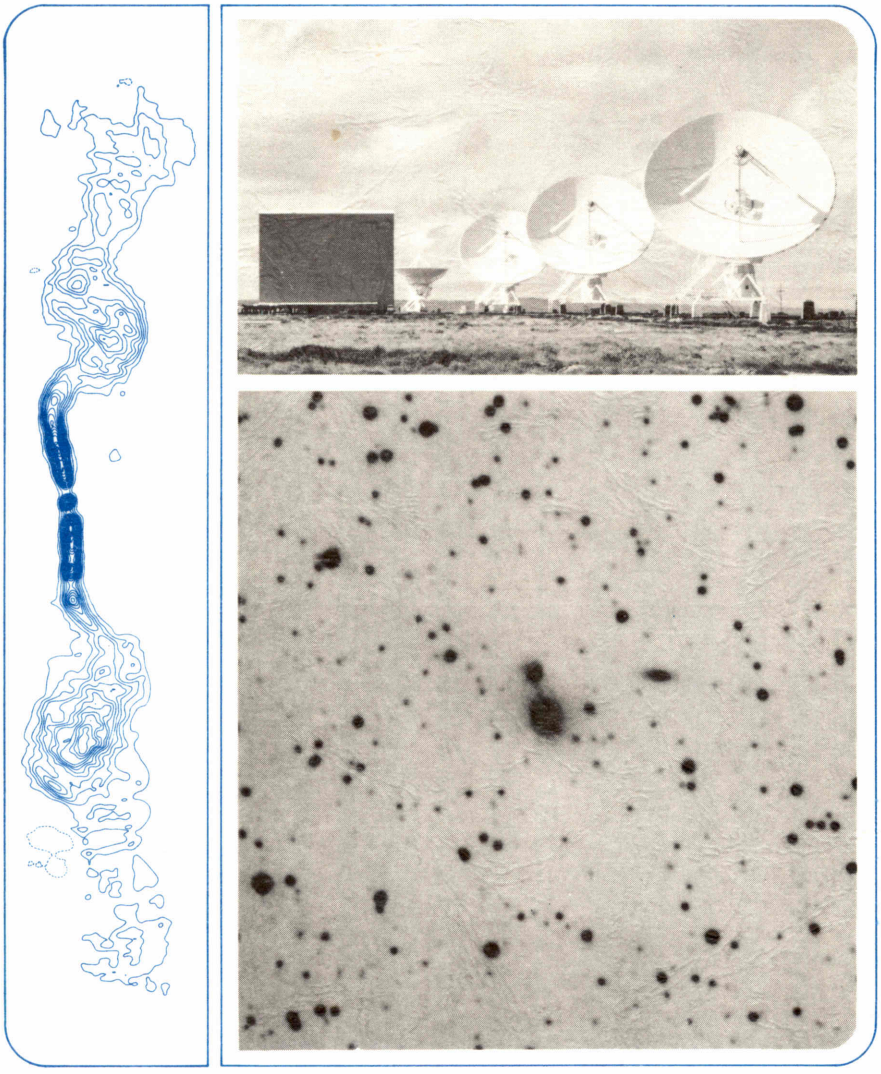
NATIONAL RADIO ASTRONOMY OBSERVATORY



PROGRAM PLAN 1980

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CALENDAR YEAR 1980 PROGRAM PLAN

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I. INTRODUCTION

The National Radio Astronomy Observatory is funded by the National Science Foundation under a management contract with Associated Universities, Inc. The role of the Observatory as a center for basic research in radio astronomy is implemented both by the operation of its major telescope systems and by research and development in the fields of advanced electronics and data processing.

During this year the available time on the completed portion of the VLA will continue to be under heavy observing pressure, as an increasing number of scientists begin to use it in their research. The operation of the three single dishes--the 36-foot millimeter wavelength telescope, the 140-foot telescope, and the 300-foot meridian transit telescope--will continue. The research planned for this period by the NRAO permanent staff and the visiting investigators is summarized in the following section. More than 60 percent of the observing time required for this research will be used by visiting investigators.

Section III of the Plan presents a program for the development of new research instrumentation for use on the telescopes. Particular emphasis this year is placed on the development of techniques and devices to be used at frequencies above 120 GHz, and on the continuation of the construction of low-noise systems for Green Bank. An investigation of various techniques that will be useful in the analysis of radio maps (VLA, VLBI, or single-dish line data) will be continued.

Subsequent sections give the detail of the expenditures required for operations and maintenance of the Observatory. A summary of the allocation of funds is given in Section IX, the Financial Plan.

Appendices to this Plan include a summary of the scientific program of the NRAO permanent staff, a list of the staff and their principal research interests, an organizational chart for the NRAO, a list of the various committees associated with the NRAO, and a financial status report for the NRAO interferometer program.

II. SCIENTIFIC PROGRAM

A complete detailed description of the scientific programs of visiting astronomers proposing to observe with NRAO telescopes during 1980 is, of course, impossible since the proposals will be received throughout 1980. Nevertheless the proposals already in hand for the first quarter of the year are undoubtedly typical of the observations that will be made. The following is a summary by telescope of some of the representative programs, although a number of the programs request time on more than one telescope.

The VLA - Even though the VLA is only partially completed, it continues to command wide interest in the community and is consequently heavily oversubscribed. The total number of antennas available for scientific programs will increase to the maximum 27 and all three arms will become fully usable allowing all four array configurations to be put in operation for various program resolution requirements. The multichannel spectral-line system has already successfully undergone astronomical tests using several antennas on simple point sources. Several more complex spectral-line mapping programs of stellar maser sources and of the velocity structure of external galaxies have been proposed in anticipation of the system's improved capabilities during 1980.

Solar system work planned for 1980 will be dominated by studies of active regions on the sun during the Solar Maximum Year and in conjunction with the Solar Maximum Mission scheduled for launch in January 1980. Special effort is being directed toward extending the north arm of the array to maximize its map making power during the early parts of the year when the sun is at low declinations. The fundamental problems being addressed include the evolution of magnetic structures during a solar flare, the detailed temperature structure above sunspots, and the nature of coronal holes. Other solar system problems to be investigated with the VLA focus primarily on the structure of the thermospheres of Venus, Saturn, Uranus, and Neptune, and the interaction of Io with Jupiter's magnetosphere.

In the area of stellar and galactic research many investigations will focus on either the earliest or the latest stages of stellar evolution. The power of the VLA will be used to study the morphologies and interactions of molecular clouds, compact HII regions, and OH/H_2O maser sources in young star-forming regions. Detailed radio wavelength analyses, complementary to existing optical studies, are now proposed for more highly evolved objects such as pulsars, x-ray binaries, mass losing stars, and supernova remnants. Other proposals will take a more detailed look at specific properties of the Galaxy, such as the structure of the source at the galactic center and the configuration of the all pervasive galactic magnetic field.

By far the greatest demand for VLA observing time will be in the area of extragalactic research, where the study of all types of objects--from normal galaxies to pathological radio sources and quasars--will benefit from the great sensitivity and high positional accuracy of the instrument. Numerous discoveries in this discipline are already attributable to the increased resoluton of the array. The individual structural components of normal galaxies of all Hubble types will be scrutinized for correlations with their optical properties. Many programs will continue to pursue earlier preliminary results concerning detailed morphologies, spectral index distributions, polarization, and variability of individual radio source components in an effort to establish the nature of the energy transport mechanisms which connect active compact nuclear components--through jets or bridges--to extended outer radio lobes. Particular attention will be paid to quasars where the cosmological distance interpretation may be influenced by attempts to detect faint outer structures and interactions with other sources. In general the radio astrophysics of previously unresolved faint radio source components will be pursued with the VLA.

