VERY LARGE ARRAY PROGRAM

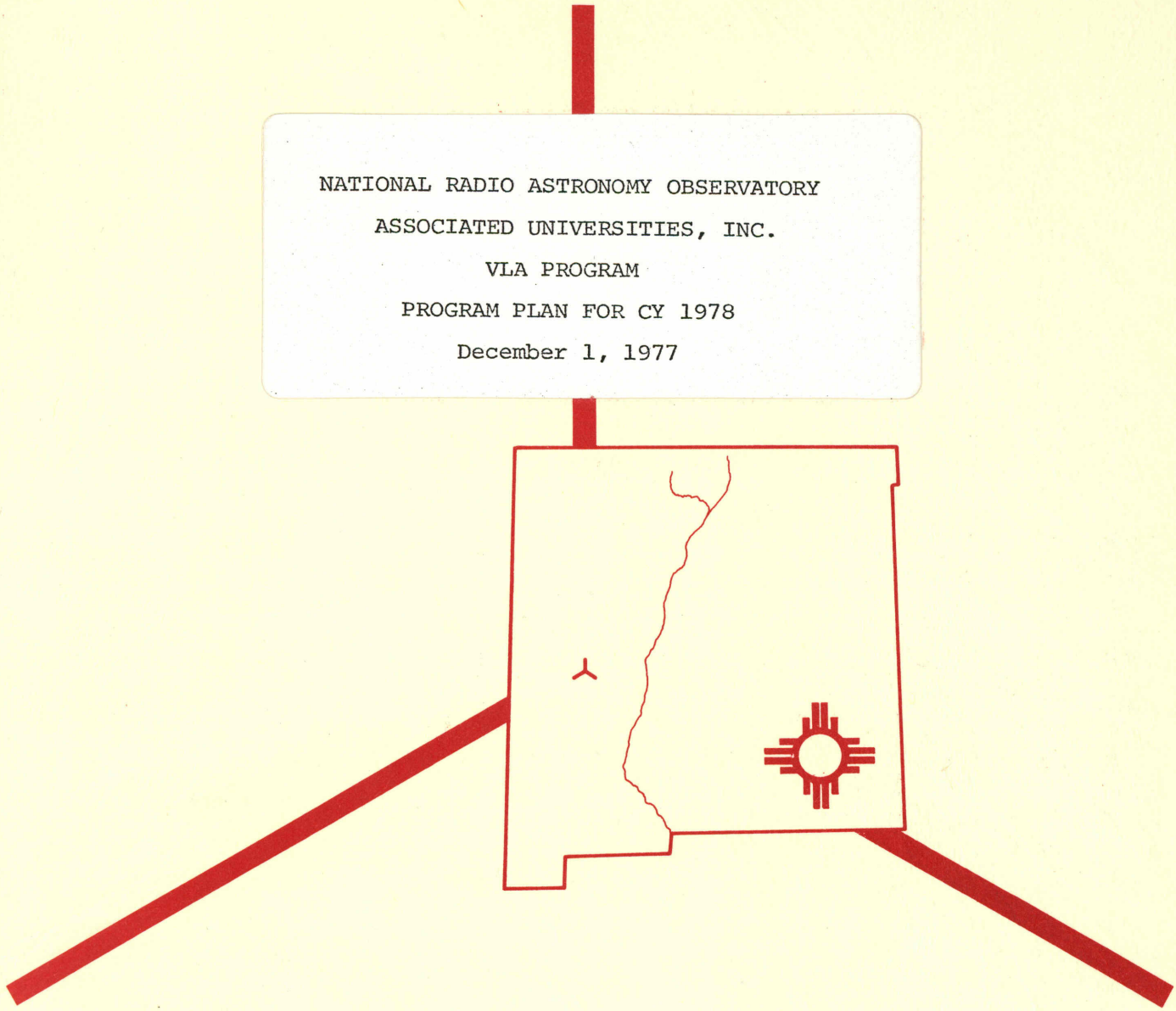
NATIONAL RADIO ASTRONOMY OBSERVATORY

ASSOCIATED UNIVERSITIES, INC.

VLA PROGRAM

PROGRAM PLAN FOR CY 1978

December 1, 1977



NATIONAL RADIO ASTRONOMY OBSERVATORY
P.O. Box 0, Socorro, New Mexico 87801

OPERATED BY ASSOCIATED UNIVERSITIES, INC.

UNDER CONTRACT WITH THE NATIONAL SCIENCE FOUNDATION

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INDEX

INTRODUCTION

This update of the Program Plan for the design and construction of the Very Large Array Program reports the progress which has been made during the last year, discusses changes which have been made in the previous plan, and forecasts activities to be undertaken in future years. In addition, revised cost estimates and commitment and expenditure schedules are included and discussed. Some sections, such as a description of the instrument and organizational details, are included to make the Program Plan understandable to one who is not intimately acquainted with the previous Plan.

The CY 1977 Program Plan was based on a funding level of $12,500,000 in CY 1977 and $13,000,000 per year level for CY 1978 and CY 1979. The total estimated cost for the VLA with this funding level was projected to be $78,152,000.

On September 26, 1977, the Foundation formally advised the National Radio Astronomy Observatory to plan on a $12,500,000 level of funding in CY 1978 instead of $13,000,000. This Plan is based on this level in CY 1978 and a level of $13,000,000 in CY 1979. It should be noted that reducing the planned funding level of the Program in CY 1978 and replacing this sum in CY 1980 should result in an increased cost for the Program of $62,000, based on a 6% rate of inflation. As the cut principally affects conventional construction and the second transporter fabrication, its actual effect on the Program cost, at an estimated 8% escalation rate, would be $83,000. It is hoped that the CY 1979 level of funding will remain at $13,000,000 so that the Program can be completed as scheduled during the last months of 1980. To reduce this level substantially will require a major construction contract in 1980 and cause the Program completion to run over into 1981, with both increased direct and overhead costs.

Based on the funding level set forth above, the August 1977 cost estimate is $78,043,000, a reduction of $109,000 below the August 1976 cost estimate. The contingency sum included is $1,733,000, which represents 5% of the uncommitted balance of funds on June 30, 1977. This is a very moderate contingency for a state-of-the-art instrument such as the Very Large Array.

It is the intention of the National Radio Astronomy Observatory that activities during CY 1978 will follow the detailed Program Plan set forth. Should unforeseen conditions arise which require a major shift of emphasis or change the material or data presented in any substantial manner, the 1978 Plan will be revised.

SUMMARY

CY 1977 saw the start-up of meaningful scientific operations although construction and test operations dominated the activities of the VLA staff. In October, nine antennas had obtained fringes, with the tenth scheduled for "first fringes" in November. Of the nine antennas, seven were declared to be fully operational, with the remaining two still undergoing test operations. Maximum available baseline was extended to 10.5 kilometers. Fabrication of antennas and electronics continued on schedule as did the development of the necessary computer software. Unfortunately, construction of the Phase IV trackage work was indefinitely postponed by an adverse Davis-Bacon wage determination by the Department of Labor. This determination was appealed to the Department's Board of Wage Appeals and a hearing set for December. During the year, the first four-room unit of the Visiting Scientist Quarters was completed as was the emergency power system and the new 25-mile dedicated electric power line to the Site.

CY 1978 will see the continued activation of fully equipped antennas so that, at the end of 1978, the VLA should consist of at least fifteen fully operational antennas working on a baseline of approximately 25 kilometers. Fabrication of antennas and electronics will continue and a number of key retrofit modules will be installed in the operating antennas. Design and construction of the spectral processor will continue as will the development of the final asynchronous computer system. During the year we plan to place approximately 18,000 meters of waveguide and construct the second Visiting Scientist Quarters building, a small office building, and a three-bay garage structure.

DESCRIPTION OF THE INSTRUMENT

Higher resolution and sensitivity have always been major goals of radio astronomy instrumental development. The general concept of a very large antenna system that could obtain radio pictures with very high resolution, sensitivity, and speed was developed in the early sixties. The initial studies at the NRAO in 1961 and 1962 led to the detailed design beginning in 1964. The design study was carried out by the NRAO staff, with the assistance of a number of radio astronomers from other institutions, and it resulted in the Proposal for the Very Large Array (VLA), published in 1967 (Vols. I and II), 1969 (Vol. III), and 1971 (Vol. IV).

In order to achieve the required angular resolutions, a radio telescope with dimensions of 35 km (23 miles) is needed. Since a conventional radio telescope having these dimensions is impossible to construct, other techniques which will simulate such a telescope must be used. By interconnecting several separated, smaller diameter antennas, the information leading to the desired resolution can be obtained. Many configurations of the antenna elements are possible, and careful studies of this problem, with the purpose of optimizing the use of a relatively small number of antennas, have resulted in the VLA system, consisting of 27 antennas, each 25 meters (82 feet) in diameter, distributed along three 21 km (13 mile) arms of an equiangular wye. All the antennas will be movable over railroad tracks so that the picture area (field of view) and the resolution may be varied within wide limits. In this respect, the VLA is the equivalent of a zoom lens.

Each antenna element consists of a steel structure carrying a shaped reflector which is movable in azimuth and elevation in order to be able to point to any part of the sky. The reflector structure supports an aluminum reflector surface consisting of 172 aluminum panels. The surface accuracy and the precision of the drive system permit operation at wavelengths as short as 1.2 cm. During operation, the antennas are placed on observing stations. Seventy-two such stations will permit the four basic different configurations planned for the array. The antennas will be moved

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between observing stations by a transport vehicle; one such transporter will be available in the early years of the Program, running on a double, standard gauge railroad track system. In later years, should funding permit, it is probable that at least one additional transporter will be procured. A reconfiguration of the antenna system, using three transporters, is estimated to take twenty-four hours. When the railroad tracks are not used for moving antennas, they will be used for transportation of maintenance personnel and equipment.

The initial operating wavelengths for the system will be 21 cm, 6 cm, 2 cm, and 1.2 cm, with full polarization measurement capabilities. Spectral-line capabilities for the array are also being developed.

The central computer system will control the telescopes, monitor the system performance, and collect and analyze the data. The system output will consist of high resolution maps of the observed objects.

Power and telephone communications between the central site complex and the observing stations will be distributed through buried cables. Signal and local oscillator distribution, as well as control and monitor signals of all antenna functions, will be accomplished by a buried circular waveguide system.

The central building complex consists of several buildings. A 22,060 square foot Control Building houses the control room, central electronic equipment, digital delay equipment, large central computers, specialized shops, laboratories, and office space. Three small, prefabricated metal buildings, which total 18,000 square feet, house maintenance shops, the electronic and cryogenic shops, storage facilities, and office space. The subcontractor, who is fabricating and assembling the antennas, has constructed a 14,600 square foot Assembly Building, which he will use during his contract and which will be available for later use for antenna maintenance. In addition, a 5,320 square foot Cafeteria Building has been constructed, and a grouping of Visiting Scientist Quarters will be constructed, as well as necessary site work, water supply, sewage, electric utility, and similar facilities.

ORGANIZATION

Program Organization

The NRAO organization is shown on the accompanying Organization Chart (Figure 2). The VLA has been designed and is being procured as a program of the NRAO, with the Observatory being its own "prime contractor" for the job. Overall responsibility for the design and procurement of the VLA rests with the Director of the NRAO, who, in turn, is responsible to the President of the Board of Trustees of AUI. AUI, in addition to its internal trustee committees, has the NRAO Visiting Committee to assist it in reviewing and evaluating the performance of the NRAO. The Director has the NRAO Users Committee, the VLA Advisory Committee, and the VLA Steering Committee to assist and advise him on VLA matters. A description and the membership of each of these committees is given in Appendix A.

Within the NRAO, primary responsibility for the VLA design has been assigned to H. Hvatum, Associate Director. Responsibility for implementation has been assigned to J. H. Lancaster, Assistant Director and VLA Program Manager.

Program Implementation and Staffing

Implementation of the VLA, including the contracting and managing of all fabrication and construction, is the responsibility of the Program Manager. This work is being carried out according to previously agreed upon drawings, specifications, budgets, and time schedules.

On January 1, 1973, the Program was officially begun with the transfer of fifteen existing NRAO staff members to the VLA. This staff has gradually increased since then to the present level of 118 full-time members. Beginning in January 1977, at the start-up of scientific operations, the staff was divided for cost-keeping reasons into Construction, Operation, and Common Cost centers. This breakdown is shown on page 7.

	1976 Program Plan Forecast 12/31/77	Present Level 10/31/77	Present Forecast 12/31/77	Planned Level 12/31/78
CONSTRUCTION GROUP				
Antennas	11	12	12	9
Electronics	42	44	45	38
Computer	14	10	10	5
Systems Integration	4	4	4	1
Site and Wye	3	2	2	2
Program Management	3	3	3	3
Totals	77	75	76	58
OPERATING GROUP				
Antenna Maintenance	2	2	2	6
Electronics Maintenance	5	5	5	11
Scientific Services	4	5	5	10
Array Operations	4	3	3	7
Totals	15	15	15	34
COMMON COST GROUP				
Business	19	18	18	19
Fiscal	4	4	4	4
Plant Maintenance	7	6	6	7
Totals	30	28	28	30
TOTAL FULL-TIME PERSONNAL	122	118*	119	122

*Includes 5 positions where replacements are now being hired.

Although for costing purposes the staff is split into Construction, Operating, and Common Cost centers, it cannot be split so in actual practice except at the penalty of very inefficient operations. Each of the groups responsible for a specific technical portion of the construction and operation of the Array works together and reports to a single Group Leader. In this manner the maximum manpower may be utilized where priorities indicate. Later in the life of the Program, more definite operating groups will be formed and by 1981 the Construction Cost center will be completed and disappear from the organizational structure. The distribution of the staff by technical groups is shown on the accompanying Organization Chart, which shows the planned PEAK STAFFING - 1978.

The Common Cost center includes general business, fiscal, and plant maintenance functions, including administration, personnel, purchasing, transportation, property, receiving, warehousing, cafeteria and housing operations, fiscal operations, communications, and plant operation and maintenance. These support function costs that cannot be properly placed in either construction or operations are fairly apportioned between these two activities on a ratio of direct payroll costs.

