CPG MEMO NO. 14

National Radio Astronomy Observatory
Tucson, Arizona

April 12, 1983

MEMORANDUM

TO: W. R. Burns

FROM: M. A. Gordon

SUBJECT: A Long Term Computer Plan for Arizona Operations

Over the past few months, we have assessed our present and anticipated needs for computers. The materials attached to this memorandum describe our situation and suggest a new course. The Tucson staff unanimously endorses this plan.

A. A few points are especially important:

1. Our existing PDP-11/40 telescope computer has only 1000 words available. Yet, new electronics modules and new pointing corrections will require more space than this.

2. Our largest projected need in the next 5 years is the support of "multibeaming" spectroscopy. This need will require a substantial increase in the capacity of our existing computers.

3. Our 10 years of experience has proven DEC equipment to be satisfactory. Over the years we've acquired a substantial inventory of DEC peripherals and spares. Our programmer, engineers, and technicians have become familiar with the philosophy of DEC design. Furthermore, Tucson has a large DEC service department.

4. Our present computers make use of DEC's UNIBUS system. All data devices and software codes have been designed to use this system. A change would be expensive in terms of manpower and hardware.

5. Experience with the new 12-m surface indicates a great future for millimeter-wave astronomy at the NRAO, especially if electronics continues to improve the performance of mm-wave receivers.

B. Our Plan:

1. Acquire, immediately, 256k bytes of additional memory for our 11/44 processor. The 11/44 system will be moved to Kitt Peak this summer. $1200.

2. Purchase, as soon as possible, a VAX-11/750 to provide the capability for developing a new mountain system and for supporting the general computing needs of our Tucson staff. $75,000.

3. Purchase, during next year, a second VAX-11/750 system to replace the mountain system developed on the VAX described above in paragraph (2). $65,000.

4. By 1985 the mountain VAX would control hardware via our PDP-11/44 and FORTH, and support all other computing needs associated with the operation of the telescope and the collection of data. (This approach is similar to the DDP 316 and ModComp systems at the 140-ft telescope). The downtown VAX would allow us to program without taking time away from the telescope, as well as supporting our downtown needs for interfacing hardware and general computing.

C. The Cost:

1. 1983.	256k additional memory for PDP-11/44:	$1,200.
	Spares for the PDP-11/44 (used unit):	15,000.
	VAX-11/750 for development:	75,000.
2. 1984.	VAX-11/750 for Kitt Peak	65,000.
	Spares for the VAXs	25,000.
	Modifications to control building	10,000.
	Second UPS for computers	10,000.
3. Total Expense of Computer Improvements:		$201,200.

By making use of both our experience with DEC and the majority of peripheral equipment on hand, we believe that this proposed computer system will provide adequate capability for the long term, and at the lowest cost to the observatory both in terms of manpower and money. I believe this plan to be a sound investment for the NRAO.

c: H. Hvatum
M. S. Roberts

Attachments

National Radio Astronomy Observatory
Tucson, Arizona

March 28, 1983

MEMORANDUM

TO: M. Balister

FROM: J. M. Payne

SUBJECT: 12-M Projects

Now that we are observing with the 12-M telescope it seems appropriate to give some thought to future projects for the new telescope.

Our top priorities for the next several months must be:

1) Test the bolometer system and fix any problems.

2) Complete and test the 200-300 GHz cooled mixer receiver and release it to observers.

3) Develop any electronic systems needed by J. Findlay for further improvements in the surface.

Assuming that there are no dramatic breakthroughs in SIS mixers (i.e., NRAO doesn't push to put one on the 12-M telescope). My list of projects looks like this:

1) 70-90, 90-120 GHz Cooled Mixer Receiver

As we all know our present cooled mixer receiver is by no means outstanding at the CO frequencies. With improved mixers and by splitting the band into two parts we will be able to achieve 200 K S.S.B. over this band. Magne, Jesse and myself have developed and tested a dual polarization diplexer that would also serve as an image terminator. Provided an SIS receiver is not on the horizon, I believe this project should have top priority.

