E.^J.A INSTITUTE OF TECHNOLOGY

OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ______

oject No. E-21-646

DATE 5/21/82

oject Director: T. P. Barnwell

School/XXX Electrical Engineering

ponsor: U.S. Army Research Office, NC

ype Agreement: D.O.D. Grant Agreement DAAG29-82-G-0008

ward Period: From 5/15/82 To ~~5/14/83~~ 5/15/84 (Performance) ______ (Reports)

ponsor Amount: $246,008

Contracted through: GTRI/XXX

ost Sharing: $13,675 (E-21-377)

itle: Digital Signal Processing Laboratory Equipment

DMINISTRATIVE DATA

OCA Contact William F. Brown X4820

Sponsor Technical Contact:

2) Sponsor Admin/Contractual Matters:

Mr. T. A. Bryant
ONR RR
Georgia Institute of Technology
206 O'Keefe Building
Atlanta, GA 30332

efense Priority Rating: None

Security Classification: None

ESTRICTIONS

e Attached ______ Supplemental Information Sheet for Additional Requirements.

avel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

uipment: Title vests with GIT

OMMENTS:

OPIES TO: Research Administrative Network

~~Administrative Coordinator~~	Research Security Services	EES Public Relations (2)
esearch Property Management	~~Reports Coordinator (OCA)~~	Computer Input
ccounting	Legal Services (OCA)	Project File
ocurement/EES Supply Services	Library	Other ______

RM OCA 4:781

EORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

Date 10/30/85

oject No. E-21-646 — School/~~Lab~~ EE

cludes Subproject No.(s) N/A

oject Director(s) T. P. Barnwell — GTRC /~~GIT~~

onsor USA Research Office

tle Digital Signal Processing Laboratory Equipment

fective Completion Date: 5/14/85 (Performance) 7/14/85 (Reports)

ant/Contract Closeout Actions Remaining:

- [ ] None
- [X] Final Invoice or Final Fiscal Report Final FCTR
- [X] Closing Documents
- [ ] Final Report of Inventions N/A
- [X] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

ntinues Project No. — Continued by Project No.

PIES TO:

oject Director
search Administrative Network
search Property Management
counting
ocurement/GTRI Supply Services
search Security Services
~~ports Coordinator (OCA)~~
gal Services

Library
GTRC
Research Communications (2)
Project File
Other Heyser; Jones

RM OCA 69.285

E-21-646

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

PHONE: (404) 894-2961

April 4, 1983

Mr. James Gault
U. S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709

Subject: Contract #DAAG29-82-G-0008, Semiannual Progress Report
Project Entitled, "Digital Signal Processing Laboratory Equipment", Project Director - Dr. Thomas P. Barnwell, III

Dear Mr. Gault:

The subject report is submitted in conformance with contract specifications.

If you have any questions or comments, please contact Dr. Thomas P. Barnwell at (404) 894-2914.

Thank you.

Sincerely,

Marsha Segraves
Admin. Asst.

cc: T. P. Barnwell
P. Heitmuller, OCA (2)

DIGITAL SIGNAL PROCESSING LABORATORY EQUIPMENT

Semiannual Progress Report

March, 1983

T.P. Barnwell, III

This is the semiannual report on the progress of the "Digital Signal Processing Laboratory Equipment" grant no. DAA029-82-6-0008. This grant covers equipment expenditures for upgrading the Digital Signal Processing Laboratory at Georgia Tech. Figures 1 and 2 show the original system and the proposed upgrade for all three years. Expenditures in the first nine months of this contract have fallen into four categories: (1) the acquisition of new peripheral equipment for upgrading the existing computer network; (2) the acquisition of the VICOM image display and processing system; (3) the acquisition of the new 16-bit D/A - A/D system; (4) and the upgrade of the physical environment. All of these developments are well underway, and all should be complete well before the end of the first year of the project.

The equipment acquired as part of the computer network upgrade is detailed in Table 1. This equipment was augmented by an additional $28,000 worth of equipment and software donated by Data General. Before this upgrade, the network was based on the RDOS operating system, which allowed only four simultaneous users to use the two research computers. The network upgrade allowed the use of the AOS operating system under a Data General supported fully distributed network. When considered together with the "Education" Eclipse S250, the network now supports sixty-nine ports, and can easily support 15-20 on-line users, plus several background batch and print streams.

The bulk of the software conversion for the network was accomplished in the Winter quarter (September - December) of 1982. During this period, 400 existing signal processing programs were converted, an extensive on-line "help" facility was implemented to support these programs, and a multi-task program set was developed for communications with the NOVA 830 peripheral control computer. This latter item allows shared and controlled access to the peripherals controlled by the NOVA 830 (A/D; D/A; COMTAL image display; line printer; speech quality stations; etc.) from anywhere in the network, and serves as a standard for shared peripheral access. The shared operating system has been in use since October.

The image processing upgrade which consists primarily of a VICOM image processing system and a MATRIX color camera system, was delivered in February, 1983. Although certain elements of the system are yet to be delivered by VICOM, the bulk of the system has been installed and is operable. The software delivered by VICOM, which supported a single user for the system, has been modified and extended to allow full access to the system by any user on the network. This portion of the development has been in operation since mid March.

The bulk of the equipment for the A/D and D/A upgrade arrived in late February, 1983, and the interface hardware is now being constructed. This interface is based on a custom MC6809 co-processor design which allows great flexibility in the interfacing software. This work should be completed in April, 1983.

This physical environment upgrade, which consists primarily of an air-conditioner, an extention of the computer floor, and additional electrical service, has been designed by the Georgia Tech Physical Plant, and is currently being bid by outside contractors. The work on this project should begin in the next month.

The primary purpose of this computer network is the support of research in digital signal processing. The system directly supports the research of ten faculty members and a large group of graduate students. The currently active research areas include general multi-dimensional digital signal processing, image coding, image enhancement, two-dimensional sampling and algorithms, iterative reconstruction techniques, short-time frequency representatious, speech quality measures, low and very low rate speech coding techniques, optimal coding, multi-processors architectures for digital signal processing, speech recognition, and many more. Table 2 gives a partial list of papers presented or published during last year which were based on work performed on this facility. The effect of the ongoing upgrade is to increase enormously the accessibility and usability of the DSP laboratory, which will allow an associate increase in the amount of research which can be accomplished.

TABLE 1

Equipment Purchased as Part of the First Year Upgrade

Network Upgrade

Item No.	Quantity	Specifications
1	4	8656 256KB Memory
2	1	4254 DCU/200
3	1	4251 ComChassis
4	2	4257 16 line mux
5	8	4261 ElA modules
6	1	6061 190MB disc with controller
7	1	6061-A 190 MB disc
8	1	4065 I/O interface with schematics
9	1	4068 PIT with schematics
10	1	UCEEl map upgrade with schematics
11	1	3827-02-M AOS X25
12	1	3828-00-M Xodiac
13	1	3813-02-M RDOS X25
14	1	3629-00-M AOS Fort 77
15	1	3956-01-M AOS SWAT
16	1	AOS subsequent license

A/D - D/A Upgrade

Item No.	Quantity	Specifications
1	1	Data Acquisition System Part DAS6915-D-002-D-P-0/2 SSH/2 EDAC 3716 Specifications: 2 channels 15-bit A/D with Simultaneous sample and holds; 2 channels 16-bit D/A; chassis wired for expansion to 8 input and 4 output channels.
2	2	Dual Hi/Lo Analog Filters Model 852-01 with option 04 - (rack mount).

3	2	4040/4041/4042 General Purpose Data Channel Interface Board for Data General Systems.

Image Processing Upgrade

1	1	VICOM System
2	1	Matrix Instruments Model 3000 Hard copy camera with programmable front panel, and battery back up.
3	1	35 mm slide back option
4	1	4" x 5" folded optic back fr type 558 Polacolor 2 film

TABLE 2

Partial List of Recent Papers from Projects Utilizing the DSP Laboratory

Iterative Signal Restoration Algorithms

1. R. Marucci, R. M. Mersereau, and R. W. Schafer, "Constrained Iterative Deconvolution Using a Conjugate Gradient Algorithm," 1982 International Conference on Acoustics, Speech, and Signal Processing, pp. 1845-1848.

2. R. M. Mersereau, M. H. Hayes, R. W. Schafer, "A Survey of Methods for Iterative Signal Restoration," 1982 International Conference on Communications, pp. 3G4.1-3G4.5.

3. M. H. Hayes and R. W. Schafer, "On the Bandlimited Extrapolation of Discrete Signals, accepted for presentation 1983 International Conference on Acoustics, Speech, and Signal Processing, Apr. 1983.

4. A. Katzaggelos and R. W. Schafer, "Iterative Deconvolution Using Several Different Distorted Versions of an Unknown Signal, accepted for presentation 1983 International Conference on Acoustics, Speech, and Signal Processing, Apr. 1983.

Spectrum Analysis and Parametric Modelling

1. R. M. Mersereau and T. C. Speake, "A Unified Treatment of Cooley-Tukey Algorithms for the Evaluation of the Multi-Dimensional DFT," IEEE Trans. Acoust., Speech, Signal Processing, Vol. ASSP-29, pp. 1011-1018, Oct. 1981.

