REPORT NO. DOT-TSC-OST-72-15

A BRIEF SURVEY OF TSC COMPUTING FACILITIES

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MAY 1972
SPECIAL PUBLICATION

PREPARED for:

DEPARTMENT OF TRANSPORTATION
OFFICE OF THE SECRETARY
~~CAMBRIDGE~~, MA. 20590

1. Report No. DOT-TSC-OST-72-15	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle A BRIEF SURVEY OF TSC COMPUTING FACILITIES		5. Report Date May 1972
		6. Performing Organization Code
7. Author(s) Andres Zellweger		8. Performing Organization Report No.
9. Performing Organization Name and Address Department of Transportation Transportation Systems Center 55 Broadway, Cambridge, MA 02142		10. Work Unit No. R2558
		11. Contract or Grant No. OS223
12. Sponsoring Agency Name and Address Department of Transportation Office of the Secretary Washington, D.C. 20590		13. Type of Report and Period Covered Special Publication
		14. Sponsoring Agency Code

15. Supplementary Notes

This report was prepared for the TASF Program Office, TSC/PA.

16. Abstract

The Transportation Systems Center (TSC) has four, essentially separate, in-house computing facilities. We shall call them Honeywell Facility, the Hybrid Facility, the Multimode Simulation Facility, and the Central Facility. In addition to these four, several laboratories have their own minicomputers. This report reviews the hardware and software capabilities of these facilities. A final section discusses the strength and weaknesses of the current in-house general purpose computer capability.

17. Key Words	18. Distribution Statement
Computers, Facility, Transportation Systems Center	Availability is Unlimited. Document may be Released To the National Technical Information Service, Springfield, Virginia 22151, for Sale to the Public.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	31	

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF TABLES

1.0 INTRODUCTION

The Transportation Systems Center (TSC) has four, essentially separate, in-house computing facilities. We shall call them (1) the Honeywell Facility, (2) the Hybrid Facility, (3) the Multimode Simulation Facility, and (4) the Central Facility. (See Table 1-1). In addition to these four, several laboratories have their own mini-computers. Finally, TSC personnel can access a number of non-TSC time-sharing, remote batch, and batch oriented systems.

TABLE 1-1 COMPUTERS AT THE FOUR TSC FACILITIES

Honeywell Facility	Honeywell H-832 Honeywell DDP-516 (GOTS) Honeywell DDP-516 (TAG)
Hybrid Facility	XDS 9300 Beckman 2200 (analog)
Multimode Simulation Facility	Digital PDP-10 Honeywell DDP-516
Central Facility	IBM 7094-II IBM 360/30

This report is concerned primarily with the first category, the in-house general purpose computing facilities, since these constitute the take-off point for any projected transportation simulation and analysis facility. The four facilities are described in terms of physical configuration, available software, and typical applications. For the sake of completeness, a short section on the Center's stand-alone minicomputers is included. The final section discusses the strengths and weaknesses of the current in-house general purpose computer capability.

The contribution of information for this report by users of the various facilities and by AQ staff members is gratefully acknowledged.

2.0 THE HONEYWELL FACILITY

The Honeywell Facility, located on the 11th floor of the Program Management building, consists of three operationally independent computers: the TAG (Transportation Animated Graphics) DDP-516, the GOTS (Graphics Oriented Transportation Simulation) DDP-516, and the H-832. The system contains two high speed couplers (2 x 10^6 bits/sec), one connecting each DDP-516 to an H-832 IOP channel. Figures 2-1 and 2-2 are schematic diagrams showing the various components of the Honeywell facility; Table 2-1 gives the salient features of the computers. The Honeywell Facilit is an open-shop in the sense that there is no operator (i.e. each user operates the computer(s) himself).

The three systems will be discussed separately below since they are generally used in stand-alone mode. Programs do exist to permit transmission (and conversion) of files between the H-832 and the DDP-516s and to provide run-time communication between programs in different computers. The GOTS coupler is used chiefly to send DDP-516 files to the H-832 for printing (plans include using the H-832 for processing and the DDP-516 for I/O graphics). The TAG coupler is used chiefly to take advantage of FORTRAN (not supported on the TAG-516) computations in programs that use CRTs and other specialized hardware of the TAG system.

2.1 TAG DDP-516

The TAG-DDP-516 has its own operating system and file conventions. Since it has only 16K words of core it uses a non-relocatable assembler. The assembler is augumented by a powerful macro language, but no higher level languages are supported by the system. There is a text editor and a program for scanning files on the CRTs, but the two have not yet been combined. A graphics language (i.e. a set of macros and related subroutines) permits construction of pictures and subpictures, but graphics data structures must be constructed and maintained by the individual user. There is a general network entry and manipulation program. Finally, a number of routines exist for use of the flying spot scanner. The TAG-DDP-516 is used primarily for dynamic graphics oriented applications. Some pattern recognition work involves use of the Transportation Imagery (TRIM) flying spot scanner.

2.2 GOTS-516

The GOTS-516 has the maximum (32K 16 bit word) core offered b) Honeywell as well as paging hardware[1] developed for this machine

[1] Some CPU modifications were made to permit addition of the paging hardware.

