09:30:49 OCA PAD INITIATION - PROJECT HEADER INFORMATION 10/14/88

Active

Project #: E-21-667 Cost share #: E-21-398 Rev #: 0
Center # : R6613-0A0 Center shr #: F6613-0A0 OCA file #:
Work type : RES
Contract#: DAAL03-88-G-0065 Mod #: Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #:

Project unit: EE Unit code: 02.010.118
Project director(s):
BARWELL T P III EE (404)894-2914
MCCLELLAN J H EE

Sponsor/division names: ARMY / ARO, RES TRIANGLE PARK, NC
Sponsor/division codes: 102 / 001

Award period: 881001 to 890930 (performance) 891130 (reports)

Sponsor amount	New this change	Total to date
Contract value	125,000.00	125,000.00
Funded	125,000.00	125,000.00
Cost sharing amount		31,250.00

Does subcontracting plan apply ?: N

Title: WORKSTATION ENVIRONMENT FOR DIGITAL SIGNAL PROCESSING RESEARCH

PROJECT ADMINISTRATION DATA

OCA contact: Ina R. Lashley 894-4820

Sponsor technical contact

(000)000-0000

Sponsor issuing office

PATSY S ASHE, GRANT OFFICER
(919)549-0641
US ARMY RESEARCH OFFICE
P O BOX 12211
RESEARCH TRIANGLE PARK NC 27709

Security class (U,C,S,TS) : U ONR resident rep. is ACO (Y/N): Y
Defense priority rating : N/A N/A supplemental sheet
Equipment title vests with: Sponsor GIT X
PER PART II, PARA 8.C., P.3. PARA 8.B ADDRESSES "SUBSTITUTE" EQUIPMENT PURCH.

Administrative comments -
INITIATION OF EQUIPMENT GRANT.

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 02/02/90
Original Closeout Started ********

Project No. E-21-667 Center No. R6613-0A0

Project Director BARNWELL T P III School/Lab EE

Sponsor ARMY/ARO, RES TRIANGLE PARK, NC

Contract/Grant No. DAAL03-88-G-0065 Contract Entity GTRC

Prime Contract No.

Title WORKSTATION ENVIRONMENT FOR DIGITAL SIGNAL PROCESSING RESEARCH

Effective Completion Date 890930 (Performance) 891130 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory & Related Certificate	Y	
Classified Material Certificate	N	
Release and Assignment	Y	
Other	N	

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
OCA/CSD	N
Other	N
	N

NOTE: Final Questionnaire sent to PDPI.

E-21-667

A WORKSTATION ENVIRONMENT FOR DIGITAL SIGNAL PROCESSING

Final Report

T. P. Barnwell, III, J. H. McClellan and P. A. Jensen

January 24, 1990

U.S. Army Research Office
Contract DAAL03-88-G-0065

School of Electrical Engineering
Georgia Institute of Technology
Atlanta, Georgia 30332-0250

Unclassified

CURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approval for public release. Distribution unlimited.
2b. DECLASSIFICATION/DOWNGRAOING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Georgia Institute of Technology 6b. OFFICE SYMBOL *(If applicable)*	7a. NAME OF MONITORING ORGANIZATION U. S. Army Research Office
6c. ADDRESS *(City, State and ZIP Code)* School of Electrical Engineering Atlanta, Georgia 30332-0250	7b. ADDRESS *(City, State and ZIP Code)* Research Triangle Park, NC 27709
8a. NAME OF FUNDING/SPONSORING ORGANIZATION U. S. Army Research Office 8b. OFFICE SYMBOL *(If applicable)*	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER DAAL-03-88-G-0065
8c. ADDRESS *(City, State and ZIP Code)*	10. SOURCE OF FUNDING NOS. PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT NO.
11. TITLE *(Include Security Classification)* A Workstation Env. for Digital Signal Processing	
12. PERSONAL AUTHOR(S) T. P. Barnwell, III, J. H. McClellan and P. A. Jensen	
13a. TYPE OF REPORT FINAL	13b. TIME COVERED FROM 10-1-88 TO 9-30-89
14. DATE OF REPORT *(Yr., Mo., Day)* 1990, Jan 24	15. PAGE COUNT

16. SUPPLEMENTARY NOTATION The views, opinions, and/or findings contained in this report are those of the authors and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other documentation.