Engineer - New Engineer or Payne

2) Consolidation of Optical Devices

The basic concept of receiver mounting and selection outlined in my original memo has been well demonstrated over the past several weeks. The system right now is "bare bones". Here is a list of things that need to be done:

a) Build an automatic drive system for the selection mirror.

b) Incorporate the path length modulator into the selection mirror.

c) Build a cooled chopper calibration system to sit under the selection mirror.

d) Build an image termination system to terminate the unwanted sideband in a 15 K load.

e) Build a fast beam switch into the optical path.

Engineer - Payne

3) Inductosyn Electronics and Interface

The Baldwin encoder situation keeps me awake at nights. We could be just fine for the next couple of years or we could be caught with our pants down. I think fast action is justified and we seem to be doing this.

Engineer - Freund

4) 130-170 GHz Receiver

There doesn't seem to be a tremendous amount of demand for a good receiver in this band. I believe the correct way to proceed is to modify our existing receiver (as far as I know it is still the best around) and make do with this for the next year. We should then build an improved dual channel, dual band receiver.

Engineer - Payne/Cochran

5) Edge Ball Measurer

John Findlay has suggested a way of measuring the edge balls quickly and accurately. A fair bit of mechanical and electrical design needs to go into this to do it right. I think it's a high priority job.

Engineer - Payne

6) New Digitized Cable System

Rich LaCasse has been working on a digital multiplexer for eliminating the majority of the control cables on the telescope. This is important if we wish to have three receivers cold and operational at the same time. Quite a bit of modifications to receivers and control room will be needed.

Engineer - Moorey

7) New Spectral Line Backend

The time has come to stop building filter receivers. The acousto-optic spectrograph has been well demonstrated at Caltech and I think it's time for NRAO to pick it up. A new back end consisting of several AOS devices and an autocorrelator would seem ideal for a spectral line back end that will last for the life of the telescope. A dual 1000 channel AOS with a 500 MHz BW and a dual 100 MHz 100 channel correlator would appear to be a good start. I'd like to talk to Sandy and Ray about this in detail.

Engineers - Payne - Optical
Moorey - Digital

8) A New Computer System

The time seems to be ripe for a complete overhaul of our control and analysis system. Times have changed since the conception of the present control system some 12 years ago and many old fashioned home made interfaces can be eliminated now. Betty Stobie, Bob Freund and Graham Moorey are working on this at the present time. They have a rough idea of the cost and will be writing a separate memo on this. This major change will require a lot of engineering support.

Engineers - Freund, Moorey

9) Array Receiver

There has been a great deal of interest expressed in an array receiver for spectral line work. A 3 x 3 array seems to be a reasonable start from a hardware point of view but a major question needs to be answered. Does each of the 9 feeds illuminate the whole dish with suitable spatial separation to produce nine separate beams? Or does each feed illuminate 1/9 of the dish and using VLA techniques so generate 36 beams? Someone needs to look at the concept and find out what astronomers want.

Engineers - ?

There are other projects that come to mind, of course, but these seem to be the major ones. At any rate I hope this quickly written memo can be used as a starting point for some discussion.

National Radio Astronomy Observatory
Tucson, Arizona

April 4, 1983

MEMORANDUM

TO: M. A. Gordon

FROM: E. B. Stobie EBS

SUBJECT: Short and Long Term Computer Projects

As the 12-meter telescope conversion shutdown comes to a close it is time to organize software plans for the future. I have listed major software projects below in two groups, those that must be completed before or during the 1983 summer shutdown and those that will require more time. The plans of Electronics will have considerable bearing on the order of these projects. Some of the projects listed below were initially described in John Payne's 12-M Projects memo to M. Balister dated 28 March 1983.

Projects due on or before Summer Shutdown

1. Monitor klystron temperatures with thermistors and have the control program generate appropriate warning messages when temperatures are too high.

2. Software changes for the new 1 mm receiver. It is possible that portions of the spectra will have to be inverted. Hardware is built into the receiver for more software monitoring of the receiver.

3. Control the north-south translation stage of the focus. Currently there is a software command to drive the north-south translation stage to a given position. An analytical expression to automatically drive the north-south translation stage as a function of elevation has not been implemented. Also, the pointing correction required as a function of the position of the north-south translation stage has not been determined.

