NATIONAL RADIO ASTRONOMY OBSERVATORY

PROGRAM PLAN 1981

N A T I O N A L R A D I O A S T R O N O M Y O B S E R V A T O R Y

CALENDAR YEAR 1981 PROGRAM PLAN

Cover: Radiograph made with the VLA of the supernova remnant Cassiopeia A. The angular resolution is 3 seconds of arc. The total angular size of the image is approximately 4 minutes of arc.

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CALENDAR YEAR 1981 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.

The NRAO operates the Very Large Array Radio Telescope (VLA) as well as three single telescope systems--the 36-ft millimeter wavelength telescope, the 140-ft telescope, and the 300-ft meridian transit telescope--these latter will continue normal operation throughout the year. Observing pressure has been constantly increasing as new receivers and telescope modifications open up new wavelength regimes. 1981 promises to be no different. The observing schedule of the VLA, now in operation with its full complement of 27 antennas, will gradually increase during 1981 to satisfy the already heavy demand as its data handling capacity is increased and continuing test observations are evaluated. The research planned for this period by the NRAO permanent staff and the visiting investigators is summarized in the following section. More than 60% 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. Millimeter wave technology will continue to receive significant support as techniques and devices for observing at frequencies above 120 GHz will be developed for use on both the present 36-ft telescope and the future 25-m telescope. Modifications and improvements in VLBI techniques will also require more engineering efforts. Continued efforts to construct improved low noise systems for Green Bank will be maintained as the capabilities of the Green Bank telescopes continually expand. At the VLA efforts are already underway to extend its wavelength coverage with additional low frequency receivers. The bulk of the support required at the VLA will be for extended data processing capabilities to further utilize the tremendous power of the instrument.

Subsequent sections give the detail of the expenditures required for operations and maintenance of the Observatory. A summary of the allocations 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

Throughout 1981 visiting astronomers proposing to carry out research with NRAO facilities will be submitting detailed requests for observing time which will subsequently be evaluated for scientific merit by peer review groups advisory to the NRAO scheduling committees. Because the time between proposal receipt and scheduling can be shorter than six months, not all of the 1981 observing programs can be summarized at this time. Nevertheless the proposals already in hand are a representative group that are undoubtedly typical of the observations that will be made during the entire year. The following summary by telescope will aptly serve to outline the type of research projects and the major thrusts to be emphasized by the NRAO's varied clientele.

The VLA - With all of the 27 antennas completed, and most of the site construction finished, the VLA began operation in one of the four standard configurations in July 1980. Operation in the C configuration during the summer months proceeded on a restricted basis in order to give priority to ongoing construction requirements and to relieve data handling problems which have surfaced only as a result of the telescope's tremendous power. Regular rotation through the other configurations follows a rough schedule according to need that was already initiated in October with a switch to the most extended A configuration. The broad range of resolutions available, the four continuum band capability, and the initial success of several detailed spectral-line mapping programs have continued to attract interest from an ever widening base of users in the astronomical community. The resulting oversubscription rate for observing time has consequently been heavy and promises not to decrease into 1981. Strong competition for VLA observing time virtually ensures that only the highest calibre science projects will manage to obtain time.

Solar system work planned for 1981 will continue to be dominated by studies of active regions on the sun in conjunction with parallel x-ray and optical studies coordinated for the Solar Maximum year. Preliminary observations of a few active regions will be followed up in hopes of encountering especially important flare activity. With the highest VLA resolution available from the A array in early 1981, the opportunity arises of observing fine structure in flares. The VLA resolution is especially critical in permitting researchers to pinpoint detailed optical features in the radio regime in order to critically assess the nature and evolution of magnetic structures and other morphological features. Other solar system research that has been proposed involves a critical study of the interaction of Io with Jupiter's magnetosphere and a continuing probe of the thermospheres of several planets.

There are many areas of stellar and galactic research which demand the ever expanding capabilities of the VLA. In young star forming regions the detailed nature of individual objects and their interaction

with other similar and dissimilar objects needs further study. Molecular clouds, compact HII regions, and OH/H_2O maser sources will all receive attention, as researchers attempt to specify the physical conditions and time scales involved in star formation and early evolution. Clues to the physical processes involved in the later stages of stellar evolution will be investigated in studies of pulsars, x-ray binaries, mass losing stars, and supernova remnants. Coordinated multiwavelength observations between the x-ray, optical, infrared, and radio regimes will emphasize the power of the VLA in the study of stellar objects. Several studies of specific properties of the region of the galactic center are planned also as investigators undertake statistical studies of diverse objects such as HII regions, planetary nebulae and x-ray sources near the center of the Galaxy.

Demand for the VLA will continue to be strong in the area of extragalactic research where the great sensitivity and high positional accuracy and resolution of the instrument are critically important to studies of a wide variety of sources. 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 investigation of normal galaxies will only be one of the areas where kinematic studies will depend critically on the spectral line capability of the VLA.

The 36-ft Telescope - The completion and installation of a new ^{3}He bolometer with improved sensitivity and low noise will play a critical role in several studies extending spectral coverage into the 1 mm to 3 mm regime. Plans have already been made to observe objects ranging from Pluto, where bolometer flux measurements could improve values of the planet's diameter and mass, to spiral galaxies, radio galaxies, compact extragalactic objects, and QSOs, where millimeter measures of these faint objects will lead to improved models of energy generation.

The energetics and physical processes involved in young star formation regions continue to play a central role in many investigations. Extended velocity features seen in CO studies of molecular clouds indicate potentially exciting aspects of the interaction between the clouds and young stellar objects. Numerous molecular line studies of dark clouds have been proposed to probe the chemistry of the interstellar medium.

Several programs are directed to the study of extragalactic molecules. Molecular gas is a major constituent of some spiral galaxies and attempts are being made to relate the overall structure to the molecular structure of these galaxies in a perspective unavailable to studies of our Galaxy. Other programs will map in barred spirals and irregulars in order to further investigate the conditions for star formation in other galaxies.

The 140-ft Telescope - The availability of the new upconverter maser receiver for the 5-26 GHz range has stimulated a great number of proposals in this short centimeter wavelength range. Sensitive seaches will be made for a number of molecular species in dark clouds, including HDCO, NH_2, NH^+, acetone, CO Dimer, rotationally excited CH, vibrationally excited H_2O, and isotopes of formaldehyde. In many cases the intercomparison of centimeter and millimeter transitions will allow density determinations to be made. Several HII regions and planetary nebulae will be searched for carbon recombination lines and the 3 cm fine structure transition of hydrogen in order to better understand the ionization structure of these objects. In extragalactic studies the new receiver will undertake a search for small scale anisotropy in the microwave background radiation.