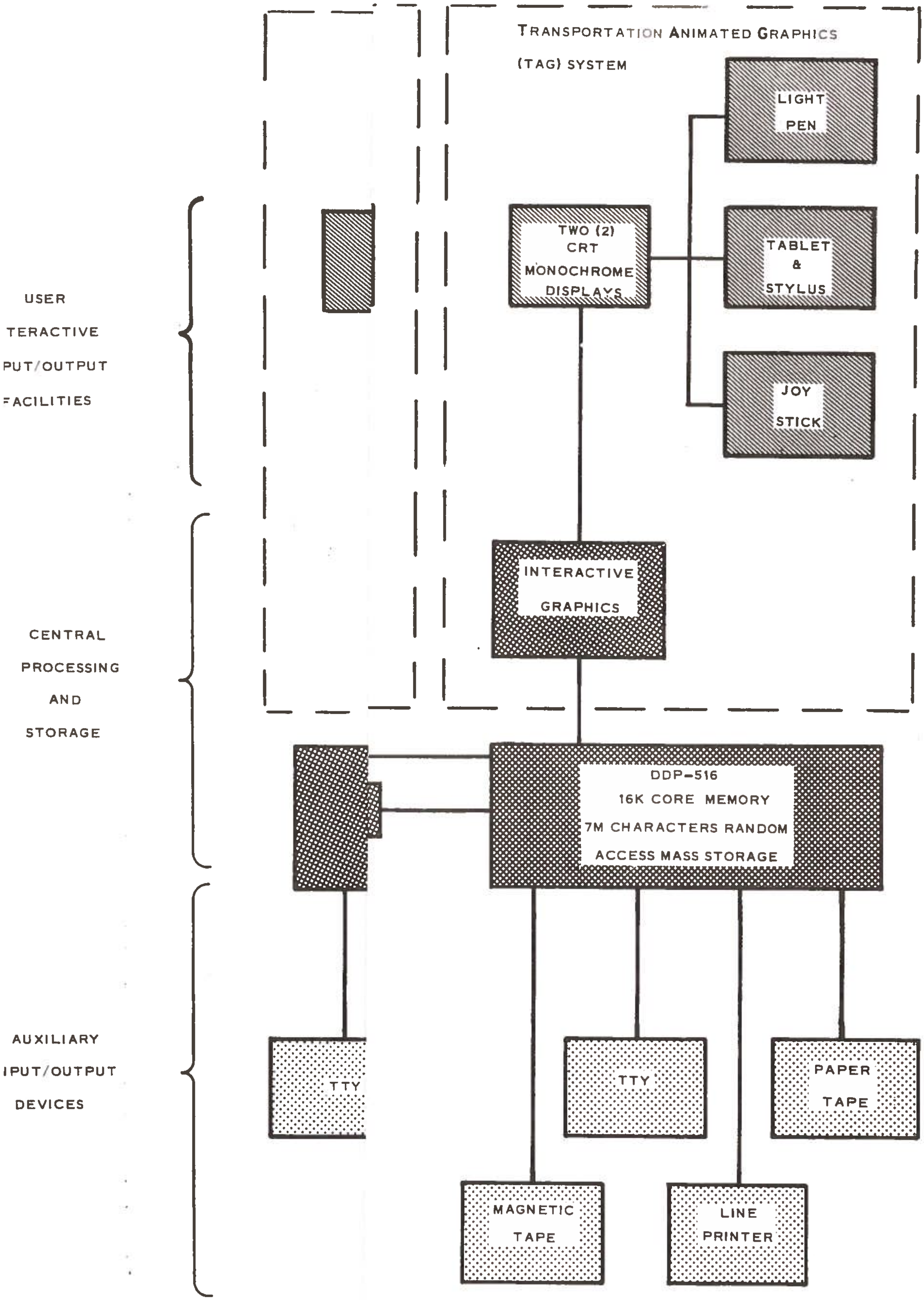

Figure 2-1. DOT Transportation Systems Center Computer Technology Computer System

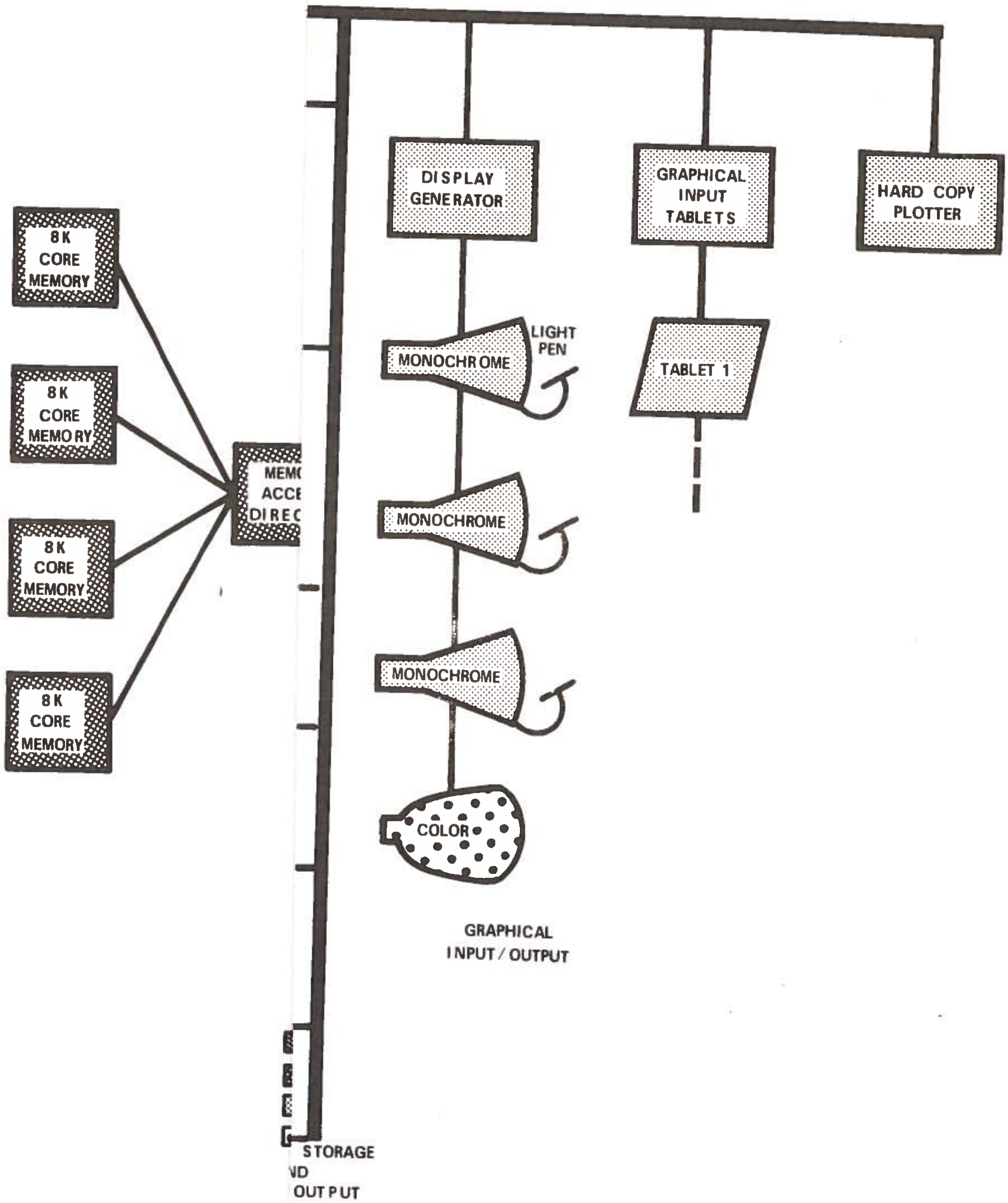

Figure 2-2. Graphics Oriented Transportation Simulation Facility Computer Technology Division

TABLE 2-1 THE HONEYWELL FACILITY

	H-832	GOTS-516	TAG-516
mory size	32,768 words	32,768 words	16,384 words
rd length	32 bits	16 bits	16 bits
cle time	1.25 μsec	1.08 μsec	.96 μsec
x. storage	2 disk drives @ $14x10^6$ chars.	3 disk drives @ $7x10^6$ chars.	1 disk drive @ $7x10^6$ chars.
erator console	2 KSR 35 TTY	1 ASR 35 TTY	1 ASR 35 TTY
inter	300 lpm	-	300 lpm
rd reader	400 cpm	-	300 cpm
rd punch	-	-	-
g. tape drives	2 7-track	connector to one of H-832 drives	1 7-track
g. tape deck	-	-	-
per tape reader	300 cps	300 cps	300 cps
per tape punch	110 cps	110 cps	110 cps
rminals	-	5 KSR 35 TTY	-
splays	-	1 ITT color, 3 IDI, 1 ARDS	2 VG1's
blets	-	1 Sylvania	1 graphacon 1010A
otters	-	1 Calcomp drum plotter	-
nership	government owned	government owned	government owned
her equip.	couplers to GOTS and TAG-516s single line controller option to 2400 band data phone	single line controlled multiple line controller for 16 TTY's high level analog input system joystick(not used) Vermont Res Drum(not used)	flying spot scanner (TRIM) switch box

under NASA Electronics Research Center. A fairly sophisticated disk operating system (DOS) has been developed for this machine. DOS is used without the paging hardware and can thus be used on standard DDP-516s. DOS is in fact used on the DDP-516 that is part of the Multimode Simulation Facility and on the TIF DDP-516. Only one version of the DOS machine resident nucleus and the FORTRAN compiler and library needs to be maintained, but differences in the peripheral devices make other portions of DOS incompatible from machine to machine.