The 36-foot Telescope - Surveys of the dynamics and morphology of the general molecular cloud population will continue, however it is expected that more attention will be focussed on specific regions of the interstellar medium. Young star formation regions will command a great deal of interest as the evolutionary relationships between large molecular clouds, IR sources, and HII regions become more detailed. Dark clouds will also be important for understanding the initial stages of star formation as appropriate laboratories in the search for molecules such as propynal, ethylene, cyanoacetylene and the CCH^+ ion. Other specific interactions to be studied include the chemistry across shocked boundaries and the effects of rapidly evolving Wolf-Rayet stars on molecular clouds.

The 36-foot telescope will continue with a CO survey to probe the molecular gas in external galaxies. Many programs in the 1 mm to 3 mm spectral range will take advantage of the completion of a new He^3 cooled bolometer to look with much improved sensitivity at compact extragalactic objects as well as stellar sources. The millimeter wavelength spectrum is a much sought after link between radio wavelengths and the IR/optical regime.

The 140-foot Telescope - Requests for galactic line work continue to be the most numerous among the problems proposed for the 140-foot telescope. General galactic studies to be carried out deal with the distributions of neutral hydrogen, OH, and HNCO. Other, more specific investigations, will search for CH in globular clusters and for NH_3 and HC_5N in suspected prestellar condensations in dark clouds. Several recombination line studies of HII regions have also been proposed. Prospective galactic continuum programs are aimed at high-frequency observations of the galactic center and at a detection of the 13 day periodicity in the thermal component of the peculiar source SS433.

Extragalactic work is principally concentrated in HI studies of galaxies and clusters. Also included are a search for radio recombination lines in quasars and a long-term monitoring program of variable radio sources. Of especially noteworthy interest is the anticipated availability of the new Model IV autocorrelator receiver with 80 MHz bandwidth, which now makes a number of the above programs feasible.

Very Long Baseline (VLBI) programs will continue to occupy approximately 25 percent of the observing time. Continuum observations will concentrate on the mapping of superluminal sources, on the study of compact components in normal and radio galaxies, and on astrometric and geodetic measurements. Line observations will continue to probe the detailed morphology of maser activity in star formation regions.

The 300-foot Telescope - This telescope is particularly well suited to surveys or to studies of a large number of selected objects, since in these cases the limitation imposed by the fact that the 300-foot is a transit instrument is of lesser importance. It is also useful to note that with the current 6-cm receiver the telescope is confusion limited at a level of about 5 mJy in one transit.

Active continuum programs include monitoring the variation of flux density of extragalactic variables and a study of the nature of the suspected supernova remnant, the CMa loop.

Line work envisioned for the next year includes extensive surveys of neutral hydrogen in selected types of galaxies as well as a search for HI in the outer portions of the Coma cluster of galaxies. A precise determination of the gas to dust ratio in directions in the Galaxy towards galaxies with known colors is also planned as an outcome of a detailed HI survey in those directions. Programs aimed at determining fundamental characteristics of quasars and the intergalactic medium will both search for red-shifted 21-cm absorption lines and search for 21-cm absorption features in quasar/galaxy pairs.

All proposals for telescope time, whether by visitor or staff, are sent for evaluation to referees who are not on the NRAO staff. The programs that are run on the telescopes represent the best of the proposals. It is anticipated that approximately 300 visitors will use the NRAO telescopes during 1980.

The program of the NRAO staff, which comprises about 30 percent of the total program, is described in greater detail in Appendix A.

III. RESEARCH INSTRUMENTS

The research instruments at the National Radio Astronomy Observatory consist of (1) the 140-foot telescope; (2) the 300-foot telescope; (3) the 36-foot telescope; and (4) the Very Large Array. At this time the bulk of the program of new instrumentation is in support of the first three telescopes. The VLA, still under construction, requires little equipment money at this point, although in the future it will become a major factor in this budget.

The CY 1980 program for new instrumentation has three categories, with budget allocations as follows (in thousands of dollars):

Item 1.	Other Observing Equipment	$1,005
Item 2.	Research Equipment	250
Item 3.	Test Equipment	45
	Total Available	$1,300

The estimated funds for research instruments will provide auxiliary instrumentation and equipment to maintain and improve the capabilities of the telescopes, including new systems development and modifications and upgrading of existing systems. The ability of the NRAO to maintain an active research and development program in electronic and computer hardware is essential if the Observatory is to continue in its role as the nation's principal center for research in radio astronomy. Because of rapid and unpredictable changes in "state-of-the-art" electronics hardware and unforeseen short notice

requirements of the scientific community, it is desirable that flexibility within the general area of the program be maintained. The table (on next page) shows the planned distribution of funds for the "Other Observing Equipment" account. The NRAO continually updates this table as scientific priorities change. These estimates provide funds for the completion of already started projects, items of continuing and general development, and funds for new development.

A. Other Observing: Items to Complete

The items expected to be completed in 1980 include:

1. 300-foot Low-Noise Systems. An upconverter-FET system, which will give low-noise coverage at 300-1000 MHz, will be completed in 1980.

B. Other Observing Equipment: Continuing Development Items

1. Maser, Upconverter System for the 140-foot Telescope. There will be continued development of a dual-channel upconverter-maser system giving very low noise temperature covering the frequency range 5-25 GHz. Also included is a dual-channel upconverter-maser system covering 1-5 GHz which can be used on either the 300-foot or the 140-foot telescope.

2. 40-50 GHz Maser. There will be continuing maser development; plans are for a maser covering 40-50 GHz.

3. 130-170/200-230 GHz Receivers. These receivers will cover the 130-170/200-230 GHz frequency range using cooled resistive mixers.

4. Millimeter Tube Development. This will cover development of backward wave oscillator tubes for atmospheric windows above 130 GHz. To be used as local oscillators for fundamental mixers to 390 GHz.

5. 1-3 mm Bolometer Receiver. One millimeter and three millimeter bolometer receiver for 36-foot telescope. Bolometer will be cooled to 0.36 K using ^{3}He.

6. VLA Map-Processor. Further work will be done on a VLA map-processor to enable observers to analyze VLA data.

7. VLBI. The plan includes the continuing development of Mark III VLBI recording terminals.

8. Diode Development. Development work on Schottky diodes will continue. The development is important for further improvements of millimeter receivers.

9. Computer Equipment: For upgrading of various telescope computers.

1. Other Observing Equipment (in thousands of dollars)

	Estimate to Complete (k$)	Estimate Continued Development (k$)	Estimate New Development (k$)
140-foot Telescope			
Maser, upconverter system		130	
Spectral-line receiver development			25
40-50 GHz maser development		50	
300-foot Telescope			
300-foot low-noise system	30		
36-foot Telescope			
130-170/200-230 GHz receivers		150	
Millimeter tube development		100	
1-3-mm bolometer		50	
Other			
VLA map processor		55	
VLBI		30	275
Diode development		60	
Computer equipment		50	
Subtotal	30	675	300
Total			1,005

C. Other Observing Equipment: New Development Items

The following new items are planned for 1980:

1. Spectral-Line Receiver Development. This will cover an investigation into the development of wide-band spectral-line receivers using state-of-the-art, high-speed integrated circuits in an autocorrelator. Also, an investigation of the feasibility of the acousto-optical spectrograph will be made.