17. COSATI CODES		
FIELD	GROUP	SUB. GR.

18. SUBJECT TERMS *(Continue on reverse if necessary and identify by block number)*
workstations, DSP (digital signal processing)

19. ABSTRACT *(Continue on reverse if necessary and identify by block number)* This final report describes the results of a one-year contract to upgrade the computer facilities of the Digital Signal Processing Laboratory in the School of Electrical Engineering at Georgia Tech. A network of 9 SUN workstation was purchased and integrated into our existing facility. The new network, which is significantly more powerful, now contains a variety of workstations and supports special-purpose computational and display equipment. The new SUN workstations have provided an extremely powerful interactive graphics and computational environment that supports a wide range of research in DSP algorithms, applications and implementations. These workstations are also being used to develop software to support DSP research throughout the entire design cycle from theory, to algorithm testing, to implementations in one environment.

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS ☐	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL T. P. Barnwell	22b. TELEPHONE NUMBER *(Include Area Code)* (404)894-2914 22c. OFFICE SYMBOL

)D FORM 1473, 83 APR EDITION OF 1 JAN 73 IS OBSOLETE.

SECURITY CLASSIFICATION OF THIS PAGE

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CONTENTS

1 Introduction

This report describes the results of a one-year contract to upgrade the computer facilities of the Digital Signal Processing Laboratory at the School of Electrical Engineering of the Georgia Institute of Technology. A network of 30 SUN workstations was requested as the basis for upgrading the existing computer network used by the Digital Signal Processing Laboratory for experimental work in applications and implementations of DSP algorithms. The proposal was funded at roughly a third of the requested amount. This allowed us to purchase a network of 9 SUN workstations. The integration of the systems into our facility caused no unexpected problems. We have been able to continue using most of the original general purpose and special purpose computational and display equipment. The new network has placed extremely powerful graphics and local computational capability in the hands of individuals doing research in DSP algorithms, applications and implementations. Present research projects are benefiting enormously from the improved computer resources and a better interactive graphics system. As a result, more sophisticated multidimensional DSP algorithms and applications are now within our reach.

Another important component of the equipment upgrade is the companion program to consolidate and upgrade the design tools to support the DSP research and development environment. Part of this work is new research to develop a more sophisticated environment; part is on-going support to evolve and maintain the environment. One specific project with obvious benefit is the integration of the OSCAR-32 (a DSP supercomputer under construction in the DSP Laboratory) into this working environment. This will stimulate new research on ways to map high-level algorithm descriptions onto the OSCAR-32, as well as continued research and work on the tools needed for compilers, debuggers and other support tools for this multiprocessor machine. (See Appendix B for a list of faculty and research projects that use this network in their research.)

Finally, this equipment and the companion design tools are helping to support a broader style of DSP research in which the whole design problem from theory, to algorithm testing, to implementation, to system testing and evaluation can be addressed in one environment. The new laboratory environment serves to "extend the reach" and improve the efficiency of the entire DSP research program.

2 Original Network

A block diagram of the computer facility in use at the beginning of the upgrade is shown in Figure 1. At that time, the research laboratory was using the following equipment:

Quantity	Specifications
2	Data General Eclipse S250
1	Data General MV10000
1	DEC Vax 11/780
4	DEC VaxStation II
1	Multiflow Trace/7
2	HP HP9000/320
30-40	IBM PC or Compatible

Table 1. Equipment Before the Upgrade

The entire research system supported over 100 users through the PC systems connected to the Vax 11/780, the Data General systems, and the Multiflow system. The VaxStation systems were all used by the Faculty. The HP systems were the only high quality graphics workstations available to the general user community. These systems were all connected with a local ethernet. Access to the campus network was not available as there was no equipment for use as a network gateway.

3 Equipment Upgrade

A block diagram of the computer facility after the network upgrade is shown in Figure 2. A detailed listing of the equipment purchased is shown in Table 2 and Table 3. Table 2 describes the equipment purchased with sponsored funds and total costs.

Budget Report for Sponsored Funds

Amount	Description
2390.00	327Mb disk for SUN-3/60 (Perip. Designs)
4395.00	327Mb disk & 1/4" Tape for SUN-3/60
38005.00	SUN-4/260HM and Software
52647.22	6 SUN-3/60 workstations and Software
11960.00	1.1GB disk for SUN-4/260
1761.68	2 Multiport Transceivers
3442.65	14 1Mb SIMMs for Sun-3/60 (Clearpoint)
3360.00	16 1Mb SIMMs for Sun-4/60 (Clearpoint)
300.64	Shipping for Sun Workstations
1600.00	Mathematica for Sun-4
900.00	Matlab for Sun-4
1540.00	760Mb drives for Sun-4 systems
1011.33	2nd ethernet for Sun-4/260
Total 123,313.52	

Table 2. Equipment Purchased with Sponsored Funds

Table 3 describes the equipment purchased to date with matching funds and total costs.