Galactic line work continues to dominate the work to be done with other receivers on the 140-ft telescope. The addition of the Model IV autocorrelator significantly expands the velocity limits of these studies. Details of the general HI distribution in the Galaxy will be probed, and specific aspects of the HI structure in R associations and HII regions will be sought after. Extragalactic line work will continue to emphasize kinematic studies of a wide variety of galaxies of differing morphological type and an extended HI search in clusters of galaxies. The program to search for highly redshifted molecular absorption lines in quasars will also continue.

Continuum observations with the 140-ft telescope will concentrate on variability studies of extragalactic objects and high frequency observations of galactic and extragalactic sources.

Very Long Baseline Interferometry (VLBI) programs will continue to occupy approximately 25% 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-ft Telescope - As a meridian transit instrument, the 300-ft telescope is especially effective as a survey instrument or in the study of a large number of selected objects. With the addition of a travelling feed, the integrating capability of the telescope-receiver system has been extended.

Planned and ongoing continuum programs include a radio survey of luminous x-ray stars aimed at improving the data base for stellar chromospheric and coronal modelling. Several variability monitoring programs of both galactic and extragalactic sources are planned as well as a survey of unidentified sources from the series of Ooty lunar occultation studies in order to establish radio spectral indices in parallel with a deep optical survey of each field. Other continuum surveys will be made for E/SO galaxies and planetary nebulae.

Most of the line work that will be carried out with the 300-ft telescope will involve the 21-cm HI line. HI will be surveyed in galaxies of all different morphological types and in many clusters. Redshifed HI will be sought in bright quasars and confirmation of a redshifted absorption feature seen at Arecibo in the radio galaxy 3C 293 will be attempted.

Pulsar research will dominate the use of the new low frequency receiver for the 300-100 MHz range. Several programs are planned which will extend pulsar timing experiments and explore pulsar polarimetry and Faraday rotation in order to gain insight into both the structure of neutron stars and the nature of the propagation medium. Low frequency observations of interstellar clouds in search of neutral carbon recombination lines will also be attempted with this receiver.

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 more than 350 visitors will use the NRAO telescopes during 1981.

The program of the NRAO staff, which comprises about 30% 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-ft telescope; (2) the 300-ft telescope; (3) the 36-ft telescope; and (4) the Very Large Array.

The CY 1981 program for new instrumentation has three categories, with budget allocations as follows (in thousands of dollars):

Item 1.	Other Observing Equipment	~~$1,649~~ 1170.0
Item 2.	Research Equipment	~~330~~ 295.0
Item 3.	Test Equipment	80 85.0
Total Available		$2,059

Item

1. Other Observing Equipment (in thousands of dollars)

	Estimate to Complete (k$)	Estimate Continued Development (k$)	Estimate New Development (k$)
140-ft Telescope			
5-26 GHz receiver		60	
300-ft Telescope			
1-5 GHz receiver		50	
36-ft Telescope			
Diode development		65	
SIS development		50	
Cooled mixer receivers	50	60	
0.3 K bolometer receiver		60	
40-50 GHz maser		50	
	50	285 =	335
VLA Systems			
Hydrogen maser oscillator			~~300~~
Upgrade of modules			50
VLA computer improvements			75
Improve 1 cm and 2 cm receivers			30
Miscellaneous improvements			150
VAX #2 postprocessor		200	
VLBI			
MkIII projects		45	
Other			
Spectral line receiver development		50	
Cooled GASFET development		50	
Array processor			125
Misc. computer equipment		80	
Miscellaneous		49	
Subtotal	50	869	730
Total			~~1,649~~ 1170.0

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 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 Equipment: Items to Complete

1. Cooled Mixer Receivers. A cooled mixer receiver covering 200-250 GHz for the 36-ft telescope will be completed in 1981.

B. Other Observing Equipment: Continuing Development Items

1. 5-26 GHz Receiver for the 140-ft Telescope. The first channel of this upconverter-maser receiver was completed in 1980.

2. 1-5 GHz Receiver for the 300-ft Telescope. This upconverter-maser system covering 1-5 GHz will also be used on the 140-ft telescope, and will have a very low system temperature in this frequency range.

3. Diode Development. Contract with the University of Virginia supplies NRAO with all Schottky diodes used in millimeter wave receivers.

4. SIS Development. This program covers the development of superconductor-insulator-superconductor junctions suitable for low noise mixers for future millimeter receivers.

5. Cooled Mixer Receivers. Covers continued development of cooled mixers in 36-ft receivers.

6. 0.3 K Bolometer Receiver. Continuum receiver for the 1, 2, and 3 mm atmospheric windows. Composite Germanium bolometer cooled to 0.36 K using ^{3}He.

7. 40-50 GHz Maser. A four stage ruby maser is being built for the 40-50 GHz frequency range.

8. VAX #2. To upgrade a VAX computer purchased in 1980 for VLB data processing to also facilitate VLA postprocessing in Charlottesville.

9. MkIII Projects. Projects include a MkIII to MkII interface to enable MkIII tapes to be run on NRAO processor, and also a network controller for MkIII VLBI experiments.

10. Spectral Line Receiver Development. Covers development of new spectral line receivers for the 36-ft and proposed 25-m telescope.

11. Cooled GASFET Development. This project covers continuing development of cooled GASFET amplifiers for use as low noise amplifiers for frequencies to above 22 GHz.

12. Miscellaneous. Various smaller projects.

C. New Development Items

1. Hydrogen maser oscillator. A hydrogen maser frequency standard to enable VLBI experiments to be routinely run at the VLA site.

2. Upgrade VLA Modules. Modifications to improve the performance and reliability of various modules throughout the VLA electronic system.

3. VLA Computer Improvements. Continuing upgrades and improvements of the VLA computer systems.

4. Improve 1 cm and 2 cm. Improve the sensitivity of the VLA 1 cm and 2 cm receivers using cooled GASFET amplifiers.

5. Miscellaneous Improvements. Many smaller projects to improve performance, reliability and maintainability of the VLA.

6. Array Processor for the Central Computer. An array processor attached to the IBM 360/65 computer or its replacement to greatly increase mapping capabilities.

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.