A compatible version of DOS called TSDOS is used when the GOTS-516 is in time-sharing mode. In time share mode, five users can access the 516 simultaneously. One of these users can use the graphics terminal, but software does not yet exist for use of the ARDS terminal or the Calcomp plotter in time-sharing mode.[1] The time-sharing is set up so that users can access the computer over phone lines from remote locations.

The GOTS system supports DAP (the assembler language), BASIC, FORTRAN, and a version of the FORTRAN-based simulation language GASP. A well designed graphics package consisting of FORTRAN callable subroutines exists. The graphics package can be used for dynamic graphics on the IDI displays, for the ARDS terminal storage CRT, and for the Calcomp plotter. The GOTS-516 applications, like those on the TAG-516, are primarily graphics oriented. A CRT terminal for usage via data phone and an electrostatic printer are being procured for the GOTS computer.

2.3 H-832

The H-832 is a dual CPU, 32-bit word, 1.25 microsecond comput intended as the processing heart of the Honeywell Facility (i.e. t H-832 could provide processing and secondary storage for the 516s the two couplers). The machine has standard peripheral equipment (two tape drives, two disk drives, printer, card reader, and paper tape reader-punch) as well as hardware segmentation and other sophisticated hardware features to facilitate multiprocessing, multiprogramming, or time-sharing. Unfortunately, Honeywell made very few H-832s (and H-632s, the single CPU version of the machine so that the software one normally expects for this size machine never materialized. There is no software for multiprocessing or time-sharing. Honeywell provides a simple single-batch stream operating system (OS-1), but TSC is developing[2] its own disk operating system (DOS-32) modelled after the GOTS-516 DOS. This operating system requires about one-third of the H-832 core.

Software for time shared use of the ARDS and Calcomp is being developed.

[2] The system is being developed for TSC by Cambridge Computer Associates.

[3] It should be pointed out the 32K configuration is minimal. The H-832 core can be expanded up to 256K words.

ıture plans call for expansion of this system for time-sharing, ıt currently the H-832 is used in single CPU mode, without ɜgmentation, from one on-line teletype. The H-832 is rarely ;ed in conjunction with the TAG or GOTS systems.

Honeywell provides a FORTRAN compiler and a FORTRAN library ɔr the H-832, but these are quite inefficient. It takes several ınutes to compile, link, and load even a simple FORTRAN program. ıe simulation language GASP is operable on the H-832.

3.0 THE HYBRID FACILITY

The Hybrid Facility, located in the basement of the Systems Development Building, consists of an XDS-9300 digital computer and a Beckman 2200 analog computer. The facility also contains an EAI-580 analog computer that is not connected to the Hybrid computer. A general aviation trainer (GAT) can be used under control of the Hybrid computer or else with the EAI-580 and the PDP-10. Figures 3-1 and 3-2 are schematic diagrams of the Hybrid Facility; Tables 3-1 and 3-2 give the salient features of the computers. The Hybrid Facility is used in open-shop mode.

The XDS-9300 is a second generation computer that is basically run as a tape and card oriented batch system. It has no disk and a 2 million character rapid access device (RAD), but the RAD is not used because most real-time simulations do not need mass storage and thus no RAD software was ever developed. The XDS-9300 has a dynamic CRT which is not often used, also due to lack of software. There are two monitor systems available for the XDS-9300, a BECKTRA monitor and a FORTRAN IV monitor. BECKTRAN is based on FORTRAN II and provides a large library of commands and subroutines for hybrid work. It contains a feature called ANACHECK which gives a means for checking all analog components and the correctness of patch boards. BECKTRAN also supports REQUEST, a package to help deal with the analog interface. The FORTRAN IV system has some hybrid capabilities but is not as well suited to hybrid work as BECKTRAN.

The XDS-9300 is used both in hybrid and in stand-alone mode. Typical applications include real-time, man-in-the-loop simulations involving the GAT and fast-time 4-D guidance simulations. The latter is chiefly a digital application.