2. R. M. Mersereau and T. C. Speake, "The Processing of Periodically Sampled Multi-Dimenisonal Signals," to appear in IEEE Trans. Acoust., Speech, signal Processing, Feb. 1983.

3. P. A. Maragos, R. M. Mersereau, and R. W. Schafer, "Some Experiments in ADPCM Coding of Images," 1982 Int. Conf. on Acoustics, Speech, Signal Processing, pp. 1227-1230, May 1982.

4. R. M. Mersereau, E. W. Brown, and A. Guessom, "Evaluation of Multi-dimensional DFT's on Arbitrary Sampling Lattices," 1982 Asilomar Conf. on Circuits, Systems, and Computers, Nov. 1982.

5. R. M. Mersereau, E. W. Brown, and A. Guessom, "Row-Column Algorithms for the Evaluation of Multi-Dimensional DFT's on Arbitrary Periodic Sampling Lattices," to be presented at 1983 Int. Conf. on Acoustics, Speech, and Signal Processing, Apr. 1983.

6. P. A. Maragos, R. M. Mersereau, R. W. Schafer, "Two-Dimenisonal Linear Predictive Analysis of Arbitrarily-Shaped Regions," to be presented at 1983 Int. Conf. on Acoustics, Speech, and Signal Processing, Apr. 1983.

7. E. Karlsson and R. M. Mersereau, "A Comparison of Subjective and Objective Measures for Image Quality," to be presented at 1983 Int. Conf. on Acoustics, Speech, and Signal Processing, Apr. 1983.

Multiprocessor Architectures for Digital Signal Processing

1. "Sub-band Coder Design Incorporating Recursive Quadrature Filters and Optimum ADPCM Coders," T. P. Barnwell,III, IEEE Transactions on Acoustics, Speech, and Signal Processing, ASSP-29, No. 5, October 1982.

2. "Optimal Implementation of Recursive Signal Flow Graphs on Synchronous Multiprocessor Architectures," T. P. Barnwell, III, IEEE Workshop on Digital Signal Processing and VLSI, Santa Barbara, CA, Sept. 1981.

3. "A Synchronous Multi-Microprocessor System for Implementing Digital Signal Processing Algorithms," T. P. Barnwell, III, and C. J. M. Hodges, Professional Program Session Record 21 of Southcon/82, pp. 21/4/121/4/6, March 1982 (invited).

4. "Optimum Implementation of Single Time Index Signal Flow Graphs on Synchronous Multiprocessor Machines," T. P. Barnwell, III, C. J. M. Hodges, and M. Randolf, Proceedings of ICASSP '82, Paris, France, pp. 687-690, May 1982.

5. "Optimal Implementation of Signal Flow Graphs on Syncrhornous Multiprocessor," T. P. Barnwell, III, and C. J. M. HOdges, Professional Program Session Record 22 of Electro/82, June 1982 (invited).

6. "Synchronous Techniques for Signal Flow Graph Implementation," T. P. Barnwell, III, NSF Workshop on Digital Signal Processing, Washington, DC, June 1982.

7. "Optimal Implementation of Signal Flow Graphs on Synchronous Multiprocessors," T. P. Barnwell, III, and C. J. M. Hodges, Proceedings of the 1982 International Conference on Parallel Processing, Belaire, MI, August 1982.

8. "Optimal Implementation of DSP Algorithms on Synchronous Multiprocessors," T. P. Barnwell, III, and C. J. M. Hodges, Proceedings of 1982 Purdue Workshop on Algorithmically Specialized Computer Architectures, October 1982.

Speech Processing

1. "Data Rate Reduction of Pitch and Gain Parameters in an LPC Vocoder," A. M. Wilgus, M. S. Thesis, Georgia Institute of Technology, August 1982.

2. "An Analysis of Objectively Computable Measures for Speech Quality Testing," T. P. Barnwell, III, and S. R. Quackenbush, Proceedings of 1982 ICASSP, Paris, France, April 1982 (invited).

3. "On the Standardization of Objective Measures for Speech Quality Testing," T. P. Barnwell, III, Proceedings of National Bureau of Standards Workshop on Standards for Speech Recognition and Synthesis, Gatlinburg, MD, March 1982.

4. "Low Bit Rate Coding of Pitch and Gain Parameters for LPC Speech Coding," A. M Wilgus and T. P. Barnwell, III, to be presented at 1983 ICASSP, Boston, MA, April 1983.

5. "An Algorithm for Designing Optimum Quantizers Subject to a Multiclass Restortion Criteria," J. Crosmer and T. P. Barnwell, III, to be presented at 1983 ICASSP, Boston, MA, April 1983.

6. "The Estimation and Evaluation of Pointwise Nonlinearities for Improving the Performance of Objective Speech Quality Measures," S. R. Quackenbush and T. P. Barnwell, III, to be presented at 1983 ICASSP, Boston, MA, 1983.

Two-Dimensional Optical Storage and Processing

1. C. C. Guest and T. K. Gaylord, "Optical Holographic Content-Addressable Memory System for Truth-Table Look-Up Processing," U. S. Patent No. 4,318,581, issued March 9, 1982.

2. Gaylord, T. K. and Moharam, M. G., "Planar Dielectric Grating Diffraction Theories," Applied Physis B, Vol. 28, pp. 1-4, 1982 (invited).

3. Gaylord, T. K. and Moharam, M. G., "Thin and Thick Gratings: Terminalogy Clarification," Applied Optics, Vol. 20, pp. 3271-3273, October 1, 1981.

4. Gaylord, T. K., Guest, C. C., Moharam, M. G., and Weaver, J. E., "Holographic Data Processing Applications Using Photorefractive Crystals," Ferroelectrics, Vol. 35, pp. 137-142, 1981.

5. Gaylord, T. K. and Moharam, M. G., "Interrelationships Between Various Planar Grating Diffraction Theories," Journal of the Optical Society of America, Vol. 71, pg. 1573, December 1981.

6. Moharam, M. G. and Gaylord, T. K., "Rigorous Coupled-Wave Analysis of Surface Gratings with Arbitrary Profiles," Journal of the Optical Society of America, Vol. 71, pg. 1569, December 1981.

7. Moharam, M. G. and Gaylord, T. K., "Chain-Matrix Analysis of Arbitrary-Thickness Dielectric Reflection Gratings," Journal of the Optical Society of America, Vol. 72, pp. 187-190, February 1982.

8. Moharam, M. G. and Gaylord, T. K., "Comments on Analyses of Reflection Gratings," Journal of the Optical Society of America, Vol. 72, pp. xxx-xxx, December 1982 (accepted).

9. Moharam, M. G. and Gaylord, T. K., "Diffraction Analysis of Dielectric Surface-Relief Gratings," Journal of the Optical Society of America, Vol. 72, pp. 1385-1392, October 1982.

10. Gaylord, T. K. and Moharam, M. G., "Rigorous Theory of Planar Reflection Grating Diffraction," (Abstract) Journal of the Optical Society of America, Vol. 72, pp xxx, December 1982 (accepted).

11. Moharam, M. G. and Gaylord T. K., "Vector Three-Dimensional Theory for Planar Grating Diffraction," (Abstract) Journal of the Optical Society of America, Vol. 72, pg. xxx, December 1982 (accepted).

Two-Dimensional Optical/Electronic Signal Processing

1. J. N. Mait and W. T. Rhodes, "Iterative Design of Pupil Functions for Bipolar Incoherent Spatial Filtering," in Processing of Images and Data from Optical Sensors, W. Carter, and G. Reynolds, eds., Proc. SPIE 292, 66-72 (1981).

2. H. J. Caulfield and W. T. Rhodes, "Optical Implementation of Systolic Array Processing," in Optical Information Processing for Aerospace Applications, NASA Conference, Langly, October 1981, NASA Conference Publication No. 2207.

3. A. Tarasevich, N. Zepkin, and W. T. Rhodes, "Matrix-Vector Multiplier with Time-Varying Single Dimensional Spatial Light Modulators," in Optical Information Processing for Aerospace Applications, NASA Conference, Langly, October 1981, NASA Conference Publication No. 2207.

4. W. T. Rhodes, "Acousto-Optic Matrix-Vector and Matrix-Matrix Multiplication," in Proceedings of BMD/ATC Technical Interchange Meeting, Application of Opto-Electronics, La Jolla, March 1982.

5. J. N. Mait and W. T. Rhodes, "Dependent and Independent Cosntraints for a Multiple Objective Iterative Algorithm," Optical Society of America Topical Meeting on Signal Recovery and Synthesis with Incomplete Information and Partial Constraints, Incline Village, Nevada, January 1983.

6. W. T. Rhodes, "Acousto-Optic Signal Processing: Convolution and Correlation," Proc. IEEE 69 65-79 (1981).

7. H. J. Caulfield, W. T. Rhodes, M. J. Foster, and S. Horvitz, "Optical Implementation of Systolic Array Processing," Opt. Commun. 40, 86-90 (1981).

8. W. T. Rhodes and M. Koizumi, "Linear-In-Intensity Imaging of Coherent Wave Fields," submitted to Journal of the Optical Society of America.