National Radio Astronomy Observatory
Organization Chart
November 1, 1977

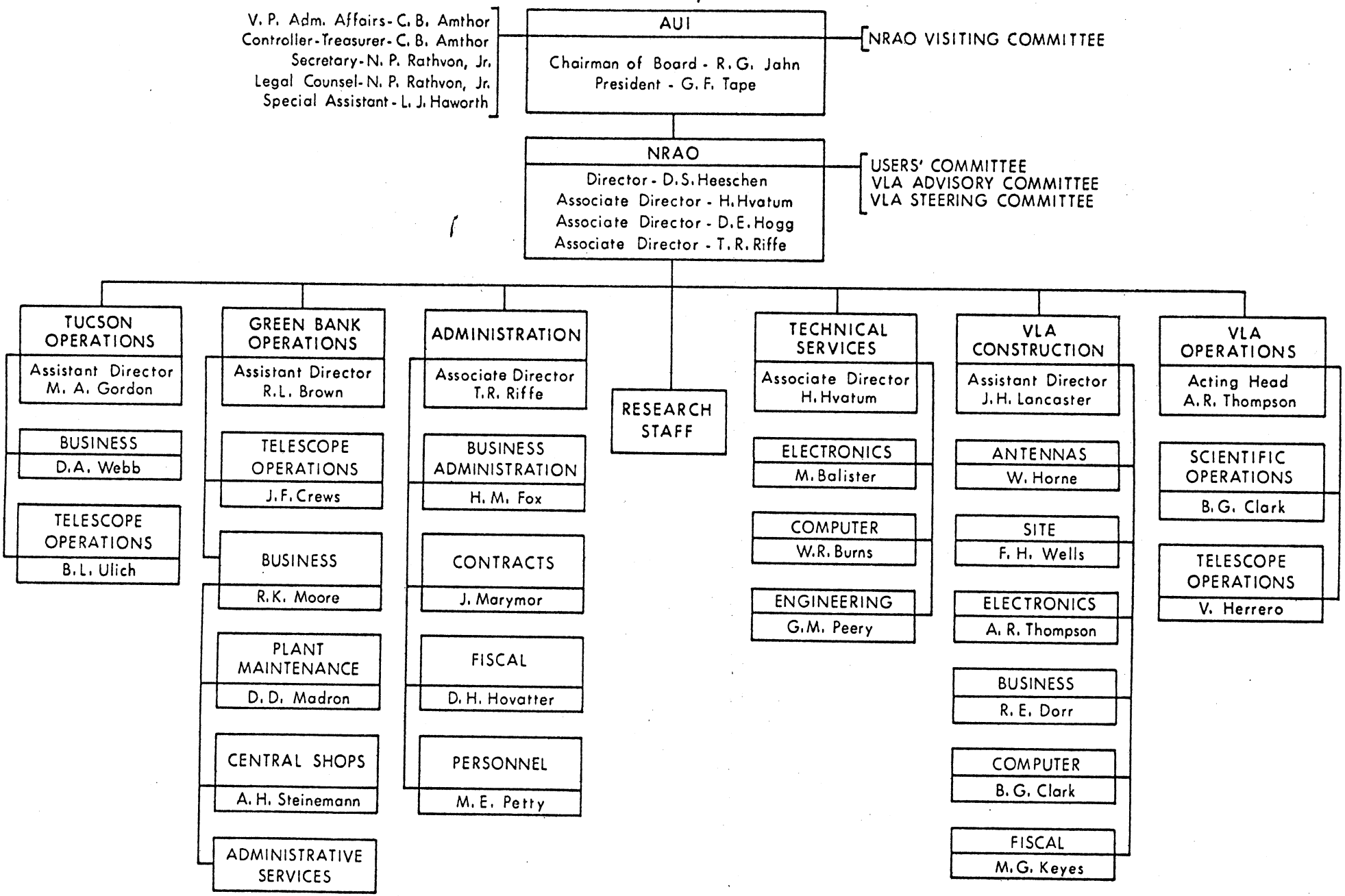
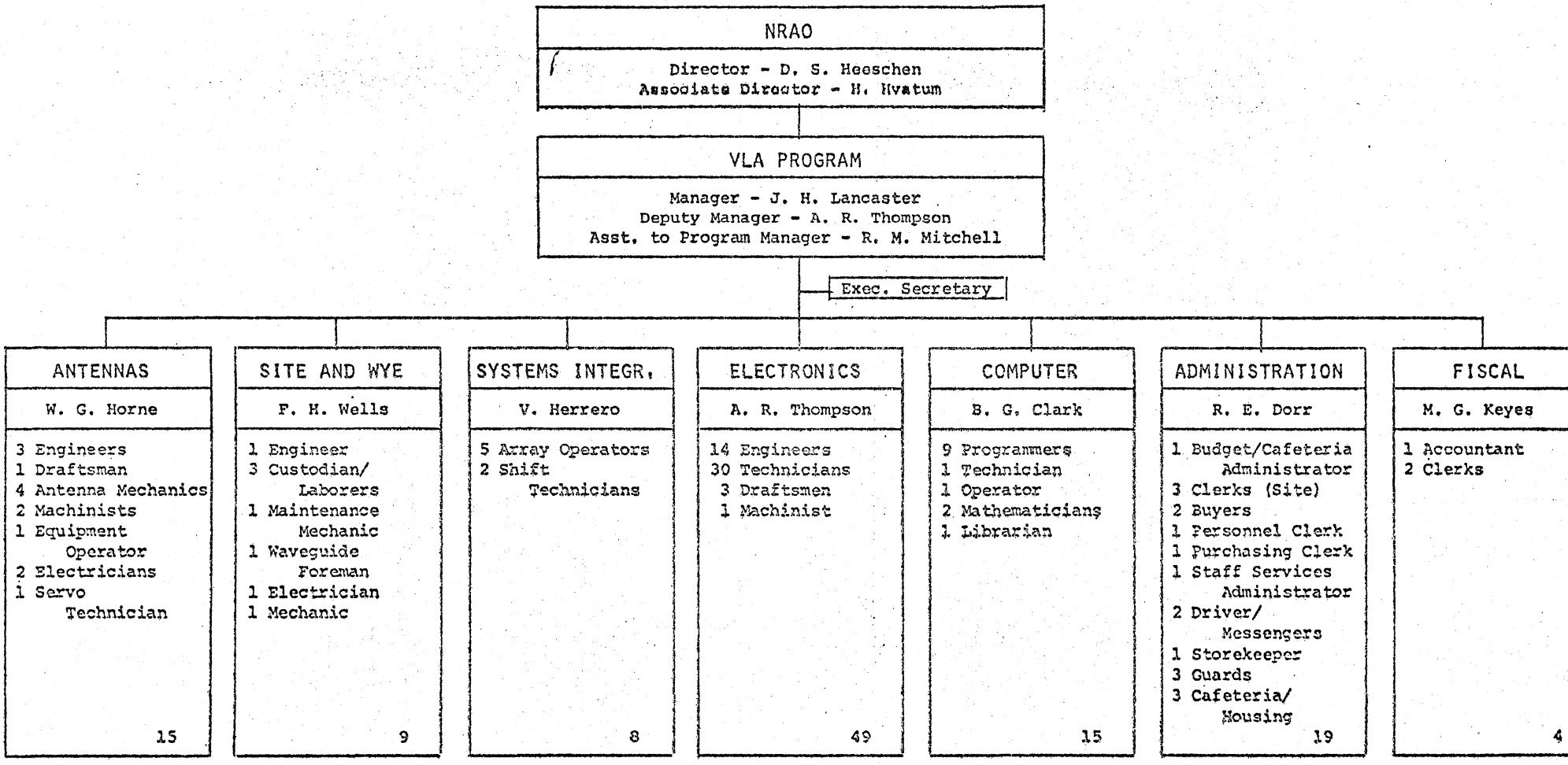


Figure 2

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM ORGANIZATION
PEAK STAFFING - 1978



TOTAL SHOWN 122

12/01/77

Figure 3

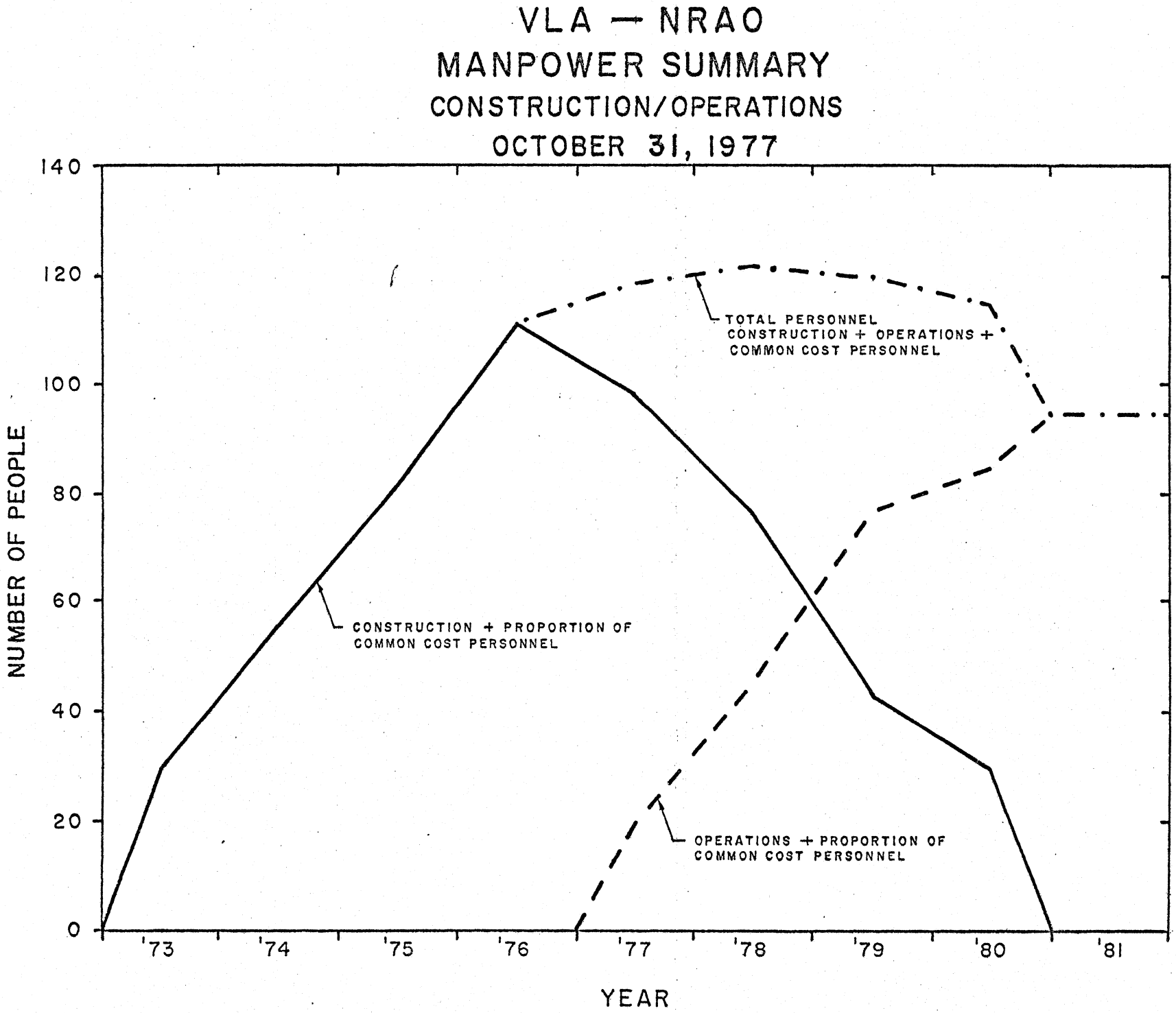

VLA — NRAO
MANPOWER SUMMARY
CONSTRUCTION/OPERATIONS
OCTOBER 31, 1977
NUMBER OF PEOPLE
140
120
100
80
60
40
20
0
'73
'74
'75
'76
'77
'78
'79
'80
'81
YEAR
TOTAL PERSONNEL
CONSTRUCTION + OPERATIONS +
COMMON COST PERSONNEL
CONSTRUCTION + PROPORTION OF
COMMON COST PERSONNEL
OPERATIONS + PROPORTION OF
COMMON COST PERSONNEL

Figure 4

PROGRAM ACCOMPLISHMENTS - 1977

General

The fifth year of the Program has been highlighted by reaching the halfway point in delivery of antennas from E-Systems; Antenna No. 14 was accepted on October 21, 1977. In addition to this, the Electronics Division has completed the design phase for modifications, primarily in the local oscillator system, and the detailed design of the spectral processor has progressed on schedule. Observations with the array also have progressed from a five element array on a 5.2 km baseline to a nine antenna array on a 10.47 km baseline. During this year a four-unit Visiting Scientist Quarters has been completed, and two 500 KW generators installed for standby power, but Phase IV wye construction was postponed pending the outcome of an appeal of a Davis-Bacon decision by the Department of Labor affecting this construction.

Contractual

Work continued under Prime Contract NSF AST 74-13427 (formerly NSF C-780). The record of funds received to date is as follows:

Available 11/02/76			$43,701,300
Amendment No. 24 (CY '77)	01/31/77	$5,450,000	$49,151,300
Amendment No. 26 (CY '77)	09/09/77	$ 23,000	$49,174,300
Amendment No. 28 (CY '77)	09/30/77	$ 1,889	$49,176,189

The total appropriated to date is $49,500,000 and the difference, $323,811, between this amount and $49,176,189 received represents $15,700 withheld by the Foundation for the ECAC study of radio interference, $293,000 withheld for land acquisition, and $15,111 withheld for the Ad Hoc Advisory Committee expenses.

New Mexico Gross Receipts and Compensating Tax

The Bureau of Revenue of the State of New Mexico in February 1977 completed an audit, begun in March 1976, of the E-Systems work on antenna fabrication and assembly. As a result of the audit, E-Systems was assessed the amount of $127,122.59 to cover the Gross Receipts Tax through 12/31/75. In accordance with the advice of the attorneys of Associated Universities, Inc. and the Foundation, E-Systems was authorized to pay this amount under protest, which they did on May 10, 1977. Upon this payment, an application for a tax refund was filed with the Bureau of Revenue. This claim was denied by the Bureau on September 1, 1977. On September 30, 1977, the United States Department of Justice filed suit against the State of New Mexico and assumed the responsibility for recovery of the amounts paid to the Bureau.

Land Acquisition

Mr. and Mrs. Jack Bruton accepted the compensation offered in the condemnation action for tracts of land along the arms of the wye and one-half of the central site. The compensation offered by the Corps of Engineers has not been accepted for the Ake, Taylor, and Dunlap tracts. This matter is now before the U. S. District Court in Albuquerque.

Archaeological Study

In April, 1977, a subcontract was issued to New Mexico State University in the amount of $96,800 to conduct the excavation, recovery, cataloging, and storage work of the archaeological site on the southwest arm of the wye. Subsequent to letting this subcontract, Mr. Ake, who owns the land around the site, refused his permission for this exploration. Hence, the work on the subcontract was held in abeyance and the question of right of access was referred to the Corps of Engineers for resolution. On September 20, 1977, an amendment had to be made to the subcontract, increasing its cost to $107,000 because of the delay in commencing the work. On October 17, 1977, the Corps of Engineers requested that the United States Attorney take action to allow the archaeological exploration to proceed. As of November first the U. S. Department of Justice in Washington is studying the matter in order to determine how to proceed.

Appeal of Davis-Bacon Decision

On October 4, 1976, Phase IV construction was issued for bid, using Light Engineering rates, as was done for Phase I and Phase III construction work. During the bid period the Department of Labor sent a letter to the Foundation, stating that Heavy Engineering rates should be used. This change of rates would result in an estimated cost increase for the VLA of $2,500,000. The Department of Labor was asked to reconsider this decision and considerable research was done by the VLA staff to determine the aptness of the Department of Labor wage survey as well as to determine the prevalent practice for this type of work in New Mexico. After considerable discussion and negotiations the Department of Labor refused to revise its determination and an appeal was filed with the Wage Appeals Board. In April, the legal firm of Steptoe & Johnson was retained by AUI to handle this matter. Meanwhile, Phase IV construction is being held in abeyance. A hearing on the appeal was scheduled for the week of October 10, 1977; however, this has been postponed several times and is now scheduled for December 8, 1977.

Ad Hoc Advisory Committee

In accordance with the recommendations of the House Committee of Science and Technology, the Foundation established an eight member committee to "examine VLA management and technical plans and activities and report findings and recommendations. Additionally, the panel should direct its attention to long-range plans (through the 1980's) for expanding the capabilities of the facility". This committee held its first meeting on May 19, 1977, visited the VLA Site on June 1st and 2nd, and continued its meetings in Washington. It is expected that a draft report will be completed for circulation in November 1977.

Systems Integration

During the year a total of 49 observing runs were completed. The time breakdown for this period shows that approximately 37% of the total time during the year was used for observing. Of the total scheduled observing time, 30% was used for testing and calibration of the array and 70% was devoted to science. During November 1976 we had four fully

operational antennas, with 832 antenna hours scheduled for observing. By contrast, during October 1977 we had seven fully operational antennas with 2,177 antenna hours scheduled, and two provisionally operational antennas that provided additional data. The period also saw the extension of the maximum baseline from 1.9 kilometers to 10.5 kilometers. The total number of division personnel was increased from four to seven to give us a full complement of array operators, plus one technician to function as a first-line troubleshooter.

During nonobserving work periods, division personnel continued efforts to update and improve system operations documentation, with considerable progress being made. In addition, they assisted in preparation of material designed to aid visiting scientists in both observing and data reduction. Work also was started on a system master troubleshooting guide.