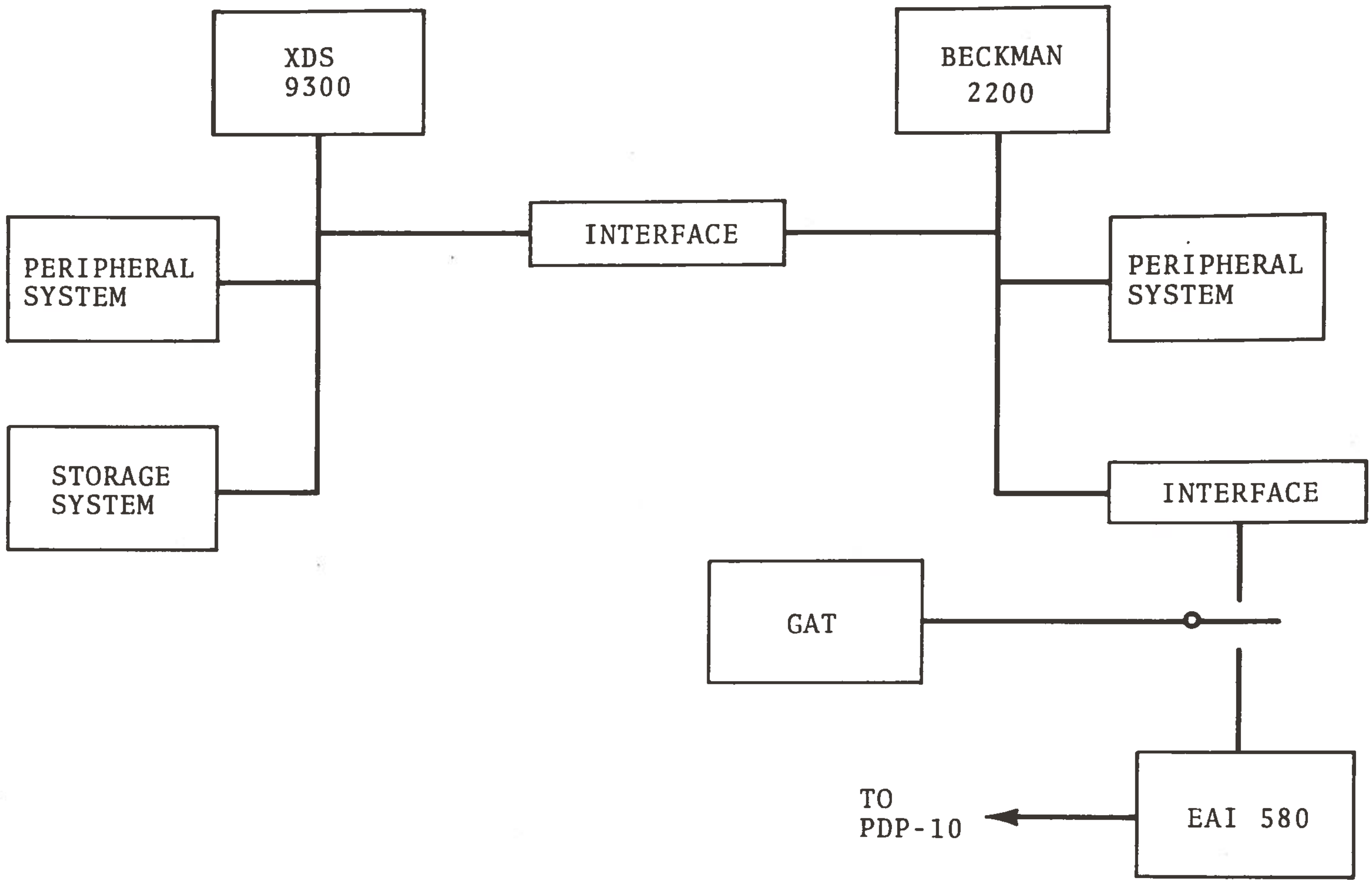

Figure 3-1. The Hybrid Facility

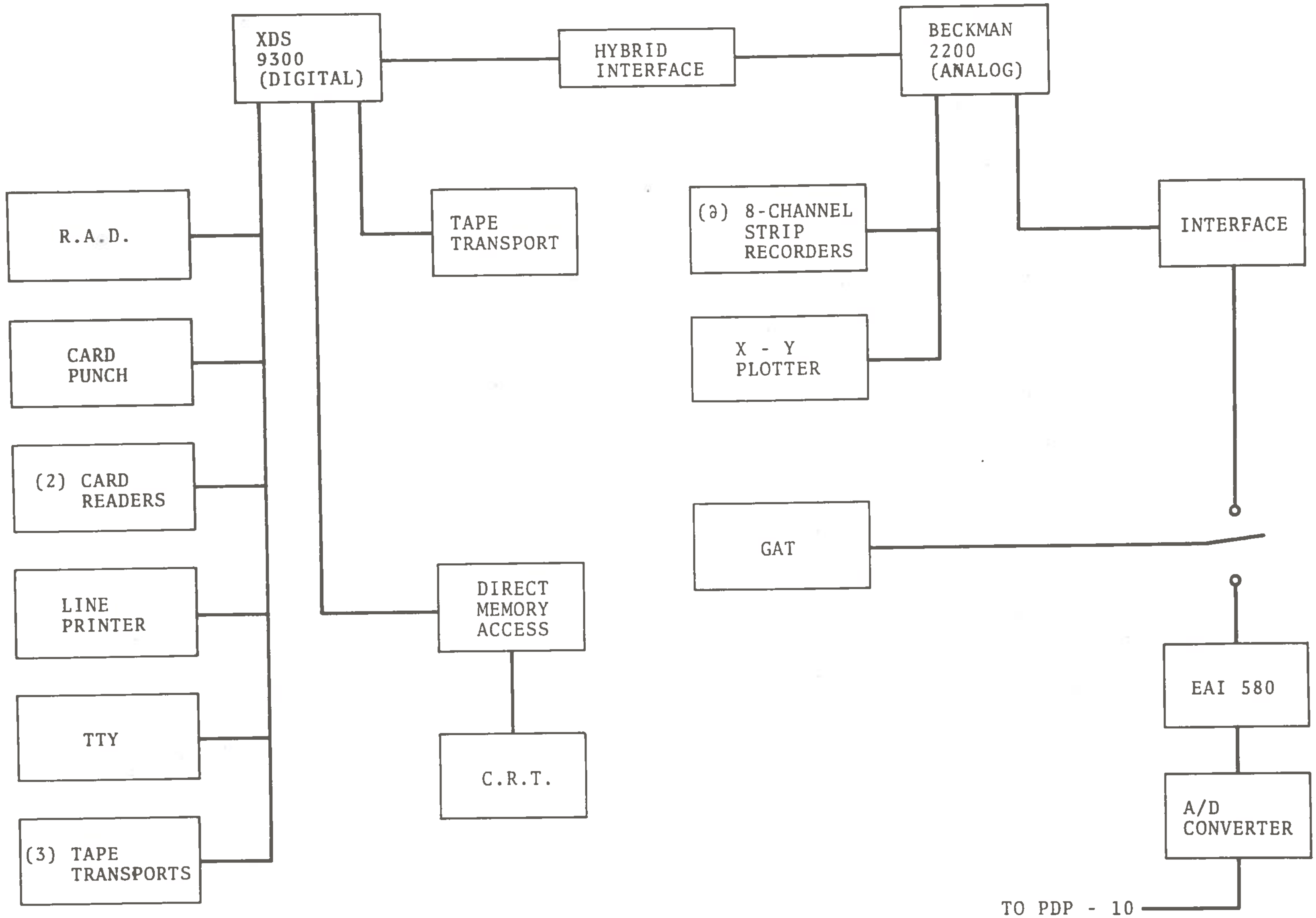

Figure 3-2 The Hybrid Facility (Detail)

TABLE 3-1 XDS-9300

emory size	32,768 words
ord length	24 bits
ycle time	1.75 μsec
ux. storage	2 million character drum (RAD)
perator console	(2) KSR model 35 TTY's
rinter	1000 lpm
ard reader	(1) 400 cpm; (1) 800 cpm
ard punch	300 cpm
ag. tape drives	(4) 7 track drives
ag. tape deck	-
aper tape reader	-
aper tape punch	-
erminals	-
isplays	XDS 9185 scope w/light pen
ablets	-
lotters	-
wnership	leased from XDS (purchase under negotiation)
ther equip.	hybrid interface: 40 D/A lines 40 A/D lines 16 D/A test lines 16 A/D test lines 10 interrupt lines

TABLE 3-2 BECKMAN 2200 ANALOG COMPUTER

Computing Components

120 Operational Amplifiers (72 can be integrators)

32 Summers

240 Servo Set Pots

12 Function Generators

48 Comparators

3 Rate Resolvers

16 Limiters

48 Electronic Switches

Logic Elements

96 Or/Nor Gates

12 One Shots

32 Flip Flops

32 Logic Inverters

4 2-Digit Reset Counters

32 3-Diode Networks

8 4-bit Shift Registers

Other Equipment

2 Eight Channel Strip Recorders

4.0 MULTIMODE SIMULATION FACILITY

The Multimode Simulation Facility, located on the first floor f the Systems Development Building, consists of a PDP-10 and a oneywell DDP-516 with a Sanders 900 display system. An RNS-10 nterface connects the PDP-10 and the DDP-516.[1] The PDP-10 can lso be connected to the EAI 580 (and thus the GAT) of the Hybrid acility.[2] Figures 4-1, 4-2, and 4-3 are schematics showing the onfiguration of the Multimode Simulation Facility; Table 4-1 ives the salient features of the computers.

The PDP-10 is a time-shared computing system without paging ut with core shuffling and swapping (to give a virtual core of 56K words).[3] It also has the capability of doing real-time work nd background multiprogramming batch work. The DDP-516 is an pen shop system that supports one user at a time. The 516 in this acility is chiefly a graphics oriented system.

The PDP-10 supports FORTRAN IV, COBOL, MACRO-10, BASIC, ALGOL, PL, LISP, GASP, AID, and REDUCE. The major software package used n the PDP-10 is ROSS, the Route Oriented Simulation System. It is esigned for real-time simulations that involve human interaction. ypical applications are in airport surface traffic model (AGATS) nd a simulation of the Atlanta air space that involves a human air raffic controller (AATMS). The PDP-10 has become a popular machine or scientific work and thus the basic systems software is well upported by DEC and much application software is available through ECUS, the user group.