9. W. T. Rhodes and A. A. Sawchuk, "Incoherent Optical Processing," in Optical Information Processings: Fundamentals, S. Lee, ed. (Springer-Verlag, New York, 1981).

10. W. T. Rhodes, "The Falling Raster in Optical Signal Processing," in Transformations in Optical Signal Processing, W. T. Rhodes, J. R. Fienup, and B. e. A. Saleh, eds. (SPIE, Bellingham, 1982), January 1983.

11. W. T. Rhodes, "Space-Variant Processing," in Applications of the Optical Fourier Transform, H. Stark, ed. (Academic Press, New York, 1982).

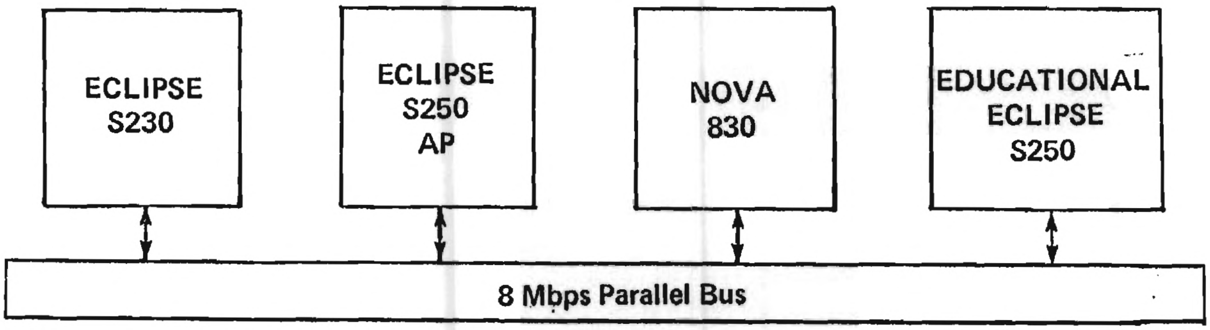

Figure 1. Existing Computer Configuration in the Digital Signal Processing Laboratory.

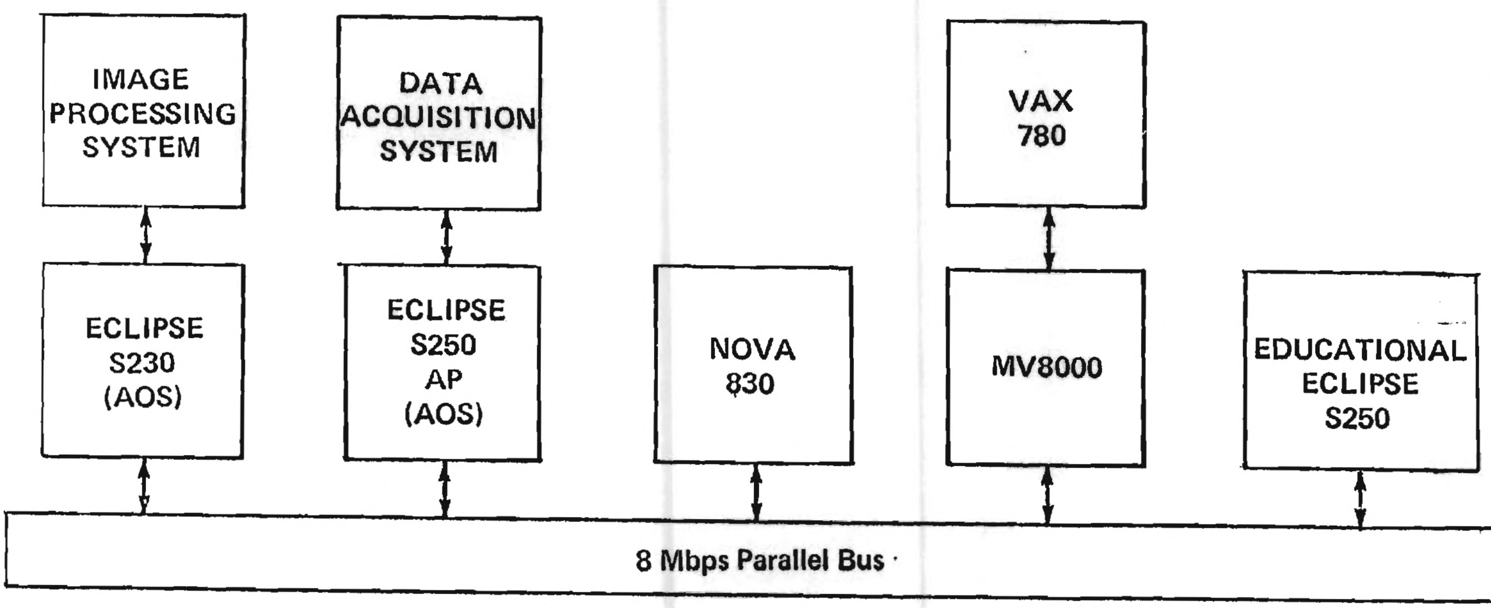

Figure 2. Proposed Computer Configuration for the Digital Signal Processing Laboratory.

E-21-646

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

EPHONE: (404) 894- 2961

November 22, 1983

U. S. Army Research Office
Attention: Abram J. Van Hall, Grant Officer
P.O. Box 12211
Research Triangle Park, NC 27709

SUBJECT: Semi-Annual Progress Report, Contract No. DAAG29-82-G-0008
Entitled, "Digital Signal Processing Laboratory Equipment",
Project Director - Dr. T. P. Barnwell

Dear Mr. Van Hall:

Enclosed are two-copies of the Semi-Annual Progress Report on the above referenced project. The period covered by this report is 12/15/82 - 11/14/83.

If you have any questions or comments regarding this report, please contact Dr. T. P. Barnwell at (404) 894-2914.

Thank you.

Sincerely,

Màrsha Segraves
Admin. Asst.

cc: T. P. Barnwell
Tom Bryant (ONR)
OCA (2)

PROGRESS REPORT

(TWENTY COPIES REQUIRED)

1. ARO PROPOSAL NUMBER: DRXRO-PR(MM) P-19037-EL

2. PERIOD COVERED BY REPORT: Up until October, 1983

3. TITLE OF PROPOSAL: Digital Signal Processing Laboratory Equipment

4. CONTRACT OR GRANT NUMBER: DAAG29-82-6-0008

5. NAME OF INSTITUTION: Georgia Institute of Technology

6. AUTHOR(S) OF REPORT: T. P. Barnwell, III

7. LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO SPONSORSHIP DURING THIS PERIOD, INCLUDING JOURNAL REFERENCES:

   Since this is only an equipment upgrade, no research is supported directly by this contract. However, numerous papers have been published on research accomplished on this equipment.

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

   See above

INTRODUCTION

This is the third semi-annual progress report on ARO contract DAAG29-82-6-0008. This report covers the completion of the first years effort and the state of the work included for the second year.

The First Year

Funding for the first year included four major items: the upgrade of the current computer facility so as to operate under a fully distributed network; the addition of a VICOM image processing system; the addition of a high-grade A/D and D/A facility; and the extension of the computer room to support the VAX 780 (part of the 3rd year) computer. At this point in time (November, 1983) all of these tasks have been completed.

As was previously reported, the major items in the computer upgrade (see table 1) were all delivered and installed during the fall quarter of 1982. At that time, all the previous software was converted and the fully distributed operating system was installed. This system has been operational since December, 1982.

The VICOM image processing system (table 2) was delivered in the spring of 1983. When it arrived, it had major problems with both its hardware and its software support. Using the source code from VICOM, we were able to correct the bugs and develop an AOS Host program that allows fully distributed access to the VICOM. This entire system is now operational, and has been in use since June, 1983.

The components for the D/A and A/D sysltem (table 3) were all delivered in the late spring of 1983. Two DMA interfaces for the Eclipse S250 AP computer were designed and tested in early summer, 1983. The software support for this hardware was completed and has been in place since August, 1983.

The physical upgrade, which includes the extension of the computer floor, the addition of a new electric service, and the installation of an air-conditioned system, has just been completed (November, 1983). In addition, considerable renovations to the student office areas (supported by other funds) have also been undertaken and are nearly complete. When these facilities are completed, there will be 15 offices, each with a graphics terminal and with either audio or video display capabilities. Although these terminals will be connected to the current system, they will only be useful when the new MV10000 computer arrives.

At this time, all of the equipment aquisitions and system modifications specified for the first year of this contract are complete.

The Second Year

The entire effort for the second year involves the aquisition and installation of a MV10000 Data General Computer system. This system, exactly as specified in the previous report, was bid under the control of the State of Georgia, and was ordered in late summer, 1983. The current projected shipping date is November 19, 1983. All power and computer room modifications have been completed for this installation, and we expect to have the system operational by mid December, 1983.