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	$ 15.0
2.	Office and Library Furnishings and Equipment	15.0
3.	Living Quarters Furniture	5.0
4.	Building Equipment	15.0
5.	Scientific Services and Engineering Equipment	10.0
6.	General Equipment for VLA Operations	109.0
		$169.0

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 $109,000 is estimated for expenditures at the VLA to provide new and replacement equipment items generally as described under Items 1 through 5 for the other NRAO accounts. The increase over the 1980 VLA operating equipment budget reflects the added outlays required as full operation comes into force during 1981.

V. OPERATIONS AND MAINTENANCE

The activities at the NRAO group naturally into six operation units which reflect both the individual operations at its three observing sites and the integrated operations which encompass all four geographic locations. The estimated costs of these major operation units are presented below.

I. Research Support - The NRAO scientific research staff, composed of staff scientists and students (summer, co-operative, and Ph.D.), engages in independent research and competes for observing time on an equal basis with visiting scientists. They are expected to carry out research of the highest calibre while at the same time assisting visiting astronomers in gaining familiarity with the NRAO instruments and facilities. Because they are at the forefront of research in their individual areas of expertise, they are an invaluable asset to the NRAO in posing new problems and stimulating new approaches to observational problems. The staff advises the technical divisions about modifications to equipment or the design of new equipment and participates in the checkout and calibration of instrumentation. Included with the research scientists and students in Research Support are the support persons at the Charlottesville headquarters who maintain the central library and the technical illustration and drafting services. These latter services will require a Material and Supply (M&S) budget for 1981 of $130k. An additional sum of $20k is included for a new program to support non-NRAO scientist travel to major foreign telescopes in 1981.

II. Technical Services - Observatory-wide technical support and development responsibilities in three main areas are focussed in Charlottesville. At the Central Development Laboratory ongoing research is underway on improved radiometers and on state-of-the-art techniques for expanding wavelength capabilities. A subgroup is also involved in the development of VLBI techniques and correlator improvements. The Computer Division operates the central computer and the VLB MkII

processor and assists in the development of programs for computers at the telescopes. An integral part of the Computer Division is responsible for coordinating the VLA post-processing effort. Each of the NRAO operating sites receives engineering assistance for the design of new facilities and telescopes from the Engineering Division.

The Materials, Supplies and Services (MS&S) budgets for the Central Lab, Computer Division, and Engineering Division are $60k, $335k (includes computer rent), and $15k, respectively.

III. Green Bank Operations - Activities at the Green Bank site are coordinated through six basic divisions. These divisions are responsible for maintaining and operating the 300-ft telescope, the 140-ft telescope, and the four-element interferometer (for the USNO). New instrumentation specifically for the single dishes is developed on site. These divisions and their 1981 M&S budgets are: Telescope Operations ($110k), Electronics ($150k), Shops ($22k), Plant Maintenance ($140k), Administrative Services ($110k), and Scientific Services ($25k). Communications and utilities require an additional $225k. Miscellaneous revenues, primarily from food service and housing, is estimated to be $110k. An allowance for a credit of $459k from the USNO for the operation of the four-element interferometer is made to the total Green Bank Operations budget.

IV. Tucson Operations - This smaller group maintains and operates the 36-ft millimeter wavelength telescope at Kitt Peak and develops new instrumentation for the telescope. Important aspects of the current work of this group involve the development and installation of a new bolometer for the 1 mm, 2 mm, and 3 mm wavelength windows as well as a modernization and consolidation of the on-site computer capability. The two Tucson subgroups will require the following M&S budgets for 1981: Operations and Maintenance ($175k) and Electronics ($125k).

V. VLA Operations - During 1981, when construction activities have finally terminated, the operations activities will gradually be folded into the framework of the other NRAO sites. Partly reflecting the residual construction activity, the site responsibilities will continue to fall under many groups. The Site Director and his staff of Systems Scientists will require an M&S budget of $41k. The Computer, Electronics, Array Operations, and Antenna Maintenance Divisions which are most critical to the mechanical functioning and data collecting capabilities of the telescope will require M&S budgets of $40k, $165k, $10k, and $136k, respectively. Other services related to the efficient functioning of the operation and the M&S budgets include: Plant Maintenance ($90k), Administrative Services ($248k), and Accounting ($6k). Communications, utilities, and building rent (in Socorro) will amount to $442k, while miscellaneous revenue of $43k is expected.

VI. General and Administration - Included in this unit are the Director's Office, Fiscal Office, and the Business Office, with a total

MS&S budget of $191k. Rent and maintenance of the Charlottesville buildings, including utilities, will require $340k. The management fee will be $235k.

A summary of the CY 1981 budget for these operations units is provided in the following table:

CY 1981 Budget - Operation Units*
(in thousands of dollars)

	Operation Unit	Personnel Ceiling	Salaries, Wages & Benefits	Material, Supply, Service	Travel	Total
I.	Research Support	39	$1,528.0	$ 130.0	$264.0	$ 1,912.0
II.	Technical Support & Development	46	1,468.0	510.0	61.0	2,039.0
III.	Green Bank Operation	114	2,752.0	672.0	31.0	3,455.0
IV.	Tucson Operations	24	665.0	300.0	43.0	1,008.0
V.	VLA Operations	114	2,727.0	1,280.0	84.0	4,091.0
VI.	General & Administration	25	750.0	766.0	73.0	1,589.0
	Total Operations	362	$9,890.0	$3,658.0	$546.0	$14,094.0

* Does not include commitments carried forward from 1980.
~~1 Includes $100.0k carried over for soil tests on Mauna Kea.~~
1, 3 Includes $235.0k management fee.
2, 3 Includes $518.0k for USNO interferometer support.

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 1981. 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

With the completion of the VLA, no new construction is anticipated for 1981.