The DDP-516 runs under the operating system DOS (see discussion f Honeywell Facility). Languages supported are FORTRAN IV and DISS Dynamic Display Software System). The latter is a graphics language and system used to drive the Sanders displays. The user can nteractively create the geometric characteristics of his desired isplay and specify the dynamic linkages with a program to simulate he display environment which resides in the DDP-516 or the PDP-10. hus DISS interacts with ROSS during the exercising of a simulation.

Data can be sent across this link at a rate of one word every 150 microseconds.

This is an experimental 10 bit A/D link which is not currently operational.

PDP-10 systems can be upgraded to include paging hardware, dual CPUs, and considerable more core than the 80K words in the Multimode Simulation Facility.

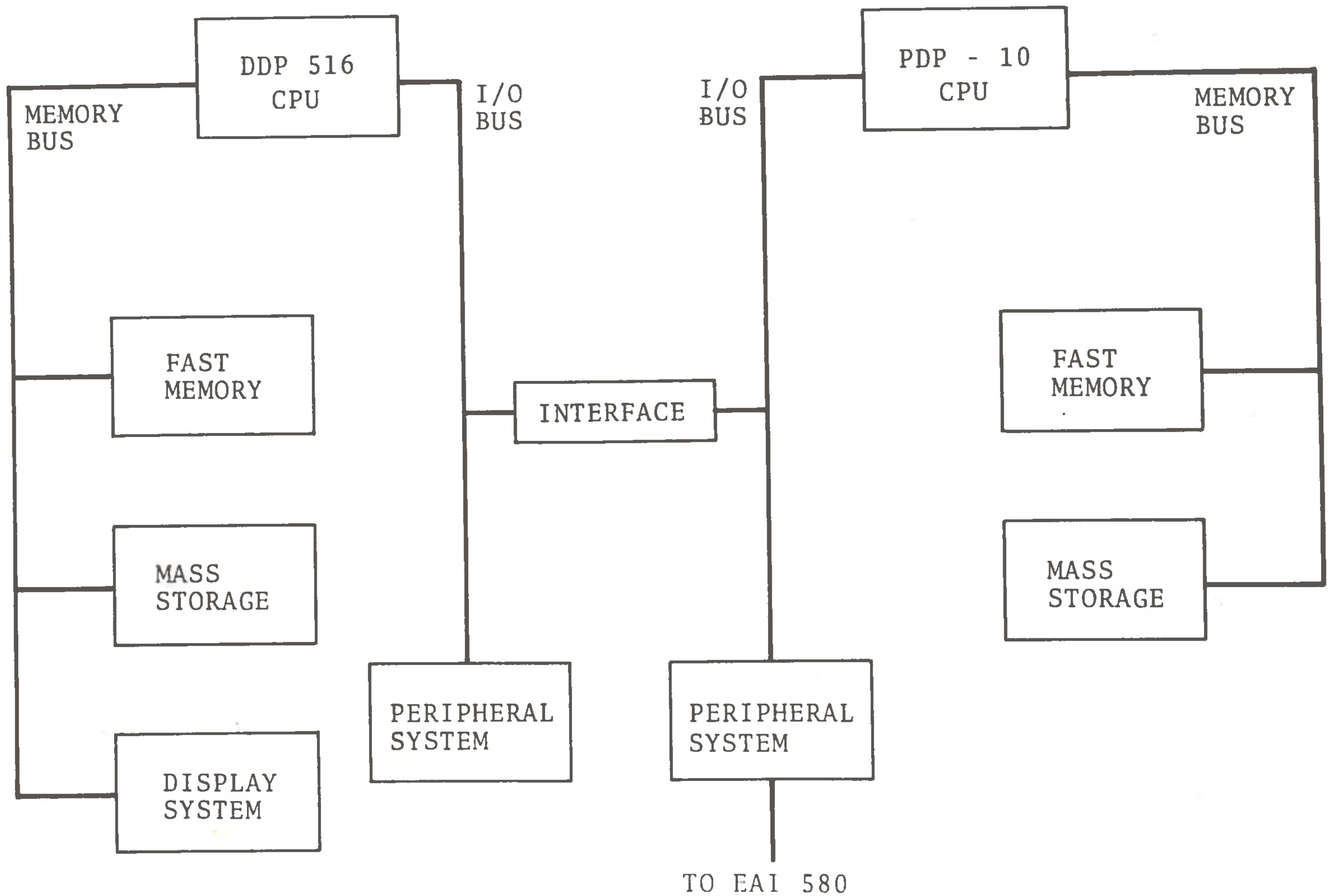

Figure 4-1. Multimode Simulation Facility

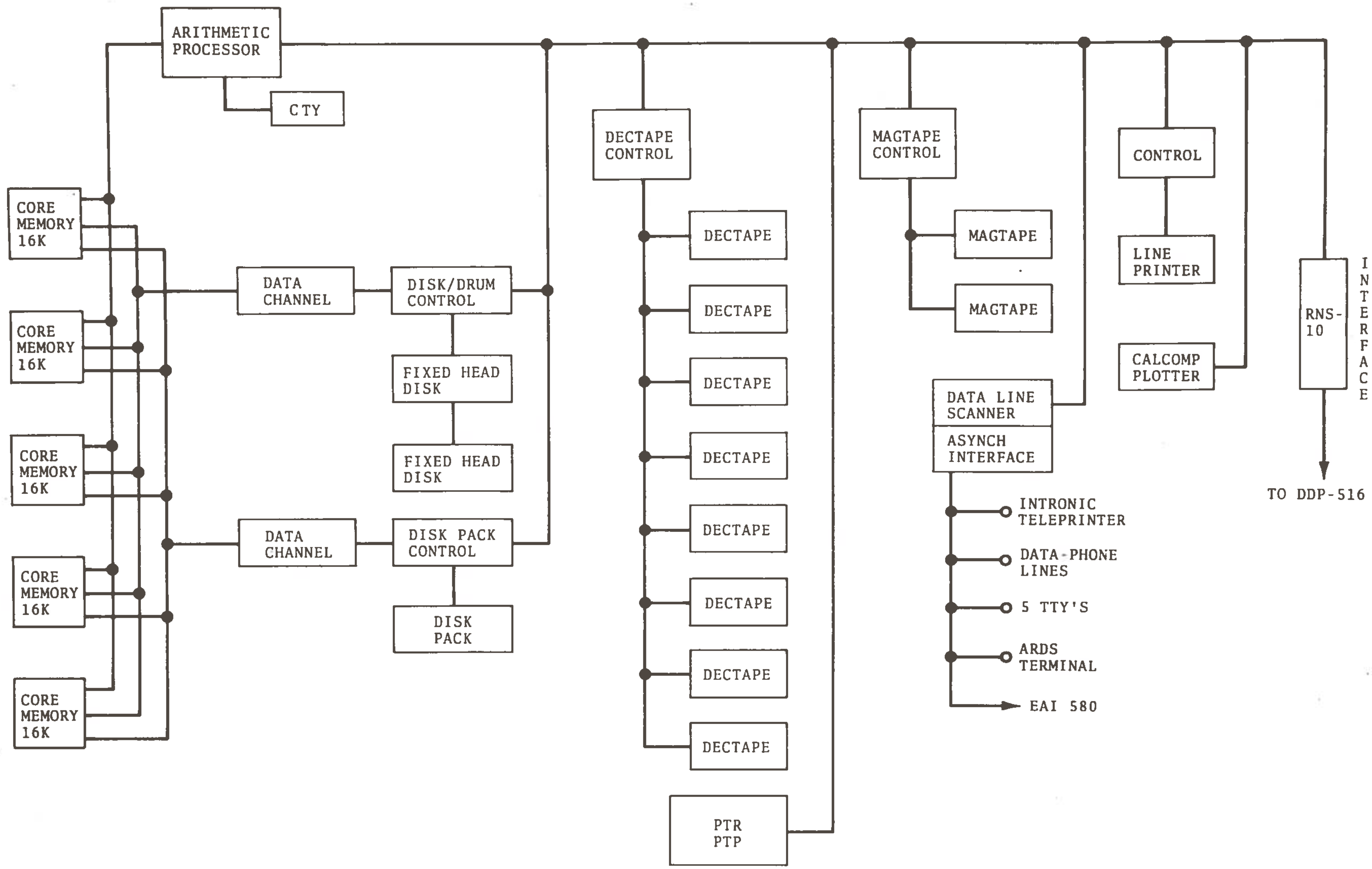

Figure 4-2 DEC System 10 Computer Facility

TABLE 4-1. THE MULTIMODE SIMULATION FACILITY

	PDP-10	DDP-516
Memory size	80,000 words	32,000 words
Word length	36 bits	16 bits
Cycle time	1.0 μsec	.96 μsec
Aux. storage	2 fixed head disks (@ 500,000 words) 1 disk drive ($5.2x10^6$ words) (second drive on order)	2 disk drive ($7.5x10^6$ chars)
Operator console	1 KSR 35 TTY	1 ASR 35 TTY
Printer	1000 lpm	-
Card reader	(1200 cpm on order)	-
Card punch	-	-
Mag. tape drives	2 7-track	-
Mag. tape deck	8 Dec Tape units	-
Paper tape reader	300 cps	300 cps
Paper tape punch	50 cps	110 cps
Terminals	12 ASR&KSR 33; 4 phone (16 lines total) (18 on order)	-