Table 1

Basic System Upgrade

Data General Equipment	99,403.46
Magtape Control Cards	2,200.00
AP Software	1,052.00
MCA	1,557.23
Console Printers	1,655.75
Terminal Upgrade	12,664.25
	$118,532.68

Table 2

VICOM	52,267.90
Matrix Camera	8,625.00
Sierra Camera	6,580.48
	$67,473.38

Table 3

A/D and D/A System

Phoenix A/D-D/A	11,750.20
Interface Cards	1,266.06
Cables	384.47
Wavetek Filters	6,058.18
	$19,458.91

Table 4

Environmental Upgrade

Computer Room Upgrade	$21,283.04

E-21-646

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

PHONE: (404) 894-2961

August 24, 1984

U.S. Army Research Office
P.O. Box 12211
Research Triangle Park, NC 27709

Ref: Semi-Annual Progress Report, Contract No. DAAG29-82-6-0008, Project Entitled - "Digital Signal Processing Laboratory Equipment, Project Director - Dr. T. P. Barnwell, III

Dear Sirs:

The attached semi-annual progress report is being submitted as per contract specifications.

If there are any questions concerning this report, please contact Dr. T. P. Barnwell at (404) 894-2914.

Thank you.

Sincerely,

Marsha Segraves
Admin. Asst.

cc: T. P. Barnwell
OCA (2)

PROGRESS REPORT

(TWENTY COPIES REQUIRED)

1. ARO PROPOSAL NUMBER: DRXRO-EL-19037

2. PERIOD COVERED BY THE REPORT: Through June 30, 1984

3. TITLE OF PROPOSAL: Digital Signal Processing Laboratory Equipment

4. CONTRACT OF GRANT NUMBER: DAAG29-82-6-0008

5. NAME OF INSTITUTION: Georgia Institute of Technology

6. AUTHOR OF REPORT: Thomas P. Barnwell III

7. LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO SPONSORSHIP DURING THIS PERIOD, INCLUDING JOURNAL REFERENCES:

   None. This contract is for equipment to upgrade the Digital Signal Processing Laboratory, and does not include any direct research funds.

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD.

   None. This contract is for equipment to upgrade the Digital Signal Processing Laboratory, and does not include any direct research funds.

BRIEF OUTLINE OF RESEARCH FINDINGS

As previously noted, this is a laboratory upgrade contract rather than a research contract and hence no funds were used for direct support of research. The contract is currently beginning the third year of a three year effort. This report addresses the completion of the tasks from the second year and the initiation of the tasks from the third year.

The primary goal of the second year was the acquisition, installation, and integration of an Data General MV/10000 computer into the Digital Signal Processing Computer Network. This task is now entirely complete, and the MV/10000 is integrated into the system. The performance of the MV/10000 has been quite satisfactory, and the computational bottleneck which was present in the old system has been largely removed. In addition, by augmenting the ARO funds with funds from the Franklin Foundation Chair (held by Ron Schafer), we have provided 25 signal processing work stations, each of which includes a graphics terminal, an audio interface, and a video interface. This development has vastly increased the system access and the associated research thoughput. The MV/10000 system hardware acquired under this contract during the second year is shown if Figure 1.

The primary goal of the third year is the acquisition and integration of a VAX-11/780 computer system for use in the Digital Signal Processing Architecture research. In order to obtain a more powerful system for the same amount of money, a proposal was written to the Digital Equipment Corporation (DEC) which resulted in an agreement under which we can buy up to $320000 worth of equipment at half of the retail price (i.e. for $160000). Under this agreement, the equipment shown in Figure 2 has been ordered with a delivery date in late August, 1984. We are also in the process of acquiring both the UNIX operating system for the new computer and the networking software necessary to integrate it into the existing system. In addition, a new support position has been allocated for the management of the new computer, and the appropriate hiring procedure has been initiated.

FIGURE 1
ARO Equip List for Second Year

	Cost to Project
1) 2 - 196 disc packs	980.00
2) 1 - Multiprocessor Communications Adaptor	1,600.00
3) 1 - MV/10000 32 bit Computer System	226,778.00
4) 1 - Nikkor Macrolens for Video Camera	170.00
5) 2 - Audio Listening Stations	438.00
6) 1 - Data Channel Line Printer Controller for MV/10000	1,133.50
7) 3 - Communication Hardware	1,425.00
8) 1 - 512 x 512 x 4 Image Memory for VICOM	1,000.00
9) 3 - Video Isolation Amps, for VICOM	432.00

FIGURE 2
Equipment in the VAX-11/780

	List Price
780XA-AE VAX-11/780 w/2 MB Memory	145,000.00
MS780-FC 6 MB Memory	24,000.00
FP780-AA Floating Point Accelerator	11,200.00
BA11-KV Expansion Box	3,500.00
DD11-DK Expansion	940.00
DW780-AA Unibus Adaptor	12,900.00
TU80-AA Tape Drive	9,900.00
DMF32-LP (4 at 3,500 32 Asynch Ports	14,000.00
LA120-DA Censole Printer	2,800.00
RUA60-CA 205 MB Disc	22,000.00
RA81-AA (2 at 19,000) 908 MB Disc	38,000.00
TOTAL LIST PRICE	284,240.00
TOTAL COST TO PROJECT	142,120.00

E-21-646

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

ONE: (404) 894-2961

April 5, 1985

U.S. Army Research Office
P. O. Box 12211
Research Triangle Park, NC 27709

Ref: Semi-Annual Progress Report, Contract No. DAAG29-82-6-0008, Project Entitled - "Digital Signal Processing Laboratory Equipment," Project Director - Dr. T. P. Barnwell, III

Dear Sirs:

The attached semi-annual progress report is being submitted as per contract specifications.

If there are any questions concerning this report, please contact Dr. T. P. Barnwell at 404/894-2914.

Sincerely,

Cindy Meyer
Administrative Assistant

CM

cc: OCA (2)

PROGRESS REPORT

(TWENTY COPIES REQUESTED)

1. ARO PROPOSAL NUMBER: DRXRO-EL-19037

2. PERIOD COVERED BY THE REPORT: Through December 31, 1984

3. TITLE OF PROPOSAL: Digital Signal Processing Laboratory Equipment

4. CONTRACT OF GRANT NUMBER: DAAG29-82-6-0008

5. NAME OF INSTITUTION: Georgia Institute of Technology

6. AUTHOR OF REPORT: Thomas P. Barnwell III

7. LIST OF MANUSCRIPTS SUBMITTED OR PUBLISHED UNDER ARO SPONSORSHIP DURING THIS PERIOD, INCLUDING JOURNAL REFERENCES:

   None. This contract is for equipment to upgrade the Digital Signal Processing Laboratory, and does not include any direct research funds.

8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

   None. This contract is for equipment to upgrade the Digital Signal Processing Laboratory, and does not include any direct research funds.

BRIEF OUTLINE OF RESEARCH FINDINGS

As previously noted, this is a laboratory upgrade contract rather than a research contract and, hence, no funds were used for direct support of research. The contract is currently beginning the third year of a three year effort. This report addresses the the tasks from the third year.

The primary goal of the third year is the acquisition and integration of a VAX 11/720 computer system for use in the Digital Signal Processing Architecture research. In order to obtain a more powerful system for the same amount of money, a proposal was written to the Digital Equipment Corporation (DEC) which resulted an agreement under which we can buy up to $320000 worth of equipment at half of the retail price (i.e., for $160000). Under this agreement, the equipment shown in Figure 1 has been ordered and has already been delivered. In addition, we have also completed the acquisition and installation of Berkeley UNIX 4.2. The entire system is now in full operation, and research activities are now commencing.

In addition to the equipment ordered directly from DEC, other equipment has also been ordered for networking the new VAX computer with the rest of the DSP computer network and for upgrading the research work stations. This equipment, which is also detailed Figure 1, has not yet arrived. It is expected that the entire upgrade will be complete by the termination date of the contract on May 15.

As per our original agreement, we are in the process of hiring a system support engineer to manage the VAX software and hardware. Several candidates have been interviewed, and we are now in the process of extending an offer.

Figure 1. Expenditure for Network Upgrade

Capital Equipment

VAX-11/780 Eight Megabytes main memory 1.1 Gigabytes disk storage 1600 BPI magnetic tape 32 - asynchronous terminal ports	$142,120
Laser Printer	8,995
Camera Back for Matrix Camera	1,370
Unix Environment for MV/10000	7,422
400 Megabytes Disk Drive MV/10000	17,000
TCP/IP Protocol & IEEE Ethernet Interface for MV/10000	6,187
Network Cabling for IEEE Ethernet	500
Research Workstation Upgrade	33,000
Total	$216,594

Materials & Supplies

Berkeley Unix 4.2	1,550
4 Disk Pack for Data General Computers	2,820
ICs & Electronic Supplies	1,300
MV/10000 Maint. 2-1-84 thru 4-1-85	19,000
VAX-11/780 Maint. 12-1-85 thru 3-1-85	6,255
5 Disk Packs for VAX-11/780	2,000
GKS Graphic Software	800
Total	$30,925

E-21-646

GEORGIA INSTITUTE OF TECHNOLOGY
SCHOOL OF ELECTRICAL ENGINEERING
ATLANTA, GEORGIA 30332

PHONE: (404) 894-7337

October 17, 1985

U.S. Army Research Office
P. O. Box 12211
Research Triangle Park, NC 27709

Re: Final Report, Contract No. DAAG29-82-6-0008, Project Entitled - "Digital Signal Processing Laboratory Equipment," Project Director - Dr. T. P. Barnwell, III

Dear Sirs:

The attached final report is being submitted as per contract specifications for the period 12/15/82 - 5/14/85.