4. Installation of the Inductosyn encoder system. Minor changes will be required in the control program.

5. Software control of an automatic drive system for the selection mirror.

6. Software control of the selection of the bolometer filters.

7. The Holography experiment. Major changes are required in the catalog system of the control program to track the satellite. Also, an automatic continuum mapping program is necessary. The Holography receiver and backend must be interfaced to the control computer and software. A crude analysis package will be needed to inspect the data in real time. A conversion program will be written to take the data from disk and write it in FITS format on tape for the VLA AIPS program.

8. Installation of the new digital multiplexor (DMUX). Much more handshake will be required between the program and the devices on the DMUX. Major changes will be required in the reading of the thumbwheels. If time permits there may be some reorganization of the devices on DMUX and the old DMUX II maybe eliminated.

9. The Jesse Davis synthesizer control box will be removed and the synthesizer control will be placed on the IEEE GPIB interface used by the frequency counter.

10. A new method of frequency switching will be implemented. The 2 GHz source will be switched at a slower rate than the current 400 MHz sources which are switched at a 5 Hz rate. It may be necessary to also maintain the 400 MHz switching option.

11. Installation of the new DEC Card Reader and interface. A new FORTH software driver will be required and probably a look-up table for conversion from hollerith to ASCII characters.

12. Upgrade the downtown PDP 11/44 RSX-11M operating system from Version 3.2 to 4.0. Also, install the driver for the new Winchester disk. An additional 256 MB of memory should be installed for a total memory of 512 MB. During the summer shutdown the PDP 11/44 would replace the PDP 11/40 analysis computer on the mountain and the PDP 11/40 would be brought downtown. There are two advantages to this move. The PDP 11/40 analysis computer has no capacity to expand and already

cannot handle its current workload effectively. With the additional memory and superior FORTRAN 4+ compiler, the PDP 11/44 can easily remedy these problems. There are no spares for the PDP 11/44 processor and full backup will cost at least $8,000. The PDP 11/40 computer will be quite useful downtown in building a new control system that will be discussed in the next section, item 3.

Longer Term Projects

1. Purchase and install a new downtown computer system. This will serve two purposes: 1) it will be used to develop a new telescope control system and 2) serve as the downtown general purpose computer until it is moved to the mountain. If this computer does not arrive before the end of the 1983 shutdown temporary arrangements will be necessary for the downtown programming.

2. Purchase a copy license for DECNET (DEC's networking program) for the downtown machine and connect the processor through DECNET to the VLA DEC computers.

3. Install the statistical multiplexor from Charlottesville. Set up the required terminals for communication with the other NRAO site computers.

4. Devise a new CONTROL system on the downtown computer. Preferably the machine would be a VAX 11-750 to be delivered by fall of this year and interfaced to the current PDP 11/40 analysis computer which will be located downtown by then. The PDP 11/40 computer would retain FORTH as its operating system and become the SERVO computer. Its responsibility would be to control all telescope hardware except the data taking devices. Some rewrite of the FORTH system will be required. All data taking devices (filterbank driven multiplexor, acousto-optic spectrograph, autocorrelator and A/D channels for continuum) would be interfaced to the CONTROL (VAX) computer as well as the card reader, operator communication and observer analysis. The new CONTROL program would be written in FORTRAN and probably be some modification of the current 140-foot control program. Considerable effort will be required to adapt this program to the 12-meter environment.

5. Change the epoch standard from 1950 to 2000.

6. Develop a new continuum mapping program from the data taking to the data analysis. Implement as much as possible of the German NOD2 continuum analysis package.

7. Observer's new system manual.

8. Record editing for spectral line observations.

9. Better systems diagnostics integrated into the SERVO and CONTROL systems.

10. Support new hardware including: autocorrelator, AOS, 3x3 array, etc.

11. Close the telescope servo loop in software. If done in the proposed SERVO FORTH computer, the basic interrupt rate would increase.

12. Ability to observe 2 frequencies simultaneously. If implemented before the new CONTROL system is ready, major changes will be required of the present FORTH system.

