REPORT NO: DOT-TSC-OST-72-24

FY 72 COMPUTER UTILIZATION AT THE TRANSPORTATION SYSTEMS CENTER

David B. Hiatt
Transportation Systems Center
Kendall Square
Cambridge MA. 02142

AUGUST 1972

FINAL REPORT

Prepared for:
DEPARTMENT OF TRANSPORTATION
OFFICE OF THE SECRETARY
Office of Research and Development Policy
Washington, D.C. 20590

TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT-TSC-OST-72-24		

4. Title and Subtitle	5. Report Date
FY 72 COMPUTER UTILIZATION AT THE TRANSPORTATION SYSTEMS CENTER	August 1972
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
David B. Hiatt	
9. Performing Organization Name and Address Department of Transportation Transportation Systems Center Kendall Square Cambridge, MA. 02142	10. Work Unit No. R2557
	11. Contract or Grant No. OS223
12. Sponsoring Agency Name and Address Department of Transportation Office of the Secretary Office of Research and Development Policy Washington, D.C. 20590	13. Type of Report and Period Covered Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

The Transportation Systems Center currently employs a medley of on-site and off-site computer systems to obtain the computational support it requires. Examination of the monthly User Accountability Reports for FY72 indicated that during the fiscal year TSC personnel made direct expenditures for the use of eighteen different digital computer systems - eight on-site systems and ten systems owned and maintained outside TSC. The magnitude of this usage was equivalent to a single CDC 6600 computer system. The total computation hours utilized were equivalent to 1860 CDC 6600 CPU hours - a single shift - and the estimated dollar value was $1.38 million - approximately the annual rental cost of a CDC 6600.

Examination of the pattern of this usage indicated that (a) TSC was still oriented toward hardware testing and component design - generally termed hard technology - in FY 72, and (b) TSC's scientific computer users rely on off-site systems for the bulk (69%) of their computer support.

17. Key Words	18. Distribution Statement
Computers, Digital Computers, Utilization Computers, Hours Computers, Expenses	DOCUMENT IS AVAILABLE TO THE PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22151.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	21	

Form DOT F 1700.7 (8-69)

PREFACE

The investigation described in this report was planned and conducted by the TASF Program Office (TPO) at the Transportation Systems Center, Department of Transportation. The goal of the investigation was to describe the magnitude and nature of current computer usage at TSC as a guide to assessing the import of TSC's FY 77 computation demands. The FY 77 demands were projected by TPO as a separate task in the TASF program effort.

The TPO investigator received the willing and valuable assistance of Mr. Richard Gaudet, Chief of the Data Services Division, and members of his staff: Carmine Caso, James Connolly, Paul Doyle, Charles Pandil, and Robert Peabody.

TABLE OF CONTENTS

LIST OF TABLES

1.0 INTRODUCTION

The Transportation Systems Center currently employes a medley of on-site and off-site computer systems to obtain the computational support it requires. TSC's computer utilization is administered by the Data Services Division and summarized monthly by that division in the User Accountability Report. Examination of the monthly reports for FY 72 indicates that during the fiscal year TSC personnel made direct expenditures for the use of eighteen different digital computer systems - eight on-site systems and ten systems owned and maintained outside TSC (see Table 1). In addition, TSC personnel used at least two other systems, in conjunction with R&D contracts, for which TSC incurs no charges and maintains no utilization records (systems no. 19 and 20).

Characterizing the computer utilization of an organization which uses twenty diverse systems is a difficult task. The common approach of translating the computation hours for various machines into equivalent hours on a single machine can be used to suggest the magnitude of computation performed. At TSC, the limitations inherent in such an approach are magnified 20 times. It is, however, necessary to describe the scope of current computer usage at TSC as a guide to assessing the import of the projected FY 77 computation demands. In the following section, the estimated total computation hours used by TSC personnel during FY 72 are stated in terms of equivalent CDC 6600 Central Processor Unit hours. In Section 3.0, the dollar value of this usage is estimated for the Center as a whole and for each FY 72 PPA. In Section 4.0, the sources of computer support at TSC and factors influencing their selection are examined.