If there are any questions concerning this report, please contact Dr. T. P. Barnwell at 404/894-2914.

Sincerely,

Pam Majors
Staff Assistant

PM

cc: OCA (2)

DIGITAL SIGNAL PROCESSING LABORATORY EQUIPMENT

FINAL REPORT

Thomas P. Barnwell III

May 15, 1985

U. S. ARMY RESEARCH OFFICE

DAAG29-82-6-0008

Digital Signal Processing Laboratory
School of Electrical Engineering
Georgia Institute of Technology
Atlanta, Georgia 303032
(404)-894-2914

1. INTRODUCTION

This report describes the results a three-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. Nearly all of the money in this contract was used directly to purchase research equipment. The small percentage which was not was used to pay for the time of a technician for installing and maintaining the new equipment and an even smaller portion ($2000 per year) was used, in conjunction with other money from the Georgia Tech Foundation, to support a graduate fellowship. So this contract cannot be said to be a research contract in the usual sense. The equipment this contract provided, however, had and continues to have an immense impact on the research program in digital signal processing at Georgia Tech. It is no exaggeration to say that the equipment provided by this contract has been the key component in the expansion of the staff of the DSP Laboratory from three faculty and two professionals at the beginning of this contract to its current level of eight faculty and eight professionals. The availability of the new research equipment has also resulted in a large increase in the number of Ph.D. students studying digital signal processing with a corresponding increase in Ph.D. theses and published papers. Indeed, it is fair to say that the perceived rise of the DSP graduate program at Georgia Tech to international prominence is in no small part due to the equipment provided by this contract.

The research equipment upgrade was a three year effort. 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 three sixteen-bit minicomputers: a Data General Eclipse S250 AP; a Data General Eclipse S230; and a Data General Nova 830. In addition, another Eclipse S250 and a Nova 820 were in use for educational activities. The entire research system supported four uses, all of whom worked out of the same terminal room. At the start of this contract, the computers were being scheduled twenty four hours a day, seven days a week. In short, the system was being used to capacity and was saturating.

The first year upgrade had four basic goals. The first was to add the hardware and software necessary to increase the number of simultaneous users. The second was to provide a high quality image display system to support image processing research. The third was to provide a high quality A/D and D/A capability to support general signal acquisition and playback. Finally, the fourth was to upgrade the computer room physical environment to support the new equipment.

The purpose of the second year upgrade was to add computing power to the basic laboratory environment. The addition of the new users in the first year had the effect of degrading the system performance for all users. The second year upgrade consisted entirely of the addition of a new super-minicomputer in the form of a Data General MV-10000. Since this computer ran identical software with the old system, this upgrade had little effect on the system operation.

The purpose of the third year was the addition of yet another super-minicomputer, a Digital Equipment Corporation VAX 11/780. This machine was not so much intended to increase the computational power for existing research, but rather to support an entirely new direction of research. This was the study of the implementation of multiprocessor architectures for digital signal processing using VLSI.

A block diagram of the entire system after all of the upgrades is shown in Figure 2. The remainder of this report will describe each component of the total upgrade in detail.

2. THE FIRST YEAR EQUIPMENT UPGRADE

A detailed listing of the equipment purchased during the first year upgrade is shown in Table 1 and Table 2. Table 1 describes the equipment items while Table-2 shows the total cost figures.

Table 1

Equipment Purchased as Part of the First Year Upgrade

Network Upgrade

Item No.	Quantity	Specifications
1	4	8656 256KB Memory
2	1	4254 DCU/2000
3	1	4251 ComChassis
4	2	4257 16 line mux
5	8	4261 ElA modules
6	1	6061 190MB disc with controller
7	1	6061-A 190 MB disc
8	1	4065 I/O interface with schematics
9	1	4068 PIT with schematics
10	1	UCEE1 map upgrade with schematics
11	1	3827-02-M AOS X25
12	1	3828-00-M Xodiac
13	1	3813-02-M RDOS X25
14	1	3629-00-M AOS Fort 77
15	1	3956-00-M AOS SWAT
16	1	AOS subsequent license

A/D - D/A Upgrade

Item No.	Quantity	Specifications
1	1	Data Acquisition System Part DAS6915-D-002-D-P-0/2 SSH/2 EDAC 3716
2	2	Dual Hi/Lo Analog Filters Model 852-01 with option 04 - (rack mount)

2.1 The Network Upgrade

At the beginning of this effort, the Digital Signal Processing Laboratory was operating under a network of our own design. The configuration of this network is shown in Figure 1. At that time, the two research computers, the Eclipse S230 and the Eclipse S250 AP, were configured as a dual processor using the RDOS operating system from Data General. This system allowed for four simultaneous users. In addition, the Eclipse S250 was used as an educational computer for class related activities. It was running the AOS operating system, and could support about sixteen users. The entire network was connected by a 8 Megabit/second shared bus called a Multiprocessor Communications Adapter or MCA. A older sixteen bit minicomputer, a Nova 830, was used as a network server. The Nova computer supported access to the A/D and D/A subsystem, an eight-tract magnetic tape transport, and a Comtal image display system. These resources were allocated to individual users with a capture-and-hold protocol.

Table 2

First Year Equipment Costs

Network Upgrade

Data General Equipment	99,403.46
Magtape Control Cards	2,200.00
AP Software	1,052.00
MCA	1,557.23
Console Printers	1,655.75
Terminal Upgrade	12,664.25
	$118,532.68

Image Aquisistion and Display System

VICOM	52,267.90
Matrix Camera	8,625.00
Sierra Camera	6,580.48

A/D and D/A System

Phoenix A/D-D/A	11,750.20
Interface Cards	1,266.06
Cables	384.47
Wavetek Filters	6,058.18
	$19,458.91

Environmental Upgrade

Computer Room Upgrade	$21,283.04

Before the upgrade, the most critical problem was access to the computing facilities. The primary goal of the first year was to alleviate the overcrowding problem.

The solution was to upgrade all of the Eclipse minicomputers to the AOS time-shared operating system and to install the Data General Xodiac network software. Xodiac uses the X.25 protocol, and was capable of operating over the existing high speed bus (MCA).

Hence, the primary requirement besides the purchase of the network software was to upgrade the minicomputers for multi-user operation.

2.1.1 The Network Hardware

A list of the hardware bought for the network upgrade is shown in Table 1 and a summary of the equipment costs is shown in Table 2. There were two major components in the network upgrade. The first was the hardware necessary to support access by the additional users, and included a DCU/2000 communications controller, a communications chassis, sixteen serial ports with EIA (RS-232) options, an a programmable interval timer (PIT). The second was the hardware required to generally upgrade the system to handle the increased user activity. This included a 190 Mbyte disk system and 1 Mbyte of additional main memory.

2.1.2 The Network Software

A summary of the software purchased as part of the network upgrade is also listed in Table 1. The software was purchased in three categories: operating system software; network software; and utility software. The operating system software consisted of a subsequent license for the AOS time-sharing system. The network software consisted of X.25 for AOS, X.25 for RDOS, and the Xodiac network software. The utility software consisted of the Fortran 77 compiler and interactive debugger (SWAT) to operate under AOS.

2.2 The Audio Subsystem

The major components of the audio subsystem are shown in Table 1, while the cost summary is given in Table 2. The audio subsystem is composed of five components: a fifteen bit analog-to-digital converter; a fifteen bit digital-to-analog converter; two vaiable anti-aliasing filters; and a computer interface card. The custom hardware interface and system software for the audio subsystem was designed and built at Georgia Tech. The hardware interface was based on a design provided by Bell Laboratories.

The audio subsystem resides on the Eclipse S250 AP computer, but is shared by the entire network. A special MCA connection is provided between the MV10000 and the Eclipse S250 AP to provide extra speed for data acquisition and playback. The system is designed so that the user interface is uniform throughout the system. If the user is running on the Eclipse S250 AP, then access to the system is direct. If the user is operating on the MV10000, then access is through the special MCA connection. If the user is operating on one of the other network machines, then access is via the network using file transfers.

2.3 The Image Display Subsystem

The third major component of the first year upgrade was the image display and processing system. The digital signal processing laboratory has a traditional interest in multi-dimensional signal processing, and an image acquisition and display system was needed to support that activity.

The image processing and display system consists of three components: a VICOM 512X512 full color display processors and monitor; a Sierra video camera; and a Matrix hard copy camera. The cost summary for these items is shown in Table 2.

Like the audio subsystem, access to the image display subsystem is distributed throughout the network and has a uniform user interface. The VICOM was originally attached to the Eclipse S230 in the first year upgrade, but was later moved to the MV10000 as part of the second year upgrade.

2.4 The Environmental Upgrade

The final component of the first year was the environmental upgrade. The environmental upgrade was not really needed for the first year itself, but was required to support the equipment purchased during the second and third year. A cost summary for the environmental upgrade is given in Table 2.