Budget Report for Matching Funds

Amount	Description
18906.00	2 Sun-4/60C-8, 3.5" floppy,Dos Windows
270.00	1-Lisp Manuals - PPC
201.70	Cables and Connectors
181.25	SunOS for SPARCstations
8000.00	760Mb drives for Sun-4 systems
600.00	Matlab for Sun-4
Total 28,158.95	

All of our systems with the exception of the Data General MV10000 system are now running UNIX and using Sun Microsystem's NFS to provide network access to files on every system in the local network. The old Data General Eclipse S250 systems have both been retired because they did not fit in with the UNIX network. The Data General MV10000 system is still in use, but is also scheduled to be retired.

Because of our limited experience with the use of diskless workstations, we decided to start by purchasing the Sun-4/260 file server and 6 Sun-3/60 workstations with several combinations of disk and memory. We discovered that all of the Sun-3/60 systems required a minimum of 8Mb of memory to function most effectively. The use of local disks did not seem to give any significant performance improvement over the diskless systems. However, the diskless systems are all dependent on the Sun-4/260 system and cannot run when the server system is not working. In addition, we discovered that having all user files on a single file server was also a disadvantage. When the file server is unavailable, users are unable to access their files, making all systems unavailable.

From the experience provided by our initial configuration, we decided that distributed disks would be better than a single server. The diskless workstations were still a good idea and could be served by the single Sun-4/260 system for booting, but the user files would have to be distributed throughout the network. Now a single system failure could not disable the entire network or prevent all users from working. Because of improvements in workstation and disk storage technology, we were able to purchase three Sun-4/60 workstations with 768Mb disk drives. (Two were purchased on this grant.)

The final configuration has a single boot server for four diskless Sun-3/60 systems, two Sun-3/60 systems with local disks for booting, and three Sun-4/60 systems with local disks for booting. All of the Sun-4 systems also act as file servers for user files, also the pre-existing Vax 11/780 and Multiflow Trace systems. The Multiflow Trace remains the primary compute server, but the Sun-4 systems have added significantly to the total compute power or our network in a distributed fashion that allows more users to conduct their research with sophisticated computational methods.

In addition, we are now able to take advantage of the extensive computing resources available on the campus network. The systems on campus that are available to the Faculty and Students can now be used for access to our local network. The campus network also provides us with access to many wide-area networks such as the Internet, Bitnet, CSNet, and others. We now have direct access to Universities and other research groups throughout the world. The Vax is used for network news and electronic mail.

The Sun workstations are being used extensively for image processing, array processing, simulation, and the visualization of scientific data. Our use of the X window system from MIT has enabled us to combine our special purpose computational systems and the graphics abilities of the Sun workstations to provide an exceptionally powerful environment for research in Digital Signal Processing. The improvements have already exceeded our expectations.

4 Conclusions

The DSP laboratory computing network now provides a uniform environment to all users. All workstations present the same appearance. Users refer to the entire network as "the computer". No workstation appears better than any other so the computing load is naturally distributed over the entire network.

We have discovered that dependence on a single server is not a good idea. The new Sun-4/60 systems work fine as file servers but are not used as boot servers by any of the diskless systems. To improve accessibility, two main goals have been identified: reduce dependencies between systems so that failure of a single system will only affect that system; provide redundancy so that systems can provide the same service, ensuring that there will usually be a system providing that service.

Though the equipment purchased fills many of our needs, we presently need more workstations and servers. Our network, which has 28 machines, must support over 100 users. There is heavy demand for access to the new workstations, which are being used 24 hours a day. The load has actually increased on the original systems. We feel this is due to increased productivity and capabilities provided by the improved user interface of the new workstations.