TABLE 1. COMPUTER SYSTEMS USED BY TSC PERSONNEL - FY 72

TSC ON-SITE COMPUTER SYSTEMS

1. IBM 7094-II
2. DEC PDP-10
3. Honeywell H832
4. Honeywell DDP-516 (GOTS)
5. Honeywell DDP-516 (TAG)
6. Honeywell DDP-516 (TIF)
7. Honeywell DDP-516 (PDP-10)
8. XDS 9300

OFF-SITE COMPUTER SYSTEMS

	Organization	Machine
9.	Smithsonian Astrophysical Observatory	CDC 6400
10.	Control Data Corporation (Cybernet Service)	CDC 6600
11.	Massachusetts Institute of Technology	IBM 360/75
12.	Harvard University	IBM 360/65[1]
13.	MITRE Corporation	IBM 370/155
14.	Interactive Data Corporation	IBM 360/67
15.	Tymshare, Inc.	XDS 940
16.	First Data Corporation	DEC PDP-10
17.	GSA Timeshare Service	GE 440
18.	The Computer Company	IBM 370/155
19.	Control Data Corporation	CDC 6400
20.	Systematic Data Processing Services	IBM 370/155

[1] No longer available

2.0 COMPUTATION HOURS

Expressing TSC's FY 72 computer utilization in terms of a single machine requires for each machine employed (1) the transformation ratio used to compute the equivalent hours on the common machine, and (2) the number of computation hours used. This technique rests on the transformation ratios applied to each machine vis-a-vis the "common denominator" processor. These ratios should be based on benchmark programs which typify the work performed on each of the individual machines. But there may be no typical workload. Except in cases involving a static mix of standardized tasks, it is difficult to devise a set of benchmarks which accurately represent the spectrum of work performed on any large or medium scale computing system. The difficulties associated with machine comparisons prescribe that the transformation ratios developed be interpreted as approximations.

The ratios used (see Table 2) are based on the accumulated results of several years of benchmark and application experience by TSC personnel[1] and/or the relative add time and cycle time ratios[2]. The computation hours utilized on each machine, on-site and off-site, are taken from TSC's User Accountability Reports with the exception of the data for the Honeywell equipment, which are based on that facility's daily log, and the data for the time-sharing services (systems 14-18), which are computed as 5% of the terminal hours reported in the User Accountability Reports. This information and the equivalent CDC 6600 computation hours are shown in Table 2. In all cases, the reported full year figures are extrapolations based on less than a full year's data: three months for the Honeywell systems, nine months for all others.

---

[1] ADP Equipment Acquisition Plan, NASA Electronics Research Center, Cambridge, Mass., April 1969.

[2] Taken from Auerbach "Standard ADP Reports," August 1969.

As reporting and cost allocation policies have differed from facility to facility, three assumptions were required to estimate actual CPU utilization. First, it was assumed that a minimum of 70% of any system's total computation hours would be considered utilization and thus, at most, 30% of any computer's computation time has been designated systems and maintenance time and not recorded as utilization.

TABLE 2. FY 72 COMPUTATION HOURS

		ESTIMATED FISCAL YEAR CPU HOURS (AVERAGE)	CONVERSION RATIO	EQUIVALENT CDC 6600 CPU HOURS
1.	IBM 7094 II	960	.15	144
2.	Honeywell 832	675	.25	169
3.	Honeywell 516 (GOTS)	459	.10	46
4.	Honeywell 516 (TAG)	231	.10	23
5.	Honeywell 516 (TIF)	184	.10	18
6.	Honeywell 516 (PDP-10)	400	.10	40
7.	DEC PDP-10	300	.17	51
8.	XDS 9300	1167	.20	233
	On-Site Sub Total			724
9.	SAO: CDC 6400	35	.43	15
10.	CDC: CDC 6600	63	1.00	63
11.	MIT: IBM 360/75	70	.45	32
12.	Harvard: IBM 370/155	3	.40	1
13.	MITRE: IBM 360/50	13	.11	1
14.	IDC: IBM 360/67	--	.33	--
15.	T/S: XDS 940	38	.01	--
16.	FDC: DEC PDP-10	49	.17	8
17.	GSA: GE 440	12	.07	1
18.	TCC: IBM 370/155	--	.40	--
	Off-Site Sub Total			121
	Center Total			845