National Radio Astronomy Observatory
Tucson, Arizona

April 5, 1983

MEMORANDUM

TO: M. A. Gordon

FROM: E. B. Stobie

SUBJECT: Future Computer Systems for Arizona Operations

It was determined during the 12-meter telescope conversion shutdown that the FORTH control program has approximately 1,000 words of memory available for program expansion. This means that only a minimum number of hardware changes can be implemented in the immediate future. It is certain that the current control system cannot accommodate the hardware proposed by John Payne in his 28 March 1983 memo to M. Balister. If a major investment is made in new instrumentation for the 12-meter telescope, a major upgrade in computer equipment and software is required.

One absolute restriction for a new computer system is the necessity to support the DEC UNIBUS. All in-house devices are interfaced to the UNIBUS in the PDP 11/40 CONTROL computer. Considerable redundant effort would be required from Electronics to interface these devices to a different computer communications medium. Also, we have a large investment in spares for DEC equipment. In 1982 we purchased two DEC RL02 10 MB disk drives and controller for the next generation telescope control computer system. Taking into account our experience with and the assistance available within the observatory for DEC hardware and operating systems, there is a tremendous advantage in purchasing DEC equipment.

The trend in mini computers is toward the 32-bit processor. Certainly DEC will not announce any new 16-bit processor for the future, our PDP 11/44 is the last of the line. DEC's emphasis is on its VAX 32-bit processor series, especially smaller and more affordable VAXes. In the late seventies, DEC's only 32-bit processor was the VAX 11-780 with a price tag over $200,000 for the processor alone. Today DEC sells two smaller VAXes, the 11-750 at $46,750 and the 11-730 at $28,500.

All of the above mentioned facts point to the VAX for the next generation telescope control computer system. It is the opinion of the local DEC software specialists and myself that a VAX 11-730 system with the approximate computional power of a PDP 11/44 will

probably support our current system plans but would be running at near full capacity. Any new developments could not be supported. A VAX 11-750 with almost twice the computional power of the VAX 11-730 would give us room to grow beyond our current expectations.

Because of our limitations in funds and particularly manpower it is necessary to optimize our use of existing hardware and software. The 12-meter environment is similar to that of the 140-foot telescope which divides the labor of the control system in two computers. We would retain the current PDP 11/40 control computer (eventually to be replaced by the PDP 11/44) for the purpose of controlling telescope and all other hardware except the data taking devices. It would become the SERVO computer. Some modifications of the current FORTH control program would be required but would otherwise remain as is. There are many advantages to preserving portions of the current FORTH system. Primarily, it works and it is a convenient language for controlling hardware. Its major limitation is that the current system cannot be expanded beyond the current 28KW of memory.

The proposed VAX 11-750 computer system (CONTROL computer) would control the PDP 11/40 (SERVO computer), collect data from the data taking devices (filterbank driven multiplexor, autocorrelator, acousto-optic spectrograph and continuum A/D channels), provide the operator interface and the observer analysis. In the past telescope control and data analysis functions at NRAO single dish telescopes were performed by separate computers. Considering the cost of an additional processor, the space limitations in the control building and the capacity of the VAX 11-750 system this division of functions is not feasible. The control program will be written in FORTRAN under VMS and will probably be a modification of the 140-foot control program. Considerable effort will be required to adapt this program to the 12-meter environment.

A Step by Step Plan

1. Immediately purchase 256 KB of memory @ $1,200 for the downtown PDP 11/44. During the 1983 summer shutdown move the PDP 11/44 processor, LA120 console and DZ11 communication board to the mountain. There are two advantages to this move. The current PDP 11/40 analysis computer is running at capacity and can no longer run two data analysis programs and the link task simultaneously. The PDP 11/44 with the additional memory will solve this problem. Also, the PDP 11/40 analysis computer would be useful downtown for building a prototype new control system.

2. Purchase a VAX 11-750 computer system with the following equipment:

VAX 11-750 processor	49,390.00
LA 120 Console, DZ11-A	
FP 750 floating point processor	17,890.00
2 MB memory	
VAX 11 FORTRAN copy license	
2 VT 102 video terminals @ 1,453.50	2,907.00
DA11-B interprocessor communications link	5,000.00
	75,187.00

This system would be used to support all downtown programming and develop a new control system. If the computer were to arrive downtown during the fall of this year, a tentative installation date for the new control system would be 1985 summer shutdown.