2. VLBI. With the increased use of the VLBI Mark III technology, the following items are planned:

(a) A Mark III to Mark II interface that makes it possible to use the NRAO Mark II processor for processing Mark III tapes.

(b) The development of a network control system that will enable a user to control a network observing session and obtain online test fringes.

2. Electronics Research Equipment

Items funded under this part of the program are numerous smaller experiments and development projects--usually costing less than $20k each. These funds are made available in response to visitor and staff requests for minor modifications to existing observing equipment and relatively inexpensive "off-the-shelf" new items.

3. Electronic Test Equipment

These funds are used to add to and update the Observatory's general bank of test equipment for use in laboratories and also for monitoring and testing the complex observing systems on the telescopes.

Millimeter-Wavelength Instrumentation

The 25-meter millimeter wavelength telescope has been described in two volumes of a report, the second volume of which was sent to the NSF in July, 1977. The project is now awaiting favorable action by the Foundation. A program of soil samples will be started to provide the data necessary for specifications of the foundations of the astrodome and telescope. Also the search for the best possible surface plates is continuing.

IV. EQUIPMENT

No major equipment acquisitions are planned for 1980. The distribution of funds (in thousands of dollars) in the various equipment accounts is as follows:

1.	Maintenance, Shop and Repair Equipment	$ 20.0
2.	Office and Library Furnishings and Equipment	15.0
3.	Living Quarters Furniture	5.0
4.	Building Equipment	20.0
5.	Scientific Services and Engineering Equipment	15.0
6.	General Equipment for VLA Operations	50.0
	Total	$125.0

Item

1. Maintenance, Shop and Repair Equipment

Funds planned in this account provide for the replacement and/or acquisition of items for the shops at Green Bank, Charlottesville, and Tucson, and for the Green Bank maintenance division. Items included in this account are: tractors and mowers, replacement trucks and other vehicles, machine shop equipment, and several auxiliary items and accessories to be used with existing equipment.

2. Office and Library Furnishings and Equipment

These funds provide for replacement, updating and acquisition of typewriters, adding machines, desk calculators, desks, chairs, and other office furnishings for the Green Bank, Charlottesville, and Tucson sites.

3. Living Quarters Furnishings

These funds provide for replacement of household appliances and furnishings, such as beds, tables, lamps, draperies, carpets, etc., used in the residences at the sites.

4. Building Equipment

These funds provide for items that are generally attached to and become a part of the buildings. Included are such items as small air conditioners, small heating units, water heaters, etc.

5. Scientific Services and Engineering Equipment

These funds provide for small equipment additions in the darkroom, public education, and engineering divisions. Items such as cameras, film processing units, projectors, measuring equipment, etc., are included in this amount.

6. General Equipment for VLA Operations

An amount of $50,000 is estimated for expenditures at the VLA to provide new and replacement equipment items generally as described under Items 1 through 5 for other NRAO accounts.

V. OPERATIONS AND MAINTENANCE

Because the NRAO now has significant operations at four sites, we have found it desirable to adopt a presentation which more clearly reflects the estimated costs of the principal activities at the Observatory. These activities have been grouped into six operations units, as follows:

I. Research Support - This group is composed of the scientific research staff and the students (summer, co-operative, and Ph.D.). As well as undertaking research, the staff assists visiting observers in gaining familiarity with the NRAO telescopes, advises the technical divisions about modifications to equipment or the design of new equipment, and participates in the checkout and calibration of instrumentation.

II. Technical Support and Development - This unit has the general responsibility for the Observatory-wide technical and instrumental programs. The Central Development Laboratory explores new concepts in radiometers, and has provided design support for very long baseline and correlator development. The Computer Division operates the central computer and the VLB MK II processor, and assists in the development of programs for computers at the telescope. The Engineering Division provides engineering assistance to the operating sites, and undertakes the design of new facilities and telescopes. The Scientific Services Group maintains the central and branch libraries and provides technical illustration and drafting.

The Materials, Supplies, and Services (MS&S) budgets for the Central Lab, Computer, Engineering, and Scientific Services are $60k, $360k, $15k, and $130k, respectively.

III. Green Bank Operations - There are five divisions with the responsibility of maintaining and operating the 300-foot telescope, the 140-foot telescope, and the four-element interferometer, with developing new instrumentation for the single dishes, and with maintaining the Green Bank site. These divisions, and the 1980 MS&S budgets, are: Telescope Operations ($100k); Electronics ($140k); Shops ($22k); Plant Maintenance ($150k); and Administative Services ($125k). An additional $190k is required for communications and utilities, and miscellaneous revenue is estimated to amount to $100k.

IV. Tucson Operations - This smaller group maintains and operates the 36-foot millimeter wavelength telescope at Kitt Peak, and develops new instrumentation for the telescope. An important aspect of the recent work is the effort to obtain state-of-the-art radiometers at 2 mm and 1.3 mm. The MS&S budgets for this group include $185k for Operations and Maintenance and $120k for Electronics.

V. VLA Operations - This group continues to expand as the array approaches completion. The end of 1980 should see the full complement of 27 antennas, plus one spare, in operational status, and the number of people in VLA operations will reach 105 by the end of the year. At this year-end period, the array will be making astronomical observations at least

75 percent of the time. The four divisions--Array Operations, Scientific Services, Electronics Maintenance, and Antenna Maintenance--will require MS&S in the amount of $662k. The Operations' share of common cost is $878k.

VI. General and Administration - Included in this unit are the Director's Office, the Fiscal Office, and the Business Office, with total MS&S budget of $150k. Rent and maintenance of the Charlottesville buildings, including utilities, will require $285k. The management fee will be $220k.

A summary of the CY 1980 budget for these Operations Units is provided in the following table:

CY 1980 - OPERATION UNITS*
(in thousands)

		Salaries and Wages	Employee Benefits	Materials, Supplies, Services	Travel	Total
I.	Research Support	$1,025.0	$ 230.0	0	$205.0	$ 1,460.0
II.	Technical Support and Development	1,158.0	259.0	$ 565.0	60.0	2,042.0
III.	Green Bank Operations	2,076.0	465.0	627.0	33.0	3,201.0
IV.	Tucson Operations	500.0	112.0	305.0	40.0	957.0
V.	VLA Operations	1,425.0	320.0	1,540.0	65.0	3,350.0
VI.	General and Administration [1]	550.0	124.0	655.0	72.0	1,401.0
	Total [2]	$6,734.0	$1,510.0	$3,692.0	$475.0	$12,411.0

* New Funds Only
1 Includes Management Fee of $220.0k
2 Includes $476.0 for USNO Operations

VI. INTERFEROMETER OPERATIONS

Under a Memorandum of Understanding between the National Science Foundation and the U.S. Naval Observatory (dated September 26, 1978), the NRAO will continue to operate the four-element interferometer in Green Bank through 1980. The agreement may be extended for successive one-year terms at the mutual agreement of the parties. The status of the interferometer program is detailed in Appendix E.