The second assumption deals with the Center's Honeywell equipment. The only data available for these five systems comprise wall clock hours taken from the daily log as they have no internal CPU clocks; i.e., each user records his identification information with the wall clock time at which he begins and ends sole use of the system. The problem lies in converting the amount of time a user is using the computer to the amount of CPU time utilized. This CPU time/log time ratio is determined chiefly by the type of work being performed. Conversations with the principal users of this system indicate that they can be divided into two homogeneous groups - those performing substantial input/output work (e.g. program editing and data structuring and manipulation) in an interactive mode and those performing heavy batch processing requiring little input/output. The CPU time/log time ratios suggested by members of each group are 0.10 and 0.75 respectively. The conversations with each group also indicate that each believes it is the principal user, but the data for the month of February indicates that the usage is fairly evenly divided among them. The second assumption, then, is that the two CPU time/log time ratios - 0.1 and 0.75 - provide the range of CPU time values for the Honeywell equipment, and thus for the Center, and that the mean of this range is the most reasonable estimate. All three sets of figures are shown in Table 3.

Finally, the data available for the XDS 9300 are also wall clock hours. The personnel using this system indicate that the CPU time/log time ratio is .60 to .95. However, due to the special nature of hybrid work, the XDS 9300 must be dedicated on line throughout each session. Thus, the ratio used for this system is 1.0.

Table 3 shows that TSC personnel performed computation equivalent to at least 600 and at most 1100 CDC 6600 CPU hours during FY 72. Table 2 shows that the estimated actual utilization, assumed to be the mean of this range (assumption number 2 above), was equivalent to 845 CDC 6600 CPU hours. This figure is representative of the magnitude of computation work performed during the fiscal year.

TABLE 3. RANGE OF COMPUTER UTILIZATION

Equipment	Projected Full Year Wall Clock Hours	Projected full year CPU hours based on CPU time/wall clock time ratios of:[2]			Conversion Ratio to CDC 6600 CPU Hours	Equivalent full year CDC 6600 CPU hours based on Honeywell CPU time/wall clock time ratios of		
		0.10	0.75	(avg) 0.425		0.10	0.75	(avg) 0.425
IBM 7094-II	na	na	na	na	.15	144	144	144
Honeywell 832	1588[1]	159	1191	675	.25	40	298	169
Honeywell 516 (GOTS)	1080	108	810	459	.10	11	81	46
Honeywell 516 (TAG)	544	54	408	231	.10	5	41	23
Honeywell 516 (TIF)	432	43	324	184	.10	4	32	18
Honeywell 516 (PDP-10)	941[1]	94	706	400	.10	9	71	40
DEC PDP-10	na	na	na	na	.17	51	51	51
XDS 9300	1167	na[3]	na	na	.20	233	233	233
					On-Site Sub Total	497	951	724
					Off-Site Sub Total (see Table 2)	121	121	121

1,2.3
Footnotes correspond to the three assumptions discussed

Center Total - Equivalent Full Year CDC 6600 CPU Hours	Low	High	Avg
	618	1072	845

The 845 CDC 6600 CPU hours represent approximate chargeable hours of utilization and do not make allowance for system idle time or systems and maintenance operations time. Assuming that systems and maintenance amounts to 30% of total utilization, the equivalent total utilization for FY 72 is 1210 CDC 6600 CPU hours. If it is also assumed that the system is idle 35% of the time (system idle time is time that cannot be "captured" and is typically 20-50% of the total available time), the required system (CDC 6600) availability would have been 1860 hours. In sum, TSC's FY 72 computer usage can be exemplified by a single CDC 6600 with the following utilization:

Actual utilization	845 hours	(45%)
Systems operations and maintenance	365 hours	(20%)
Machine idle time	650 hours	(35%)
Total available hours	1860 hours	(100%)