3. Purchase a second VAX computer system for downtown programming and systems development for the mountain.

VAX 11-750 processor	46,750.00
LA 120 console, DZ11-A	
FP 750 floating point processor	
2 MB memory, FORTRAN license	17,000.00
VT 102 video terminal	1,453.50
	65,203.50

In summary, I propose the purchase of two VAX 11-750 computer systems. The first will be purchased in 1983 for developing a new control system: the existing PDP 11/40 computer as a SERVO computer and the VAX as the CONTROL/ANALYSIS computer. The installation of this system in 1985 would free up the PDP 11/44 analysis computer which will go to the mountain during the 1983 shutdown as the analysis computer. At a later date the PDP 11/44 would replace the PDP 11/40 SERVO computer. The second VAX would be purchased and installed in 1985 as the downtown computer system.

digital

DIGITAL EQUIPMENT CORPORATION

PHONE: AC 617 897-5111 TWX: 710-347-0212-CABLE: DIGITAL MAYN, TELEX: 94-84-57

8301V30069
DATE 25-Mar-83
PLEASE REFER TO THIS QUOTATION NO IN ALL CORRESPONDENCE AND ORDERS

cc Betty
Bob
Graham
John
mark

RECEIVED
M. A. GORDON
NRAO

RECEIVED
NRAO
MAR 30 1983
TUCSON

MAR 28 1983

QUOTATION EXPIRES: 24-May-83
REFERENCE:

DISCOUNT AGREEMENT NO.: 0000100609
WHICH EXPIRES: 30-Sep-83

TO:
National Radio Astronomy
Observatory
2010 N. Forbes Blvd., Ste. 100
Tucson , AZ 85745
ATTN: DALE WEBB

FROM:
DARLENE MORGAN
Digital Equipment Corporation
SUITE 101
6377 EAST TANQUE VERDE RD
TUCSON AZ 85715

Thank you for your inquiry, we are pleased to quote as follows

ITEM	QTY	MODEL NUMBER AND DESCRIPTION	TERMS	DIS %	UNIT PRICE	NET AMOUNT
1	1	11750-UH 11750 UPGRADE PKG N/S 120/60	5	15	$55,000.00	$46,750.00
2	1	MS750-CB 2 MB ECC MOS expansion memory (in 64K arrays). PREREQUISITE: VAX-11/750-CA CPU or MS750-D upgrade.	5	15	$16,000.00	$13,600.00
3	1	QD001-HV VAX/VMS UPD N/S RK07	5	0	$2,640.00	$2,640.00
4	1	DW750 VAX-11/750 Second UNIBUS Adapter.	5	15	$7,000.00	$5,950.00
5	1	E75VD-DZ An FP750 high-performance Floating-Point Accelerator, 2 MB of ECC MOS memory (MS750-CB), VAX-11 FORTRAN license only (QD100-DZ), and requires 120 V/60 Hz of power.	5	15	$20,000.00	$17,000.00
6	1	QD100-HG VAX-11 FORTRAN UPD N/S TU58	5	0	$890.00	$890.00
7	1	VT102-AA VT102 tabletop video terminal. PREREQUISITE: EIA/CCITT serial line interface or equivalent both Digital and non-Digital systems. Also can be used for	5	15	$1,710.00	$1,453.50

EXPORT OF THESE PRODUCTS REQUIRES PRIOR WRITTEN AUTHORIZATION FROM THE U.S. DEPARTMENT OF COMMERCE.