Dated Highlights for the Period

November 1976	Four operational antennas with a maximum baseline of 1.9 kilometers, five observing runs for a total of 832 antenna hours* scheduled.
December 1976	Four observing runs for a total of 1,192 antenna hours scheduled.
December 13, 1976	Fifth antenna declared operational.
December 16, 1976	Maximum baseline extended to 5.2 km.
January 1977	Six observing runs for a total of 1,648 antenna hours scheduled.
January 3, 1977	Sixth antenna declared operational.
January 27, 1977	Begin retrofitting one operational antenna (#5) with modified electronics.
February 1977	Three observing runs with a total of 940 antenna hours scheduled.
March 1977	Five observing runs with a total of 1,292 antenna hours scheduled.
April 1977	Five observing runs with a total of 1,784 antenna hours scheduled. Beginning this month, antennas #3 and #5 were assigned special status as a second subarray devoted to instrumental tests for an indefinite period.
May 1977	Antenna #7 brought on line but not declared fully operational. Four observing runs with a total of 1,800 antenna hours scheduled.

June	1977	Antenna #8 brought on line for testing but not declared fully operational. Four observing runs with a total of 1,536 antenna hours scheduled.
July	1977	Three observing runs with a total of 1,650 antenna hours scheduled.
August	1977	Five observing runs with a total of 2,152 antenna hours scheduled.
August	25, 1977	Maximum baseline extended to 7.6 kilometers.
August	25, 1977	Antenna #8 declared fully operational.
September	1977	Two observing runs with a total of 1,449 antenna hours scheduled. Begin systematic coding and entry of maintenance reports into a computer database. The database will allow faster and more accurate statistical analysis of maintenance and hardware problems.
October	1977	Three observing runs for a total of 2,177 antenna hours scheduled. One highlight for the entire division was the successful completion of an observing run planned for the solar eclipse of October 12, 1977.
October	31, 1977	Maximum baseline increased to 10.5 kilometers.

*Antenna hours scheduled are defined as the length of an observing run in hours multiplied by the number of fully operational antennas available for that run.

Antenna Systems

During the period of November 1976 to November 1977, the antenna subcontractor, E-Systems, Inc., completed the delivery of the remaining antennas of Amendment No. 9 of the contract, covering Antennas 3 through 10, and started delivery of Antennas 11 through 28 covered by Amendments No. 18 and No. 19.

Mechanical and electrical outfitting, including installation of cable trays and cabling, addition of cryogenic compressor platform, installation of subreflector and subreflector support, and installation of antenna feeds, were performed by the AUI mechanical forces on Antennas 7, 8, 9, 10, and 11 during this period.

A problem with the position transducers on the antennas became apparent during this period and was corrected. The transducers began to exhibit much higher turning torque than was specified due to friction in

their bearings which caused a coupling wind-up error (nonrepeatable). This behavior was caused by dust and moisture infiltrating the transducer seals and accumulating in the bearings and was corrected by providing forced, heated air to the interior of the transducers, which places the transducer interior under positive pressure.

A modified air conditioning system was retrofitted on Antennas 1 through 10 and is being installed as original equipment on Antennas 11 through 28. The advantages of the new system are separation of the compressor from the rotating part of the antenna, increased cooling coil capacity, and increased air flow through the system, elimination of the rotary joint in the supply and return air ducts, and shortening of the duct system.

A modified access walkway and platform for the antennas was designed and is being installed by NRAO mechanical forces. This walkway permits access to the upper portion of the antenna by service personnel without climbing a vertical ladder. The modified walkway has been installed on Antennas 7, 8, 10, and 11. It will be retrofitted to all operational antennas and is being installed on new antennas as they are outfitted on the maintenance station.

Following as Figure 5 is the status of the antenna schedule for Antennas 3 through 28, and Figure 6 sets out the design and achieved tolerances for Antennas 8 through 14.

Transporter

The transport vehicle was utilized extensively during the period for movement of the antennas at the Assembly Building during assembly, movement of antennas to outfitting and to test stations, and for movement to regular observing stations. To date the transporter has made 74 antenna moves without difficulty. In the early part of the year, excessive lateral movement of the wheel and axles in the bearing blocks was discovered and in February NRAO mechanical forces dismantled the wheels, axles, and bearings from Trucks 1 and 4 of the transporter, discovered that a thrust collar was wearing, and modified the bearing block to take this thrust force properly. E-Systems came on site in early June and modified Trucks 2 and 3.

NATIONAL RADIO ASTRONOMY OBSERVATORY

VLA PROGRAM

STATUS - PROCUREMENT OF ANTENNAS 3 THROUGH 28

E-SYSTEMS DELIVERY DATES

ANTENNA NUMBER	SCHEDULED	ACCEPTANCE	ANTENNA NUMBER	SCHEDULED	ACCEPTANCE
3	04/15/76	04/20/76	16	02/15/78	
4	05/24/76	06/07/76	17	04/07/78	
5	07/15/76	07/16/76	18	05/31/78	
6	08/30/76	09/03/76	19	07/21/78	
7	10/15/76	10/29/76	20	09/13/78	
8	11/30/76	12/17/76	21	11/03/78	
9	01/17/77	02/25/77	22	01/12/79	
10	03/01/77	04/26/77	23	03/09/79	
11	04/29/77	06/09/77	24	05/03/79	
12	06/22/77	07/15/77	25	06/22/79	
13	08/12/77	09/02/77	26	08/15/79	
14	10/12/77	10/21/77	27	10/05/79	
15	12/09/77		28	11/30/79	

Figure 5

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

ANTENNA MECHANICAL PARAMETERS

ITEM	UNIT	SPEC.	ANTENNA NO. 8	NO. 9	NO. 10	NO. 11	NO. 12	NO. 13	NO. 14
PANEL MANUFACTURE	IN RMS	0.015	0.013	0.0139	0.0137	0.0129	0.0132	0.0134	0.0135
PANEL SETTING AT 50° EL.	IN RMS	0.018	0.010	0.012	0.010	0.010	0.0092	0.010	0.014
AZ CENTER TO FDN CTR	IN	0.500	0.400	0.375	0.370	0.400	0.437	0.400	0.425
AZIMUTH LEAN	ARCSEC	18	9	14	12	17	7	7.5	7
ELEVATION ORTHOGONALITY	ARCSEC	18	10	5	2.5	7	6	3	10
ELEVATION OFFSET	IN	0.100	0.060	0.050	0.00	0.080	0.020	0.060	0.010
COLLIM. ORTHOGONALITY	ARCSEC	18	9	9	8	7	5	6	15
COLLIMATION OFFSET	IN	0.250	0.040	0.010	0.040	0.060	0.040	0.062	0.010
ALIGNMENT FOCAL MOUNT TO COLLIM. AXIS	ARCSEC	18	15	10	10	10	2	15	10
SERVO ERROR	ARCSEC RMS	3.24	----	----	----	----	----	----	----
RESONANT FREQUENCY (ROCKING)	Hz	2.07	2.35	2.4	2.48	2.3	2.2	2.3	2.4
RESONANT FREQUENCY (TORSIONAL)	Hz	2.15	2.45	2.5	2.3	2.35	2.4	2.45	2.6
SLEW RATE (ELEVATION)	O/MIN	20	20	20	20	20	20	20	20
SLEW RATE (AZIMUTH)	O/MIN	40	40	40	40	40	40	40	40

Figure 6

A design review contract was let to E-Systems to revise the design of the transporter to incorporate changes considered desirable based on operating experience with the transporter. Among these features are:

(1) increased jack speed and load;
(2) increased stroke at suspension cylinders;
(3) change truck rotary actuators to hydraulic cylinder actuation;
(4) provision of derrick with longer reach and higher capacity;
(5) redesign truck rotary collar and hydraulic routing;
(6) provide truck centering action at spur intersections.

This design review has been completed and incorporated on the design drawings. The hydraulic routing and truck centering modifications have been accomplished on the existing transporter by NRAO forces. In the coming year, NRAO forces will accomplish the rotary collar modification and increase the jack speed. It is planned to increase the suspension stroke of the existing transporter after Transporter 2 becomes operational. It is not planned to change the truck rotary actuator or to provide the larger derrick on the existing transporter.

Electronic Systems

During 1977 the electronic outfitting of antennas has largely followed the planned schedule. Antenna #5 was first operated in December 1976 and #6 during the first week of January 1977. These were followed at varying intervals by antennas through #10 for which the first fringes were obtained during November. In most areas the electronics construction covered seven systems, beginning with Antenna #11. Testing of the electronics, and making modifications where necessary, has continued.

The modifications to the original electronics design fall within four categories: (1) changes required to bring performance within specifications, (2) changes to improve reliability and maintainability, (3) incorporation of bandwidth selection filters at the antennas, (4) redesign of the first IF amplifier modules to incorporate the filters required for the spectral processor. In the first category, the modifications are all related to the local oscillator system and involve either improvement of phase stability or elimination of leakage into the front-ends. In the

second category they are related to such things as elimination of components that have proved unreliable, improving the locking reliability of phase lock loops, and extending the monitoring to a few functions which have proved to require it. Installation of bandwidth selection filters at the antennas will improve the selectivity of the instrument against interference and eliminate some known spurious responses. Interference by other spectrum users is happily not a serious problem at the present time. Except for the spectral line IF modules, almost all of the redesign was completed in time to allow inclusion in the build for systems 11 and onwards.

In the cryogenics area, we have continued to make modifications to the Air Products systems to improve their reliability. These have included repacking the agglomerator units of the oil separation system with a finer grade of glass wool and modifying an oil flow control tube which was unsatisfactory during cold weather. The major remaining problem is the failure of compressor valve plates, and Air Products have stated that they will try to find a solution.

The Cryomech refrigeration system, which was earlier judged to be inadequate for the VLA, has been improved by the manufacturer and a unit was tested satisfactorily in the laboratory early in the year. This led to the purchase of Cryomech units for Antennas 7, 10, and 11. Reliability of the unit on Antenna #7 has not, however, been altogether satisfactory and CTI units have been ordered for the next procurement. This last choice was made after a detailed consideration of our experience with Air Products and Cryomech systems and the experience at Green Bank, Tucson, and JPL with CTI systems.

The change from Comtech to AIL parametric amplifiers was made starting with Antenna #7, and these amplifiers have had fewer failures than the Comtech ones. AIL is, however, having some difficulties in producing units on time for continuing orders. This appears to be associated to the small physical size of the amplifiers and absence of tuning adjustments in AIL's design. They are continuing to work on this problem.

The problem of the increase of attenuation in the 60mm TE_{01} mode waveguide has now been overcome. No change in attenuation has been found for waveguide installed by the new technique adopted in 1976, which depends upon much more careful preparation of the trench bottom and compacting of

the soil during backfill. The first 1·24 km of waveguide that was installed on the west arm prior to the improvement has shown a deterioration of about 0·9 dB per km at 50 GHz from mid-1975 to the end of 1976, and thereafter has remained essentially constant. The measured attenuation as a function of time is shown in the accompanying figures, No. 7 and No. 8.

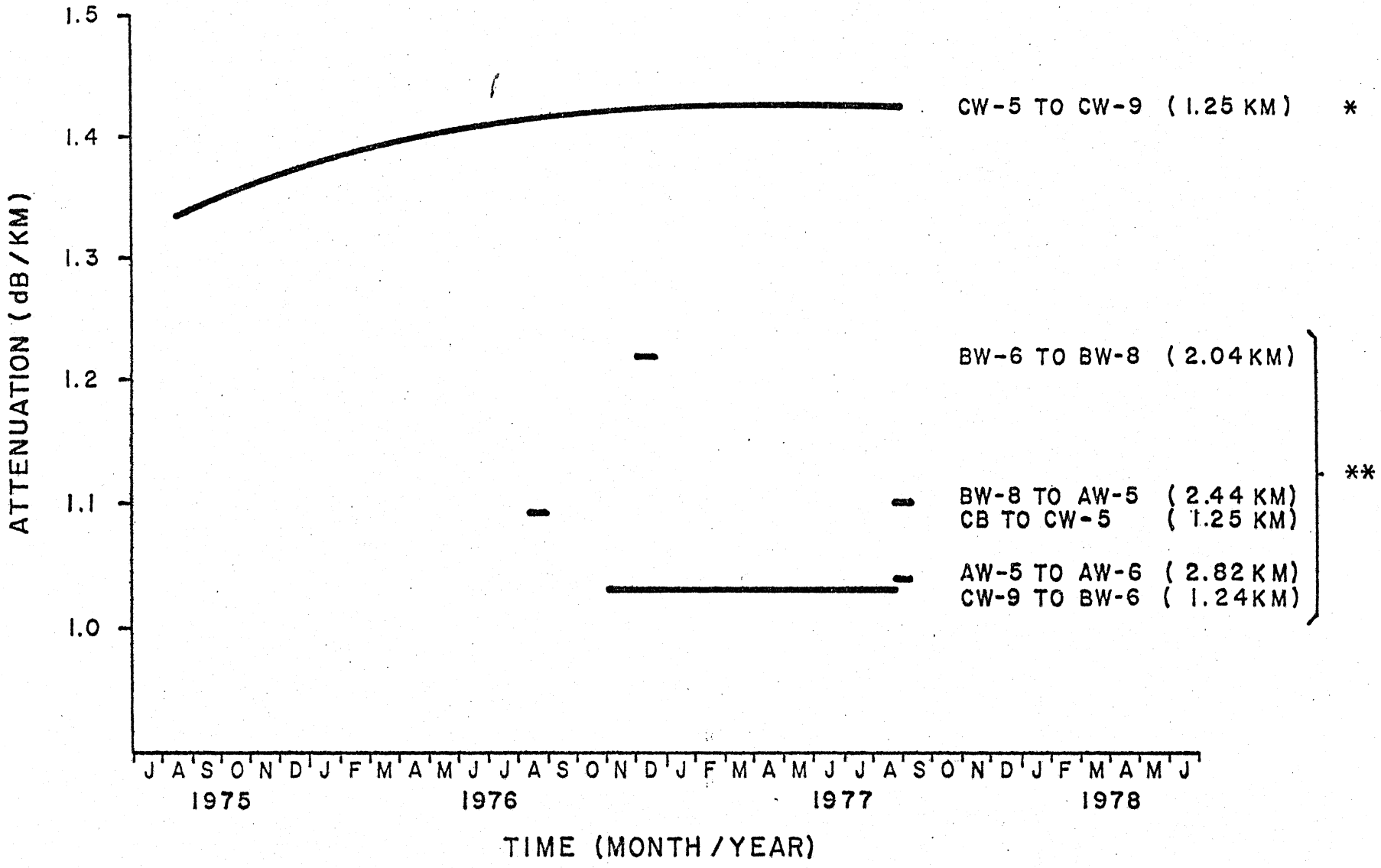
Prototypes of the two custom integrated circuits for the spectral processor were received and tested during 1977 and found to exceed specifications in all respects. All circuit boards for the spectral processor have been designed and it is expected that a system with half of the final capacity will be ready for testing early in 1978.

In other parts of the electronics, such as the modems, IF amplifier, and continuum delay and multiplier system, no particular problems have been found and very few changes have been required.

At the present time, in late 1977, three areas which limit the system performance are being worked on. First, the phase stability of the array is typically a factor of five worse than the design goal, and finding the cause of this behavior is the top priority investigation. Measurements are being made on Antennas 3 and 5, which have been dedicated to instrumental testing and have been fitted with most of the local oscillator modifications. Results thus far seem to indicate that much of the problem is due to the accumulated effects of various minor malfunctions and misadjustments and no specific problem areas have been found. It is hoped to understand the situation much more fully by the end of the year. The second area concerns pickup of unwanted signals from the local oscillator system when observing in the 18-21 cm band. This effect has been reduced to a level tolerable for continuum observations by shielding certain oscillator modules. The third area concerns the reliability of the 17-20 GHz local oscillator module which has limited operation in the 2 and 1·3 cm bands. Only relatively straightforward engineering problems are involved and satisfactory performance should be attained before the end of the year.