VIII. PERSONNEL

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

Category	Actual 1980 Level*	Actual 1980 Salaries	Actual 1980 Benefits	Planned 1981 Level	Planned 1981 Salaries	Planned 1981 Benefits
Operations						
Scientific & Engineering	91 ~~99~~	2,439.0 ~~$2,815.0~~	$ 507.0 ~~632.0~~	111 ~~109~~	3,132.0 ~~$3,259.0~~	$ 703.0 ~~733.0~~
Technical	113 ~~112~~	1,903.0 ~~1,848.0~~	396.0 ~~415.0~~	127 ~~116~~	2291.0 ~~2,077.0~~	514.0 ~~467.0~~
Administrative & Clerical	63 ~~71~~	1,459.0 ~~1,586.0~~	304.0 ~~356.0~~	76 ~~90~~	1,785.0 ~~2,034.0~~	400.0 ~~457.0~~
Operations & Maintenance	41 ~~34~~	617.0 ~~485.0~~	127.0 ~~109.0~~	53 ~~47~~	782.0 ~~704.0~~	175.0 ~~159.0~~
Total Operations	308 ~~316~~	6,413.0 ~~$6,734.0~~	1,334.0 ~~$1,512.0~~	367 ~~362~~	7,990.0 ~~$8,074.0~~	1,792.0 ~~$1,816.0~~
VLA Common Costs	21 ~~27~~	632.0 ~~433.0~~	135.0 ~~97.0~~	-	-	-
VLA Construction	26 ~~26~~	426.0 ~~658.0~~	88.0 ~~152.0~~	-	96.0 ~~135.0~~	22.0 ~~30.0~~
Total Personnel	355 ~~369~~	7,471.0 ~~$7,825.0~~	1,555.0 ~~$1,761.0~~	367 ~~362~~	8,086.0 ~~$8,209.0~~	1,814.0 ~~$1,846.0~~

Personnel levels include approximately 10 man-years charged to Interferometer Operations.

The major increase in operations level results from transferring ~~43~~ 47 VLA Common Cost and Construction positions to VLA Operations and the addition of ~~3~~ 5 new positions to non-VLA Operations plus 7 Vacant positions @ 12-31-80

* Includes 4 positions (3 Sci + Eng + 1 Tech) on LOA @ 12-31-80.

IX. PRELIMINARY FINANCIAL PLAN - 1981
(in thousands)

	Actual 1979	Estimated 1980	Commitments to 1980	Uncomm. Funds to 1980	New Funds 1981[1]	Available for Exp. & Comm. 1981
I. SCIENTIFIC RESEARCH						
A. Operations						
Personnel Compensation	$ 5,422.0	$ 6,345.6			$ 8,074.0	$ 8,074.0
Personnel Benefits	1,033.2	1,383.2			1,816.0	$ 1,816.0
Travel - Domestic	435.4	482.1			506.0	506.0
Travel - Foreign	4.4	25.0			40.0	40.0
Material & Supply	2,675.0	3,356.7	$ 375.0	$ 100.0	3,323.0	3,798.0
Management Fee	210.0	220.0			235.0	235.0
Subtotal	$ 9,780.1	$11,812.6	$ 375.0	$ 100.0	$13,994.0	$14,469.0
B. Equipment						
Research Equipment	$ 1,151.2	$ 1,048.4	$ 400.0	$ 539.8	$ 1,520.0	$ 2,459.8
Operating Equipment	59.0	144.8	120.0	-	169.0	289.0
Subtotal	$ 1,210.2	$ 1,193.2	$ 520.0	$ ~~639.8~~ 539.8	$ 1,689.0	$2,748.8
Total - Scientific Research	$10,990.3	$13,005.8	$ 895.0	$ 639.8	$15,683.0	$17,217.8
II. CONSTRUCTION						
Very Large Array	$13,024.3	$ 7,486.4	$1,000.0	$ 622.4	-0-	$ 1,622.4
Total - Construction	$13,024.3	$ 7,486.4	$1,000.0	$ 622.4	-0-	$ 1,622.4
TOTAL	$24,014.6	$20,492.2	$1,895.0	$1,262.2	$15,683.0	$18,840.2

* Estimated @ 11/01/80

[1] Includes $518.0k for Interferometer Operations and $20.0k for foreign travel for non-NRAO (US) astronomers' travel abroad.

15145
15897
248

Preliminary Financial Plan - 1981
(in thousands)

	Actual 1979	Actual* 1980	Commitments to 1981	Uncomm. Funds to 1981	New Funds 1981	Available for Exp. & Comm. 1981
1. Excludes VLA						
Personnel Comp.	$ 4,394.9	$ 4,985.5			$ 5,847.0	$ 5,847.0
Personnel Benf.	835.4	1,091.7			1,316.0	1,316.0
Travel	375.4	419.1			462.0	462.0
Other M&S	1,774.7	2,118.5	$300.0	$100.0	2,043.0	2,443.0
Management fee	210.0	220.0			235.0	235.0
Subtotal - Opns.	$ 7,593.4	$ 8,834.8	$300.0	$100.0	$ 9,903.0	$10,303.0
Equipment	1,210.2	1,141.2	400.0	539.8 (- 459.0)	580.0	1,519.8
Subtotal - Opn. & Eqpt.	$ 8,803.6	$ 9,976.0	$700.0	$639.8	$10,483.0	$11,822.8
2. VLA Only						
Personnel Comp.	$ 1,027.1	$ 1,360.1			$ 2,227.0	$ 2,227.0
Personnel Benf.	194.8	291.5			500.0	500.0
Travel	64.4	88.0			84.0	84.0
Other M&S	900.4	1,238.2	$ 75.0		1,280.0	1,355.0
Subtotal - Opns.	$ 2,186.7	$ 2,977.8	$ 75.0		$ 4,091.0	$ 4,166.0
Equipment		52.0	120.0	(- 200.0)	1,109.0	1,229.0
Subtotal - VLA Opn. & Eqpt.	$ 2,186.7	$ 3,029.8	$195.0		$ 5,200.0	$ 5,395.0
Total - Opns. & Eqpt.	$10,990.3	$13,005.8	$895.0	$639.8	$15,683.0	$17,217.8

* Estimated @ 11/01/80

APPENDIX A

RESEARCH PROGRAMS FOR THE NRAO SCIENTIFIC STAFF

During 1981 the permanent staff of the NRAO will be working in a number of research areas, as described below. Some of the research will be done in collaboration with visiting scientists.

A. PLANETARY STUDIES

Preliminary VLA studies of the atmospheres and magnetospheres of the Jovian planets which were undertaken without the full complement of antennas will be followed up with the completed array. High resolution VLA maps of Jupiter's radio emission will be used to resolve apparent conflicts between the currently known emission of the planet and the distribution of the source relativistic electrons as probed by Pioneer. Peculiar features in the atmosphere of Uranus will be reobserved and an attempt will be made to interpret the planet's year-to-year flux density variations.

The newly developed cooled ^{3}He bolometer on the 36-ft telescope has stimulated an interest in reobserving Pluto at 1 mm in order to try to understand why previous radio sources show the thermal emission from Pluto to appear anomalously low.