While the primary purpose of this upgrade was to improve the hardware for computing, the importance of having software to take advantage of the new hardware cannot be stressed enough. Public domain software which runs under the UNIX operating system has provided many useful tools. The X window system from MIT has proved to be an excellent environment for developing software for accessing distributed resources. Software for text formatting on these new workstations is helping to get research publications ready faster than ever before. Two commercial products, Mathematica and Matlab, provide exciting new possibilities for mathematical analysis and allow quick prototyping of new algorithms. Subroutine libraries which allow users to quickly take advantage of new resources are currently under development.

Because of the success of our new network, we have become the model for the rest of the department. What we have learned about distributed networks for research is proving to be of great use to other groups in our department and at Georgia Tech.

Advances in processor and disk storage technology will make it essential to continue to upgrade our environment in the future. Because of the possibilities the new workstations have opened up, it is even more critical to increase the number and power of the workstations available for research.

A Figures

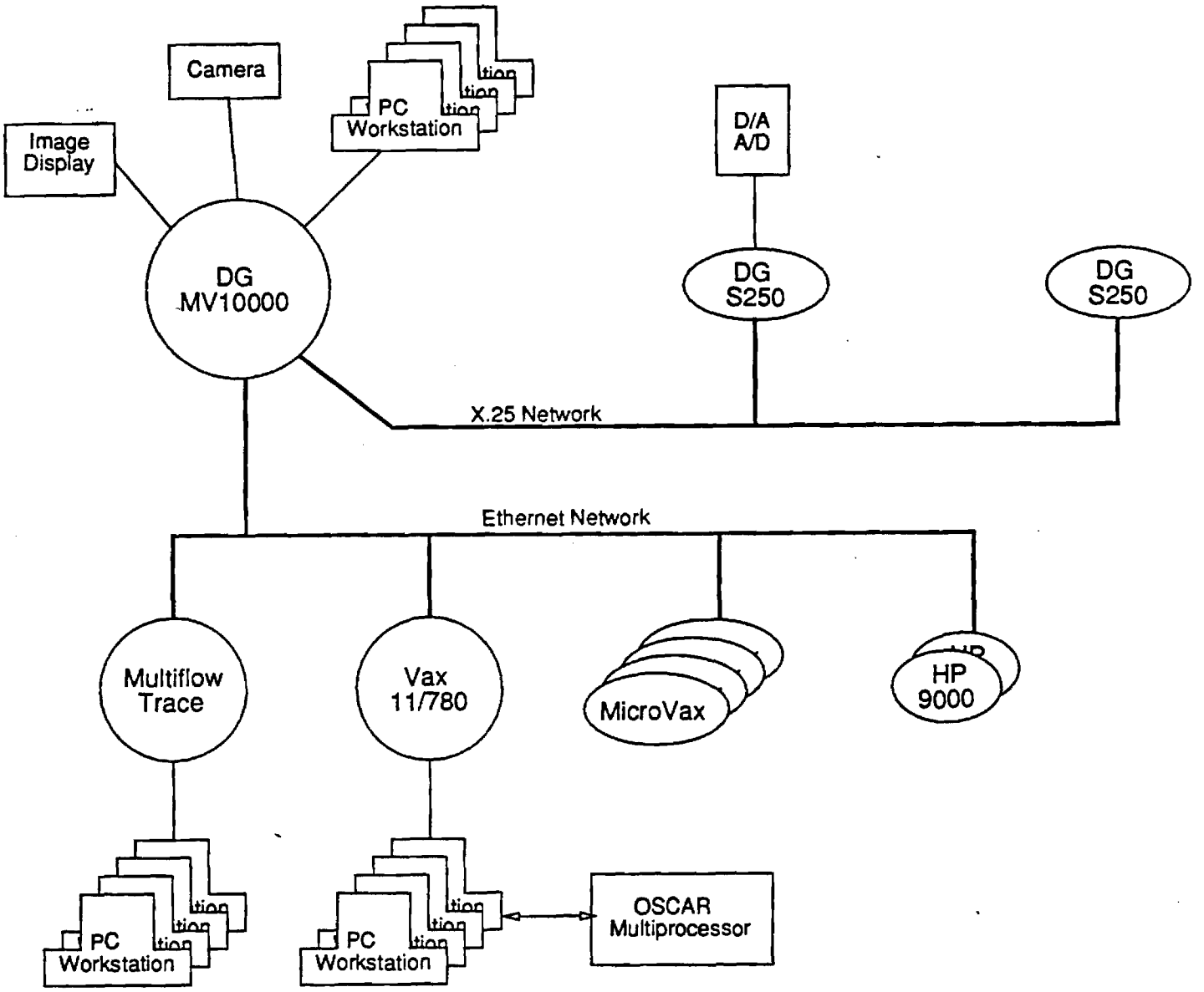

Figure 1.