DIGITAL EQUIPMENT CORPORATION
PHONE: AC 617 897-5111 TWX: 710-347-0212-CABLE: DIGITAL MAYN, TELEX: 94-84-57

8301V30069
DATE 25-Mar-83
PLEASE REFER TO THIS QUOTATION NO IN ALL CORRESPONDENCE AND ORDERS

QUOTATION EXPIRES: 24-May-83
REFERENCE:

DISCOUNT AGREEMENT NO.: 0000100609
WHICH EXPIRES: 30-Sep-83

ITEM	QTY	MODEL NUMBER AND DESCRIPTION	TERMS	DIS %	UNIT PRICE	NET AMOUNT
		data processing or word processing on models with the DECWORD word processing keycaps. Features advanced video and built-in printer port characteristics, and the U.S. and European half- and full-duplex communications and modem controls, plus local echo. Character and line insert editing features are standard which include normal or reverse video, blinking, underline and bold characters up to 132 characters per line with an 83-key detachable key board, smooth scrolling, split screen, and composite video output which facilitates versatile and custom screen use. PREREQUISITE: DMF32, DZ11-A, DZ11-B OR DZ11-E				
8	1	H9642-DB Expansion cabinet without end panels. Provides 31.5 in (80.0 cm) vertical mounting space. Receptacles required NEMA #L5-30R(120V); NEMA #6-15R(240V)	5	15	$1,490.00	$1,266.50
9	1	BA11-KW The BA11-KW is a cabinet mountable expander box with bezel and slides for use in H9642-DB(DC) or H9602-CC(CD) cabinets. Fans located between the power supply and modules produce front to back cooling. It provides five system units of mounting space and is compatible with the DD11-CK/DK expansion backplanes. The power supply	5	15	$3,500.00	$2,975.00

digital
DIGITAL EQUIPMENT CORPORATION
PHONE: AC 617 897-5111 TWX: 710-347-0212-CABLE: DIGITAL MAYN, TELEX: 94-84-57

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REFERENCE:

DISCOUNT AGREEMENT NO.: 0000100609
WHICH EXPIRES: 30-Sep-83

ITEM	QTY	MODEL NUMBER AND DESCRIPTION	TERMS	DIS %	UNIT PRICE	NET AMOUNT
		is rated at 50 amps @ +5V total with 25 amps @+5V for SU 1-2, and 25 amps @ + 5V for SU 3-5 , 4 amps @ + 15V for SU 1-5, and 10 amps for @ -15V for SU 1-5. Includes BC11A cable. NOTE: Backplane not included.				
10	2	DD11-DK Nine slot expansion backplane for use in BA11-K and BA11-L expander boxes. Also mounts in PDP-11/24, PDP-11/34A, and PDP-11/44 CPU boxes. EACH	5	15	$940.00	$1,598.00
		Subtotal				$94,123.00
		NET TOTAL AMOUNT				$94,123.00