VII. CONSTRUCTION

The construction of the Very Large Array (VLA) will continue in 1980, its final funding year, with new funds in the amount of $4,700,000. A detailed description of this program will be found in the VLA Program Plan submitted separately.

VIII. PERSONNEL

Personnel Services and Benefits (Level = Full-Time at December 31)

	1979			1980		
	Level	Salaries	Benefits	Level	Salaries	Benefits
Operations						
Scientific and Engineering	74	$1,949,000	$ 400,700	85	$2,453,000	$ 549,200
Technical	104	1,466,700	301,500	114	1,942,000	434,800
Administrative and Clerical	64	1,326,200	272,700	66	1,528,000	432,100
Operations and Maintenance	49	626,300	128,700	53	777,000	173,900
Total: Operations	291	$5,368,200	$1,103,600	318	$6,700,000	$1,500,000
VLA Common Costs	31	407,000	83,700	31	438,000	111,000
VLA Construction	40	755,000	155,300	28	633,000	160,000
Total Personnel	362	$6,530,200	$1,342,600	377	$7,771,000	$1,771,000

The Personnel Levels shown for 1980 include ten persons directly associated with the Interferometer.

IX. PRELIMINARY FINANCIAL PLAN - 1980
(in thousands)

	Actual CY 1978	Actual* CY 1979	Commitments to 1980	Uncomm. Funds, to 1980	New Funds 1980	Exp & Comm. 1980
I. SCIENTIFIC RESEARCH						
A. Operations						
Personnel Compensation	$ 4,763.9	$ 5,368.2			6,734.0	6,734.0
Personnel Benefits	995.4	1,103.6			1,510.0	1,510.0
Travel - Domestic	334.6	399.9			445.0	445.0
Travel - Foreign	19.3	6.0			30.0	30.0
Other MS&S	2,288.3	2,670.8	$ 482.1	$ 160.8	3,472.0	4,114.9
Management	165.0	210.0			220.0	220.0
Subtotal	$ 8,566.5	$9,758.5	$ 482.1	$ 160.8	$12,411.0	$13,053.9
B. Equipment						
Research Equipment	$ 752.8	$1,075.6	$ 350.0	$ 614.4	690.0	1,654.4
Operating Equipment	381.1	70.0	5.8		125.0	130.8
Subtotal	$ 1,133.9	$ 1,145.6	$ 355.8	$ 614.4	$ 815.0	$ 1,785.2
Total - Scientific Research	$ 9,700.4	$10,904.1	$ 837.9	$ 775.2	$13,226.0**	$14,839.1
II. CONSTRUCTION						
Very Large Array	$10,277.8	$13,120.0	$6,000.0	$(1,766.5)	$ 4,700.0	$ 8,933.5
Total Construction	$10,277.8	$13,120.0	$6,000.0	$(1,766.5)	$ 4,700.0	$ 8,933.5
TOTAL	$19,978.2	$24,024.1	$6,837.9	$ (991.3)	$17,926.0	$23,772.6

*Est. @ 11-01-79 ** Includes $476.0 for USNO operations.

PRELIMINARY FINANCIAL PLAN - 1980
(in thousands)

	Actual 1978	Actual* 1979	Commitments to 1980	Uncomm. to 1980	New Funds** 1980	Total Available for Exp. & Comm. 1980
A. OPERATIONS						
1. Excludes VLA						
Personnel Compensation	$4,216.5	$ 4,345.3			$ 5,309.0	$ 5,309.0
Personnel Benefits	882.6	888.8			1,190.0	1,190.0
Travel	312.9	328.8			410.0	410.0
Other MS&S	1,764.3	1,764.3	$428.0	$135.0	$ 1,932.0	2,495.0
Management Fee	165.0	210.0			220.0	220.0
	$7,341.3	$ 7,537.2	$428.0	$135.0	$ 9,061.0	$ 9,624.0
2. VLA Only						
Personnel Compensation	$ 547.4	$ 1,022.9			$ 1,425.0	$ 1,425.0
Personnel Benefits	112.8	214.8			320.0	320.0
Travel	41.0	77.1			65.0	65.0
Other MS&S	202.8	209.6	$ 54.1	$ 25.8	662.0	741.9
Common Costs	321.2	696.9			878.0	878.0
	$1,225.2	$ 2,221.3	$ 54.1	$ 25.8	$ 3,350.0	$ 3,429.9
Total Operations	$8,566.5	$ 9,758.5	$482.1	$160.8	$12,411.0	$13,053.9
B. EQUIPMENT - TOTAL	$1,133.9	$ 1,145.6	$355.8	$614.4	$ 815.0	$ 1,785.2
TOTAL - SCIENTIFIC RESEARCH	$9,700.4	$10,904.1	$837.9	$775.2	$13,226.0	$14,839.1

* Estimated @ 11-01-79 ** Includes $476.0 for USNO operations

APPENDIX A

RESEARCH PROGRAMS FOR THE NRAO SCIENTIFIC STAFF

The permanent staff of the NRAO has planned for 1980 to work in a number of research areas, as described below. Some of the research will be done in collaboration with visiting scientists.

A. SOLAR AND PLANETARY STUDIES

The continually improving synthesized VLA beam for observing at solar declinations in combination with the anticipated high degree of solar activity during 1980, the "Solar Maximum Year", have made possible a planned study of solar active regions. Observations making use of the high angular resolution of the VLA will be made in an attempt to understand the relation of polarized and unpolarized radio emission regions with magnetic field structures and neutral regions. The expressed interest in solar observations during 1980 has already lead to modifications in the normal VLA gain calibration procedures with the installation of an appropriate switchable attenuator for use with normal VLA calibrators.

Several investigations have been proposed making use of the VLA for planetary studies. The characteristics of the atmospheres and magnetospheres of Io, Titan, Uranus, and Neptune will be the subject of one study aimed primarily at providing higher accuracy data in order to test current theories. The integrated nonthermal radio emission from Jupiter will be mapped in detail in order to resolve apparent conflicts between the currently known emission and the distribution of the source relativistic electrons as probed by Pioneer.

Astrometric measurements of several minor planets throughout their entire orbits around the sun are planned with the VLA. Two principal results of fundamental interest are hoped for: a refined location of the vernal equinox and the establishment of an absolute VLA reference frame without reference to any optically determined standard.

B. GALACTIC STUDIES

1. The Structure of the Milky Way and the Galactic Center

Two areas of the Green Bank OH survey will be extended to answer the questions (i) What is the scale height of the OH distribution perpendicular to the galactic plane, and how does it compare with that of CO, HII regions, and supernova remnants? (ii) What is the luminosity function of OH masers?

In the inner galactic regions an extensive mapping program of ^{13}CO in the longitude interval 30° to 50° will be undertaken in order to derive a

better estimate of molecular cloud sizes and intercloud velocity dispersions. Former investigations of low-latitude molecular emission spectra have concentrated almost exclusively upon the observation of the more abundant CO isotope and have suffered the consequent blending of individual line profiles at velocities near the terminal velocity where the two-fold distance ambiguity is normally removed.