Displays	1 ARDS, 1 DELTA DATA Disp.	1 Tasker Color Display 1 Sanders ATC Console Display 1 Sanders 960 Display 1 Sanders 930 Display 1 Sanders 900 Display Generator
Plotters	Calcomp model 563	1 Sac Graf/Pen Tablet w. stylus 1 Track Ball; 1 lightpen; 1 Touch-entry
Ownership	government owned	government owned
Other equip.	CPU has Flt. pt. hardware fast registers, dual memory protection and relocation. 1 techtronic teleprinter (100 chars/sec) RNS-10 Interface to 516	128 light function keys

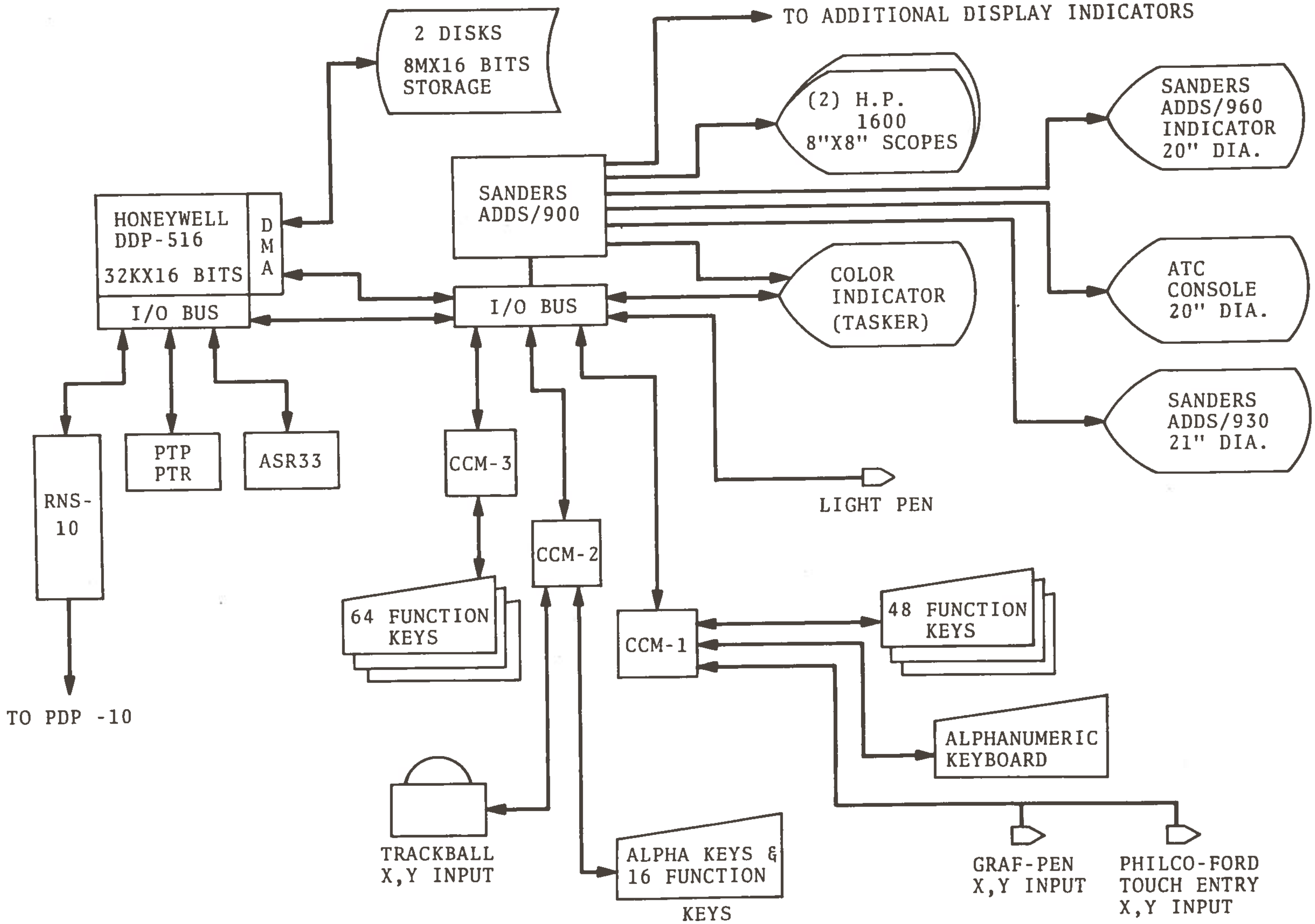

Figure 4-3 Honeywell DDP-516 Computer Facility

5.0 CENTRAL FACILITY

The Central Computing Facility, located on the 10th floor of the Program Management building, consists of an IBM 7094, an IBM 360/30, and an assortment of punch-card accounting machines. Figure 5-1 is a schematic diagram of the Central Facility; Table 5- gives the salient features of the computers. The Central Facility is operated in closed-shop batch-oriented mode. The 7094 is a tape oriented system that receives I/O support from the 360/30. The 360/30, besides doing all pre and post processing for the 7094, is used for utility processing, paper tape work, CALCOMP microfilm and pen plotting, and some stand-alone processing.

The IBM 7094 is a second generation computer with a cycle time of 1.4 µsec and an operating system (IBSYS) that is quite primitive by today's standards. The computer has no drum or disk for seconda storage, so that all data bases must reside on magnetic tape (the 7094 has 10 tape drives). FORTRAN IV, COBOL, FORMAC, COGO, MAP, and FMS are supported on the 7094.