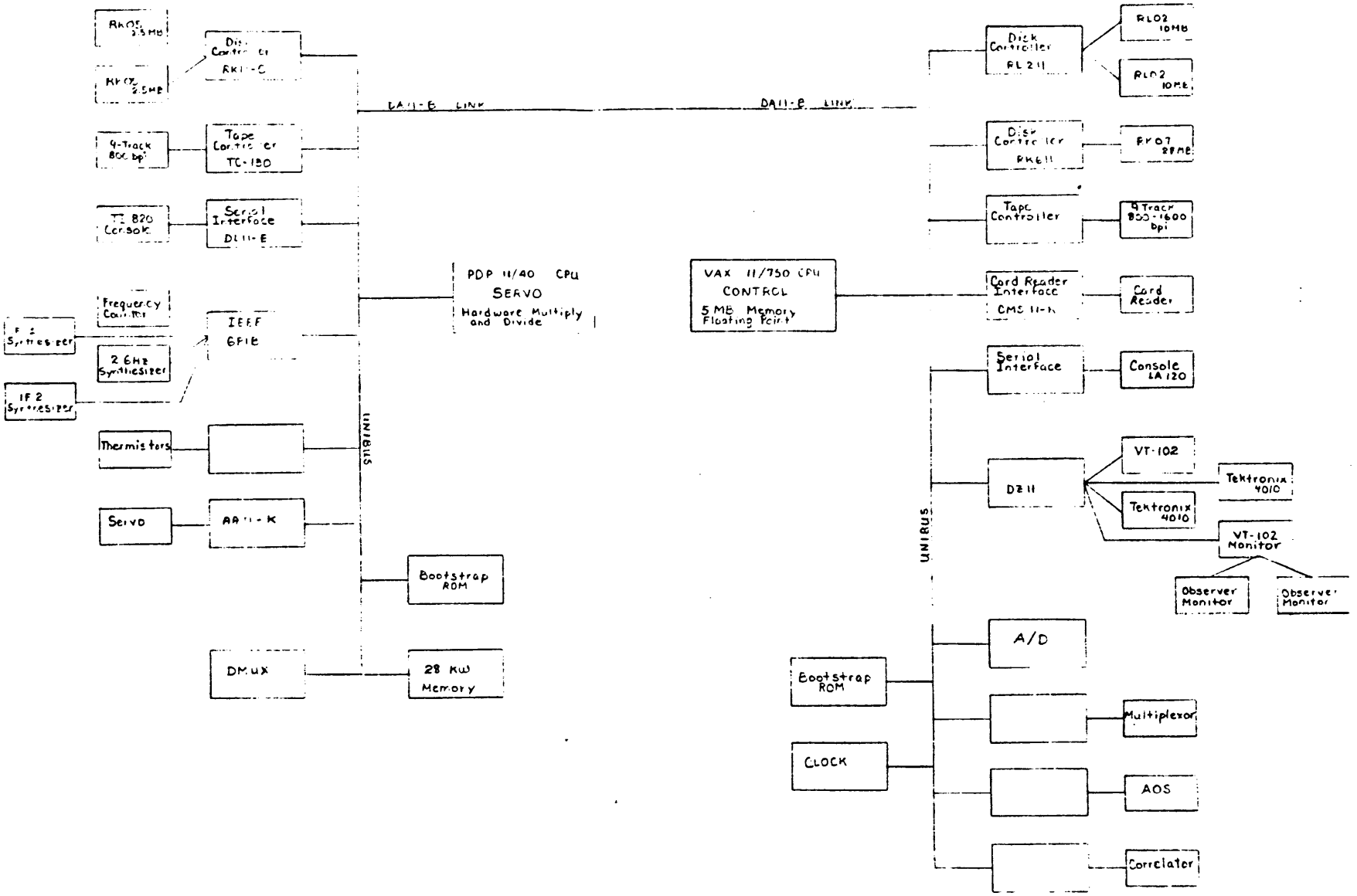
This equipment is being quoted under GSA contract number GS-00C-03404.

This quotation is being issued to provide information on products and prices contained on the GSA contract referenced above. Verification of products and prices or information on pertinent terms and conditions of the above referenced GSA contract may be found in DIGITAL's published GSA Price List. (A copy will be furnished upon request). DIGITAL cannot deviate from prices or terms contained in the above referenced GSA contract. Therefore, in case of a conflict between the information provided above and the prices, terms and conditions of the GSA contract referenced, the terms and prices of the GSA contract will apply.

5* Discount agreement between purchaser and DIGITAL as filled in above

Quotation Prepared by Darlene Morgan
DARLENE MORGAN

EXPORT OF THESE PRODUCTS REQUIRES PRIOR WRITTEN AUTHORIZATION FROM THE U.S. DEPARTMENT OF COMMERCE.


RK05 2.5MB
RK05 2.5MB
Disk Controller RK11-C
9-Track 800 bpi
Tape Controller TC-180
TI 820 Console
Serial Interface DL11-E
Frequency Counter
F 1 Synthesizer
2.6Hz Synthesizer
IF 2 Synthesizer
IEEE GPIB
Thermistors
Servo
AA11-K
DMUX
Bootstrap ROM
28 KW Memory
UNIBUS
DA11-B LINK
PDP 11/40 CPU
SERVO
Hardware Multiply and Divide
DA11-B LINK
VAX 11/750 CPU
CONTROL
5 MB Memory
Floating Point
Disk Controller RL211
RL02 10MB
RL02 10MB
Disk Controller RK611
RK07 28MB
Tape Controller
9 Track 800-1600 bpi
Card Reader Interface CMS11-K
Card Reader
Serial Interface
Console LA120
DZ11
VT-102
Tektronix 4010
Tektronix 4010
VT-102 Monitor
Observer Monitor
Observer Monitor
UNIBUS
A/D
Bootstrap ROM
CLOCK
Multiplexor
AOS
Correlator