B. GALACTIC STUDIES

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

A program is underway to determine scale sizes of interstellar clouds in order to facilitate the modelling of star formation within the Galaxy. Observations of some 50 clouds in CO emission are presently complete. This year will see an analysis and modelling of the data. Observations in search of ^{12}CO emission in the direction of 80 moderately reddened early-type stars are also complete. Some 35 lines have been detected and the data will be subjected to kinematic analysis to determine the local scale height, mean free path, and velocity dispersion of molecular clouds. They will also be used in conjunction with observations of other species (H_2, NaI, CH, etc.) to establish physical conditions inside the clouds.

VLBI techniques over relatively short baselines will be employed in order to make high resolution HI absorption line observations towards galactic and extragalactic continuum sources of low latitudes. Low latitude absorption spectra are important to trace the structure (in ℓ-v space) of cold atomic clouds. They can also be used to correct emission surveys for obscuration, giving a better estimate for the total HI mass of the galaxy. It may even be possible to measure variation of the

interstellar temperature with height above the plane, z. A pilot project carried out at Green Bank combining the 140-ft and 300-ft telescopes has already verified the appropriateness of the technique. An order of magnitude improvement in sensitivity is hoped for with a similar experiment at Arecibo in order to map out the galactic magnetic field using 21-cm Zeeman splitting. Time variations in opacity toward compact sources will also be searched for as a probe of velocities and small scale structure in the interstellar medium. In addition, the VLA will allow spectral line aperture synthesis of galactic absorption toward very high surface brightness sources such as 3C 123 in order to study the internal structure and interaction of complexes of molecular and atomic gas clouds in the Galaxy.

Pulsar observations will continue to serve as useful probes of the Galactic environment. Analysis is planned of HI absorption studies in order to sample the homogeneity of both neutral and ionized interstellar gas. Arecibo observations will add to the data already obtained.

A program will be started to determine the rotation measures of sets of closely spaced pulsars. The improved sensitivity of the new 300-1000 MHz receiver on the 300-ft should allow a great increase in the number of pulsars whose rotation measure has been determined. The main goal of this project will be to determine characteristics of the irregular component of the interstellar magnetic field, such as magnitude of this component and its scale length.

The Green Bank OH survey will provide the necessary data for several investigations. The scale height of the OH distribution perpendicular to the galactic plane is being derived and will be compared with that of CO, HII regions and supernova remnants. The OH maser luminosity function will also be determined. Plans have also been made to extend the Type I OH maser luminosity function to much fainter masers using the Arecibo telescope. Preliminary drift-scans along and near the galactic plane with this instrument suggest that Type I properties remain unaltered to a sensitivity factor ~4 greater than the Green Bank survey.

As part of the study of the morphology of gas observed near the galactic nucleus an atlas will be prepared which details the nearly 2000 HI spectra used to construct the tilted-disk models of the long scale nuclear gas distribution. Further CO emission mapping of the vicinity of the Sgr continuum source complex will be carried out in order to substantiate several new kinematic features that have already been found. HI absorption toward Sgr A will also be synthesized using the VLA this year.

Measurements of the secular parallax of the galactic center carried on with the Green Bank interferometer over several years will be supplemented with an additional long term project initiated at the VLA. At the level of 0.005 arcsec/year, the VLA should allow a significant improvement in accuracy.

2. HII Regions, Infrared Sources, and Planetary Nebulae

A study of high velocity H_2O masers will be continued with analysis of VLBI maps of W49, W43, and 0.55-0.85. The analysis should provide insight about the pump mechanism for H_2O masers and about the geometry and dynamics of star formation regions. The VLA will also be used to study the environment in which the masers are found, particularly in W49.

The observational study of the unusual Type I masers associated with Herbig-Haro objects, which was successfully completed with the Arecibo telescope, will be interpreted based upon new kinematic and infrared information related to these objects. The physical nature of the spatially-extended, pervasive Type II(a) OH anomalies (enhanced 1720 MHz emission) discovered in the Green Bank OH survey, will be pursued by making absorption studies with the Nancay (France) radio telescope. In this way the 1720 MHz excitation temperature may be determined and compared with theoretical models (involving far-infrared pumping). An attempt will also be made to understand why the Type II(a) OH masers do not appear associated with continuum objects in contrast to the nearly perfect correlation found for Type I OH masers.

A detailed and precise theoretical model of gaseous nebulae will be used to study the radiative transfer of forbidden line, recombination line, and fine structure line radiation. Comparison will be made between the expected and observed line strengths in order to assess the efficacy of the recent calculations of the Lyman continuum radiation from early-type stars.

The new Mark IV autocorrelator on the 140-ft 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.

A new observing technique for the 36-ft telescope, making use of beam switching to overcome atmospheric extinction even for sources of large angular extent, will be employed to study the continuum emission from HII regions. Maps at 3, 2, and 1 mm may permit the separation of the free-free radiation from the ionized gas from the black body radiation of the imbedded dust.

Radio emission from the winds of two Wolf-Rayet stars was detected with the VLA. The flux densities found were, however, a factor of four less than predicted from infrared measurements and will require that the current theory of acceleration of the wind material to terminal velocity be modified. Observations will be made in the coming year to measure the spectral index at radio wavelengths and to detect the emission from other WR stars.

3. Radio Stars, Pulsars, Novae, and Supernovae

The VLA will be used to map the structure of the Crab Nebula in order to search for evidence of the interaction of the pulsar wind with the surrounding nebulae material and to test the hypothesis that the nonthermal emission is enhanced in the region of the optical filaments because of current flow in the filaments.

The compact radio source in SS 433 will be studied with high sensitivity Mk III VLBI observations. These observations complement monitoring observations of the 0".1 structure, which appears to be precessing with the optical jets. SS 433 provides an opportunity to study a source similar in character to the large, extragalactic radio sources but small enough to exhibit major structural changes on time scales reasonable for study.

An attempt will be made to find radio emission from KR Aurigae, a unique variable star and x-ray source. Optical data suggest strongly that it may be a black hole. The x-ray source Sco X-1 will continue to be monitored with medium and high resolution. The nature of the Sco X-1 triple radio source hinges on an improved knowledge of its structure and evolution with time. Other galactic x-ray sources will be searched for evidence of radio jet structures. Transient gamma ray sources will also receive radio attention.

4. Molecular Line Studies

It is expected that about a dozen or so new species will be safely identified in the final analysis of the ongoing project to identify the 227 unidentified lines which were observed in the 77-115 GHz region. At a density of one U-line every 160 MHz, attempts to identify by comparison with calculated spectra for hundreds of potentially relevant molecular species must remain largely statistical in nature. The probability of matching several U-lines to a given species purely by chance is significant.