The previously described morphology and kinematics of gas within 2 kpc of the galactic nucleus involving a non-coplanar gas distribution and pervasive non-circular motions were based on HI observations over the inner 400 square degrees of the Galaxy. An atlas describing the many very high sensitivity observations will be prepared. As a continuation of the study a survey of CO emission in the vicinity of Sgr A and Sgr B is underway in an effort to decipher the puzzling small-scale behavior of these source.

Twenty-one centimeter observations with the Arecibo, Westerbork, and Green Bank 300-foot and VLA telescopes will be employed in a study of the hierarchy of sizes of interstellar condensations. Various mathematical techniques will be used to describe the galactic HI brightness distribution, including autocorrelation analysis and fluctuation statistics. The final goals of the study are to identify the various physical processes which cause condensations in the interstellar medium and to trace the development of instabilities of different sizes in the gas.

CO emission profiles towards globular clusters will be measured in order to study the H_2 contribution to the gas/dust ratio. This should also provide some information on the high-latitude (nearby) molecular gas.

The suggestion of a bar at the center of the Galaxy necessitates a more thorough study of the morphlogy of the continuum ridge underlying the Sgr A-East component. Since an 89 GHz map of the area sheds doubt on the conventional nonthermal interpretation of the Sgr A-East spectrum, an analysis at an intermediate frequency of 22 GHz will be carried out.

Analysis of a 120-point map of CH in the galactic center will continue in parallel with the analysis of the interstellar chemistry of CH utilizing a previous survey of CH in many other regions of the Galaxy.

A study is underway which analyzes ^{12}CO emission in the direction of moderately reddened early-type stars. By using the presence of narrow interstellar absorption lines, the observations, when compared to optical results, may provide some insight into the lack of correlation of molecular column density (in species other than H_2) with extinction. This strongly impacts all models of interstellar chemistry since they are influenced by the assumed extinction, and at present none of the models readily reproduce the qualities of the observations.

In certain directions toward extragalactic continuum sources it will be possible to use the relatively higher spatial resolution of molecular

^{12}CO measurements as opposed to 21-cm data to study the diffuse interstellar gas. Previous studies towards specific sources have already detailed a possible correlation beween observed ^{12}CO antenna temperature and HI column density, and this analysis will be extended.

As a further probe of the interstellar medium, a program will be carried out with the VLA to search for interstellar scintillation of weak extragalactic sources. Once detected these scintillations provide valuable information on the small-scale irregularities in the ISM, as well as constraining models for radio source variability.

2. HII Regions, Infrared Sources, and Planetary Nebulae

A VLBI study of high velocity H_2O masers will be continued. An extremely detailed map of W49N, produced last year, will be analyzed and maps of other sources will be produced. The geometry of the regions in which the high velocity features originate is unclear. Specifically, it is unclear if all the high velocity features in a given source such as W49N are the result of some global phenomenon or if they are related to several centers of activity. The observations should help clarify the geometry and should, in turn, help specify the geometry of a star formation region.

The VLA will be used to search for ultra-compact continuum sources, representing the earliest luminous phases of newly formed massive stars still within their dense placental cocoons, at the positions of Type-I OH masers. Accurate positions for several more such masers, needed for this project, have recently become available from VLA observations made last year.

Ionization front driven star formation at the edge of a molecular cloud will be studied numerically using a two-fold combined hydrodynamics and radiation transfer two-dimensional code. The aim of the project is to understand the means by which discrete OB associations are formed at the edges of molecular clouds.

Dense gas in active star formation regions will be the subject of another series of studies using both the 140-foot telescope and the Arecibo telescope. The particular tracers to be used will be 6 cm H_2CO, and OH emission from DR 21 and W49 will be studied, and quasi-thermal behavior will be sought in other excited states. A new variety of OH maser associated with Herbig-Haro objects will also be investigated.

The new Mark IV autocorrelator on the 140-foot telescope has a bandwidth sufficiently wide to allow simultaneous observations of the H and He radio recombination lines in the same spectral window. A program is therefore envisaged to reassess the He^+/H^+ ratio in 30 galactic HII regions. Former observations have been limited by difficult calibration procedures which the new autocorrelator circumvents. The cosmologically fundamental He^+/H^+ abundance ratio will provide interpretive information on the temperatures and densities in the HII regions studied.

The apparently thermal radio emission exhibited by approximately 20 stars will be further confirmed through five-point spectral analysis. The objects are generally associated with IR sources and may be circumstellar shells or compact planetary nebulae. The analysis will also search for deviations from spherical symmetry in the structure of the stellar envelopes. A general survey of known planetary nebulae will also be extended to cover spectral information at 22 GHz.

Observation with two widely different resolutions of Wolf-Rayet stars in symmetric nebulae will be combined in order to estimate the duration of the evolutinary stage during which WR stars lose mass. VLA observations will yield the rate of mass loss whereas single dish measurements will yield the total mass lost by each star, assuming that it is contained in the currently detectable symmetric nebulae.

3. Radio Stars, Pulsars, Novae, and Supernovae

VLBI observations begun last year on the peculiar galactic object SS433 will be continued in an effort to determine any time-dependent effects. SS443 may be similar to the powerful extragalactic radio sources in that it shows jet structure and is seen on size scales covering many orders of magnitude. However, it is much smaller and closer and varies on much shorter time scales, thus making itself particularly attractive for monitoring observations. Preliminary results give a position angle consistent with the supernova remnant, W50, and a precessing jet model based on optical observations.

The VLA has proven to be an important tool in the study of radio stars. Plans are underway to complete a detailed aperture synthesis of the Sco X-1 triple radio source in order to accurately delineate the structure of the radio emission and to evaluate the reality of suspected changes in the extended part of the radio structure. The moving radio "jets" around SS443 will also be monitored and possibly correlated with any time-dependent effects from the abovementioned VLBI program.

The evolution of the radio emitting shell associated with Nova Vulpecula 1976 will continue to be monitored and modelled. The 1400 MHz flux from the supernova remnant Cas A has been measured with the Green Bank interferometer and will be continued with the intention of possibly stepping lower in frequency, to around 400 MHz.

An attempt will be made to confirm the detection of interstellar scintillation toward a continuum source in W66. If this is in fact a new type of object with very small angular size (but not a pulsar), a search will be initiated with the Green Bank 300-foot telescope for other similar sources.

4. Molecular Line Studies

Searches, using the new 7-16 GHz receiver on the 140-foot telescope, are planned for the following molecular species: NH_2, acetone, NH^+, $HC\ell^+$ CO-dimer, and rotationally-excited CH. Also, a confirming transition for CH_2ND will be sought. A search for atomic hydrogen fine-structure emission will also take place.

The long-standing project to identify what now amounts to about 200 U-lines will continue. Observations of the 80-115 GHz region for such lines will be completed. These observations will seek confirming lines from a dozen or so new species that have been tentatively identified in this program, and will particularly emphasize possible ring compounds, hitherto unknown in the interstellar medium.

Searches for NHD and HDS will be made. A confirmation of the previous tentative detection of CCD will be attempted. The new species, along with other deuterated molecules, will be analyzed in terms of ion-molecule formation schemes which so far explain the strong deuteration of many interstellar species adequately.

The previously detected and elusive NO radical will be studied in some detail as soon as reliable 2-mm klystrons are available for the improved (cooled) NRAO receiver. NO is a very sensitive tracer of nitrogen chemistry in dense interstellar clouds.