60 MM HELIX WAVEGUIDE

ATTENUATION vs TIME @ 50 GHz



* PROTOTYPE INSTALLATION TECHNIQUE
** PRESENT INSTALLATION TECHNIQUE

Figure 7

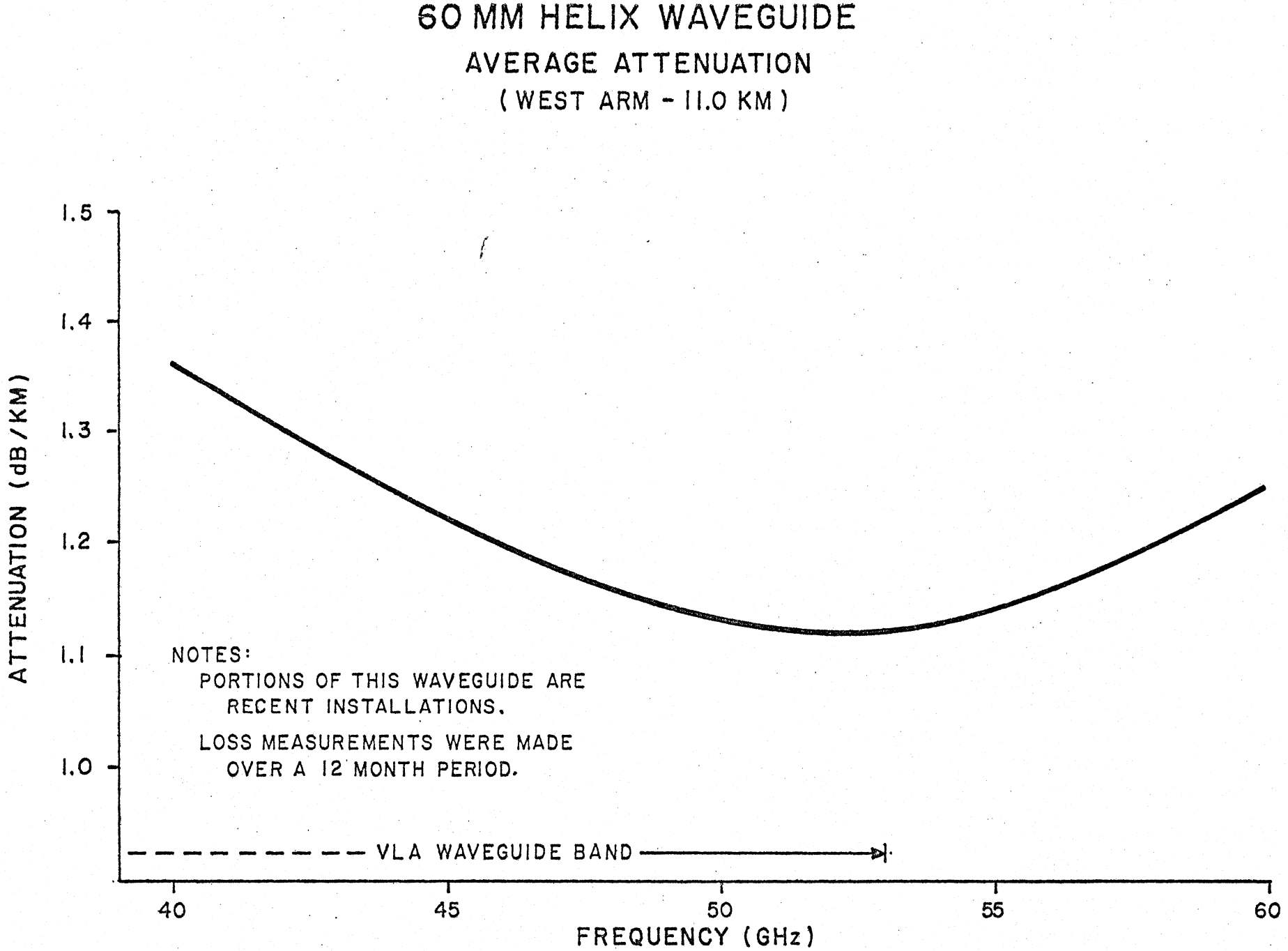

60 MM HELIX WAVEGUIDE
AVERAGE ATTENUATION
(WEST ARM - 11.0 KM)
ATTENUATION (dB/KM)
1.5
1.4
1.3
1.2
1.1
1.0
NOTES:
PORTIONS OF THIS WAVEGUIDE ARE RECENT INSTALLATIONS.
LOSS MEASUREMENTS WERE MADE OVER A 12 MONTH PERIOD.
VLA WAVEGUIDE BAND
40
45
50
55
60
FREQUENCY (GHz)

Figure 8

Computer Systems

Work has continued through 1977 on improvements to the on-line program system in the Modcomp computers. The programs have been operational throughout the year, and have been used with no significant errors. The direction of work has been primarily to remove operational inconveniences and to make the programs less susceptible to error caused by operator error or unanticipated conditions (power failure, etc.).

The exception to this rule is that significant extensions have been made to the real-time electronics and astronomical display and debugging routines. These have reached the point that, on those modules where the testpoints really check the common failure conditions, it is possible and convenient to do the first stages of diagnosis from the Control Room.

The computer which will eventually manage the new correlator system has been procured and delivered, and systems level work directed toward the use of the new correlator has been pursued. This computer is a Modcomp II/45 (compatible with the rest of the on-line Modcomp systems), with an attached Floating Point Systems AP120B array processor, which will perform the FFT to convert from the correlator system's correlation lag function output to the cross spectral correlation. By October, the interfaces to the hardware were beginning to be well enough defined that the detailed programming can be done.

The two computers which most frequently communicate in the existing system have been modified so that they will be able to share part of their memory, saving not only communications bandwidth but solving some of the synchronization problem. At the same time, the memory sizes were increased to allow the computer to service background users, for electronics debugging and observing list preparation.

A backup Modcomp system, with an example of most of the peripherals in the system, has been ordered. This computer can be substituted in any position in the system with the swapping of only a few cables.

1977 has been a year of great activity and accomplishment in the area of DEC-10 programming. There are now effective programs to list and plot interferometer data, to solve for baseline parameters and system gains,

and to make and display radio maps of the sky. Programs for polarization studies are undergoing development - programs exist, but are not necessarily suitable for the actual behavior of the instrument.

In September, 1977, we accepted delivery of a PDP 11/70 system which will support a Floating Point Systems AP120B processor for use in map making and manipulation. Work has started on the DA28 communication link which connects the DEC-10 computer to the PDP 11. The hardware was delivered in early October and work is progressing on the software support, which is being done in-house, as the DEC supported software was judged too expensive for the features that we want to use.

The AP120B has been used in conjunction with the PDP11/40 display system to explore its graphic capabilities and to gain experience with its way of doing things. The graphics system has received only a little attention this year, mostly involving experiments to see what displays might look like, rather than finished programs. Work has started, though, in planning for the final configuration of the display system. In this connection the 11/40 has been expanded by the purchase (not yet delivered) of an additional 32K words of memory and a large disk memory (176M bytes) capable of holding several large maps. Planning is just beginning on a map manipulation software system.

A considerable portion of the effort on the part of the programming group has been the support of observations and especially the education of users in the use of the VLA system and its software. This is particularly true in the case of the two astronomer/programmers, who have made invaluable contributions in understanding the instrumental behavior as well as in user education and software development.

During the latter part of 1976 and the early part of 1977, the Environmental Research Institute of Michigan (ERIM) was studying the design of an optical processor which would solve the large data handling problems associated with the making of spectral line maps. Their final report was available by the end of the summer and this design was then studied by an NRAO committee. The eventual conclusion was that the processor built according to the ERIM design, although it would handle "good" cases (the cases which we recommended that ERIM design the processor about), there were many cases that the processor could handle only by special processing, dependent on the particular case. Further, it was not clear that all

important VLA problems could be handled at all. Therefore, the recommendation of the committee was that the NRAO not pursue this design further.

In the evaluation of the optical processor system, a paradigm digital system was developed, based on minicomputers and fast array processors. This system, although not as fast as an optical processor, is fast enough to serve most of the data processing needs for making VLA maps. The system includes two CPU's (PDP 11/38 or equivalent) and three array processors (Floating Point Systems AP120B or equivalent). Its cost is approximately the same as the contemplated optical processor ($800,000). Other approaches are also being investigated, using larger digital devices instead of minicomputers. These have the advantage that they are somewhat easier to program and that they are more expandable than the mini-array processor system, which is about as large as it is feasible to construct such a system.

Site and Wye

Phase III construction, consisting of 13.1 kilometers (8.1 miles) of wye trackage, 49 antenna foundations, and electrical utility system, was accepted as complete in late February of 1977.

The first four unit, motel-type prefabricated Visiting Scientist Quarters building was received in January 1977. The slump block veneer was installed, patio access walks were poured, and the unit was ready for occupancy in April.

During 1977 modular offices and partitions were installed in two areas of the Control Building. In the computer room a computer maintenance area was enclosed and a graphics room installed. In the downstairs electronics area, three offices were installed and two stockroom areas were enclosed.

The emergency power system was installed during CY 1977. The two 500 KW diesel powered electric generators acquired as surplus from NASA were tested, repaired, and installed with required switchgear in an addition to the Maintenance Shop building. They were placed in automatic mode operation on 8 August 1977. The system is designed to start automatically after utility power has been out for a period of approximately ninety seconds. Site electrical loads, except the wye arms, are shed on initial start-up

in order that the power demand remain within the capability of just one of the two engine-generators. After all antennas have been brought to stow position and if both engine-generators are operating, the remaining Site loads, except for the computer, may be manually brought on-line. Site diesel and gasoline storage tanks and pumps were installed as part of this project.

The wye communications system was expanded, with four additional antennas and the Technical Services Building office being added to the original six antennas and the Control Room on the party line telephone system. A repeater was added to permit operation of the twelve stations now being served by the southwest arm cable. Antenna control functions of "Emergency Stop", "Power Reset", and "Fault Reset" were implemented for all operating antennas through the telephone cable. Signal lights, to indicate status of the emergency generators to the telescope operator in the Control Room, were also implemented through the telephone cable. The original nonarmored cable has suffered damage by pocket gophers. It is being replaced and all additional cable to be installed will be armored, gopher-protected cable.

Installation of the 60mm waveguide has proceeded to AW6 on the west arm, to CE9 on the east arm, and, by the end of CY 1977, will have proceeded to CN9 on the north arm. By the end of the year, a total of 15,640 meters will have been installed, 10,440 meters during CY 1977. Twenty millimeter waveguide has been installed from manholes to the center of twenty-five foundations ready to accommodate antennas.

A network of gravel roads was built to the antenna foundations within the central section of land owned by the Government and to the "D" array stations which are included within the central site fencing. These roads will be upgraded with better drainage as waveguide installation is completed in these areas.

Plans and specifications have been prepared for the second Visiting Scientist Quarters. This will be a six room, motel-type, either prefabricated or built-in-place building with slump block veneer to match existing buildings. This unit should be bid in November and construction started by the end of CY 1977.

The 25-mile dedicated electric power line from Magdalena to the VLA Site was completed and placed in service. This line was constructed for the VLA by the Socorro Electric Cooperative at its cost.

One and one-half miles of old Highway 60 was added to the New Mexico Highway Department system as a spur to State Highway 78. This section of road, which serves as access road to the VLA Site, has been widened and a penetration coat with chips surfacing applied.

Program Management

During the year ending November 15, 1977, the Program Management Group has issued in excess of 2,700 purchase orders and subcontracts, having a total value of $9.5 million. Efforts have continued to negotiate every cost savings possible in order to minimize the effects of inflation.

Thirty-six new employees have been found, interviewed, and hired to fill vacancies that have occurred and to meet the planned additional requirements of Program staffing. An active effort has been continued to help new employees find housing in the local area.

Both the National Science Board and the AUI Trustees met in Socorro and toured the Site this year. There also has been an increasing number of visits from the interested public. In response to this, an open house was held, handling some two thousand visitors. In addition to these visitors, there have been some 108 visiting observers at the Site.

The effort to obtain additional amounts of excess rail material has continued. There is now sufficient rail from known sources of government excess to supply the VLA needs. The largest portion of this excess rail is at Aberdeen Proving Ground and is currently out for bid. Engineering estimates indicate that this rail may not prove economical to take up. Should this be the case, then other sources will be sought.

During October two representatives of NRAO were sent to Japan to negotiate a contract for the purchase of the remaining 35,000 meters of 60mm waveguide. The resulting contract provides for the immediate purchase of 15,000 meters, using 1977 funds not required for Site and Wye construction and contains a unilateral option for the purchase of the remaining 20,000 meters on November 15, 1978, using FY 1979 funds. Total cost is $2,579,700, which is $189,000 under the 1976 cost estimate for waveguide procurement.

Fiscal Operations

During 1977 considerable growth was experienced in the volume of work. This involved implementation of the new operating accounts for scientific operations and common cost accounts, which are used to accumulate expenditures related both to operations and construction. A Burroughs mini-computer was acquired early in the year, but, due to software problems, it was not fully utilized until the latter part of 1977.

A number of items completed during the year were transferred from construction to the completed asset accounts. Among these were the Control, Technical Services, Assembly, and Cafeteria buildings. Antennas #1 and #2 were transferred, along with several smaller completed capital items.

One major change in the Fiscal operations during 1977 consisted of a change in the lines of reporting. At the suggestion of the AUI Internal Audit Group, the Fiscal Office now reports directly to the Chief Fiscal Officer of the Observatory in Green Bank. Prior to March 15, 1977, the effective date for this change, the Fiscal Office reported to the VLA Program Manager.

PLANNED ACTIVITIES - 1978

General

Although the main emphasis during 1978 will be on construction and outfitting of antennas and electronics, nevertheless an increasing emphasis will be placed on scientific operations. The year's goal remains the same as the original schedule, that is, to increase the fully operational antennas to fifteen by the end of the year.

Considerable effort will be expended in the electronics area in improving the performance of a number of modules so that overall performance will achieve research levels.

During CY 1978 thirty-four people at the VLA Site will be charged to support of research operations. Summary details of personnel and costs of operations are included within this Program Plan for completeness, but details of scientific programs, objectives, personnel, and costs for this and future years are included within the regular NRAO Program Plan.

Systems Operation

The systems integration group of the VLA Program is charged with the primary responsibility of operating the telescope to perform scientific observations, and instrumental calibrations and tests, in a round-the-clock, seven-day-a-week basis. The major tasks involved in this function are as follows:

a) Command the real time computing system, to assure the timely execution of the observing program desired by the visiting scientist.

b) Monitor the correct performance of the instrument and maintain logs of the scientific program.

c) Assist the visiting scientist in the use of the off-line computing system for data reduction.

d) Schedule and coordinate the movement and activities of all personnel on the wye.

e) Perform basic maintenance critical to the performance of the telescope and request and coordinate maintenance work from the appropriate staff when malfunctions are observed.

During 1978 the division is anticipating that full-time operation of the array will begin and that the systems integration division will be absorbed by the operations division. At that time a fully trained crew of array operators will be ready to support full-time operation.

Antenna Systems

Advance funding of CY 1978 funds will permit the authorization in late 1977 of fabrication, manufacture, and assembly of Antennas 21 through 28. This authorization is needed to assure the orderly and continuous process of fabrication of the structure of the antennas. This authorization to E-Systems in the amount of $3,125,083 completes authorization for all twenty-eight antennas.

In the light of E-Systems' success at meeting the antenna delivery schedule established in July 1976 with only minor deviations, and when consideration is given to the fact that materials are on hand, it is not anticipated that any difficulties will be experienced in meeting the antenna delivery schedule set forth previously. This schedule will provide NRAO with Antennas 15, 16, 17, 18, 19, 20, and 21 in the period November 1977 to November 1978. NRAO has previously procured out of 1977 funds for Antennas 15 and 16 those items which it must furnish to E-Systems for installation on the antennas at assembly and is procuring now out of advance 1978 funds those same items for Antennas 17, 18, 19, 20, 21, and 22. These items are the focusing feed mounts, the feed support rings, feed towers, and compressor platforms.

