associated with disk drives at WCC was very small. By contrast, source documents showed several hundred times more soft fails associated with tape than with disk drives. Although FEDSIM believes that the tape units represent a serious problem at WCC, FEDSIM cannot understand why WCC chose soft fails as a measure of disk drive performance.

4. Incidents

FEDSIM compared the count of incidents in the WCC report to the manual logs maintained at WCC. The report was consistent with the data in the manual logs. However, FEDSIM found several problems with using the number of incidents as an indication of system degradation. First, there is no correlation in the WCC report between (1) incidents and (2) the hard fails, soft fails, or downtime degradation measures. It is therefore impossible to determine the severity or duration of an incident. Second, there is the question of equivalency in system degradation. Incidents may result from either hard fails (permanent errors) or soft fails (temporary

The WCC report uses not directly the cause, severity, or duration of incidence. Incidents can therefore be considered only indicators rather than measures of system degradation. It is consequently meaningless to compare incident counts for IBM and ITEL.

5. Downtime Hours

One measure of the effectiveness of each vendor's disk drives is the amount of time the equipment is available for use. The WCC report used the inverse of the equipment availability--downtime hours--as a performance measure. FSDSIM attempted to validate the very high ITEL downtime figures contained in the addendum to the WCC report. FSDSIM discovered that a different method had been used to prepare the addendum data than had been used to prepare the initial report. The WCC used information extracted from the Daily Trouble Reports to prepare the equipment downtime summaries for each vendor for the initial WCC report. The downtime data for ITEL reported in the addendum were extracted from the ITEL Problem Reports. Those reports consider each disk drive attached to a controller to be "down" if the controller is down. This method effectively multiplies the controller downtime by the number of attached disk drives. This method was not valid because (1) similar data were not available for IBM (and thus were not used) and (2) the entire string of ITEL disk drives is not down simply because a controller is down (since ITEL has dual port capability). (Although all the modules of disk are available through an alternate port if the controller is down, the system could be degraded to an undetermined extent if a high use system file were resident on a string being accessed through an alternate port.) Table IV-4 shows the original and recomputed downtime data for the two months described by the addendum. The recomputations were based on comparable records and methods.

MONTH	<u>ORIGINAL ADDENDUM DATA</u>		<u>RECOMPUTED DATA</u>	
	IBM	ITEL	IBM	ITEL
Dec 1976	8.5	108.7	12.0	18.2
Jan 1977	16.7	122.3	19.3	20.4

COMPARISON OF ORIGINAL AND RECOMPUTED DOWNTIME HOURS

TABLE IV-4

6. System Availability

The addendum to the original report added a sixth measure of system degradation--"system availability." In reviewing the data in Table IIIa of the addendum, FEDSIM found that the calculations for ITEL system availability erroneously used the number of incidents from Table Ia in the WCC report rather than the ITEL downtime hours. The WCC report therefore contained the incorrect conclusion that there was a significant difference between IBM and ITEL system availability.

E. FEDSIM'S ANALYSIS OF WCC MANUAL LOGS

FEDSIM reviewed the WCC manual logs to verify the accuracy of the WCC report hard fails data and to identify any unusually large counts of hard fails. FEDSIM found minor differences between the data presented in the WCC report and the manual logs; the WCC report attributed 1173 hard fails to ITEL, while FEDSIM could find only 1142.

FEDSIM found seven occasions when more than 10 hard fails were recorded for a single device in one day. These seven occasions accounted for 1056 (or 92.5%) of the 1142 hard fails. It seems unreasonable that these hard fails actually caused 1056 jobs to be terminated abnormally. In fact, as discussed earlier in this document, 761 of the hard fails occurred during one 40-minute period. FEDSIM also observed that six of these occasions (and 1024 hard fails) occurred during the ITEL acceptance test months of July, August, and September 1976. To obtain a more reasonable assessment of the possible degradation caused by ITEL hard fails, FEDSIM reduced the number of hard fails for each of these seven observations to one (although any reasonable small number would have sufficed).

Figure IV-1 displays the hard fail counts FEDSIM extracted from the manual logs and the adjusted counts. Figure IV-1 clearly shows that most (1106 or 96.8%) of the hard fails occurred during the ITEL acceptance test months. After acceptance test period, hard fails diminished to the point that they were insignificant. The adjusted hard fails (dashed line) totaled 94 for the eight-month period. They reached a monthly high of 33 during August 1976. There were only four hard fails recorded from October 1976 through January 1977.