The 360/30 can operate under OS, DOS, or PONY. Languages sup- ported include FORTRAN IV (F level), COBOL, RPG, PL1, and ALG. The 360/30 has a 1000 line per minute printer and a 1000 car per minute card reader, two 7 track tape drives, a 2311 disk, a paper tape rea and punch, and a CALCOMP CRT and plotter, all of which are used for the Central Facility's I/O processing. The Central Facility is use for all the business data processing for TSC and also for scientifi work. The split between these applications on the IBM 7094-II is about 60 (business) - 40 (scientific). Currently the 7094 runs for two 8-hour shifts a day at about 50 percent of its total capacity.

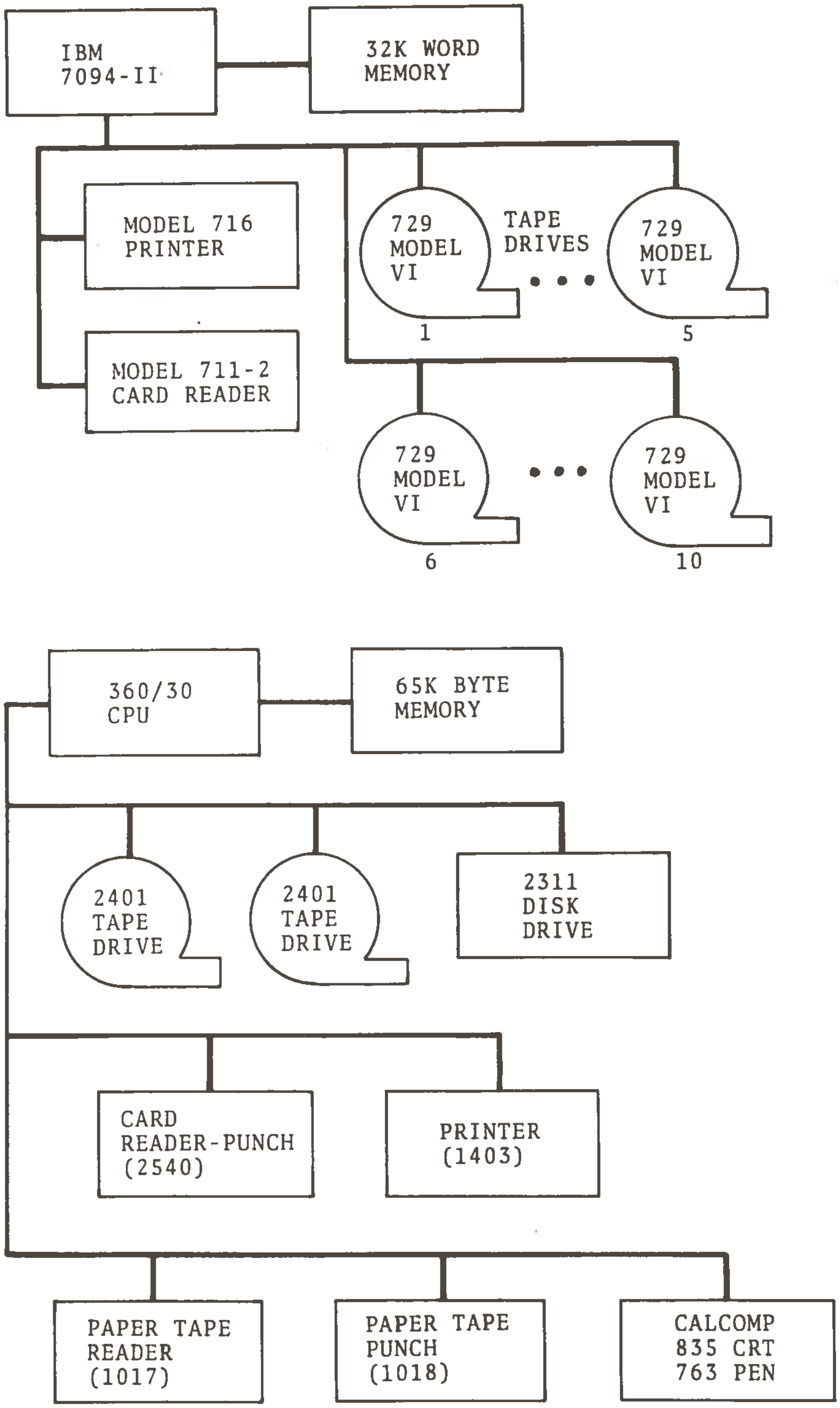

Figure 5-1 The Central Facility

TABLE 5-1 THE CENTRAL FACILITY

	IBM 7094-II	IBM 360/30
Memory size	32,000 words	65,000 bytes
Word length	36 bits	8 bit byte/32 bit
Cycle time	1.4 μsec	1.5 μsec
Aux. storage	-	1 2311 disk drive ($7.5x10^6$ chars)
Operator console	7151 model 2	model 1052
Printer	716 model 1	1000 lpm
Card reader	711 model 2	1000 cpm
Card punch	-	(model 2540 reader punch)
Mag. tape dirves	10 7-track	2 7-track
Mag. tape deck	-	-
Paper tape reader	-	1017 model 2
Paper tape punch	-	1018 model 8
Terminals	-	-
Displays	-	-
Tablets	-	-
Plotters	-	CALCOMP 835 CRT 763 pen 110 Interf
Ownership	government owned	leased from IBM
Other equip.	-	-

6.0 STAND-ALONE MINICOMPUTERS

In addition to the four facilities discussed so far there are number of minicomputers in use at TSC (see Table 6-1). Only the F DDP-516 (by far the largest of the five mini systems) is used a general purpose computer. The other four are used for special-ed applications. The two PDP-11s are used primarily to reduce d process analog field data. Both can be used in mobile units. e PTH DDP-516 is a machine recently obtained from the Coast Guard. its current minimal configuration it cannot be used for general rpose computing. The IBM 4Π is a special purpose aerospace gital computer that can be used in space capsules. It is owned NASA.

The TIF DDP-516 has a 32K (16 bit) word core, a 7.5 million aracter disk, a 300 lpm printer, an ASR35 teletype, and a paper pe reader and punch. It is attached to an Image Module MK5 and lpar Image Dissector. This DDP-516 is used for general purpose mputing and, together with the above special equipment, for image ocessing work. The computer, under the operating system DOS[1], pports FORTRAN IV and BASIC.

TABLE 6-1 STAND ALONE MINICOMPUTERS

Computer	Contact (organization)
Honeywell DDP-516	P. W. Davis (TIF)
DEC PDP-11	P. W. Davis (TIF)
DEC PDP-11	S. Karp (TEC)
Honeywell DDP-516	B. G. Nagy (PTH)
IBM 4 Π	R. L. Wiseman (PGS)

[1]ee Honeywell Facility description.

7.0 DISCUSSION

The existing TSC facilities are quite adequate for many of th current computer applications. The computing load at TSC is low enough so that only a few of the larger computer programs (in term of CPU and primary and secondary memory requirements) must be run at other facilities.[1] For example, the Air Traffic Control Radar Beacon System (ATCRBS) simulation, which at times requires runs of several hours on a CDC 6600, is operated from a remote entry terminal at TSC for execution in the CYBERNET system. Some programs developed on outside computers have been successfully converted to run on one or more of the TSC computers. For example, the noise abatement program that ran in a 250,000 byte partition of a 360/75 now is operational, with graphics, on the GOTS DDP-516.