Mechanical outfitting of antennas by the NRAO mechanical forces during the period will consist of Antennas 12, 13, 14, 15, 16, 17, and 18. During this same period of time, scheduled maintenance on all antennas will be performed, as well as repair of any breakdowns. By November 1978 the warranty period on all antennas through Antenna 14 will have expired. A spare parts inventory is being built up to support this repair activity. A servo test facility is being built on site, which duplicates the manufacturer's test facility and will permit the shop repair and test of all servo components as well as the determination of the source of malfunctions without tying up an antenna.

Transporter #1 will be modified as suggested by operating experience and in accordance with the design review. These modifications will consist of increasing the stabilizing jack speed and load in order to decrease the turning time at spur intersections and modification of the truck rotary collar to provide additional strength and clearance. This work will be accomplished by NRAO mechanical forces.

During the period November 1977 to November 1978, NRAO mechanical forces will complete the modification of the access stairway on the present operating antennas and will modify the azimuth inductosyn rollers on Antennas 1, 2, 3, 4, 6, and 8. It was discovered this past year that the inductosyn rollers used by E-Systems were not satisfactory, and AUI installed a different type roller and support on Antennas 7 and 5 to demonstrate their suitability. E-Systems has furnished the new rollers and support to NRAO for retrofit of operating antennas and is installing the new type as original equipment on Antennas 12 and up.

Electronics

During 1978 the installation of electronics for Antennas 11 through 17 will be completed and these antennas brought into operation. The electronics units used will be mainly from the 1977 procurement. In 1978, procurement will cover six systems in the area of feeds and front-ends, providing for antennas through 21. In most other areas of the electronics, it will cover seven systems, providing for antennas through 24. A small additional number of modules will be obtained from operations funding to provide spares for maintenance purposes. Electronics procurement and outfitting will continue to include only two of the four IF channels, except for the two test antennas, Nos. 3 and 5, which will be used to verify operation of the full bandwidth system. Procurement of the standby master local oscillator is also planned for 1978. Remaining cabling for racks in the electronics room of the Control Building will be completed.

Retrofits of the electronics modifications which fall within the first two categories described earlier will be completed within the first half of the year on antennas through 10. For Antenna 11 and onwards the modifications will have been incorporated in the electronics

procurement in 1977. The bandwidth selection filters at the antennas will have been tested on Antennas 3 and 5 in 1977 and in 1978 a further twelve sets to complete antennas through 14 will be installed. The design of the final IF stages for operation with the spectral processor will start in late 1977 and will be completed by about April 1978. Production to provide units for antennas up to 24 will then begin, allowing installation during the latter half of the year.

The spectral processor, including its computer interface and control units, will be completed to half of its final capacity by mid-year and testing will then begin. The first phase of testing will involve operation in the continuum mode only, and when this is satisfactorily achieved, the spectral processor will replace the present continuum delay and multiplier, which will not be expanded beyond the capacity to handle twelve antennas. Limited tests of operation in the spectral line mode can begin, using the present IF amplifiers if this stage is reached before the redesigned IF modules are ready. Testing and putting the spectral processor into operation is expected to take several months since a good deal of software development is also involved.

The first antenna to be outfitted with a CTI cryogenics system will be #14, which will go into operation in June. Testing of the cryogenics in the laboratory will start several months earlier, however, so by the end of 1978 firsthand information on the relative maintainability of cryogenics equipment by the three manufacturers will have been gained. The investigation of the phase stability of the array, which became a top priority item in September of 1977, should be completed early in 1978 if not before then. The ability to operate in the spectral line mode in the latter half of 1978 will allow more stringent tests of the signal leakage in the 18-21 cm band and of the flatness of the frequency response of the buried waveguide. Detailed performance testing in both of these areas should begin during 1978.

Computer Systems

The major effort in the on-line system during 1978 will be to provide the software to handle the line correlator system. This will be done in stages to minimize the amount of reworking necessary. The first

stage will be to simply provide software to emulate the behavior of the current (interim) continuum correlator system. This must be done by April, as the interim correlator will not handle more than twelve antennas. The second stage will be to write a special line interferometer program, which will handle the case of all interferometers in a single line mode subarray. Only when this is written and stabilized will we attempt to write a program capable of using the many modes and subarray capabilities of the correlator hardware. This third stage should be started by the end of the year. This stage is the last major programming task for the on-line system.

Much of the effort in the off-line programming in 1978 will be directed to making a reliable and convenient system by which the various minicomputers communicate with each other and with the DEC-10. This construction of an infrastructure of programs will result in little apparent progress until a usable subset appears about midyear; at that time we should be moving a significant number of computation bound tasks into the minicomputers.

One modest effort we shall engage in will be to modify the Gronigen system of map manipulation for use with VLA maps. Using the already developed logic will save a great deal of effort and quickly give us a usable capability of examining our maps.

One of the consequences of not having an optical processor is that we must provide an alternate way to make high quality images. During 1978 we plan to purchase a graphic output device for making high resolution radio photographs (we currently can photograph the screen of the interactive map display system, but this has insufficient resolution to do justice to a complicated VLA map).

We shall also have to begin, in 1978, to provide some of the off-line and quasi off-line ("pipeline") data processing for the spectral line data. This will involve the purchase of a "sorting system", which will consist of two or three small CPU's and enough disk space to hold several hours of full array spectral line data.

Also during 1978 we shall be investigating and probably purchasing the map making system which is the alternate to the optical processor.

Site and Wye

Phase IV documents will be updated after resolution of the Department of Labor construction wage classification problem. Construction will consist of 12.4 kilometers (7.7 miles) of wye trackage and five antenna foundations. The Site and Wye Group will supervise the construction with the assistance of the Engineer/Architect, who will make monthly inspection visits to the Site and assist in other technical and administrative matters as requested. It is anticipated that a major package of wye trackage and services will be designed and bid during the summer of 1978 and awarded as soon as 1979 funding becomes available.

Construction of the second Visiting Scientist Quarters will be completed and the building placed in operation.

A Library-Office Building has been designed to provide a library and eleven single offices for scientific, engineering, and administrative staff. Construction will be similar to the VSQ buildings and should be completed in CY 1978.

Two prefabricated metal buildings should be erected in 1978: one garage building about 24 feet by 40 feet to house the ambulance and four on-site electrical vehicles; the other, a shed to cover the two NRAO buses, will be about 26 feet by 46 feet in plan.

Waveguide installation will proceed on all arms of the wye, with the goal of installing 18,000 meters during the year.

Program Management

The efforts of the Program Management Group in CY 1978 will be similar to activities during CY 1977. It is planned to place an additional six room Visiting Scientist Quarters into operation during the spring to accommodate the increasing number of observers; also, to place a self-guided tour into operation. This tour will be designed to explain radio astronomy and the purpose of the VLA to the nontechnical visitor. It is felt that such a tour will satisfy the casual visitor without extensive involvement with the staff. This year should see the stockpiling at the Site of 100% of the track needed for the Program. There already is sufficient material on hand for the next planned construction phase.

Fiscal

With increasing emphasis on operations in 1978 and future years, the Fiscal Group will be focusing more attention on the accounting for those funds. The common costs, that is, costs related to both operations and construction, will be accumulated and prorated to operations and construction on the same basis as they were in 1977.

Increasing effort will be expended in transferring completed assets from construction into the various fixed asset accounts.

Other areas of concentration during 1978 will include review of the existing procedures and internal controls and making improvements or changes where necessary. Other areas would include inventories, property, and any special requests or projects requested by management. Completion of the software programming and debugging on the Burroughs minicomputer will be of top priority.

PLANNED ACTIVITIES - 1979

General

Scientific operations are expected to be on a twenty-four hour per day, seven day a week basis in 1979, utilizing fifteen antennas in January and gradually building up to twenty-one antennas by the end of the year.

Antennas

During 1979 the delivery of Antennas 22 through 28 by E-Systems is scheduled. NRAO will be conducting the inspection and checking of the assembly work to ensure compliance with the specifications. NRAO mechanical forces will continue the mechanical, electrical, and feed outfitting of accepted antennas. Scheduled for outfitting during this period are Antennas 18 through 24. Scheduled maintenance of the previously outfitted antennas will, of course, consume a larger amount of time, as will unscheduled repair of malfunctioning components.

The year 1979 will see the completion of procurement of NRAO-supplied items for original installation on antennas.

Procurement proposals for Transporter #2 will be solicited in August 1978 for procurement in November 1978 when 1979 funds become available. Due to long delivery time items, it probably will not become operational until 1980 when acceptance testing will be conducted.

Electronics

During 1979 antennas through 24 will be outfitted with electronics and put into operation. Procurement will cover seven systems in the front-end area and four in other parts of the electronics. This will provide for antennas through 28, thus completing the electronics in many areas. The major part of the expansion of the spectral processor to its full capacity will also be carried out in 1979. Sufficient operating experience of the array should have been gained to permit the design of a permanent console

in the Control Room to replace the present temporary arrangement of terminals on tables, et cetera.

Of the electronics modifications started in 1977, only the installation of the bandwidth selection filters on Antennas 15 through 20 should remain and this will then be completed during 1979. Investigation of the performance of the array under the more stringent requirements of the spectral processor can be anticipated to be in progress during 1979.

Computer Systems

Work on the hardware and software for the spectral line and map making systems will continue. Other areas which will be under study and development will be mass storage capabilities and additional display equipment.

Site and Wye

The Site and Wye Group will continue to oversee the construction of wye trackage and antenna stations. A major contract for trackage and services will be in progress during CY 1979.

Waveguide installation will proceed, with a goal of 18,000 meters during the year.

Program Management and Fiscal Operations

Work will continue along the same lines as in 1977 and 1978.

PLANNED ACTIVITIES - 1980

General

Construction activities will be drawing to a close, with the scientific work predominant. The year should start with twenty-one antennas on the line, gradually building up to twenty-eight by year's end. Should 1979 funding be cut below the $13,000,000 used in this plan, a major Site and Wye contract will have to be let in 1980, which may cause the VLA construction program to run over into 1981, with increased costs for both construction and overhead items, such as program management.

Antennas

Mechanical outfitting of Antennas 25 through 28 is scheduled in 1980 and should be completed by midyear. At this time it is planned to initiate the program of removing one antenna at a time from service and repainting and refurbishing. It is anticipated that this refurbishing period will take approximately five to six weeks. Operational maintenance and unscheduled repairs will be performed. Spare parts inventory will be re-evaluated and brought to a status at which it can support full-scale operation.

The operational testing of Transporter #2 will be completed and it will be placed into operation. It is the plan to modify the stroke length of the suspension cylinders on Transporter #1.

Electronics

During 1980, electronics will be outfitted to Antennas 25 to 28. The major procurement will be of the modules to increase the number of IF channels from two to four. Slots to receive these modules, with all connectors in place, will be ready in the existing racks and bins. Thus, bringing the additional channels into operation should not be a difficult procedure. The spectral processor will also be completed and brought into

operation at its planned capacity. Testing of the array with its full IF bandwidths and spectral line capability will begin.

Computer Systems

Work will be in the software field in updating and making the various programs more efficient and useful to the changing needs of the scientific program.

Site and Wye

The Site and Wye Group will continue to oversee construction of wye trackage and services.

Waveguide installation will proceed, with the goal of installing the remaining 11,000 meters.

Program Management and Fiscal Operations

Work will continue along the same lines as in 1978 and 1979.

FINANCIAL PLANNING

This section of the CY 1978 Program Plan will present the various budget estimates and other schedules necessary for the proper financial planning of the Program. Presented are the following:

VLA FINANCIAL STATUS REPORT - Program summary report which details the financial condition of the Program from the standpoint of the authorized program ceiling compared to total program outlook.

VLA COST ESTIMATE - 11/01/77 - Shows in summary and detail the current cost estimate for the Program and compares the present estimate with that presented in the CY 1976 Program Plan. To show the magnitude of the sums assigned to escalation and contingency, these items have been set forth separately.

BUDGET ANALYSIS BY PROGRAM YEAR - CY 1973 THROUGH CY 1980 - Shows the cost estimate by program year. Details current (escalated) and base (unescalated) cost and total Program escalation.

SUMMARY OF CONSTRUCTION/OPERATING BUDGETS - CY 1973 THROUGH CY 1980 - Shows the cost estimate by Program year for construction and operations, including distribution of Common Cost.

SUMMARY OF COMMON COST BUDGET - CY 1977 THROUGH CY 1980 - Shows Common Cost estimate by Program year.

COMMITMENT SCHEDULE - CY 1973 THROUGH CY 1980 - A commitment schedule to show actual commitments through 1976 and how the estimated commitments will be divided among the various calendar years.

FINANCIAL PLAN - CY 1978 - The financial plan for CY 1978 broken down into various categories. For comparison, the actual allocation of CY 1973 through CY 1977 funds has also been included.

CY 1977 REVIEW OF FINANCIAL PLAN - A detailed analysis of the revisions that have been made to the CY 1977 Financial Plan, giving the reasons for the changes.

EXPENDITURES AND COMMITMENTS - CY 1977 CUMULATIVE ACTIVITY - A report in graph form, showing scheduled and actual expenditures and commitments by months.

EXPENDITURES AND COMMITMENTS - CY 1978 CUMULATIVE ACTIVITY - A graphic presentation, showing planned CY 1978 expenditures and commitments by months. This graph will be the basis of monthly reports.

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

FINANCIAL STATUS REPORT
(thousands)
AS OF: NOVEMBER 1, 1977

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		ALLOCATION TO DATE				OUTLOOK			
ITEM	PROGRAM CEILING	ALLOCATED	EXPENDED AND COMMITTED	ALLOCATED BALANCE	UN-ALLOCATED BALANCE	ESTIMATE TO COMPLETE	ESTIMATE TOTAL	(OVER) UNDER CEILING	NOTES
Site and Wye	27,860	14,491	12,931	1,560	13,369	14,172	27,103	757	
Antennas	20,400	17,361	17,336	25	3,039	4,779	22,115	(1,715)	
Electronics	17,000	10,920	10,310	610	6,080	6,915	17,225	(225)	
Computer	4,850	3,450	3,109	341	1,400	2,489	5,598	(748)	
Systems Integration	400	193	179	14	207	26	205	195	
Program Management	2,650	1,700	1,675	25	950	428	2,103	547	
Common Cost	-	691	544	147	(691)	1,417	1,961	(1,961)	
Subtotal	73,160	48,806	46,084	2,722	24,354	30,226	76,310	(3,150)	
Contingency	2,840	370	232	138	2,470	1,501	1,733	1,107	
TOTAL	76,000	49,176	46,316	2,860	26,824	31,727	78,043	(2,043)	

Notes: (1) Escalation included for future years for Site and Wye work (8%); NRAO labor (6%), certain antenna equipment items (6.5%), and certain electronic elements (6%). Antenna estimate is based on the existing contract costs for fabrication of the antennas.

(2) Estimate excludes the airstrip ($268K), a deferred item. Transporter #3 is not included within the estimate. Estimate excludes tax payment to New Mexico State ($127K).

(3) Total estimate includes $303K for land acquisition under Site/Wye, $16K withheld by NSF for ECAC under Electronics, and $15K withheld by NSF for the Ad Hoc Advisory Committee under Program Management. These amounts were funded directly by NSF.

Figure 9

NATIONAL RADIO ASTRONOMY OBSERVATORY

VLA PROGRAM

VLA - FINANCIAL STATUS REPORT

As of: November 1, 1977

EXPLANATION TO ACCOMPANYING STATEMENT

Column (2) - PROGRAM CEILING: Original Estimates.

Column (3) - ALLOCATED: Funded by NSF and included in total funds provided in Contract C-780 and NSF AST 74-13427.