The environmental upgrade consisted of the installation of an extended computer floor, the addition of a 200 amp power service box, and the installation of a new air-conditioner. The new area was in a room adjacent to the original existing computer room, and the computer floors and air-conditioners were interconnected. The new area is now occupied by the VAX 11/780 computer purchased during the third year.

3. THE SECOND YEAR EQUIPMENT UPGRADE

After the completion of the first year upgrade, the major problem was not system access but system performance and the working environment. The system could now have many simultaneous users, but the overall system performance was correspondingly degraded. Likewise, the computer terminal room, which was completely adequate for four users, was completely inadequate for ten. The first of these problems was addressed by the addition of a new super-minicomputer to the computer network, a Data General MV10000. The second problem was addressed by distribute the system access away from the terminal room and into the offices of the students and staff.

3.1 The MV10000

The major components of the MV10000 computer system and the associated cost summary are shown in Table 3 and Table 4. The major advantage of the MV10000 system as compared to other possible choices is that it required no special hardware to be integrated directly into the existing network. Since the MV10000 both supported X.25 and Xodiac operating across an MCA, then it would run nearly all of the existing software which had been developed on the other computers. Of course, the MV10000 has the additional advantage of being a virtual memory computer, which allows for great flexibility in application development.

3.1.1 The Computer System

A description of the components of the MV10000 system is given in Table 4. The primary hardware components consisted of the MV10000 computer itself, a 190 Mbyte disk drive, two megabytes of main memory, sixteen extra EIA ports, and two synchronous ports. The primary software components consisted of the AOS-VS operating system, a Fortran 77 compiler, a Fortran 5 compiler, a Pascal compiler, the Sort/Merge utility, and the network software. The computer system was ordered in May of 1983, and was fully operable by December of 1984.

Table 3

Hardware and Software for the MV10000

Hardware

Item No.	Quantity	Model	Description
1	1	E9881-BA	MV/10000 Pkg:2MB, 4368, 6026-H
2	1	8765	2.0MB Memory Module
3	1	4370	IAC/16 for use with 4372
4	1	4372-A	TCB/16 and rack
5	1	4380	ISC/2 (Synch)

Software

Item No.	Quantity	Model	Description
1	1	3900-75HK	AOS/VS 1 Year SSS/STR/MSS
2	1	3907-78H	AOS/VS DGL. 90 Day CSS, 1 YR SSS, STR, Installation
3	1	3991-75H	One Year SSS/STR
4	1	3990-75H	One Year SSS/STR
5	1	3901-10N	AOS/VS Fortran 77:
6	1	3901-40H	AOS/VS Fortran 77
7	1	3902-10N	AOS Fortran 5 (Under AOS/VS)
8	1	3902-40H	AOS/FORTRAN 5 (under AOS/VS)
9	1	3904-10N	AOS Extended basic (under AOS/VS) subsequent license
10	1	3904-40H	AOS Extended basic (under AOS/VS) comprehensive SSS
11	1	30051-01H	AOS/VS Pascal Init LIC/STR/CSS/SSS/IN
12	1	3938-10N	AOS/VS Swat Debugger subsequent license
13	1	3915-10N	AOS/VS Sort/Merge subsequent license with STR service
14	1	3915-40H	AOS/VS Sort/Merge comprehensive SSS annual fee
15	1	3625-40M	AOS Comprehensive SSS
16	1	3827-40M	AOS X.25 Comprehensive SSS
17	1	3828-40M	AOS Xodiac Comprehensive
18	1	30064-03M	Initial License

Table 4

Equipment Purchased as Part of the Second Year Upgrade

	Computer Upgrade	
1	2 - 196 disc packs	980.00
2	1 - Multiprocessor Communications Adaptor	1,600.00
3	1 - MV/10000 32 bit Computer System	226,778.00
4	1 - Data Channel Line Printer Controller for MV/10000	1,133.50
5	3 - Communication Hardware	1,425.00
	Image Aquisition and Display	
1	1 - 512 x 512 x 4 Image Memory for VICOM	1,000.00
2	3 - Video Isolation Amps, for VICOM	432.00
3	1 - Nikkor Macrolens for Video Camera	170.00
	A/D and D/A System	
1	2 - Audio Listening Stations	438.00

After the MV10000 was fully integrated into the system, the network was reconfigured as shown in Figure 2. The main changes were that the VICOM image processing system was moved to the MV10000 computer from the Eclipse S230 and an extra MCA channel was installed between the MV10000 and the Eclipse S250 AP. The function of this extra high speed channel was to support direct communications between the MV10000 and the audio subsystem residing on the Eclipse S250 AP.

3.1.2 The Network

The MV10000 network interface is a virtual memory version of the Xodiac network software which was available from Data General. Like the other Data General computers in the network, the MV10000 supports the X.25 network protocol on the multiprocessor communications adapters(MCA). This makes all of the existing network resources available to MV10000 users and all MV10000 resources available to other network users. In particular, users can sign on to any computer from any communications port, as well as open files, read files, and write files on any computer in the network. This allows for a uniform interface for all network users to such devices as the VICOM, the A/D-D/A subsystem, printers, tape drives, and so forth.

3.1.3 The Communications

In the initial upgrade, the MV10000 was equipped with 32 RS232 asynchronous ports and 2 synchronous ports. The access to these ports was distributed throughout the building to terminals in staff and student offices, to other computers, to printers, and to other auxiliary devices.

The MV10000 has now become the most heavily used computer in the DSP Laboratory network. Its speed and flexibility have made it an invaluable tool for simulating and testing new algorithms. The major problem with the MV10000 is that its software is generally expensive. This is not a problem for the system processing application for which all the required software was acquired with the system. But for many other auxiliary, yet important tasks, this is definitely a problem. In particular, such tasks as word processing for papers and theses, data base functions for bibliographies, presentation graphics for talks, etc. cannot be accomplished on the network computers in a cost effective way. However, all of these functions are available in codt effective forms for personal computers. Hence, a good approach is to use personal computers wherever they are cost effective, and minicomputers where they are not.

Figure 3 shows the way personal computers were used as part of the second year upgrade. Using twenty four Datavue microcomputers donated to Georgia Tech by the Intelligent Systems Corporation, twenty four of the MV10000 ports were attached directly to individual microcomputers. These microcomputers are configured in clusters of eight processors which share a 15 Mbyte hard disk. Each microcomputer is equipped with a Z-80 processor, 64 Kbytes of memory, two serial ports, and one parallel port. These two serial ports on the microcomputers were attached a to graphics terminals and to an MV10000 port, respectively. In the "standard" mode, the microcomputer connects the MV10000 directly to the graphics terminal, and the system operates exactly as if the microcomputers were not there at all. In the "microcomputer" mode, the terminals interface to the microcomputer CPM operating system, and the MV10000 is used as a peripheral for such tasks as data storage, mail, and printing. Hence most tasks related to word processing, presentation graphics, terminal emulation, data base management, ect. are relegated to the micro-computers while most DSP and interactive graphics tasks are performed by the MV10000.

3.2 The Environmental Upgrade

A large environmental upgrade was performed as part of the second year laboratory development. In all, about forty thousand dollars was spent on this part of the project. However, over half of the funds used were provided by the Franklin Foundation Chair (Ron Schafer) through the Georgia Tech Foundation. All of the contract funds used in the second year environmental upgrade were allocated on the first year budget as showm in Table 1 and Table 2.

The goal of the second year environmental upgrade was to provide sixteen DSP work-stations for research simulations. Each station contains a graphics terminal, two audio lines, three video lines, a port into a personal computer cluster (see Figure 3), and a second port into the laboratory computer network. If the station was to be used for audio research, then an audio listening station was also provided. If a work station was to be used for video research, then a video monitor was also provided. In all, ten audio listening stations and five video monitors were purchased.

4. THE THIRD YEAR EQUIPMENT UPGRADE

The third year upgrade had three specific goals. The first goal was to purchase and install a VAX 11/780 super-minicomputer as part of the Digital Signal Processing Laboratory facility. This computer is to be used to initiate a new joint research area involving multiprocessor architectures for digital signal processing and VLSI. The second goal was to integrate the new computer fully into the existing computer network. This was more of a challenge than for the MV10000 because of the dissimarlity between the VAX 11/780 and the existing network computers. The final goal was to complete the development of the DSP workstations begun in the first two years of this contract. This consisted primarily of replacing the older CPM based microcomputers with IBM PC clone personal computers.

4.1 The VAX 11/780

The VAX 11/780 computer was obtained through a joint proposal to the Digital Equipment Corporation (DEC) from the Digital Signal Processing Laboratory and the Microelectronics Research Center. Under the terms of this proposal, the Digital Equipment Corporation provided up to three hundred thousand dollars of equipment to Georgia Tech at half of the retail price. A description of the system purchased from DEC under this agreement is shown in Table 5.