An analysis of the detection of the ν_4 state of ammonia will be made. The ν_4 state is highly excited ($\sim$2500 K) and therefore must utilize infrared radiation rather than collisions for its excitation; yet the ν_4 state is not observed in the Orion cloud, known for its strong IR fields, but rather only in Sgr B, yielding another indication of the highly unusual conditions that must occur in this unique molecular source.

Calculations and analysis of the behavior of formaldehyde lines in turbulent molecular clouds over a wide range of density, kinetic temperature, and molecular abundance will continue. The associated study of formaldehyde excitation and radiation transport in dark and molecular clouds still suffers from sufficiently detailed observational characteristics to allow an adequate comparison between cloud models and observation.

Observations of OH, H_2CO, CH, and CO in diffuse molecular clouds with prominent HI absorption features are planned. The objectives are to compare the molecular line center velocities and velocity widths with the corresponding HI absorption lines to measure the internal velocity structure of diffuse clouds. Separation of the contributions of thermal and turbulent motions to the line shapes may be possible. Comparison of brightness distributions of molecules with different excitation structure may also give information on the variation of physical properties on small angular scales.

C. EXTRAGALACTIC STUDIES

1. Normal Galaxies

Many problems continue to demand detailed observational material in order to better understand the differences between galaxies and their comparison to the Milky Way. The traditional field of extragalactic hydrogen will receive continued emphasis in order to probe the distribution and kinematics of this major constituent of galaxies. Continuum and line emission of several samples of spirals, barred spirals, and irregulars will be studied with all of the NRAO telescopes.

A VLA study of the radio continuum structures of clumpy irregular galaxies will be undertaken. These galaxies are also being extensively studied at many other wavelengths. They appear to contain supergiant HII regions in which star formation may be proceeding at a very active rate.

A program is underway to explore the continuum structure of the barred spirals using the VLA in the context of exploring the radio continuum associated with the dust lanes and hot spots in the bars.

The radio nuclei of selected spiral and Seyfert galaxies will be scrutinized with the VLA and with VLBI observations. The correlation between the radio structure and the shape and intensity of the forbidden line emitting region of the Seyfert nuclei will be searched for. Compact radio components in other nearby galaxies will be explored for the effects of galaxy interaction and Hubble type on nuclear emission. Hydrogen recombination-line emission stimulated by nuclear continuum sources will be searched for in selected spirals and irregulars, and galaxies with suspected strong thermal components will receive further 3-mm continuum analysis.

Normal elliptical galaxies will also receive continuing attention in a study of their variability, polarization, and structure. With the help of large samples of optical data, a program will also be carried out in order to understand the frequency and distribution of optical emission line regions in elliptical galaxies. Influencing factors include the presence or absence of a radio nonthermal continuum source, the total optical size and luminosity, and the galaxy's possible location and kinematics in a cluster of galaxies.

The analysis of the molecular components of galaxies continues to receive high priority. Surveys of various samples of nearby galaxies will therefore be pursued, and maps of known sources such as M83, NGC 253, NGC 6946 and IC 342 will be correlated with other radio, IR, and optical data. Additional attempts will be made to delineate spiral structure in CO. OH, which has presently been detected in six galaxies, will be searched for in additional galaxies using the Arecibo telescope. HNC will be sought for in M82. H_2CO absorption against nuclear continuum sources should be present in a few galaxies and nearby face-on systems will be inspected for H_2CO

anomalous absorptions. All of the above molecular surveys will continue to shed light on the nature of star forming regions in external galaxies according to their morphological type and as compared to molecular clouds in our Galaxy.

Supernovae and supernova remnants in external galaxies will continue to be an area of major interest and a good test for the capabilities of the VLA. The 1979 supernova in M100 was not a detectable radio emitter just after its optical discovery but further attempts to map it will be made in 1980. The characteristics of the radio emission as a function of time and frequency will be sought. The radio spectrum and polarization of a peculiar optical object near the center of NGC 4449 will be obtained with the VLA in order to test its possible interpretation as a supernova remnant that is potentially much younger than Cas A in our Galaxy.

2. Radio Galaxies and Quasars

Attempts to understand the morphologies, energy generation mechanisms and evolution of radio galaxies will figure prominently in the overall research effort. One of the brightest and closest radio galaxies, Fornax A, will be mapped in detail with the VLA. Observations of M87 with the VLA and the VLBI network will be combined with previous observations in order to test the apparent magnetic field structure. A theoretical investigation of this galaxy is also underway to test if the distorted radio and optical line emission can be explained by motion of the galaxy relative to the center of mass of the cluster to which it belongs. Galaxies with strong nuclear continuum sources that show evidence of either flat spectra or very compact structure will be surveyed for 3-mm emission.

Investigation of the variability of extragalactic sources will continue, with 140-foot, 300-foot, and 36-foot observations. A homogeneous sample of sources has been selected and some of its variability parameters determined. Further establishment of the frequency and time dependence of the variability is now desired. Multifrequency monitoring of 20 sources found to be variable at 318 MHz will be started.

VLBI observations are also being carried out of 10 selected extragalactic sources at 6 and 18 cm. The spectra of these objects indicate that they may be inhomogeneous synchrotron sources or sources which emit synchrotron radiation from a relativistic Maxwellian electron distribution. The VLBI observations will be used to tell if (a) the structure of the sources is dominated by a single component, and (b) if the angular size scales with frequency in the manner expected of an inhomogeneous synchrotron source.

Recently it has been found that many compact radio sources with angular size of several milliarcsec are also associated with arcsecond, steep spectrum emission. The morphology of these sources suggests that they are not obviously related to the more classical double radio sources. Observations of about 40 of these sources will be made using the VLA.

The study of small scale jets in quasars and radio galaxies is an important subject in distinguishing the differences between "classical double" steep spectrum extragalactic sources and compact flat spectrum objects. Small scale objects, such as 3C 147, 3C 138 and others, will be mapped with the high resolution of the VLA in order to study the astrophysical models of jets incorporating geometric and relativistic beaming effects. Dual polarization maps of the sources with jets will contain information on the magnetic field configurations and parameters associated with the thermal density.

Work on a model for energetic electron transport in double radio sources is proceeding. This model seeks to explain the lack of large spectral index gradients as due to compensation of synchrotron losses by pitch angle scattering of electrons from a low-pitch angle "reservoir". Previous work on this topic yielded an analytic solution to the Boltzmann equation for cosmic ray transport which predicted zero spectral index gradient. The next phase of the project will consist of a numerical solution of a more general equation and will incorporate more realistic boundary conditions. Detailed comparisons with observations are planned.

A study is planned of the propagation of high energy electrons in high temperature, low magnetic field plasma, paying particular attention to the growth and damping of Alfven waves that interact resonantly with the particles under such conditions. Another approach to particle acceleration mechanisms will re-examine first and second order Fermi mechanisms using a realistically calculated self-consistent turbulence spectrum.

VLBI observations of very high redshift quasars will be continued in a search for possible evolutionary and/or cosmological effects. Very preliminary results suggest these objects may be smaller than closer quasars but the statistics are very poor so far. A systematic set of observations to compare sizes of near and far QSO's will be initiated.