Column (4) - EXPENDED AND COMMITTED: Actual cash paid out and orders written and accepted by vendors.

Column (5) - ALLOCATED BALANCE: Column (3) less Column (4). Current funds available for expenditure and commitment.

Column (6) - UNALLOCATED BALANCE: Column (2) less Column (3). Funds due from NSF to fund the total Program as originally estimated.

Column (7) - ESTIMATE TO COMPLETE: Original estimate updated to take into account current or known costs.

Column (8) - ESTIMATE TOTAL: Column (4) plus Column (7).

Column (9) - (OVER) UNDER CEILING: Column (2) less Column (8).

NATIONAL RADIO ASTRONOMY OBSERVATORY

VLA PROGRAM

ESTIMATED COST - DESIGN AND CONSTRUCTION ON 11/01/77

(THOUSANDS)

ITEM	CEILING	ESTIMATE 8/1976	ESTIMATE 8/1977	CHANGE 1976 vs. 1977
SITE AND WYE	27,860	26,779	27,103	+ 324
ANTENNA SYSTEMS	20,400	21,866	22,115	+ 249
ELECTRONIC SYSTEMS	17,000	17,154	17,225	+ 71
COMPUTER SYSTEMS	4,850	5,526	5,598	+ 72
SYSTEMS INTEGRATION	400	261	205	- 56
PROGRAM MANAGEMENT	2,650	1,968	2,103	+ 135
COMMON COST	-	2,071	1,961	- 110
SUBTOTAL	73,160	75,625	76,310	+ 685
CONTINGENCY/RESERVE	2,840	2,527	1,733	- 794
TOTAL PROGRAM	76,000	78,152	78,043	- 109
EXCLUDES DEFERRED ITEMS - AIRSTRIP		268	268	
TRANSPORTER #3		-	-	

Figure 10

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

COST ESTIMATE 11/01/77
(thousands)

	1977 PROGRAM PLAN 12/01/76	PROGRAM COST ESTIMATE 1977 BASE	ESCALATION	TOTAL
ANTENNA SYSTEMS				
Antenna Element Design	225	230	-	230
Prototype Antennas	1,624	1,624	-	1,624
Production Antennas	17,283	17,301	62	17,363
Transporter Design	83	121	-	121
Transporter Prototype	375	364	-	364
Transporter Production Model	525	560	34	594
Assembly Structure	403	403	-	403
E.D.I.A.	1,348	1,376	40	1,416
TOTAL	21,866	21,979	136	22,115

Figure 10

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

COST ESTIMATE 11/01/77
(thousands)

	1977 PROGRAM PLAN 12/01/76	PROGRAM COST ESTIMATE 1977 BASE	ESCALATION	TOTAL
ELECTRONIC SYSTEMS DEVELOPMENT				
Feed System	153	142		142
Front-end System	329	324		324
Local Oscillator System	100	111		111
Monitor/Control System	85	85		85
Waveguide System	297	256		256
IF Transmission	234	216		216
Delay/Multiplier System	21	21		21
Spectral Processor	127	173		173
General Electronics	13	13		13
E.D.I.A.	562	535	18	553
Subtotal Development	1,921	1,876	18	1,894
ELECTRONIC SYSTEMS PRODUCTION				
Feed System	1,566	1,510	72	1,582
Front-end System	2,950	3,019	151	3,170
Local Oscillator System	887	1,001	7	1,008
Monitor/Control System	619	637	31	668
Waveguide System	484	382	6	388
IF Transmission System	1,300	1,326	42	1,368
Delay/Multiplier System	320	300	0	300
Spectral Processor	1,236	1,009	53	1,062
General Electronics	1,489	1,385	23	1,408
E.D.I.A.	4,366	4,223	138	4,361
Subtotal Production	15,217	14,792	523	15,315
TOTAL ELECTRONICS SYSTEMS	17,138	16,668	541	17,209

Figure 10

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

COST ESTIMATE 11/01/77
(thousands)

	1977 PROGRAM PLAN 12/01/76	PROGRAM COST ESTIMATE 1977 BASE	ESCALATION	TOTAL
SITE FACILITIES AND WYE				
Site Acquisition	-	-	-	-
Preliminary Design	225	225		225
Detailed Design	510	510	3	513
Construction Supervision	175	144	11	155
Survey/Soils	340	322	25	347
Construction Site Preparation	78	80	6	86
Computer Site Trailers	40	42		42
Archaeological Preservation	100	107		107
Construction Facilities	156	146		146
Equipment/Maintenance Vehicles	122	155		155
Building Complex	2,274	2,479		2,479
Site Work/Utilities	857	810		810
Wye Construction	13,595	12,934	1,032	13,966
Waveguide Procurement	5,105	4,750	380	5,130
Waveguide Installation	1,487	1,321	106	1,427
Waveguide Antenna Stations	729	464	37	501
E.D.I.A.	693	664	47	711
TOTAL	26,486	25,153	1,647	26,800
COMPUTER SYSTEMS				
Synchronous Subsystem	486	485		485
Asynchronous Subsystem	3,130	3,367		3,367
Computer Maintenance	200	189		189
E.D.I.A.	1,710	1,517	40	1,557
TOTAL	5,526	5,558	40	5,598

Figure 10

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

COST ESTIMATE 11/01/77
(thousands)

	1977 PROGRAM PLAN 12/01/76	PROGRAM COST ESTIMATE 1977 BASE	ESCALATION	TOTAL
SYSTEMS INTEGRATION				
Personnel Costs	153	151	1	152
Material, Services, Supplies	81	31		31
Travel	27	22		22
TOTAL	261	204	1	205
PROGRAM MANAGEMENT				
Personnel Costs	1,222	1,205	33	1,238
Material, Services, Supplies	609	724		724
Travel	137	126		126
TOTAL	1,968	2,055	33	2,088
CONTINGENCY/RESERVE	2,527	1,733	-	1,733
COMMON COST	2,071	1,818	143	1,961
Subtotal Program	77,843	75,168	2,541	77,709
Funded by NSF	309	334	-	334
TOTAL PROGRAM	78,152	75,502	2,541	78,043

Figure 10

NATIONAL RADIO ASTRONOMY OBSERVATORY

Revised 11/01/77

VLA PROGRAM

BUDGET ANALYSIS BY PROGRAM YEAR

(in thousands)

ESCALATED DOLLARS

	1973	1974	1975	1976	1977	1978	1979	1980	Total Escalated	Total Base	Escalation
SITE AND WYE	964	875	4,924	4,884	2,823	3,714	7,468	1,148	26,800	25,153	1,647
ANTENNA SYSTEMS	315	2,453	2,740	7,717	4,134	3,618	1,064	74	22,115	21,979	136
ELECTRONIC SYSTEMS	816	1,460	2,292	2,520	3,836	2,897	2,377	1,011	17,209	16,668	541
COMPUTER SYSTEMS	29	415	1,289	661	1,053	958	971	222	5,598	5,558	40
SYSTEMS INTEGRATION	-	-	46	80	67	12	-	-	205	204	1
PROGRAM MANAGEMENT	158	236	500	685	100	122	107	180	2,088	2,055	33
COMMON COST	-	-	-	-	691	579	383	308	1,961	1,818	143
SUBTOTAL	2,282	5,439	11,791	16,547	12,704	11,900	12,370	2,943	75,976	73,435	2,541
CONTINGENCY	-	-	-	-	413	600	630	90	1,733	1,733	-
TOTAL	2,282	5,439	11,791	16,547	13,117	12,500	13,000	3,033	77,709	75,168	2,541
Add for cost of ECAC Study (16), Land Acquisition (303), and Ad Hoc Advisory Committee (15), funded directly by NSF and not carried in NRAO costs									334	334	-
									$78,043	$75,502	$2,541

Figure 11

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

11/01/77

SUMMARY OF CONSTRUCTION/OPERATING BUDGETS

ESCALATED DOLLARS

	1973	1974	1975	1976	1977	1978	1979	1980	TOTAL
CONSTRUCTION									
Site and Wye	964	875	4,924	4,884	2,823	3,714	7,468	1,148	26,800
Antenna	315	2,453	2,740	7,717	4,134	3,618	1,064	74	22,115
Electronics	816	1,460	2,292	2,520	3,836	2,897	2,377	1,011	17,209
Computer	29	415	1,289	661	1,053	958	971	222	5,598
Systems Integration	-	-	46	80	67	12	-	-	205
Program Management	158	236	500	685	100	122	107	180	2,088
Contingency	-	-	-	-	413	600	630	90	1,733
Common Cost	-	-	-	-	691	579	383	308	1,961
Subtotal Construction	2,282	5,439	11,791	16,547	13,117	12,500	13,000	3,033	77,709*
OPERATIONS									
Site Operations	-	-	-	-	-	-	36	47	83
Data Processing	-	-	-	-	75	193	255	280	803
Array Operations	-	-	-	-	57	100	137	145	439
Electronic Maintenance	-	-	-	-	72	197	454	519	1,242
Antenna Maintenance	-	-	-	-	27	94	160	246	527
Subtotal Salary	-	-	-	-	231	584	1,042	1,237	3,094
Benefits	-	-	-	-	50	125	230	279	684
Travel	-	-	-	-	7	8	25	32	72
Misc. Material, Services, Supplies	-	-	-	-	166	144	341	425	1,076
Operating Equipment - New	-	-	-	-	-	-	56	229	285
Spares	-	-	-	90	156	-	149	340	735
Common Cost	-	-	-	-	135	339	647	818	1,939
Subtotal Operations	-	-	-	90	745	1,200	2,490	3,360	7,885
GRAND TOTALS	2,282	5,439	11,791	16,637	13,862	13,700	15,490	6,393	85,594

*Does not include $303K for land acquisition under Site/Wye, $16K for ECAC Study under Electronics, and $15K for Ad Hoc Advisory Committee withheld by NSF.

Figure 12

NATIONAL RADIO ASTRONOMY OBSERVATORY 11/01/77

VLA PROGRAM

SUMMARY OF COMMON COST BUDGET

CY 1977 - CY 1980
(in thousands)
ESCALATED DOLLARS

		1977	1978	1979	1980	Total
18910	Salary/Wages	329	358	380	375	1,442
18920	Benefits	68	77	81	80	306
18930	Travel	7	8	9	10	34
18940	Material, Services, Supplies	134	165	188	200	687
18942	Power	104	175	225	300	804
18943	GSA Vehicles	40	44	47	50	181
18944	Bus Operations/Maintenance	18	19	21	23	81
18947	Communications	70	76	83	91	320
18952	Cafeteria/Housing Expense	14	16	17	19	66
18953	Miscellaneous Income	(16)	(20)	(21)	(22)	(79)
	TOTAL - COMMON COST	768	918	1,030	1,126	3,842

Figure 13

NATIONAL RADIO ASTRONOMY OBSERVATORY

VLA PROGRAM

COMMITMENT SCHEDULE - CY 1973 THROUGH CY 1980
(thousands)

11/01/77

ITEM	CY 1973 THROUGH CY 1977	1978	1979	1980	TOTAL
SITE AND WYE	14,470	3,714	7,468	1,148	26,800
ANTENNA SYSTEMS	17,359	3,618	1,064	74	22,115
ELECTRONIC SYSTEMS	10,924	2,897	2,377	1,011	17,209
COMPUTER SYSTEMS	3,447	958	971	222	5,598
SYSTEMS INTEGRATION	193	12	-	-	205
PROGRAM MANAGEMENT	1,679	122	107	180	2,088
COMMON COST	691	579	383	308	1,961
CONTINGENCY/RESERVE	413	600	630	90	1,733
PROGRAM TOTAL	49,176	12,500	13,000	3,033	77,709

Notes: Column 1: Actual through 10/30/77; estimated through 12/31/77.

Does not include $303K for land acquisition funded directly to Corps of Engineers, $16K for ECAC, and $15K for Ad Hoc Advisory Committee, funded directly by NSF.

Figure 14

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

FINANCIAL PLAN - CY 1978
11/01/77
(thousands)

	ESTIMATE	ACTUAL CY-1973	ACTUAL CY-1974	ACTUAL CY-1975	ACTUAL CY-1976	PLAN CY-1977	PLAN CY-1978
TASK I & V SITE FACILITIES/WYE							
Site Acquisition	-						
Preliminary Design	225	225					
Detailed Design	513	443	30		11	12	21
Construction Supervision	155		30	51	30	28	12
Survey/Soils	347	223	4	34	18	12	20
Construction Site Preparation	86	15	33	8	11	15	10
Construction Facilities	146			141	4	-	-
Construction Equipment	155			16	54	39	35
Computer/Site Trailers	42			36	1	1	4
Archaeological Preservation	107					100	7
Building Complex	2,479			1,814	323	86	190
Site Work/Utilities	810			615	215	143	37
Wye Construction	13,966		616	837	3,395	816	2,820
Waveguide Procurement	5,130		60	1,114	413	1,072	0
Waveguide Installation	1,427			116	134	305	385
Waveguide Antenna Stations	501				121	136	101
E.D.I.A.	711	58	102	142	154	76	72
TOTAL SITE FACILITIES/WYE	26,800	964	875	4,924	4,884	2,823	3,714

Figure 15

FINANCIAL PLAN - CY 1978
11/01/77
(thousands)

	ESTIMATE	ACTUAL CY-1973	ACTUAL CY-1974	ACTUAL CY-1975	ACTUAL CY-1976	PLAN CY-1977	PLAN CY-1978
TASK II ANTENNA SYSTEMS							
Antenna Element Design	230	225				5	
Prototype Antennas	1,624		1,623				
Production Models	17,363			2,454	7,465	3,771	3,325
Transporter Design	121		83			36	
Transporter Prototype	364		311	6	16	15	16
Transporter Production Models	594						
Assembly Structure	403		312	86	5		
E.D.I.A.	1,416	90	124	194	231	307	277
TOTAL ANTENNA SYSTEMS	22,115	315	2,453	2,740	7,717	4,134	3,618
TASK IV SYSTEMS INTEGRATION							
Personnel Costs	152			33	59	45	10
Materials, Supplies, Services	31			6	18	10	1
Travel	22			7	3	12	1
TOTAL SYSTEMS INTEGRATION	205			46	80	67	12

Figure 15

FINANCIAL PLAN - CY 1978
11/01/77
(thousands)

	ESTIMATE	ACTUAL CY-1973	ACTUAL CY-1974	ACTUAL CY-1975	ACTUAL CY-1976	PLAN CY-1977	PLAN CY-1978
TASK IV COMPUTER SYSTEMS							
Synchronous Subsystem	485		248		21	178	20
Continuum Asynchronous Subsystem	2,650			871	120	145	584
Display I/O Equipment	312			33	88	55	100
Spectral Line Computer	405					320	85
Computer Maintenance	189			48	62	23	18
E.D.I.A.	1,557	29	167	337	370	332	151
TOTAL COMPUTER SYSTEM	5,598	29	415	1,289	661	1,053	958
TASK III ELECTRONIC SYSTEMS DEVELOPMENT							
Feed System	142		80		53	17	-
Front-end System	324	96	64	81	23	48	8
Local Oscillator System	111	33	20	4	29	15	7
Monitor/Control System	85	74	9	2	-	-	-
Waveguide System	256	83	11	32	55	51	15
I.F. Transmission System	216	63	32	94	2	20	3
Delay/Multiplier System	21	7	14		-	-	-
Spectral Processor	173			4	29	128	13
General Electronics	13		13		-	-	-
E.D.I.A.	553	188	117	109	96	101	90
SUBTOTAL DEVELOPMENT	1,894	544	360	326	287	380	136

FINANCIAL PLAN - CY 1978
11/01/77
(thousands)

	ESTIMATE	ACTUAL CY-1973	ACTUAL CY-1974	ACTUAL CY-1975	ACTUAL CY-1976	PLAN CY-1977	PLAN CY-1978
TASK III ELECTRONIC SYSTEMS PRODUCTION							
Feed System	1,582		105	36	262	412	295
Front-end System	3,170		214	384	395	596	642
Local Oscillator System	1,008		80	118	140	268	242
Monitor/Control System	668		15	85	97	188	148
Waveguide System	388	46	28	21	118	86	51
I.F. Transmission System	1,368		103	289	208	236	316
Delay/Multiplier System	300	24	62	122	21	19	12
Spectral Processor	1,062				3	597	112
General Electronics	1,408	108	135	254	232	256	234
E.D.I.A.	4,361	94	358	657	757	798	709
SUBTOTAL PRODUCTION	15,315	272	1,100	1,966	2,233	3,456	2,761
TOTAL ELECTRONICS SYSTEMS	17,209	816	1,460	2,292	2,520	3,836	2,897

Figure 15

FINANCIAL PLAN - CY 1978
11/01/77
(thousands)

	ESTIMATE	ACTUAL CY-1973	ACTUAL CY-1974	ACTUAL CY-1975	ACTUAL CY-1976	PLAN CY-1977	PLAN CY-1978
TASK VIII PROGRAM MANAGEMENT							
Personnel Costs	1,238	128	178	248	334	85	90
Materials, Supplies, Services	724	17	35	216	334	2	18
Travel	126	13	23	36	17	13	14
TOTAL PROGRAM MANAGEMENT	2,088	158	236	500	685	100	122
Contingency/Reserve	1,733					413	600
Common Cost	1,961					691	579
TOTAL PROGRAM	77,709	2,282	5,439	11,791	16,547	13,117	12,500

Figure 15

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

CY 1977 REVIEW OF FINANCIAL PLAN
(thousands)

11/01/77

TASK	ITEM	PLAN 11/01/76	ALLOCATION 11/01/77	Change
I & V	Site Facilities and Wye	2,488	2,823	+ 335
II	Antenna Systems	3,908	4,134	+ 226
III	Electronic Systems	3,633	3,836	+ 203
IV	Computer Systems	1,020	1,053	+ 33
VI	Systems Integration	82	67	- 15
VII	Program Management	100	100	-
	Common Cost	691	691	-
	Contingency/Reserve	578	413	- 165
	TOTAL PROGRAM	12,500	13,117 (1)	+ 617

(1) Includes $617 Carryover.