Table 5

Equipment in the VAX-11-780

	List Price
780XA-AE VAX-11/780 x/2 MB Memory	145,000.00
MS780-FC 6 MB Memory	24,000.00
FP780-AA Floating Point Accelerator	11,200.00
BA11-KV Expansion Box	3,500.00
DD11-DK	940.00
DW780-AA Unibus Adaptor	12,900.00
TU80-AA Tape Drive	9,900.00
DMF32-LP (4 at 3,500 32 Asynch Ports)	14,000.00
LA120-DA Console Printer	2,800.00
RUA60-CA 205 MB Disc	22,000.00
RA81-AA (2 at 19,000) 908 MB Disc	38,000.00
TOTAL LIST PRICE	284,240.00
TOTAL COST TO PROJECT	142,120.00

4.1.1 The Computer System

A block diagram of the VAX computer system installed is shown in Figure 4. The VAX computer order was initiated in May, 1984. The equipment arrived in December, 1984 and was installed and operating in January, 1984.

4.1.1.1 The Hardware

A detailed description of the VAX 11/780 hardware is shown in Table 5 and Figure 4. The computer is composed of a central processing unit with 8 Mbytes of main memory, a floating point processor and accelerator, and an expansion chassis. Attached to the computer are disk drives totaling 1113 Mbytes, a nine track tape drive, thirty-two asynchronous serial ports, two synchronous serial ports, and a console printer.

4.1.1.2 The Software

The operating system for the VAX 11/780 is Berkley Unix version 4.2. This system was purchased directly from the University of California at Berkley. Other software included a GKS graphics software package for the MV10000 and a computer aided design package for the IBM PC clones.

4.1.2 The Laser Printer

As part of the third year upgrade, a laser printer was purchased. The original plan was to purchase this printer from DEC, but the evolution of technology made this non-cost effective. The laser printer purchased was from QMS, and cost about nine thousand dollars. The laser printer was attached to the MV10000, where it is serviced by a print queue. Currently, many applications use this printer including word processing, presentation graphics, research graphics hard copy, image hard copy, and many more.

4.1.3 The Network

To include the VAX 11/780 in the existing network required a different network protocol and a different network medium from that in current use. The medium used was an IEEE ethernet operating between the VAX 11/780 and the MV10000. The interface for the MV10000 was purchased on this contract, while the interface for the VAX was purchased out of internal funds. The protocol used was TCP/IP. Using the TELNET software available as part of UNIX for the VAX 11/780 and from Data General for the MV10000, the new computer was included in the existing network.

4.1.4 The Communications

The VAX 11/780 supports thirty two terminal ports. These ports are split equally between the Digital Signal Processing Laboratory and the Microelectronics Research Center. Three ports are used to interface to the Georgia Tech Network, and three more are used for system functions (printers and the system console). The rest is used for terminal access.

Table 6

Equipment Purchased as Part of the Third Year Upgrade

Capital Equipment

VAX-11/780 Eight Megabytes main memory 1.1 Gigabytes disk storage 1600 BPI magnetic tape 32 - asynchronous terminal ports		$142,120
Laser Printer		8,995
Camera Back for Matrix Camera		1,370
Unix Environment for MV/10000		7,422
400 Megabytes Disk Drive MV/10000		17,000
TCP/IP Protocol & IEEE Ethernet Interface for MV/10000		6,187
Network Cabling for IEEE Ethernet		500
Research Workstation Upgrade		33,000
	TOTAL	$216,594

Materials & Supplies

Berkeley Unix 4.2		1,550
4 Disk Pack for Data General Computers		2,820
ICs & Electronic Supplies		1,300
MV/10000 Maint. 2-1-84 thru 4-1-85		19,000
VAX-11/780 Maint. 12-1-85 thru 3-1-85		6,255
5 Disk Packs for VAX-11/780		2,000
GKS Graphic Software		800
ACAD		1,350
	TOTAL	$32,275

4.2 The Environmental Upgrade

The rest of the money in the third year was spent to complete the environmental upgrade, to address some overall system problems, and to pay for system maintenance. The environmental upgrade was completed with the purchase of 23 IBM PC clones. These systems were purchased as individual components, and assembled at Georgia Tech. In addition, a new disk drive was purchased to alleviate an overcrowding problem on the MV10000, and five disk packs were bought for system backup.