Radio recombination lines from the brightest quasars will be searched for using the newly developed broadband autocorrelation receiver on the 140-foot telescope. Previous searches for redshifted 21-cm absorption lines will be pursued in a sample of quasars that have extremely compact radio cores. The detection of this line in 3C 286, 0235+164, 1229-021, and 1331+170 provides compelling evidence that the material in which the absorption arises is not located in the vicinity of the energetic quasar; rather it is gas located along the line of sight to the quasar but unrelated to the quasar. This is a valuable test of the nature and origin of the optical absorption lines toward quasars.

VLA observations of two complete samples of quasars discovered by objective-prism spectroscopy will be analyzed. Quasars selected as variable ultraviolet-excess objects will be observed with the VLA to see if more are active radio sources than those discovered spectroscopically.

Millimeter-wavelength observations of the optically brightest quasars will be made using the newly developed bolometer on the 36-foot telescope. These measurements should detect or put limits on the quasar spectrum as it cuts off toward longer wavelengths.

A program has been started to investigate the radio structures of some of the highly peculiar galaxy-QSO pairs found by Arp and others. The VLA will be used to define structures and to try and determine the relationship, if any, between the pair members.

VLA maps and optical identifications of 200 sources stronger than 10 mJy from the NRAO 6-cm deep survey are nearly complete. Optical spectra of the 24 quasar candidates will be obtained. The 6-cm number counts down to 1 mJy will be determined statistically. Fourteen hundred megahertz flux densities of the survey sources will be measured.

3. Cluster Sources and Clusters of Galaxies

A 20-cm VLA survey of sources in the directions of rich clusters of galaxies discovered with the 300-foot telescope will continue. This survey, among other things, will provide the basic data for statistical comparison with x-ray maps from the Einstein x-ray satellite.

Analysis of existing VLA data for a number of head-tail radio galaxies, including NGC 1265, 3C 66B, and 3C 465 will continue. These head-tail sources have also stimulated a study of the role of shear flow instabilities in producing such environmentally distorted radio structures in clusters of galaxies.

High resolution radio studies of spiral galaxies in clusters will be made in order to examine the interaction of the galactic disks with the intergalactic cluster medium. For high redshift clusters ($z = 0.3$ to 0.6), high resolution radio observations should provide direct evidence for evolution of the radio galaxy luminosity function and of the evolution of radio galaxy structure.

Optical, x-ray and radio high resolution imagery of the quasar PKS 0837-12 is planned. PKS 0837-12 is imbedded in an underlying nebulosity and surrounded by several faint objects, thus suggesting membership in a cluster of galaxies with the quasar possibly at the center of a bright galaxy.

Using a recently developed technique for calculating the temporal evolution of three dimensional MHP turbulence, the origin of the magnetic fields observed in clusters of galaxies will be investigated. Turbulent "stirring" by the member galaxies may provide the required dynamo mechanism.

D. MISCELLANEOUS

The VLA offers exciting possibilities for the measurement of accurate radio positions. Programs now under consideration include a study of approximately 50 pulsars, to compare the interferometric positions with the timing positions, the measurement of the parallax and proper motion of selected radio stars, and the measurement of the positions of asteroids, with a view towards refining the fundamental coordinate system. Positional accuracy of 0.07 arcsec can now be achieved and this should improve to about 0.02 arcsec within a year.

Continued research effort will be applied to the study of possible methods for improving the 140-foot telescope. A strengthened deformable subreflector is already foreseen as well as a fixed shift of the Sterling mount to make the telescope performance symmetrical. Possible additional work will include a computer controlled variable shift for avoiding strong coma sidelobes and the use of a two-feed method for accurate surface measurements.

APPENDIX B

NRAO PERMANENT SCIENTIFIC STAFF WITH MAJOR SCIENTIFIC INTERESTS
(November 1979)

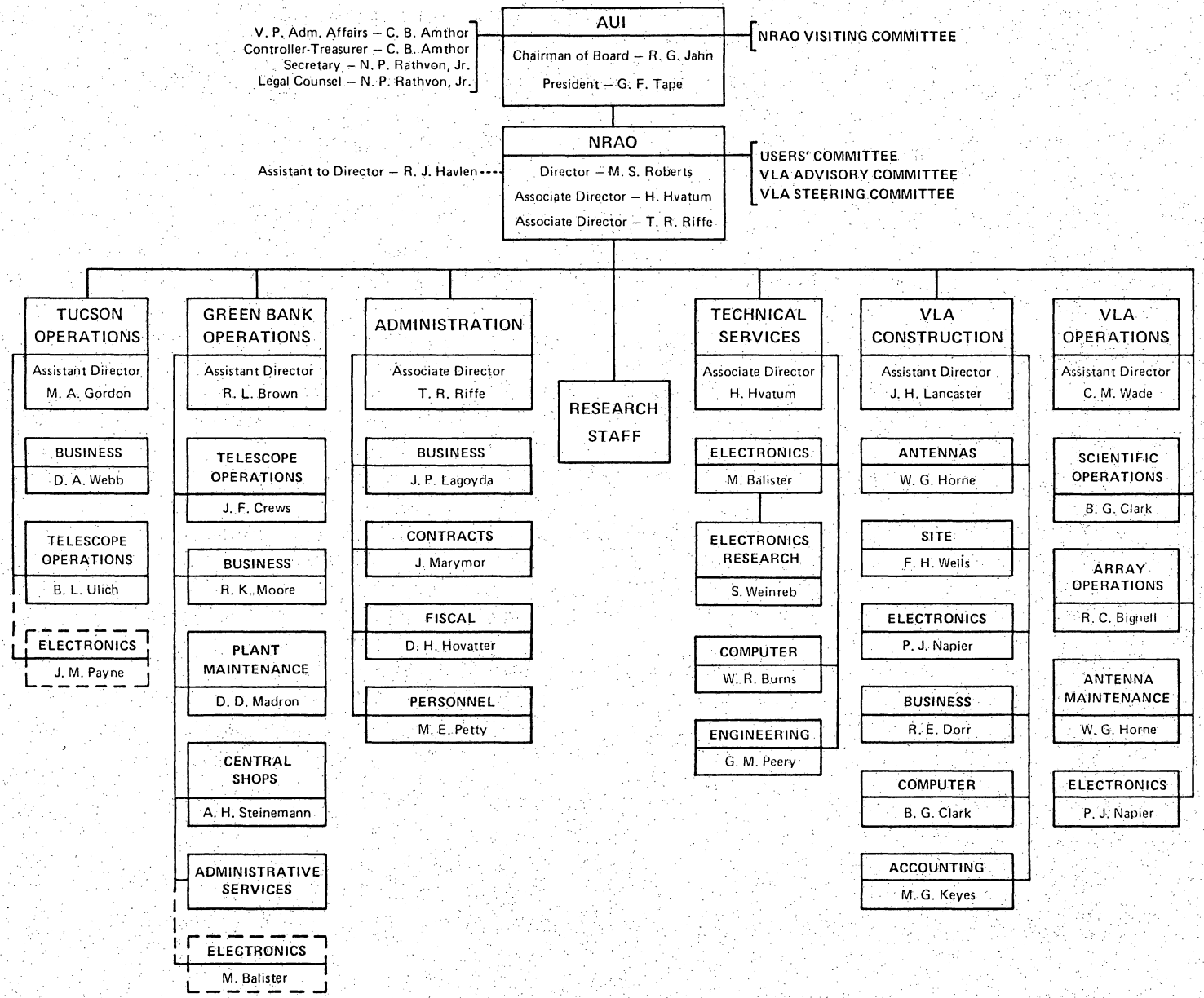
Bignell, R. C.	Planetary Nebulae; Polarization of Radio Sources
Brown, R. L.	Theoretical Astrophysics; Interstellar Medium
Clark, B. G.	VLA Development; VLB; Interferometry
Condon, J. J.	Quasars; Normal Galaxies; Compact Radio Sources
De Young, D. S.	Theories of Extragalactic Radio Sources; High Energy Astrophysics
Dickey, J. M.	Interstellar Medium of Spiral Galaxies
Findlay, J. W.	Absolute Flux Density Measurements; Telescope Design
Fomalont, E. B.	Interferometry; Extragalactic Radio Sources; Relativity Tests
Gisler, G.	Evolution of Galaxies; Clusters of Galaxies; Cosmology
Gordon, M. A.	CO; Galactic Structure
Greisen, E. W.	Structure of Interstellar Clouds
Heeschen, D. S.	Variable Radio Sources; Normal Galaxies; QSO's
Hjellming, R. M.	Radio Stars; VLA Development
Hogg, D. E.	Radio Stars; Mass Loss; Interferometry
Jaffe, W.	Radio Galaxies; Clusters of Galaxies
Liszt, H. S.	Molecular Lines; Galactic Structure
Owen, F. N.	Clusters of Galaxies; QSO's; Radio Stars
Rickard. L. J	Galactic and Extragalactic Interstellar Molecules
Roberts, M. S.	Properties and Kinematics of Galaxies
Rots, A. H.	Dynamics and Structure of Galaxies