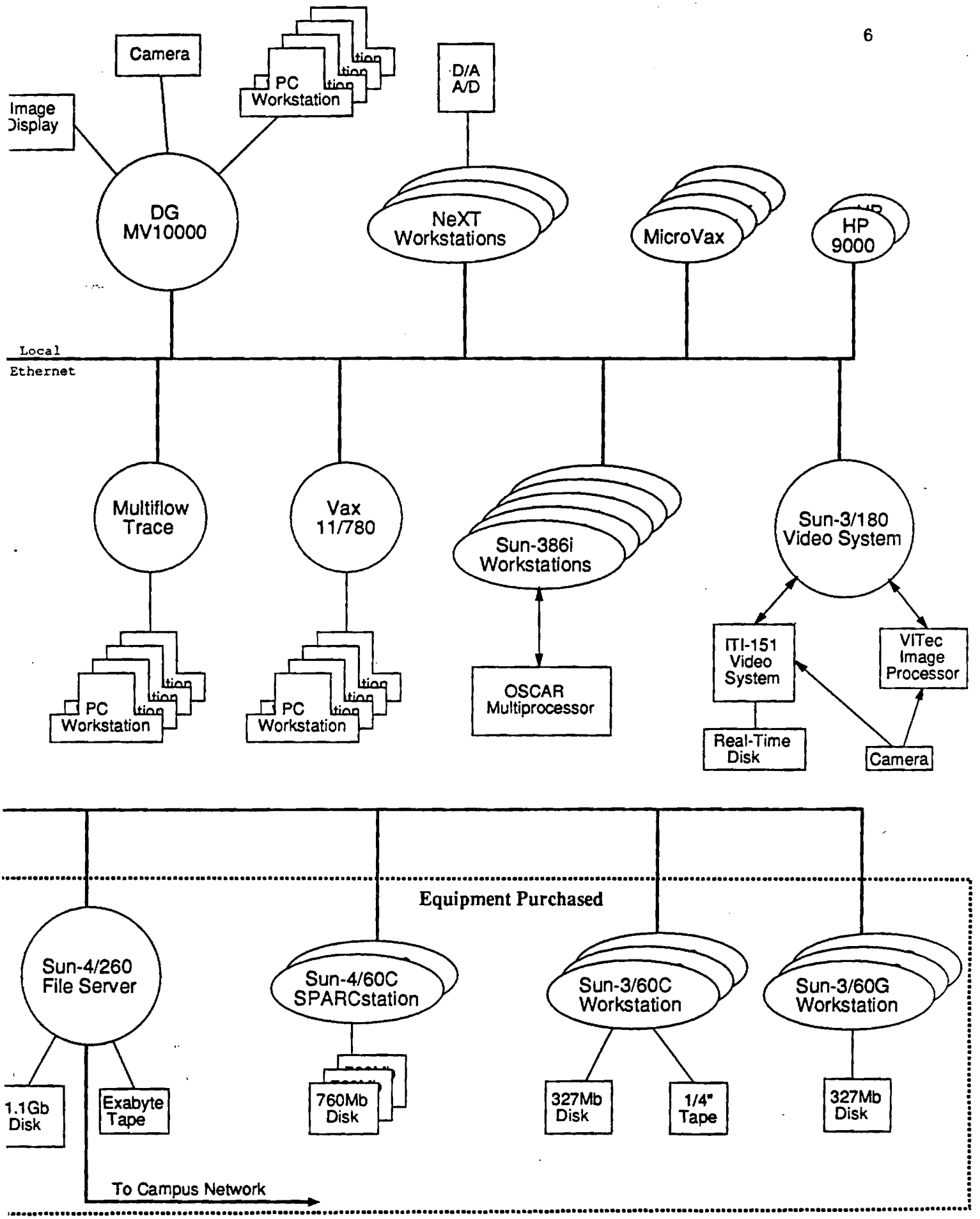
Camera
PC Workstation
D/A A/D
Image Display
DG MV10000
NeXT Workstations
MicroVax
HP 9000
Local Ethernet
Multiflow Trace
Vax 11/780
Sun-386i Workstations
Sun-3/180 Video System
PC Workstation
PC Workstation
OSCAR Multiprocessor
ITI-151 Video System
VITec Image Processor
Real-Time Disk
Camera
Equipment Purchased
Sun-4/260 File Server
Sun-4/60C SPARCstation
Sun-3/60C Workstation
Sun-3/60G Workstation
1.1Gb Disk
Exabyte Tape
760Mb Disk
327Mb Disk
1/4" Tape
327Mb Disk
To Campus Network

Figure 2.