A confirmation of a previous tentative detection of CCD will be attempted. New lines of NH_2D, a previously discovered species, will be sought to better understand its excitation and abundance. A search for $\lambda 2$ cm lines of CH_2ND may be attempted to confirm its identification as made in the U-line project.

Analysis of the properties of interstellar CH as observed at high spatial resolution (4.2' using the Bonn 100-m telescope) will be completed. A search for the 7450 MHz rotationally-excited state $^2\pi_{1/2}$, J = 3/2) will be made with the new, cooled upconverter receiver at Green Bank.

Using the new, cooled upconverter receiver, searches in the 8-16 GHz region will be made for NH_2, NH^+, acetone, and the CO dimer. In the

millimeter wavelengths a search for the elusive $HCNH^+$, central to ion-molecule chemistries, will be based on new calculated values of its rotational constants. Searches for CCNC and HCCNC will be made, based upon possible identification from the U-line project.

When the required sensitivity at 2 mm is available, survey observations of the NO radical will be continued. NO is visible in only the very highest column density sources. Until detections are added in more sources, a full examination of interstellar nitrogen chemistry will not be possible.

The anticipated availability of receivers at 1.3 mm at the NRAO and elsewhere will make possible the search for interstellar O_2. Most models of interstellar chemistry in dark clouds indicate that most of the free oxygen in heavily shielded regions should reside in molecular form. Detection of molecular oxygen or very good upper limits on its abundance will go a long way toward establishing the free elemental abundances in molecular clouds which probably constitutes the single greatest limitation upon construction of chemical models.

C. EXTRAGALACTIC STUDIES

1. Normal Galaxies

The study of clumpy irregular galaxies will continue. Observations will be made with the VLA at 20-cm wavelength to complement those already available at 6 and 2 cm and determine the spectra of the continuum emission. Twenty-one centimeter observations of HI will also be made at the VLA, and x-ray observations will be obtained with Einstein Observatory.

Radio and optical properties of normal elliptical galaxies will continue to be investigated. Observations will be made with the VLA and the 36-ft of the continuum emission at radio wavelengths and with the VLA of the 21-cm line emission. The IRTF on Mauna Kea will be used again to obtain additional IR data. The 4-m telescope at KPNO will be used to obtain pictures of the light distribution.

In order to define more precisely the nature of the connection between nonthermal radio cores and ionized gas in elliptical galaxies, some 400 elliptical galaxies with good optical spectroscopic data will be searched for radio continuum compact core sources with the 300-ft telescope. Some of the detected galaxies will be further mapped with the VLA for comparison to $H\alpha$ maps.

VLA maps of a dozen Seyfert galaxies have now been made at 6 cm for a study of the relationship of the radio emitting and forbidden line emitting regions of the objects. Maps at other radio frequencies will be made to obtain the spectral index distribution of these galaxies.

In April, 1980 radio emission from the supernova 1979c in M100 was detected. Radio emission from such a young supernova was quite unexpected since the expanding supernova shell should be opaque. Continuing measurements will be made to study the evolution of the spectra of this object.

VLA, 10 μm infrared, and optical emission-line maps of spiral galaxies with strong central radio sources will be made to test the hypothesis that large bursts of star formation are occurring in regions defined by the radio emission. The VLA will also be used to search for compact sources at the centers of nearby normal spiral galaxies. Radio and optical polarization of the radio cores associated with bright galaxies will also be compared.

The multi-frequency high resolution VLA maps of the radio emission of the galaxy NGC 4449 will be used to test the hypothesis that the peculiar optical object near the galaxy center is a supernova remnant that is potentially younger than Cas A in our galaxy.

Several VLA HI spectral line studies will be aimed at collecting information on the structure and dynamics of spiral and irregular galaxies. OH spectral line studies will aid in establishing conditions in the interstellar medium of such galaxies. VLBI techniques will further allow the study of the extended disks of spiral galaxies toward compact background sources.

The molecular component of galaxies will be the subject of extensive investigations with several telescopes. The Nancay (France) telescope will be used to search for OH emission in galaxies beyond those already detected from Arecibo. Those galaxies having main-line OH emission will also then be searched for OH satellite lines. It is predicted that the satellite lines will be anomalously excited by the large far-infrared flux known to be emitted by the nuclei of these galaxies. So far, the OH results suggest that the molecular abundance can vary greatly among galaxies. In order to see whether this is correlated with the ionized component, a program to detect H167α in emission will be initiated at Arecibo.

Carbon monoxide observations (both mapping and detection of new galaxies) and analysis of results will continue in an attempt to understand (i) relation of molecular gas with optical spiral structure and with expected density-wave patterns; (ii) relation between nuclear molecular component and disk component as a function of morphological type; and (iii) relation between molecular, ionized, and atomic gas and infrared emission.

2. Radio Galaxies and Quasars

Compact radio sources are often associated with quasars and the nuclei of galaxies identified with extended radio sources; but curiously

they appear to have a very different distribution in space than extended radio sources or quasars. Several investigations are planned to learn why only some quasars and radio galaxies contain compact radio sources and, in particular, to what extent relativistic beaming is important in interpreting short wavelength source counts, the luminosity volume test, rapid flux variations, and observed superluminal motions.

VLBI maps of the superluminal radio source 3C 120, covering the period 1977.56 to 1979.92, show large changes in source morphology and reveal a recent expanding component. These data will be analyzed and further observations will be made in an effort to clarify the observational picture of the superluminal motion in this source. 3C 120 is unique among the superluminal sources because it is in a galaxy and its distance is not in question.

Optical identifications of strong, flat spectrum sources in the Parkes 2700 MHz survey have been made and will be studied for dependences of the radio-optical flux correlation on the detailed radio spectra. Observations will be undertaken on the VLA to further study the variability of the compact, flat spectrum components at the center of luminous double sources. The eventual goal of this and related projects is to determine the relationship between such components and sources whose integrated spectrum is flat.

Flux density monitor programs of long standing will continue. Additional observations at 9 cm and 6 cm will be obtained with the 140-ft and 300-ft telescopes. The VLA will be used to provide supplementary information about the spectra and dimensions of some of the sources. Sources previously found to be variable at 318 MHz will be followed at five frequencies from 318 to 1400 MHz.