3.0 COMPUTATION EXPENSES

The computation expenses for FY 72 are also extrapolations of data taken from TSC's User Accountability Reports with the addition of data for the Honeywell equipment which are based on the extrapolated log time hours (Table 3) and anticipated FY 73 hourly charges for that equipment.[1] As Table 4 shows, in FY 72 TSC spent approximately $600,000 for on-site computer support and another $200,000 for the purchase of computer time from off-site facilities. These two figures, however, are incommensurable: the charges for the use of off-site facilities include the costs to the vendor of leasing (or buying) and operating the computer system. The charges for the use of TSC's on-site facilities, however, comprise operating expenses only as TSC owns all of the eight systems -- except the I/O processor (IBM 360/30) for the IBM 7094. The real "cost" of using these systems should include depreciation charges if the figures are to be used for meaningful comparisons. The purchase prices of the eight on-site systems sum to $2,860,000; assuming five-year, straight line depreciation, the annual depreciation charge would be $572,000. Therefore, TSC's FY 72 computation utilization could be characterized by inclusive computation expenses of $1,375,000, comprising $600,000 for on-site operating and rental costs, $572,000 for depreciation of on-site equipment, and $203,000 for the purchase of computer time from off-site facilities.

This level of expense is consistent with the CPU hour estimates developed in the last section. The 1860 CDC 6600 CPU hours represent a single shift for that machine and a CDC 6600 with peripherals resembling those in used at TSC would lease for approximately $100,000 per month of $1.2 million annually. Thus, the magnitude of computer work performed by TSC personnel during FY72 is approximately equal to that which could be provided by a single CDC 6600. These figures in no way imply that such a machine should or could have supplanted those which actually provided the computational support; they are merely indicative of the scope of computer work performed.

[1] Projected FY 73 charges are based on FY 72 costs and usage.

TABLE 4. FY 72 COMPUTATION EXPENSES

EQUIPMENT	ESTIMATED FULL YEAR CHARGES $K	
IBM 7094II	127.1	
Honeywell 832[1]	63.5	
Honeywell 516 (GOTS)	27.2	
Honeywell 516 (TAG)	5.6	
Honeywell 516 (TIF)	8.4	
Honeywell 516 (PDP-10)	18.8	
DEC PDP-10	220.4	
XDS 9300	131.3	
On-Site Sub Total for Maintenance and Operations		$602.3K
Depreciation of On-Site Systems		$572.0K
SAO:CDC 6400	21.9	
CDC:CDC 6600	89.4	
MIT:IBM 360/75	29.8	
Harvard:IBM 370/155	1.7	
MITRE:IBM 360/50	5.5	
IDC:IBM 360/67	5.7	
T/S:XDS 940, FDC:DEC PDP-10, GSA:GE 440	49.3	
Off-Site Sub Total for Time Purchase		$203.3K
Center Total		$1377.6K

Although these figures represent the absolute magnitude of computer support provided during FY 72, they give no indication of the relation of TSC's computation expenses to its total in-house budget. The money actually spent in-house during the fiscal year is most accurately represented by the accruals shown for each PPA in the Center's Direct Cost Summary. Data as of May 31, 1972, indicate that the TSC FY 72 in-house budget should be approximately $17.3 million; including the depreciation charges for the sake of comparison, the in-house expenditures are $17.95 million. Thus, computation expenses equal 7.66% or approximately 8% of the in-house budget for FY 72. Note that this percentage is, if anything, high because of (1) the inclusion of depreciation charges; (2) the use of accurals-which do not include funds obligated but unspent during the fiscal year-instead of obligations for the in-house budget; and (3) the exclusion of funds obligated in FY 71 but spent during FY 72.

Comparison of these figures with industry averages indicates that TSC was still oriented toward hardware testing and component design - generally termed "hard" technology - in FY 72. Computer expenses for firms involved in "hard" technology are typically near 4% of their project budgets, while those for firms in the "softer" sciences -- econometrics, preliminary systems evaluation, modeling -- are near 20% of project budgets.[1] TSC's average (computer expenditure/in-house project budget) ratio is above that of hardware oriented industries, but its evolution to date has left it considerably under that of firms involved in the "soft" sciences.