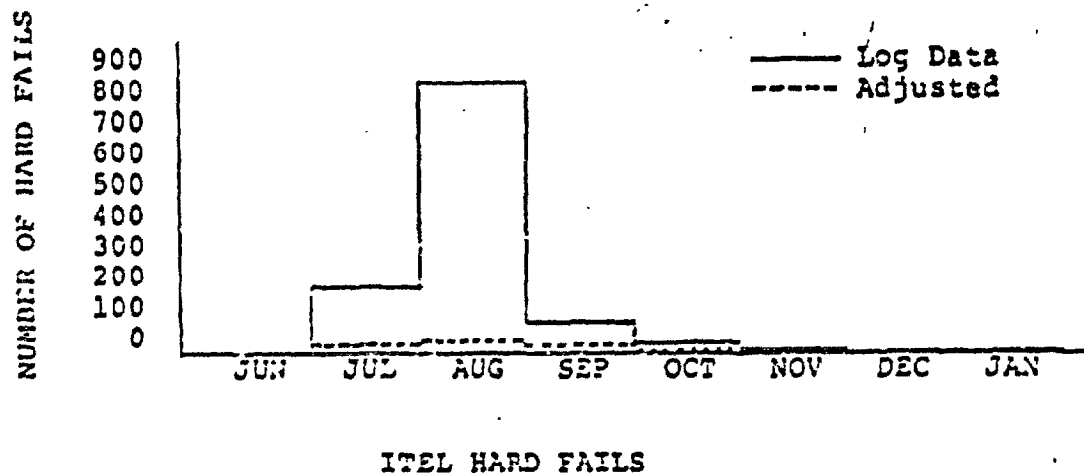


FIGURE IV-1

FEDSIM summarized the hard fails for each disk drive in order to determine whether errors were uniformly distributed among the ITEL disk drives. The results (see Table IV-5) show that hard fails were not uniformly distributed. In fact, 66.9% of all hard fails occurred on one drive and 89.9% of all errors occurred on four drives.

F. FACTORS AFFECTING DISK DRIVE PERFORMANCE AT WCC

One objective of this project was to determine reasons for performance differences between ITEL and IBM disk drives at WCC. Since FEDSIM was unable to identify meaningful performance differences between ITEL and IBM, this objective was only partially achieved. FEDSIM did, however, identify three factors that would cause performance differences (either real or apparent) between IBM and ITEL disk drives.

DISK DRIVE	PERCENT OF TOTAL ERRORS	CUMULATIVE PERCENT
580	66.8	66.8
588	9.6	76.4
581	7.6	84.0
56D	5.9	89.9
566	3.5	93.4
56F	1.3	94.7
56E	1.1	95.8
563	1.1	96.9
568	0.6	97.5
58B	0.6	98.1
58F	0.6	98.7
587	0.4	99.1
582	0.3	99.4
589	0.2	99.6

FREQUENCY DISTRIBUTION OF
ITEL HARD FAILS

TABLE IV-5

1. ITEL Acceptance Test Procedure at WCC

The acceptance test period is that period during which a newly installed piece of equipment must meet certain levels of performance for a prolonged period of time (usually thirty days). At WCC, the acceptance tests were run in a serial mode on each lot or shipment of ITEL disk drives. Each shipment had to pass acceptance tests and be signed off as accepted by the WCC before the next shipment could begin acceptance tests.

Mr Thomas Kuhn (Director of the WCC Data Center) stated at the 13 May 1977 meeting that his acceptance test procedure was designed to utilize heavily the equipment undergoing acceptance tests. During the test period, high activity files were placed on the ITEL drives, and special programs were run that heavily accessed the ITEL disk drives. The purpose of this heavy use was to ensure that, if the equipment were defective, it would fail during the acceptance tests.

Lots 1 and 2 of the ITEL disk drives began acceptance tests on 17 May 1976 and were accepted on 17 June 1976. Lots 3 and 4 began acceptance tests on 12 July 1976 and were accepted by the WCC in early September 1976 (exact date not available). An ITEL controller started failing during the last week of September 1976 and was replaced the first week of October 1976. The WCC required that the replacement controller undergo acceptance tests. The replacement controller was accepted on 2 November 1976.

Much of the data contained in the WCC report were gathered while the ITEL equipment was undergoing acceptance testing.

2. Location of System Packs

A device error has its most serious effect when it causes the system to be cancelled and results in an IPL. This can occur when the device error is associated with a system pack. Obviously, the number of IPL's attributed to either IBM or ITEL can be directly influenced by the placement of the system packs.

ITEL personnel indicated they believe that system packs were located on ITEL disk drives during the months when ITEL was credited with a relatively large number of IPL's. WCC personnel partially agreed. WCC personnel further described their policy of placing heavy activity files (e.g., system packs) on the ITEL drives during the ITEL disk drive acceptance period.

WCC provided FEDSIM no records of the location of system files (such records are not commonly kept by computer sites). FEDSIM was therefore unable to verify the location of system packs. If the system packs were on ITEL disk drives, however, FEDSIM does not believe that the number of IPL's credited to ITEL could be significant.

3. Air Conditioning at WCC

ITEL personnel expressed concern about the quality of air conditioning at WCC. This concern is apparently valid. FEDSIM personnel observed that the temperature near the ITEL disk drives was significantly higher than the temperature in other parts of the computer room. FEDSIM did not actually use temperature recording devices to obtain data and therefore cannot document these temperature differences.