Extensive usage of multi-wavelength facilities is planned in an investigation of radio sources from the 3CR and Jodrell surveys which have no apparent optical identification on the Palomar Sky survey. It is expected that the faint galaxies associated with these radio sources will be detectable with the NASA 3-m IR telescope and that red shifts will be obtainable in a comparison of the colors between 1.25 and 2.2 μm with theoretical galaxy spectra. Attempts will be made with the KPNO 4-m telescope to push the expected detections into the R and possibly the V spectral bands. The VLA will be employed to improve the reliability of the identifications and to study the extended structure of the 3CR blank field sources at higher resolution.

VLA surveys completely covering 43 square degrees will be made to clarify the relation between radio and optical emission of quasars. Objective-prism plates, 3-color plates, and time series of deep Palomar or UK Schmidt plates are available for the selected survey areas in which several hundred quasars have already been found. Other quasar survey programs will extend millimeter wavelength observations to samples of quasars which are known x-ray emitters as well as to those that are known to be radio quiet and optically bright.

Data reduction will be completed of 18 and 6 cm VLBI observations of ten quasar and BL Lac objects whose spectra indicate they may be inhomogeneous synchrotron or relativistic Maxwellian sources. The preliminary 6-cm results indicate that several of the sources are partially resolved. The 18-cm observations will then provide information on the frequency dependence of the angular size--a dependence which is predicated by the inhomogeneous synchrotron source model. For the relativistic Maxwellian model, the observations should provide an improved estimate of the electron energy.

The general morphology of radio quasars is an important parameter to the understanding of their formation and interaction with their environment. Maps of 30 Jodrell Bank quasars will be obtained with the highest VLA resolution in order to analyze their extended structure. A sample of 50 nearby quasars will be surveyed for bent radio structures which may possibly be evidence for their association with distant clusters of galaxies.

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. High resolution VLA maps of the radio emission of small scale objects such as 3C 147, 3C 148 and others will be used to study the astrophysical models of jets incorporating geometric and relativistic beaming effects.

Work will continue on several radio sources with prominent jets in order to improve our knowledge of unusual jet configurations as well as to test proposed models for their formation and maintenance. Models of jet collimation and confinement will be tested with VLA data on the sources 3C 31, NGC 315, and 0326+396. The unusual jet in Fornax A will be further observed, and combined optical and radio observations of 3C 277.3 may also allow an unambiguous determination of the velocity of a radio jet for the first time. Theoretical models of the jet in M87 will be critically tested by new VLA maps of the polarization and total intensity.

An investigation is being made of the stability of relativistic electron beams in environments characteristic of extragalactic radio sources. Particular attention is being paid to the effect of magnetic field irregularities on the wave-particle resonance which causes this instability. Theoretical and laboratory work in plasma physics has indicated that turbulent "noise" can greatly suppress an instability, and the proposed work will see if this is also the case in extragalactic radio sources.

Theoretical work is planned on the fueling of the core sources in giant elliptical galaxy radio sources and quasars using gas shed by evolving stars in the galaxy or gas in an ambient medium. Models will be developed which will be aimed at obtaining a number of sufficient conditions for the fueling of a galaxy nucleus radio core machine and at

predicting observable properties of the fueling gas for x-ray and optical studies. It is possible that self-limiting or oscillatory conditions in the fueling will be found, and these, coupled with what is already known about the evolution of the stellar and gaseous content of elliptical galaxies, may give valuable insight into the evolution of quasars and radio galaxies.

3. Cluster Sources and Clusters of Galaxies

Radio techniques will play a large role in continuing studies of the properties and evolution of clusters of galaxies. Ongoing surveys of radio sources in clusters involve the nearest clusters ($z < 0.1$) in the Abell catalogue as well as those of highest redshift. For the high redshift sample the aim of the study will be to test the evolution of the cluster luminosity function and morphology with epoch. In a sample of rich clusters additional redshifts will be obtained and the possible correlation between radio sources and binary galaxies studied. Another proposed investigation in rich clusters will attempt to determine if several classical double sources identified with galaxies much fainter than the dominant cluster galaxies are in the clusters or not. Once the possibility of background galaxy contamination can be eliminated, the hypothesis is strengthened that galaxies fainter than the first rank ellipticals can have quasar-like activity.

The optical absorption lines seen in some distant quasars may arise from gas in intervening clusters of galaxies. These clusters would be too distant to be detected optically, but evidence for their existence may be had from a study being done at the VLA of the structure of weak radio sources lying in the vicinity of several absorption line quasars.

D. MISCELLANEOUS

Measurements with the VLA to establish very accurate positions for a large number of unresolved extragalactic sources continue. The main objective is to determine a precise inertial reference frame from the VLA. Secondary objectives include refinement of precessional, nutational, and geophysical constants.

Astrometric measurements of the largest minor planets continue. The main objectives are a refined location of the vernal equinox and an absolute calibration of the VLA in right ascension. Other astrometric programs with the VLA will attempt to determine absolute parallaxes and proper motions of selected radio binary stars.