Appendix B - continued

Sinha, R. P.	Planetary Nebulae; Galactic Structure
Spangler, S. R.	Extragalactic Radio Sources; Scintillations
Sramek, R. A.	Normal Galaxies; Quasars; Astrometry
Turner, B. E.	Galactic and Extragalactic Interstellar Molecules; Interstellar Chemistry; Galactic Structure
von Horner, S.	Cosmology; Star Clusters; Antenna Design
Wade, C. M.	Astrometry; Interferometry; VLA Development
Walker, R. C.	VLBI Studies of Galactic and Extragalactic Sources

APPENDIX C

NATIONAL RADIO ASTRONOMY OBSERVATORY
ORGANIZATION CHART
November 1, 1979



APPENDIX D

NRAO COMMITTEES

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.

The current membership of the Committee is:

W. A. Fowler	California Institute of Technology
P. P. Kronberg	University of Toronto, Canada
R. B. Leighton	California Institute of Technology
J. M. Moran	Smithsonian Astrophysical Observatory
J. P. Ostriker	Princeton University Observatory
J. H. Taylor	University of Massachusetts
R. W. Wilson	Bell Telephone Laboratories

(Additional member to be appointed.)

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--developments of radiometers and auxiliary instrumentation, operation of the telescope, the computer and other support facilities, and major new instruments. This Committee is appointed by the NRAO Director and meets twice a year.

The present membership of this Committee is:

D. C. Backer	University of California, Berkeley
B. Balick	University of Washington
A. H. Barrett	Massachusetts Institute of Technology
J. J. Broderick	Virginia Polytechnic Institute and State University
B. F. Burke	Massachusetts Institute of Technology
W. B. Burton	University of Minnesota
E. J. Chaisson	Center for Astrophysics
F. O. Clark	University of Kentucky
T. A. Clark	Goddard Space Flight Center
J. R. Dickel	University of Illinois
D. M. Gibson	New Mexico Inst. of Mining and Technology
S. J. Goldstein	University of Virginia

S. T. Gottesman	University of Florida
C. Heiles	University of California, Berkeley
R. W. Hobbs	Goddard Space Flight Center
D. R. Johnson	National Bureau of Standards
K. J. Johnston	Naval Research Laboratory
F. J. Kerr	University of Maryland
G. R. Knapp	Owens Valley Radio Observatory
M. R. Kundu	University of Maryland
M. L. Kutner	Rensselaer Polytechnic Institute
R. A. Linke	Bell Telephone Laboratories
J. M. Moran	Smithsonian Astrophysical Observatory
P. Palmer	University of Chicago
P. P. Solomon	State University of New York, Stony Brook
L. E. Snyder	Univeristy of Illinois
J. H. Taylor	University of Massachusetts
P. Thaddeus	Institute for Space Studies
N. Thonnard	Department of Terrestrial Magnetism
P. A. Vanden Bout	University of Texas
J.F.C. Wardle	Brandeis University
B. Zuckerman	University of Maryland

VLA Advisory Committee

The VLA Advisory Committee periodically reviews the status and progress of the VLA. Its particular concern is with the broad elements of the Project, and especially those that directly influence the scientific capabilities and performance characteristics of the array. It advises on broad aspects of design, scientific emphasis, and priorities, as well as on general progress, to assist the Director and the Project staff in assuring that the scientific and technical specifications are met and that the VLA will be responsive to the needs of radio astronomy. This group may also advise 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 also to maintain, in the membership, reasonable geographic distribution and representation of the major radio astronomy centers. The Committee generally mets two or three times a year, depending on the nature of current project 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
R. D. Ekers	Kapteyn Laboratories
C. Heiles	University of California, Berkeley
P. P. Kronberg	University of Toronto, Canada
A. T. Moffet	California Institute of Technology
D. H. Rogstad	California Institute of Technology
G. W. Swenson	University of Illinois
H. Zirin	California Institute of Technology

VLA Post-Processing Committee

The task of this Committee is to oversee the VLA post-processing development work. Its principal responsibility is to review progress and future plans in the area and to report to the Director. The Committee, appointed by the Director, has the following membership:

R. C. Bignell
R. L. Brown
R M. Hjellming
W. Jaffe
F. N. Owen
M. J. Reid (Center for Astrophysics)
L. Rudnick (University of Minnesota)
R. A. Sramek
C. M. Wade

APPENDIX E

AUI/NRAO

Interferometer Program Financial Status @ 10-01-79

Funds actually provided and/or obligated to the NSF by the U.S. Naval Observatory under a Memorandum of Understanding by which AUI/NRAO will operate the Green Bank four-element interferometer on behalf of the USNO.

	1978	1979	1980	Total
Funds Provided:[1]				
Actual	-0-	$456,520		$456,520
Estimated			$476,185	476,185
Totals	-0-	$456,520	$476,185	$932,705
Funds Expended:				
Actual	$89,016	$283,204		$372,220
Estimated	-0-	100,000	$460,485	560,485
Totals	$89,016	$383,204	$460,485	$932,705
Balance	($89,016)	$ 73,316	$ 15,700	$ -0-

1 Actual funds provided:

Amendment 3	(03-12-79)	$221,520
Amendment 6	(05-31-79)	200,000
Amendment 11	(09-25-79)	35,000
Total - Actual		$456,520

Estimated Funds (to be) provided:

Ltr. (10-01-79) Walsh (NSF) to Smith (USNO)	$451,185
Ltr. (10-01-79) Walsh (NSF) to Paoletti (ONR)	25,000
Total - Estimated	$476,185