B Current and Pending Support

Name	Supporting Agency	Project Title	Award Amount	Period Covered	Percent Effort
T. P. Barnwell (Georgia Tech - EE)					
A. Current	ARO	1	390,091	4/87-4/90	33%
A. Current	Rockwell	2	135,000	6/1/87-6/1/89	
A. Current	ARO	3	156,000	10/88-10/89	
A. Current	NSF	4	102,305	3/89-8/90	

1. Multiprocessor Architectures for Digital Signal Processing (Work Unit of JESP)
2. Rockwell Fellowship (with R. M. Mersereau)
3. A Workstation Environment for Digital Signal Processing
   (co-PI with P. A. Jensen and J.H. McClellan)
4. A Workstation Environment for Real-Time and Multiprocessor Digital Signal Processing

M. A. Clements (Georgia Tech - EE)					
A. Current	Maryland Procurement Office	1	126,411	9/88-9/90	17%
A. Current	U.S. Army	2	256,724	12/85-6/89	33%

1. Research in Digital Speech Processing
2. Automatic Recognition of Speech in Stressful Environments

M. H. Hayes (Georgia Tech - EE)					
A. Current	NSF	1	302,500	7/84-6/89	33%
A. Current	GTE Corporation	2	77,500	7/84-6/89	
A. Current	GTE Service Corp.	3	60,000	7/84-6/89	
A. Current	Rockwell International	4	40,000	7/87-6/89	
A. Current	ARO	5	309,534	4/88-3/90	25%
A. Current	Texas Instruments	6	20,000	4/89-3/90	

1. Presidential Young Investigator Award
2. Matching Funds for PYI Award
3. Graduate Assistants Support in Conjunction with PYI Award
4. Matching Funds for PYI Award
5. Multidimensional Digital Signal Processing (Work Unit of JESP)
6. Knowledge-Based Signal Enhancement

Name	Supporting Agency	Project Title	Award Amount	Period Covered	Percent Effort
P. Allen Jensen (Georgia Tech - EE)					
A. Current	ARO	1	156,000	10/88-10/89	

1. A Workstation Environment for Digital Signal Processing
   (co-PI with T. P. Barnwell and J. H. McClellan)

J. H. McClellan (Georgia Tech - EE)					
A. Current	ARO	1	63,846	4/88-4/90	10%
A. Current	Texas Instruments	2	23,100	9/89-9/90	10%
A. Current	ARO	3	156,000	10/88-10/89	
A. Current	NSF	4	102,305	3/89-8/90	

1. Angular Spectrum Analysis for Non-Uniform Arrays (Work Unit of JESP)
2. Signal Understanding
3. A Workstation Environment for Digital Signal Processing
   (co-PI with T. P. Barnwell and P. A. Jensen)
4. A Workstation Environment for Real–Time and Multiprocessor Digital Signal Processing
   (co-PI with T. P. Barnwell)

R. M. Mersereau (Georgia Tech - EE)					
A. Current	ARO	1	309,534	4/88-3/90	33%
A. Current	Rockwell Foundation	2	67,500	6/87-6/90	
B. Pending	DARPA/NSF	3	209,510	3 years	25%

1. Multidimensional Digital Signal Processing (Work Unit of JESP)
2. Faculty Development Grant in DSP
3. Action-Oriented Image Understanding

Name	Supporting Agency	Project Title	Award Amount	Period Covered	Percent Effort
R. W. Schafer (Georgia Tech - EE)					
A. Current	ARO	1	500,000	4/87-4/90	25%
A. Current	Franklin Foundation	2	679,886	10/74-open	
A. Current	ESL	3	25,000	1 year	

1. Multidimensional Digital Signal Processing (Work Unit of JSEP)
2. John O. McCarty Audichron Chair
3. Design and Application of Morphological Systems

M. J. T. Smith (Georgia Tech - EE)					
A. Current	NSF	1	235,000	3 years	33%

1. Time Frequency Techniques for Speech Processing