The ratio of computer expenses to project budget for each FY 72 PPA can also be determined from the Direct Cost Summary. While the EDP/EAM costs reported in that summary cannot be used directly for this comparison as they include costs for contract analyst support and no depreciation costs, the ratio of each PPA's EDP/EAM

---

[1]Sussman, Joseph, "Computer Use in Engineering Consulting Operations," Internal Memorandum to TASF Program Office from MIT Transportation Computer Use Group, July 1972.

charges to the sum of EDP/EAM charges for all PPAs can be used to distribute the Center's $1.375 million computer expense. This process in effect removes the charges for analysis support (e.g. STC) from the EDP/EAM figures and adds in those for depreciation. The newly computed computer budget for each PPA can then be compared to the in-house budget for that PPA. The results are shown in Table 5. Note that, as before accruals were used to project the in-house budgets and therefore the computer budget/in-house budget ratio will, if anything, be overstated.

In addition to indicating which individual PPAs have emphasized computer analysis, this table also indicates that the emphasis on computer support varies significantly with the modal administration for which the work is performed. For example, the average computer expenses are 9.6% of in-house expenses for FAA projects and only 1.5% for FRA projects.

TABLE 5. FY 72 PPA'S: INCLUSIVE COMPUTER EXPENSES AS A PERCENTAGE OF IN-HOUSE BUDGET

PPA	IN-HOUSE BUDGET[1] - $K	COMPUTATION EXPENSES[2] - $K	RATIO - %
CG201	71.0	28.0	39.4
CG202	52.7	0	0
CG203	102.8	0	0
CG206	13.5	0	0
CG207	99.3	0	0
CG208	26.4	0	0
FA201	1.3	0	0
FA203	202.6	0.2	0.1
FA204	84.3	0	0
FA205	394.0	64.3	16.3
FA206	263.1	36.2	13.8
FA207	464.9	148.0	31.8
FA209	756.9	54.8	7.2
FA211	533.8	32.0	6.0
FA213	260.6	10.5	4.0
FA214	304.9	6.8	2.2
FA215	198.3	1.5	.8
FA217	25.6	0	0
FA218	151.2	1.2	19.9
FA220	127.3	0	0
FA221	754.1	28.0	3.7
FA222	18.4	0	0
FN201	900.5	270.7	30.1
HS201	97.6	0	0
HS202	529.5	5.5	.10
HS203	483.8	1.4	.3
HS204	141.4	0.1	.1
HS205	166.8	0	0
HW201	160.1	0	0
HW202	82.1	13.7	16.7
HW205	108.9	0	0
HW206	35.3	0	0
HW207	4.3	0	0
HW208	8.6	0	0

[1] Based on extrapolation of project accruals, less "Technical Contracts" and "Other Services," as f 5/31/72.

[2] Including distributed depreciation charges for on-site equipment.

PPA	IN-HOUSE BUDGET[1] - $K	COMPUTATION EXPENSES[2] - $K	RATIO - %
NA211	6.4	0	0
NA212	29.8	0	0
NA213	23.9	0	0
NA214	5.5	0	0
OE202	33.5	0	0
OP201	44.3	0	0
OS201	108.3	0	0
OS204	1656.2	230.5	13.9
OS205	83.7	6.9	8.2
OS207	488.3	83.8	17.2
OS208	143.3	34.7	24.2
OS212	268.1	38.9	14.5
OS213	398.7	0	0
OS214	169.6	0	0
OS215	1.6	0.3	18.8
OS216	48.0	0	0
OS217	62.4	7.0	11.2
OS218	558.5	41.6	7.4
OS219	604.9	19.9	3.3
OS220	316.5	0	0
OS221	28.4	0	0
OS222	23.6	0	0
OS223	122.4	8.8	7.2
OS224	22.1	3.0	13.6
RR201	103.1	8.2	8.0
RR202	93.7	0	0
RR204	126.1	4.2	3.3
RR205	213.4	0	0
RR207	18.7	0.3	1.6
RR209	206.8	0	0
RR210	52.4	0	0
RR211	9.9	0	0
RR212	21.5	0	0
UM200	41.7	0	0
UM201	537.4	17.2	3.2
UM202	20.1	1.7	8.5
UM203	108.0	2.8	2.6
UM204	1742.1	21.3	1.2
UM205	389.7	1.2	.3
UM206	228.8	0	0
UM207	13.0	4.2	32.3