Figure 16

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

CY 1977 REVIEW OF FINANCIAL PLAN
(thousands)

11/01/77

TASK I & V SITE FACILITIES AND WYE	11/01/76	11/01/77	Change
Site Acquisition	-	-	
Archaeological Preservation	-	100	+ 100 (1)
Engineering - Preliminary	-	-	
- Detailed	12	12	
Construction Supervision	10	28	+ 18
Survey/Soils	20	12	- 8
Construction Facilities	5	15	+ 10
Computer/Site Trailers	1	1	
Construction Equipment	45	39	- 6
Building Complex	31	94	+ 63 (2)
Site Work/Utilities	82	117	+ 35 (3)
Wye Construction	1,449	816	- 633 (4)
Waveguide Procurement	372	1,072	+ 700 (5)
Waveguide Installation	275	305	+ 30 (6)
Waveguide Antenna Stations	110	136	+ 26 (7)
E.D.I.A.	76	76	
TOTAL	2,488	2,823	+ 335

Figure 16

CY 1977 REVIEW OF FINANCIAL PLAN
(thousands)

11/01/77

TASK I & V SITE FACILITIES AND WYE

NOTES:

(1) Cost of archaeological work on southwest arm of wye.

(2) Increase due to higher VSQ cost, additional office and lab space in the Control Building.

(3) Increase due to construction of central site road network to antenna stations, repairs to surplus generating units, and addition of fuel pumping facilities.

(4) Phase IV construction not accomplished due to appeal of Davis-Bacon wage rates. Funds reprogrammed for advance procurement of 60mm waveguide and installation of wye communications system.

(5) Increase due to advance procurement of 60 mm waveguide for future years.

(6) Increase due to the installation of additional 60mm waveguide.

(7) Increase due to additional procurement of 20mm waveguide for future years.

CY 1977 REVIEW OF FINANCIAL PLAN
(thousands)

11/01/77

	PLAN 11/01/76	ALLOCATION 11/01/77	Change	
TASK II ANTENNA SYSTEMS				
Production Models	3,606	3,752	+ 146	(1)
Field Modifications	9	25	+ 16	(2)
Transporter Assembly/Test/Modifications/Spares	25	51	+ 26	(3)
E.D.I.A.	268	306	+ 38	(4)
TOTAL	3,908	4,134	+ 226	

NOTES:

(1) Increase due to $128K assessment of New Mexico Gross Receipts Tax and $18K retrofit of modified air conditioning system on Antennas 1 - 10.

(2) Increase due to modification of antenna stairways.

(3) Increase due to modifications performed on transporter in accordance with redesign and accumulation of spares.

(4) Increase due to additional servo technician and one mechanical engineer.

CY 1977 REVIEW OF FINANCIAL PLAN
(thousands)

11/01/77

	PLAN 11/01/76	ALLOCATION 11/01/77	Change
TASK III ELECTRONIC SYSTEMS			
General Electronics	272	257	- 15
Front-end System	576	644	+ 68 (1)
Local Oscillator System	283	283	
Waveguide System	132	137	+ 5
IF Transmission System	256	256	
Delay/Multiplier System	19	19	
Feed System	310	429	+ 119 (2)
Monitor/Control System	188	188	
Spectral Processor	700	725	+ 25 (3)
E.D.I.A.	897	898	+ 1
TOTAL	3,633	3,836	+ 203

NOTES:

(1) Increase due to higher cost resulting from the completion of a detailed design of the F.E. filter unit.

(2) Increase due to higher costs resulting from the new design of the L-band feed and deicer.

(3) Increase due to development of a custom IC in order to effect future fabrication savings.

Figure 16

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

CY 1977 REVIEW OF FINANCIAL PLAN
(thousands)

11/01/77

	PLAN 11/01/76	ALLOCATION 11/01/77	Change
TASK IV COMPUTER SYSTEM			
Synchronous Subsystem	155	178	+ 23 (1)
Asynchronous Subsystem	190	200	+ 10
Spectral Line Computing Equipment	320	320	
Computer Maintenance	23	23	
E.D.I.A.	332	332	
TOTAL	1,020	1,053	+ 33

NOTES:

(1) Increase due to addition of terminals and other hardware required to support electronic hardware maintenance and diagnosis.

TASK VI SYSTEMS INTEGRATION			
Personnel Costs	46	45	- 1
Materials, Services, Supplies	25	10	- 15
Travel	11	12	+ 1
TOTAL	82	67	- 15

Figure 16

NATIONAL RADIO ASTRONOMY OBSERVATORY
VLA PROGRAM

CY 1977 REVIEW OF FINANCIAL PLAN
(thousands)

11/01/77

	PLAN 11/01/76	ALLOCATION 11/01/77	Change
TASK VII PROGRAM MANAGEMENT			
Personnel Costs	85	85	0
Materials, Services, Supplies	2	2	0
Travel	13	13	0
TOTAL	100	100	0
COMMON COST	691	691	0
CONTINGENCY/RESERVE	578	413 (1)	- 165

NOTES:

(1) Decrease in allocation result of appropriation of funds to cover antenna Gross Receipts Tax, and to cover funds withheld by NSF for the Ad Hoc Advisory Committee and Corps of Engineers, and to cover final construction costs for VSQ.

Figure 16

PROGRAM REPORT
EXPENDITURES AND COMMITMENTS
CY-1977 CUMULATIVE ACTIVITY

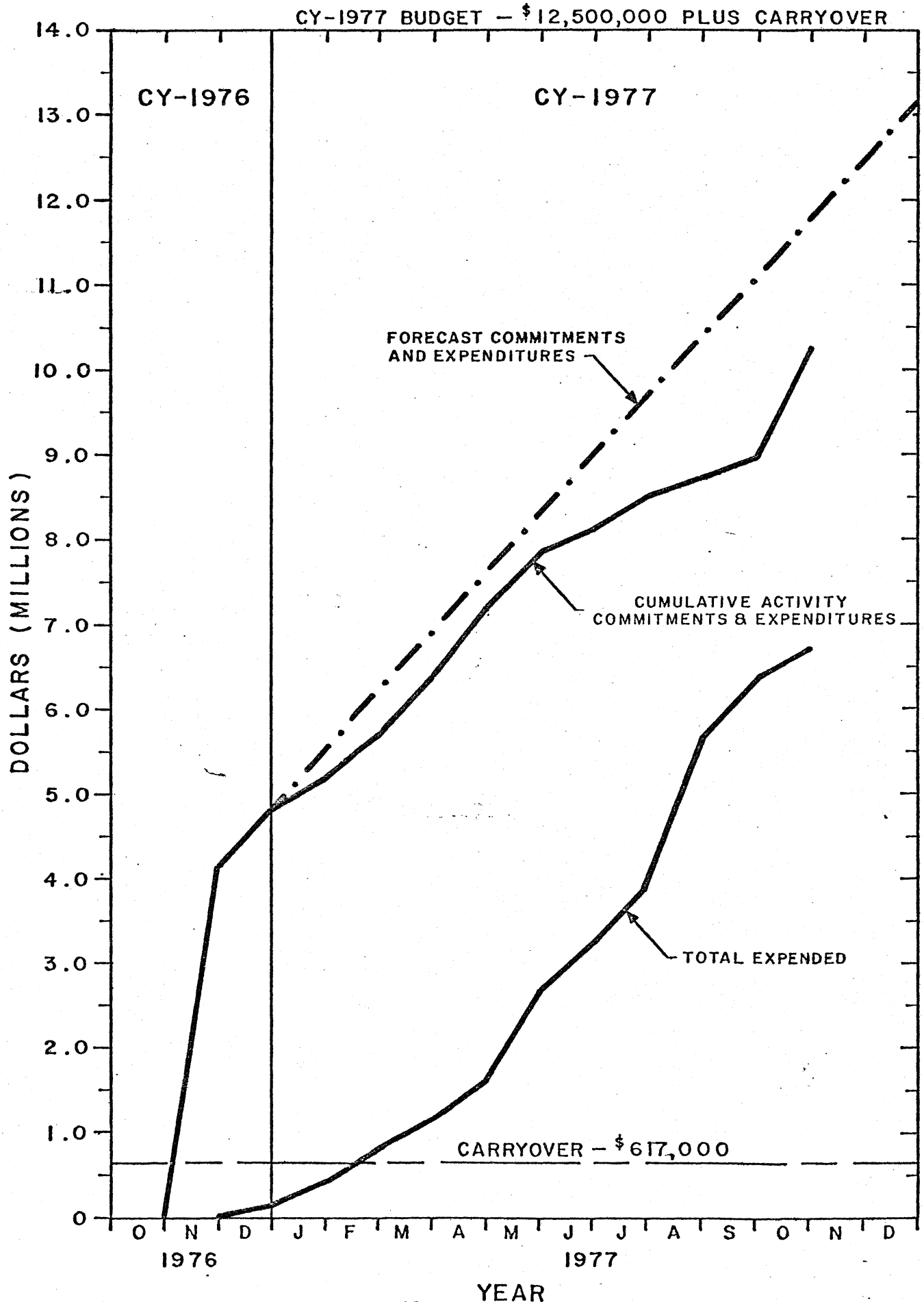


Figure 17

PROGRAM REPORT
EXPENDITURES AND COMMITMENTS
CY-1978 CUMULATIVE ACTIVITY

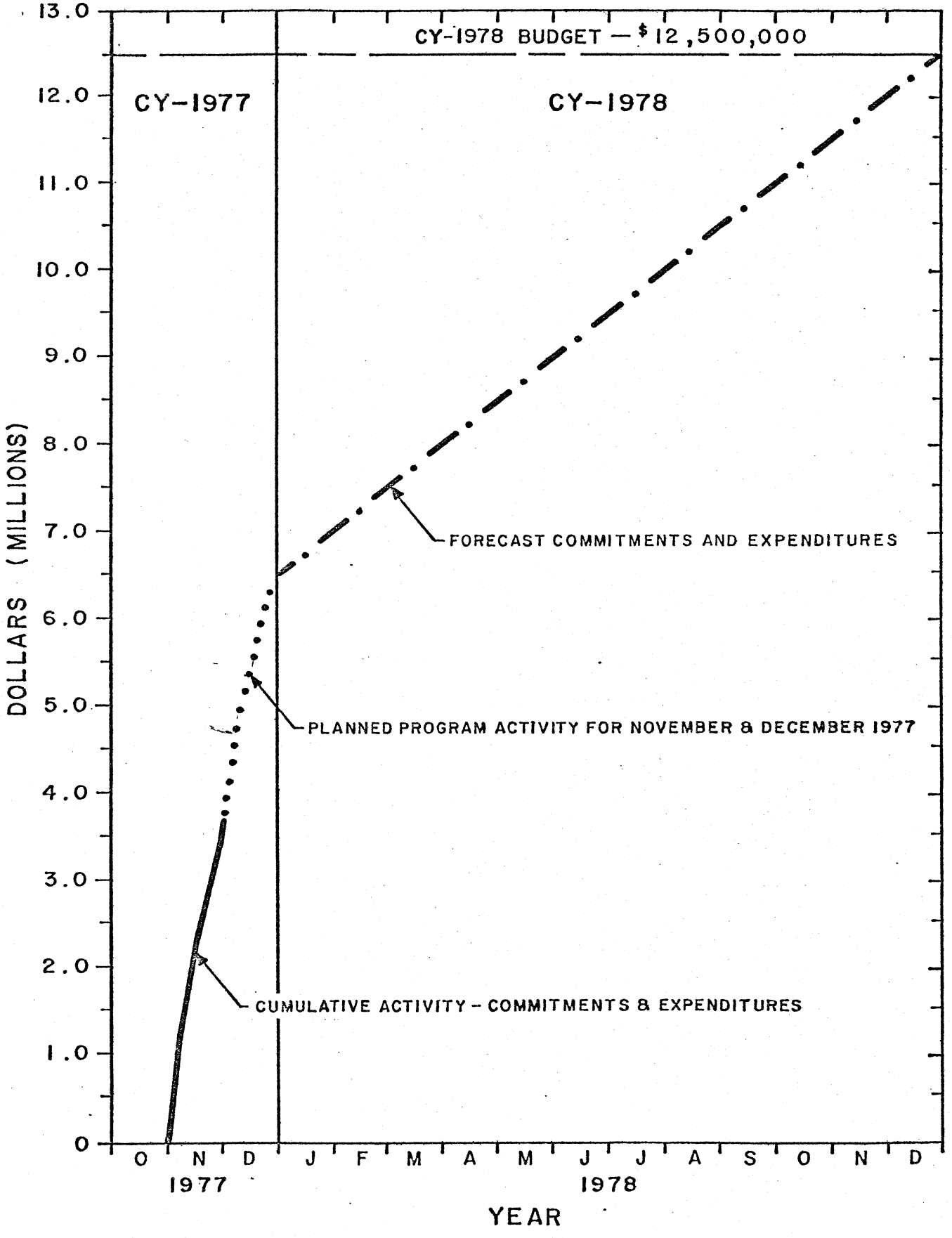


Figure 18

PROGRAM SCHEDULES

From 1973 until July 1975, a detailed PERT network was used to plan, coordinate, and monitor the progress of the design, development, procurement, fabrication, and test of the various complex subsystems required for the VLA. This took about one and one-half man years per year to accomplish the mechanics of the system plus considerable additional time of the scientists and engineers who had to input into the system. With the completion of the prototype electronics, the delivery of both computers, the delivery of the first two antennas, the move of the staff to New Mexico, and the start-up of the Systems Integration Group, it was decided to terminate the full PERT activity.