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

1. Validity of Statistical Methods

There is no basis for using the paired data t test to determine whether or not there is a statistically significant difference between the performances of ITEL and IBM disk drives. Since conclusions in the WCC report are based on the results of inappropriate statistical methods, they are invalid.

2. Validity of "Per Drive Per Month" Analysis Method

Using "per drive per month" average data is inappropriate and misleading. This method is inappropriate because it falsely assumes (1) that degradation is uniformly distributed among all disk drives and (2) that degradation is independent of device usage. The method is misleading because averaging so biases the data that ITEL performance appears far worse than IBM performance, even though both types of disk drives cause identical degradation in system performance.

3. Magnitude and Common Sense Significance of Data

After reviewing the actual values in the WCC report, FEDSIM concluded that several were so large that they were unreasonable (they were also found to be inconsistent with WCC's definition) or were so small they were inconsequential and should be ignored.

4. Accuracy and Correlation of Performance Measures

a. Initial Program Loads (IPL's). FEDSIM concludes that the numbers of IPL's caused by IBM and ITEL disk drives have been comparable since the replacement of a defective ITEL controller.

b. Hard Fails. FEDSIM found that hard fails data were inconsistent with the WCC report definition. FEDSIM concludes that the WCC report data cannot be used to compare performance.

c. Soft Fails. FEDSIM found that the number of WCC disk drive soft fails was very small and that the soft fails' effect on system performance was inconsequential.

d. Incidents. FEDSIM concludes that incidents can be considered only indicators rather than measures of system degradation. It is meaningless to compare the incident counts of IBM and ITEL equipment.

e. Downtime Hours. FEDSIM concludes that the WCC report addendum was prepared using a different (and invalid) method of reporting ITEL downtime hours than was used in the original report. The ITEL downtime hours reported with this method were significantly greater than the downtime hours reported with the method used in the original WCC report.

f. System Availability. FEDSIM concludes that the WCC erroneously used the number of incidents rather than downtime hours in computing ITEL system availability. The WCC report therefore incorrectly concluded that there was a significant difference between IBM and ITEL system availability.

5. FEDSIM's Analysis of WCC Manual Logs

FEDSIM concludes (1) that the numbers of hard fails attributed to ITEL (and to IBM on one occasion) were inconsistent with the WCC report definition, and (2) that most (almost 97%) of the hard fails attributed to ITEL occurred during the ITEL acceptance test period. FEDSIM further concludes that the hard fails were not uniformly distributed (almost 90% of the hard fails occurred on four drives).

6. Factors Affecting Disk Drive Performance at WCC

a. ITEL Acceptance Test Procedure at WCC. FEDSIM concludes that much of the data contained in the WCC report were gathered while the ITEL equipment was undergoing acceptance testing. FEDSIM believes that these data should not be used in an evaluation of ITEL versus IBM since (1) the ITEL equipment was only recently installed and needed to "settle down", and (2) the acceptance test procedure intentionally placed an unusual stress on the ITEL equipment.

b. Location of System Packs. FEDSIM concludes that the locations of system packs on ITEL and IBM disk drives may have distorted the number of IPL's attributed to ITEL.

c. Air Conditioning at WCC. FEDSIM believes that the air conditioning at WCC may have adversely affected the ITEL disk drives. FEDSIM can reach no definite conclusions about the quality of air conditioning, since no quantitative data were gathered.

7. ITEL Disk Drive Performance

FEDSIM concludes that neither the WCC report nor WCC manual logs support the belief that ITEL disk drive performance is inferior to that of IBM disk drives.

B. RECOMMENDATIONS

1. FEDSIM recommends that the GAO request the WCC to reevaluate the performance of IBM and ITEL disk drives. This reevaluation should proceed only if WCC still believes that ITEL disk drive performance is inferior to that of IBM disk drives. If requested, FEDSIM will help GAO and WCC plan and/or implement the evaluation. FEDSIM further recommends that any reevaluation exclude acceptance test period data.

2. FEDSIM recommends that any effort to quantify the net performance differences of IBM and ITEL disk drives at WCC consider the access time performance. IBM disk drive specifications indicate an average access time of 30 milliseconds. ITEL disk drive specifications indicate an average access time of 27 milliseconds. FEDSIM has not verified these specifications but has no reason to believe them incorrect. If these specifications are valid, ITEL disk drives perform better when seeking than do IBM disk drives by an average of 3 milliseconds per seek. Although FEDSIM did not determine how many seek operations were executed at WCC, the WCC report indicates that a total of 77,500,000 I/O operations was executed in October 1976. If this number is valid and if one-half the I/O operations required the execution of a seek operation, 38,800,000 seek operations would have been executed. ITEL disk drives would have performed these seeks an average of 3 milliseconds per seek faster than would IBM disk drives. The ITEL disk drives would therefore have performed the seeks approximately 116,400 seconds or about 31 hours faster during the month. (Note that the total ITEL downtime for October was only 25 hours.) This significant performance advantage should be considered as a part of any evaluation effort.