4.0 PATTERN OF UTILIZATION

In addition to the general magnitude of computer usage at TSC, the pattern of this usage is of interest. In FY 72, TSC personnel made use of twenty different computer systems (eight on-site systems and twelve off-site systems) indicating that a significant portion of the computer support required was, for some reason, obtained outside the Center. The dollar cost of the off-site support was slightly over $200,000 - a 20% increase over the previous year - and of the total, 845 equivalent CDC 6600 CPU hours estimated to have been used, 120, or about 14% were run on off-site equipment. But these usage figures include all three major types of processing - Business and Administrative, Scientific[1], and Analog/Hybrid - and print a rather murky mosaic. The user accountability system does distinguish between the three types of computer processing and thus can be used to sketch the pattern of computer usage more clearly.[2]

The User Accountability Report for March 1972, which covers three quarters of the fiscal year, indicates that virtually all of the Business and Administrative processing and Analog/Hybrid processing is performed on on-site computers. As a result, 74% of the work performed on the Central Facility (IBM 7094-360/30) is Business and Administrative processing and 100% of the work performed on the Hybrid Facility (XDS-9300, Beckman 2200) is Analog/Hybrid processing.

The scientific utilization depicted by the User Accountability Reports is quite different. For FY 72, based on the data for the

---

[1]This breakdown of usage is that used in the User Accountability System for accounting convenience. Analog/hybrid processing is, of course, a type of scientific use, but unless otherwise stated, "scientific" is used here to mean all scientific processing except analog/hybrid use.

[2]It should be noted; however, that this system does not yet include the utilization of the Honeywell Facility, which performs 35% of the directly funded computer usage, and may paint a slightly distorted picture.

first three quarters, only 24% of TSC's scientific processing was performed on on-site computer systems while 76% was performed on off-site systems. This utilization is almost identical to that in FY 71 when 75% of the Center's scientific processing was performed off-site.[1]

Although these figures indicate an unchanging trend in the source of scientific computer support, the amount of off-site scientific processing is overstated. As mentioned in the footnote above, the category "scientific" does not include any processing accounted as analog/hybrid usage. There is, however, some digital processing accounted as "analog/hybrid" which is performed outside the Analog/Hybrid Facility on the Multimode Simulation Facility's PDP-10 and should probably be included under "scientific processing." With the inclusion of this processing, the FY 72 scientific utilization (which still excludes analog/hybrid processing on the hybrid facility) was 31% on-site and 69% off-site.

These results indicate that it is the scientific processing requirements which have necessitated the use of the twelve off-site computer systems; in congruence with this, the User Accountability Reports show that virtually 100% of the processing performed on off-site systems was scientific utilization.

The reasons for the heavy reliance on off-site systems by TSC's scientific users are varied. First, many of the current projects require the use of programs written for third generation computers incompatible with any within TSC; to avoid the time and expense of conversion, the users have sought the appropriate system off-site. Second, the eight small to medium TSC systems arranged in four antonomous facilities are oriented toward programs which are relatively small in scale and do not require access to large data bases.[2]

---

[1]Peabody, Robert, FY 71 Status Report of Scientific ADP Utilization, unpublished draft report to Anthony Cotroneo, Chief, Systems Applications and Programming Branch, TSC.

[2]Zellweger, Andres, A Brief Survey of TSC Computing Facilities, TSC Special Publication, Report No. DOT-TSC-OST-72-15, May 1972.

Several FY 72 transportation programs have required computer support of a scale that simply could not be provided by TSC's current on-site equipment.[1]

If the current TSC trend away from projects with relatively small computing requirements and toward those in the "softer" sciences with heavy CPU and large data base demands continues, this problem will become increasingly acute.

---

[1]Two examples of this are the Dual Mode and Air Traffic Control Radar Beacon System (ATCRBS) Programs, both of which are heavy users of the CDC 6600. The cost/benefit model developed for the Dual Mode Program required 97,000 sixty bit words of core storage on the CDC 6600, far exceeding the capacity of any TSC on-site computer. The Radar Beacon Simulation for the ATCRBS Program requires computer runs requiring up to six hours of CDC 6600 CPU time which, for this particular simulation, would require six continuous days of PDP-10 CPU time. Again, this level of support simply could not be provided with the on-site equipment TSC now possesses.