The TSC facilities are well suited to many of the specialized applications (image processing, graphics, etc.) and TSC personnel have generally developed excellent software tools to get the most out of the available equipment. The small systems in use at TSC tend to be more flexible in the sense that small user populations and small operating systems allow one to modify a system to make it more responsive to the individual user.[2] It should be noted though that the TSC capability is geared towards small scale programs that normally do not require interaction with large data bases. Programs that have grown with time (such as the FA-206 Flow Control Simulation on the GOTS system) have been severely constrained by the limited power of individual facilities. If the current TSC trend away from projects with relatively small computi requirements and toward large systems analysis and development pro jects with heavy CPU and large data base demands continues in the in-house facilities will no longer be adequate.

A number of shortcomings of the TSC facilities are delineated below. Some apply to the current user profiles (7.1,7.2,7.3), but the more serious ones relate to the projected systems level proble that will characterize future TSC computer users (7.4,7.5).

---

[1] While this report is concerned with the capability of the TSC co puting facilities rather than with their utilization, it should pointed out that currently the in-house facilities are operating well below their full capacity.

[2] It is interesting to note that most such changes are made to han interactive graphic input/output. If a large control computer w satellite graphic processors were used this flexibility would no be lost since changes would not normally involve the operating system of the larger processor.

Many of these shortcomings could be overcome by consolidating ıe current proliferation of systems. Ideally, there would be one entral facility with a number of satellite processors to perform ıe specialized I/O functions. The DDP-516 in the Multimode Simula- ion Facility is a typical example of such a satellite. When ROSS ; run the bulk of the computations are performed on the PDP-10 ıile the graphic input and output is handled by the DDP-516. Such consolidation of facilities would provide more processing power ıd more primary memory for individual programs as well as a larger ıified file system. It is highly probable that such a facility ould lead to increased use of in-house computers because of the ımmonality of software and because of the increased processing ower and data base capability.

.1 PROGRAMMER RETRAINING

There are knowledge requirements for a programmer both in the mputer and the application areas. Ideally, a programmer should rk on one or two projects on one computer because as soon as he ıs to move either into new project areas or to a different com- ıter system some retraining becomes necessary. This is expensive cause productivity is reduced during the initial changeover riod and his efficiency does not reach a maximum until he has ıll understanding of the new computer or new problem. Because ıere are so many different computer systems at TSC suited to fferent applications, it is often necessary for programmers to itch to a different computer[1] (hopefully on a project in which has experience, but often on a new project) or to a new ap- ication area on the same computer. Much of the retraining re- ıired could be avoided if TSC had one large central facility to et all of its computing needs.

2 CONTINUITY OF SERVICE

With the possible exception of the Central Facility less phasis is placed on continuity of service at the separate TSC cilities than one normally finds at a large unified installation. e reasons for this are not clear, although the specialized ture of most applications and the absence of duplicate equip- nt in the smaller systems are certainly contributory.

ample: When the PDP-10 and DDP-516 are used for a real-time plication, particularly with ROSS, system demands are high and rvice to other users is degraded. The time-sharing system tends be less reliable when used in real-time mode. Under normal erating conditions the PDP-10 provides highly continuous service.

. recent survey showed that the Systems Development (P) directorate ıses 17 different computers, the Technology (T) directorate uses 6 different computers, and one branch in (T) uses eight different omputers.

Example: When some hardware (e.g. a paper tape reader or disk drive) fails on the TAG-516 all computer work on projects using that system comes to a standstill. If the TAG computer were a tru satellite graphics processor for a large system, some program development could continue and, depending on the nature of the hardware failure, the TAG computer could be partially usable.[1]

7.3 DUPLICATION OF EFFORT

The existence of many computers requires maintenance of an operating system for each. There have been attempts at standardization by using the operating system DOS on all DDP-516s, but differences in user requirements and preferences have led to more or less separate maintenance of these systems. An even greater duplication of effort can be found in the development of utility software for the various systems. Different editors, graphics packages, etc. are maintained on each computer. Much of this duplication of effort could be avoided in a facility with a large central computer and satellite mini-processors with enforced standards.

7.4 PROGRAM AND DATA CONVERSION

As computers begin to be used for more complex system level efforts, a simple problem solution will require use of many interrelated computer programs and access to a number of data bases. One-of-a-kind peripheral devices (e.g. the Calcomp plotter on the GOTS system, the ATC CRT in the Multimode Facility, or the GAT trainer in the Hybrid Facility) may be required in one or more steps of a solution. The current TSC computing environment will require programs or data or both to be transferred from one comput to another. Such transfers require considerable effort because of incompatibility of operating system interfaces, of computer languages, of file layouts, and of data representation. Two previously mentioned examples point out the difficulties that are encountered in transferring programs and data from computer to computer.

Example: When the previously mentioned Noise Abatement Program wa converted from a 360/75 to the GOTS 516 extensive modifications we necessary to fit a 250,000 byte IBM 360 program into the 32,000 wo (64,000 byte equivalent) memory of the DDP-516. Once the program was converted it was possible to use the existing graphics softwa to incorporate interactive controls and sophisticated hardcopy graphical output.

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[1]The H-832 was meant to play the role of a central computer in th Honeywell facility, but its hardware and software status prohibi the use of, for example, its file system as a backup to the DDP- file systems.

ample: To make possible further expansion of the Flow Control mulation (currently running entirely on the GOTS DDP-516) the asibility of using both the H-832 (for processing) and the P-516 (for graphics) was studied. It was found that many proam modifications would be required to adapt the program for eration on the H-832. Data base conversion from the DDP-516 to e H-832 turns out to be equally tedious.

5 LACK OF COMPUTING POWER

The computing power of a facility can be roughly characterized the power of its instruction set, its CPU speed, its primary mory size and speed, its ability to handle I/O requests, and the ze and speed of its secondary memory (i.e. disk and drum system). ese factors affect two things that will be of greater concern as e character of the workload changes: the processing capability d the file system capability. Although the combined power of all C facilities is considerable no one computer is capable of handng a job with a heavy processing or large data base demand. The M 7094 has no disk and thus can only deal effectively with quential tape resident data. Its cycle time is slow and its re memory is small. The PDP-10, in its current configuration, nnot be considered more than a small medium scale computer system. e other two facilities have even lower individual capabilities. o examples of projects that currently require computing capabilies not available at TSC are given below.

ample: A cost benefit model being used to study Dual Mode Transrtation possibilities in several cities is run on a CDC 6600 on e order of 10 times a week with individual runs averaging 3/4 of minute. The data base consists of approximately 1000 cards. Thus, ocessing and data base requirements are not excessive, but the proam needs 97,000 words (60 bits each) of memory and thus could not run on any of the current TSC computers.

ample: The previously mentioned ATCRBS simulation was originally arted on the Central Facility's 7094 but high CPU requirements rced a transfer to a CDC 6600. The project often has runs lasting e to six hours and annual computer costs are in the $100,000 range. study showed that the ATCRBS simulation could run on the TSC PDP-10 t that runs would take 22 times as long as on the CDC 6600.[1] us, what is currently a 6-hour run would take almost an entire ek of continuous operation on the PDP-10. Obviously, the current -house facilities cannot support such large CPU requirements.

[1] These figures are taken from test runs in double precision on the PDP-10. When the PDP-10 was run in single precision, this factor was reduced to 7.