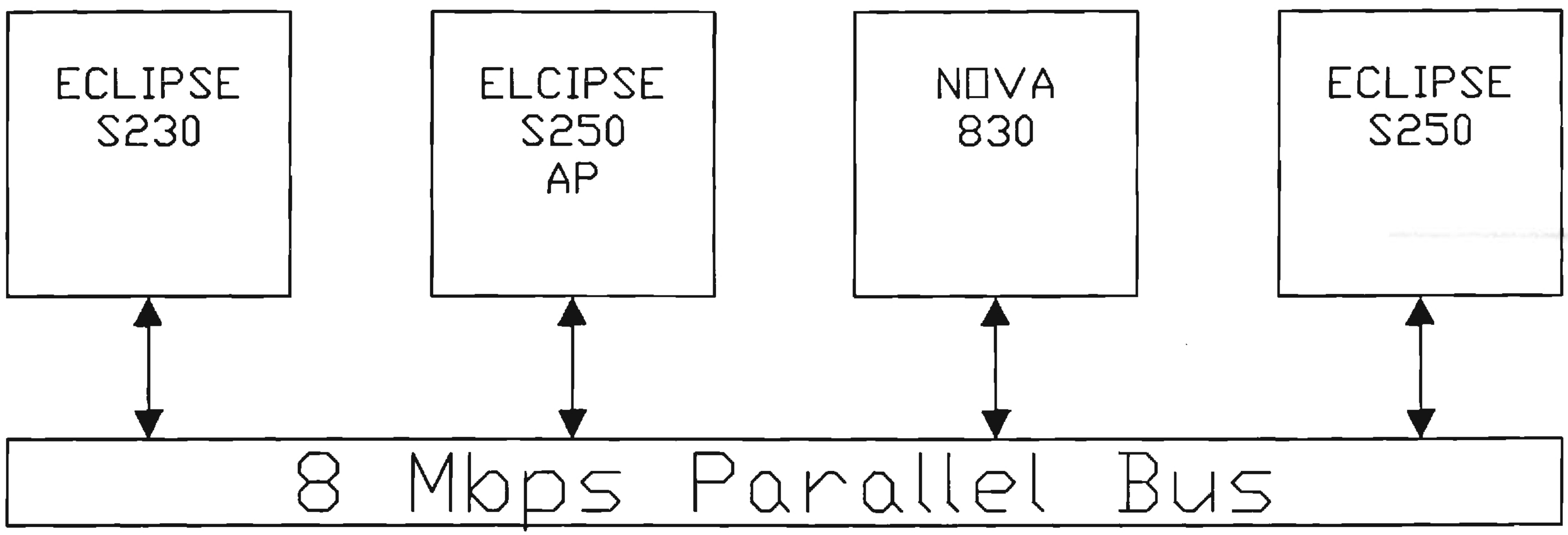

Figure 1 -- Initial Network Configuration

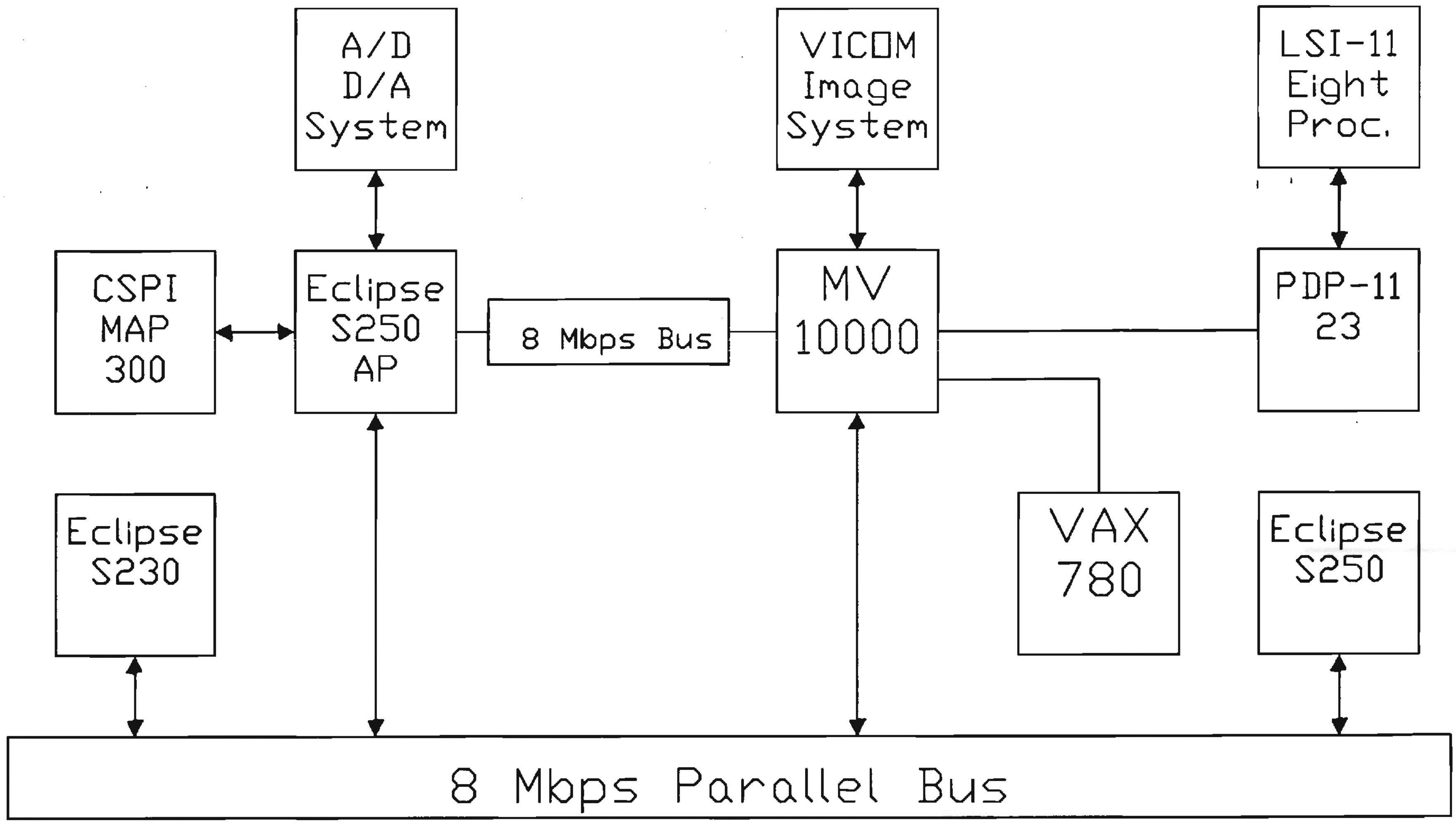

Figure 2 -- Final Equipment Configuration

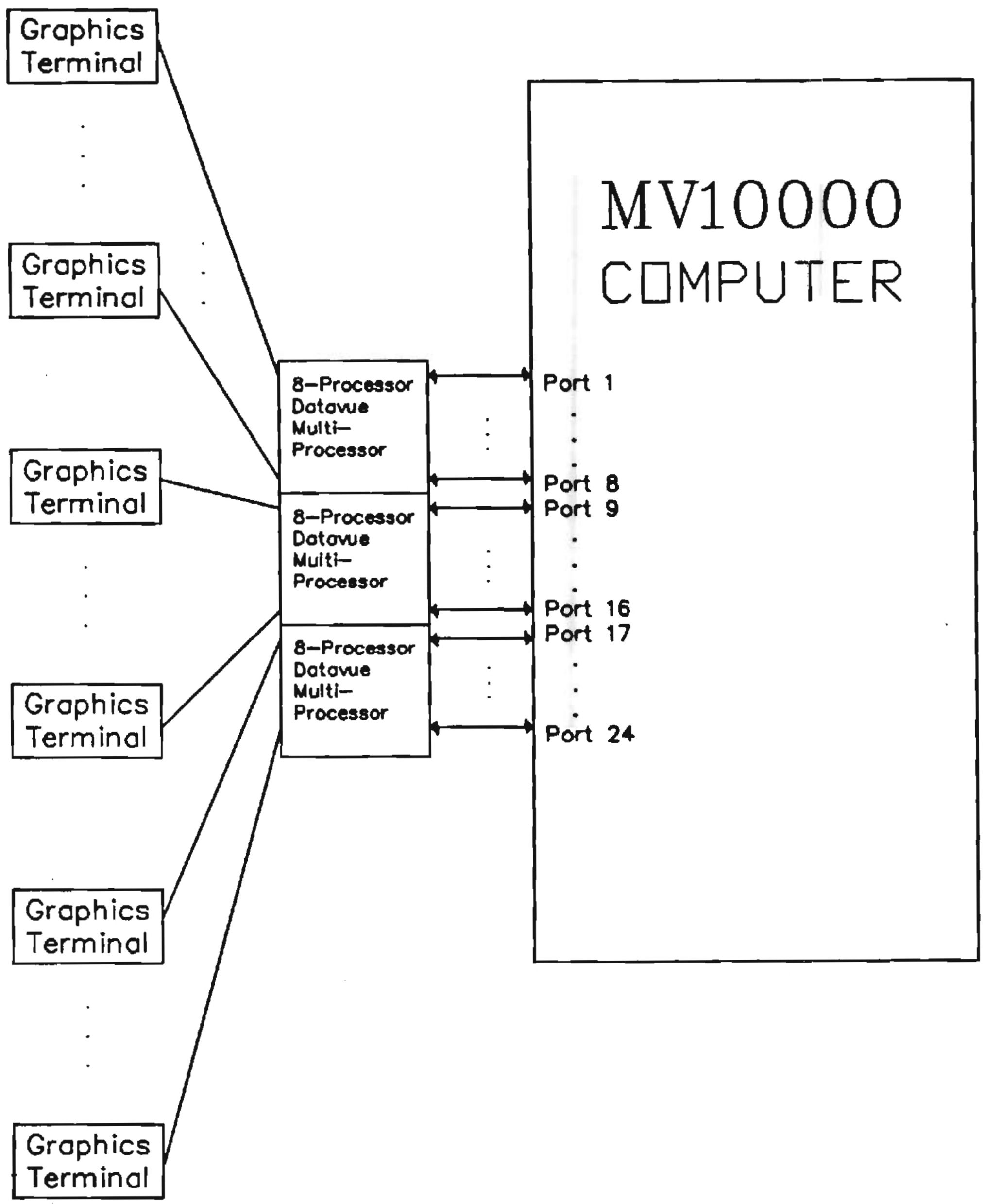

Figure 3 -- Personal Computer (CPM) Interconnections

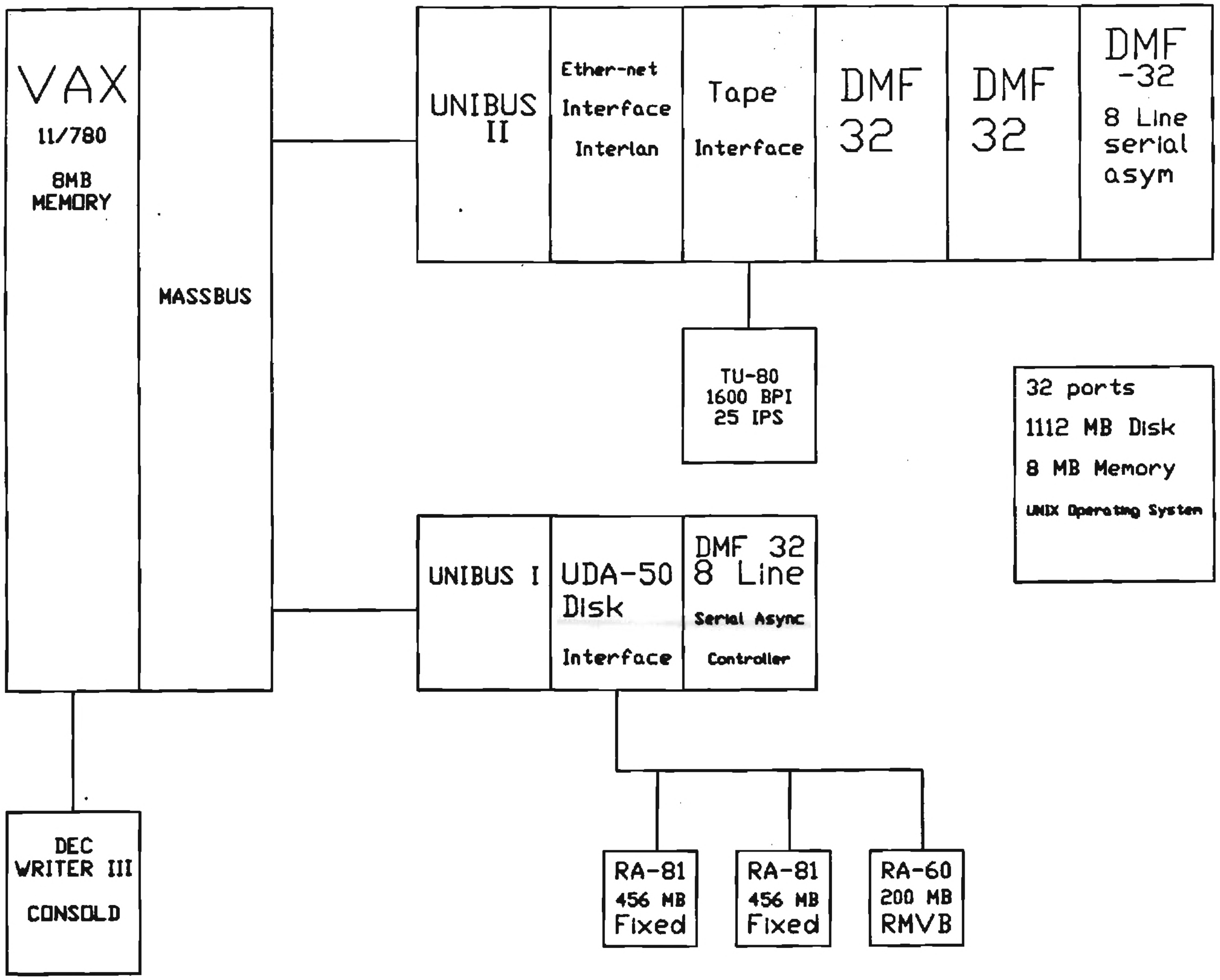

Figure 4 -- VAX 11/780 Computer System