Work at the Site is being coordinated by an assistant to the Program Manager under the supervision of the Deputy Program Manager through the use of detailed bar schedules for the outfitting of each antenna. Weekly coordination meetings of approximately one hour duration are held each Monday morning, with department heads or designated representatives from all work areas present. Schedule achievements, problem areas, and specific plans for tasks to be accomplished during the week are reviewed. In Charlottesville, for the fabrication of the electronic components, PERT is still being used for scheduling and procurement purposes. There is attached, as Figure 19, a summary sheet for the 1977 fabrication of electronic modules, racks and bins. The computer is also being used to gather data on the myriad of electronic components for each module, coordinate the requirements, and deliver to the procurement staff consolidated lists. This saves multiple requisitions and purchase orders and results in quantity discounts, which in many cases are substantial.

There follows as Figure 20 a VLA ACTIVITY SCHEDULE Bar Chart dated 11/15/77, which is time-scaled to provide a concise, overall view of the entire Program. This chart is revised monthly to indicate the current status of the Program and is revised annually or at other times when major schedule changes occur.

The schedule as planned requires near maximum effort and facility utilization in the three principal work areas, Charlottesville equipment construction, antenna outfitting, and on-site maintenance, assembly, test, installation, and retrofit activity. New construction and installation proceed at a uniform rate which results in the well defined milestone of "first fringes" being achieved on Antenna #28 at the end of June 1980. No peak work load is generated that would require additional capital equipment or recruiting and training of personnel for only short-term employment.

By following this schedule, the final six months of CY 1980 are available for testing of the full 27 element array and upgrading the instrument to provide four channel capability.

NATIONAL RADIO ASTRONOMY OBSERVATORY
CYCLE CODE BAR CHART

PROGRAM 17NOV77 REPORT DATE. ELECTRONICS - MODULES, RACKS ELCVLA RUN DATE 18NOV77
PROJECT VLA ELECTRONICS MODULES, RACKS, BINS FOR 1977 ELC007

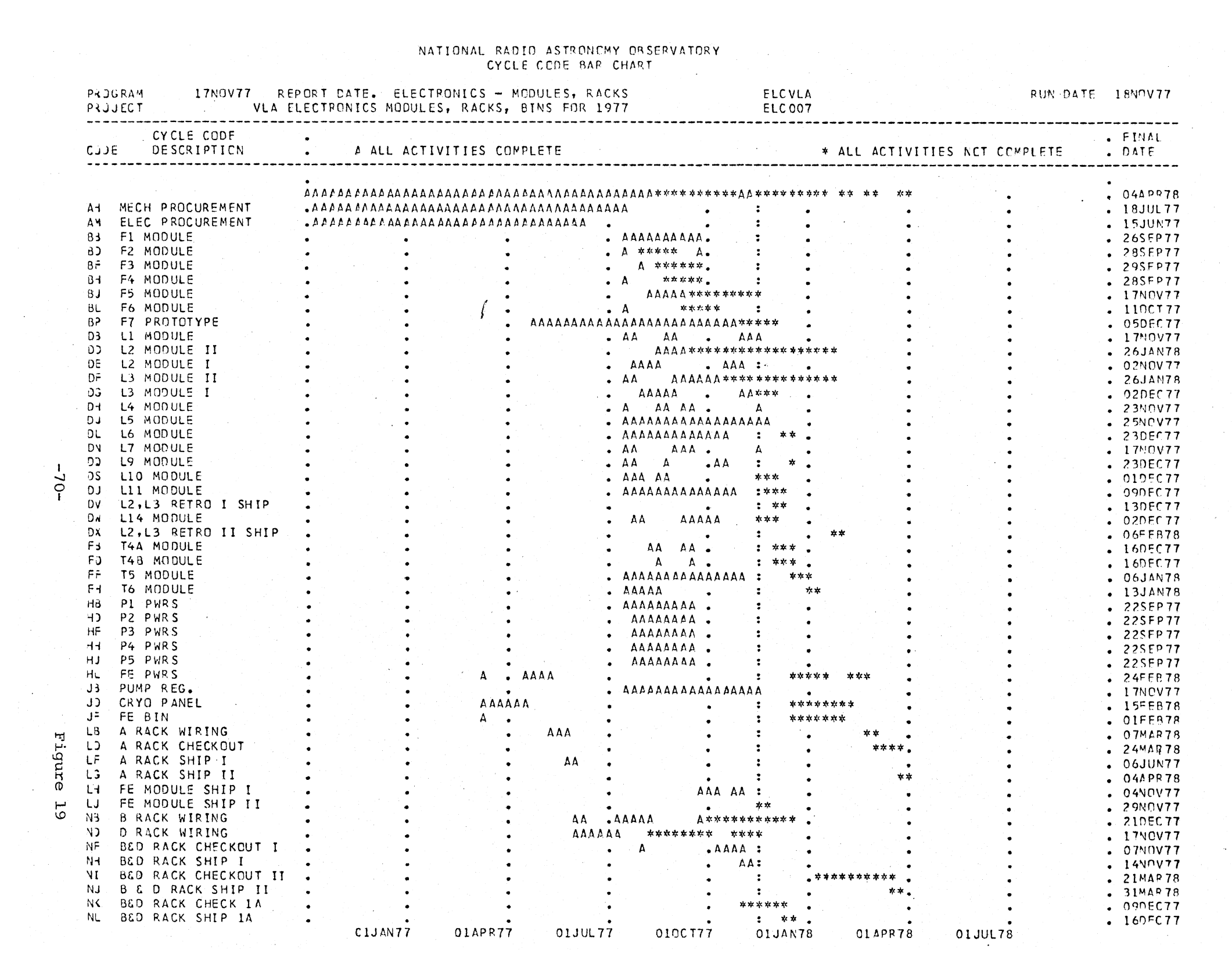
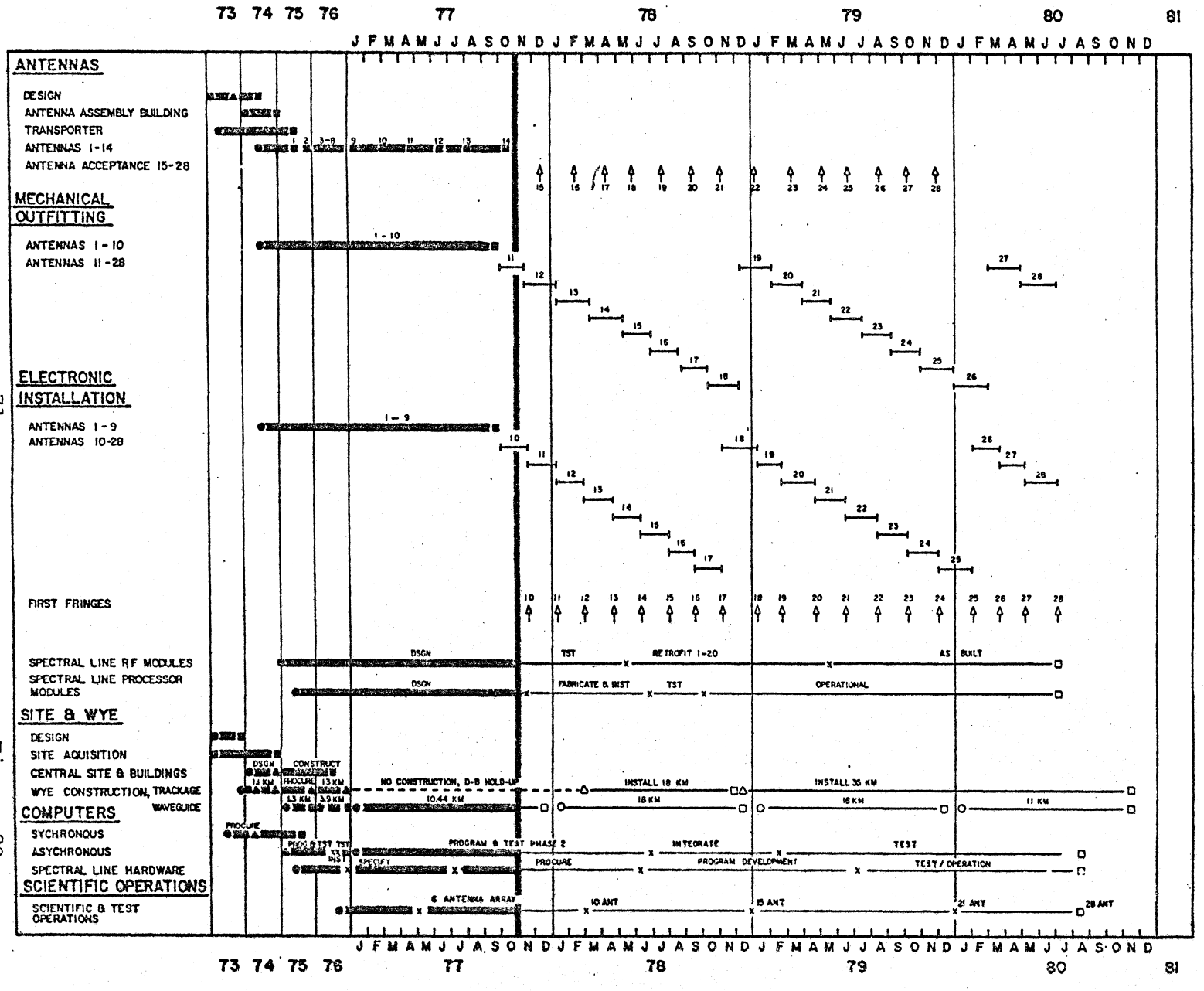


Figure 19

NATIONAL RADIO ASTRONOMY OBSERVATORY

VLA ACTIVITY SCHEDULE

UPDATE DATE: 11/15/77



ABBREVIATIONS

DSGN – DESIGN	TST – TEST
LAB – LABORATORY	PRELM – PRELIMINA
INST – INSTALL	OPNS – OPERATIONS
ANT – ANTENNA(S)	

SYMBOLS

O START OF A PHASE	△ CONTRACT AW
X END OF AN ACTIVITY	□ END OF A PHA
↑ SCHEDULED	↑ COMPLETED

REV. NO	REV DATE	DESCRIPTION

Figure 20

APPENDIX A

NRAO COMMITTEES

There are four major committees involved with the VLA - the NRAO Visiting Committee, the NRAO Users Committee, the VLA Advisory Committee, and the VLA Steering Committee. The first of these provides the AUI Board of Trustees with an independent appraisal of NRAO performance, including the VLA. The Users Committee and the Advisory Committee provide broad overall review and guidance. These two committees furnish scientific input and are the Program's liaison with the scientific community, thus assuring broad participation in the Program. The Steering Committee is responsible for more detailed reviews and advice on scientific and technical aspects of the Program.

The Visiting Committee and the Users Committee have been in existence for many years and both have been involved with the VLA since its early design stages. The Steering Committee is an outgrowth of the design group, which was formed in the fall of 1972. Each of the committees is described below in more detail and the current membership of each is given.

In addition to the above standing committees, various ad hoc committees will be appointed as needed for specific tasks, such as the evaluation of proposals and the selection of contractors.

NRAO VISITING COMMITTEE

This committee is appointed by the AUI Board of Trustees and formally reports to the AUI Board on an annual basis. Its function is to review the performance of the Observatory and advise the trustees on how well it is carrying out its function as a national center, the quality of the scientific work, and the adequacy of its instrumentation and facilities. A thorough review of the VLA Program will be conducted by this committee each year. The current membership of the committee is:

R. D. Ekers	Kapteyn Laboratory
W. A. Fowler	California Institute of Technology
C. E. Heiles	University of California, Berkeley
F. J. Kerr	University of Maryland
J. M. Moran	Smithsonian Astrophysical Observatory
J. P. Ostriker	Princeton University
V. C. Rubin	Carnegie Institution of Washington
R. W. Wilson	Bell Telephone Laboratories

NRAO USERS COMMITTEE

This committee consists of users, and potential users, of NRAO facilities from throughout the scientific community. It advises the Director and Observatory staff on all aspects of Observatory activities that affect the users of the telescopes - development of radiometers and auxiliary instrumentation, operation of the telescopes, the computer and other support facilities, and major new instruments. This committee is appointed by the NRAO Director. It meets twice a year, and a broad review and discussion of the VLA will be a principal item for these meetings throughout the life of the Program. The present membership of this committee is:

B. Balick	University of Washington
A. H. Barrett	Massachusetts Institute of Technology
J. J. Broderick	Virginia Polytechnic Institute
B. F. Burke	Massachusetts Institute of Technology
F. O. Clark	University of Kentucky
T. A. Clark	NASA - Goddard Space Center
M. M. Davis	Arecibo Observatory
W. A. Dent	University of Massachusetts
J. R. Dickel	University of Illinois
J. N. Douglas	University of Texas, Austin
F. D. Drake	Cornell University
W. C. Erickson	University of Maryland
D. M. Gibson	New Mexico Institute of Mining & Technology
S. J. Goldstein	University of Virginia
C. E. Heiles	University of California, Berkeley
D. R. Johnson	National Bureau of Standards
F. J. Kerr	University of Maryland
G. R. Knapp	California Institute of Technology
H. C. Ko	Ohio State University
M. R. Kundu	University of Maryland
A. E. Lilley	Harvard University
C. H. Mayer	U. S. Naval Research Laboratory
J. M. Moran	Smithsonian Astrophysical Observatory
P. Palmer	University of Chicago
A. G. Smith	University of Florida
L. E. Snyder	University of Illinois Observatory

P. Solomon	State University of New York (Stony Brook)
G. W. Swenson	University of Illinois
J. H. Taylor	University of Massachusetts
P. Thaddeus	Institute for Space Studies of New York
G. L. Verschuur	University of Colorado
J. F. C. Wardle	Brandeis University
J. W. Warwick	University of Colorado
G. Westerhout	U. S. Naval Observatory
D. R. W. Williams	University of California, Berkeley
R. W. Wilson	Bell Telephone Laboratories
W. J. Wilson	Aerospace Corporation, Los Angeles
B. Zuckerman	University of Maryland

VLA ADVISORY COMMITTEE

The Advisory Committee will periodically review the status and progress of the VLA. Its particular concern is with the broad elements of the Program, and especially those that directly influence the scientific capabilities and performance characteristics of the Array. It will advise on broad aspects of design, scientific emphasis, and priorities, as well as on general progress, to assist the Director and the Program staff in assuring that the scientific and technical specifications are met and that the VLA will be as responsive to the needs of radio astronomy as is possible. When scientific observing commences, this group may advise also on the observing programs to be carried out.

The committee is appointed by the NRAO Director. It is composed of scientists whose interests encompass all areas of radio astronomy and technology of concern to the VLA. An attempt is made also to maintain, in the membership, reasonable geographic distribution and representation of the major radio astronomy centers. The committee generally meets twice a year, depending on the nature of current Program activities and their rate of progress. The current membership of the committee is:

B. Balick	University of Washington
B. F. Burke	Massachusetts Institute of Technology
J. N. Douglas	University of Texas
F. D. Drake	Cornell University
R. D. Ekers	Kapteyn Laboratory
C. E. Heiles	University of California, Berkeley

M. R. Kundu	University of Maryland
A. T. Moffet	California Institute of Technology
A. E. E. Rogers	Haystack Observatory
G. W. Swenson	University of Illinois

VLA STEERING COMMITTEE

The Steering Committee is the principal technical review committee for the Program. Its principal function is to continuously review technical designs, construction plans, et cetera, to assure that they are consistent with overall performance goals and that staff or contractor technical decisions do not unknowingly affect the system's performance. In addition, the committee advises on technical matters, such as systems design, components design and selection, et cetera.

The committee is appointed by the NRAO Director. It is composed principally of NRAO scientists and engineers who are thoroughly familiar both with the scientific requirements and uses of the VLA and with the techniques and instrumentation employed in the VLA.

The current membership of the committee is:

R. L. Brown	D. E. Hogg
W. R. Burns	H. Hvatum
B. G. Clark	J. H. Lancaster
L. R. D'Addario	P. J. Napier
E. B. Fomalont	F. N. Owen
E. W. Greisen	L. Rudnick
D. S. Heeschen	A. R. Thompson
V. Herrero	N. Vandenberg
R. M. Hjellming	C. M. Wade