APPENDIX B

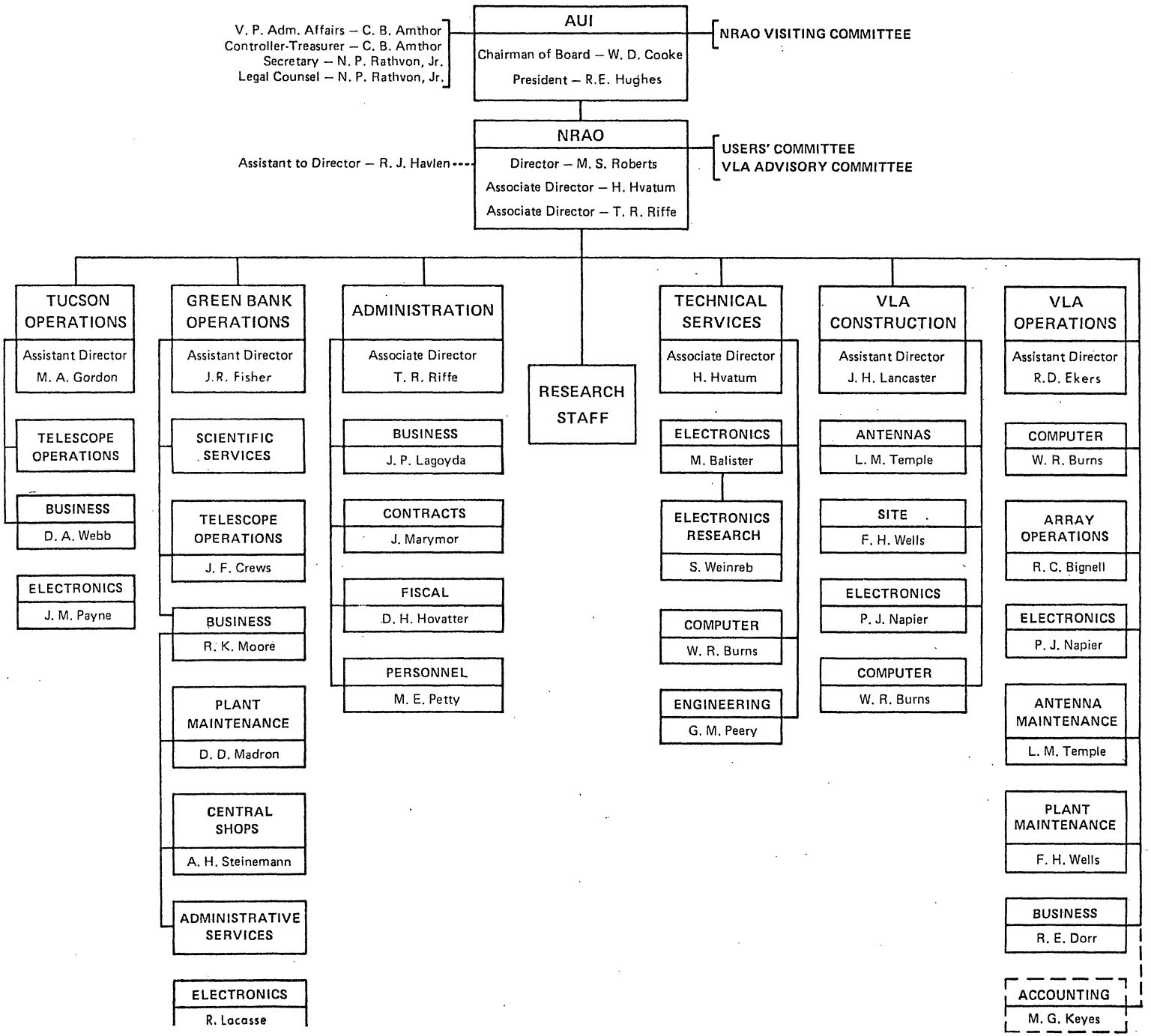
NRAO PERMANENT SCIENTIFIC STAFF WITH MAJOR SCIENTIFIC INTERESTS

Bignell, R. C.	Polarization and Mapping of Extragalactic Radio Sources; Solar System
Brown, R. L.	Theoretical Astrophysics; Interstellar Medium
Clark, B. G.	VLA Development; VLB; Interferometry
Condon, J. J.	QSOs; Normal Galaxies; Extragalactic Radio Sources
Cotton, W. D.	Extragalactic Radio Sources; VLBI; VLA Development
Dickey, J. M.	Interstellar Medium; Galactic Structure; Intergalactic Hydrogen; Normal Galaxies
Ekers, R. D.	Radio Galaxies; Instrumental Techniques
Findlay, J. W.	Absolute Flux Density Measurements; Telescope Design
Fomalont, E. B.	Interferometry; Extragalactic Radio Sources; Relativity Tests
Gisler, G. R.	Normal Galaxies; Radio Galaxies; Clusters of Galaxies
Gordon, M. A.	CO; Galactic Structure
Greisen, E. W.	Structure of Interstellar Medium; Computer Analysis of Astronomical Data
Heeschen, D. S.	Variable Radio Sources; Normal Galaxies; QSOs
Hjellming, R. M.	Radio Stars; VLA Development
Hogg, D. E.	Radio Stars and Stellar Winds; Extragalactic Radio Sources
Jaffe, W.	Radio Galaxies; Clusters of Galaxies
Kellermann, K. I.	Extragalactic Astronomy; VLBI
Liszt, H. S.	Molecular Lines; Galactic Structure
Owen, F. N.	Clusters of Galaxies; QSOs; Radio Stars
Perley, R. A.	Radio Galaxies; QSOs; Interferometric Techniques

Roberts, M. S.	Properties and Kinematics of Galaxies
Rots, A. H.	Extragalactic Research; Spectral Line Interferometry
Sramek, R. A.	Normal Galaxies; Quasars; Astrometry
Turner, B. E.	Galactic and Extragalactic Interstellar Molecules; Interstellar Chemistry; Galactic Structure
von Hoerner, 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
January 1, 1981



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:

Boesgaard, A. M.	University of Hawaii
Kronberg, P. P.	University of Toronto, Canada
Leighton, R. B.	California Institute of Technology
Moran, J. M.	Smithsonian Astrophysical Observatory
Ostriker, J. P.	Princeton University Observatory
Shapiro, I. I.	Massachusetts Institute of Technology
Taylor, J. H.	University of Massachusetts
Vanden Bout, P. A.	University of Texas

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 and meets twice a year.

The present membership of this Committee is:

Backer, D. C.	University of California, Berkeley
Barrett, A. H.	Massachusetts Institute of Technology
Bridle, A. H.	Queen's University
Burke, B. F.	Massachusetts Institute of Technology
Burton, W. B.	University of Minnesota
Chaisson, E. J.	Center for Astrophysics
Churchwell, E. B.	University of Wisconsin
Clark, T. A.	Goddard Space Flight Center
Cordes, J. M.	Cornell University
Goldstein, S. J.	University of Virginia
Gottesman, S. T.	University of Florida
Haynes, M.	Arecibo Observatory
Heiles, C.	University of California, Berkeley

Hobbs, R. W.	Goddard Space Flight Center
Johnson, D. R.	National Bureau of Standards
Johnston, K. J.	U. S. Naval Research Lab
Kerr, F. D.	University of Maryland
Knapp, G. R.	Princeton University
Kutner, M. L.	Rensselaer Polytechnic Institute
Lada, C. J.	Steward Observatory
Linke, R. A.	Bell Telephone Laboratories
Moran, J. M.	Smithsonian Astrophysical Observatory
Schwartz, P. R.	Naval Research Laboratory
Scoville, N. Z.	University of Massachusetts
Shaffer, D. B.	Phoenix Corporation
Snyder, L. E.	University of Illinois
Thaddeus, P.	Institute for Space Studies
Thonnard, N.	Dept. of Terrestrial Magnetism
Vanden Bout, P. A.	University of Texas
Wardle, J.F.C.	Brandeis University
Zirin, H.	California Institute of Technology

VLA Advisory Committee

The VLA Advisory Committee periodically reviews the status and operation of the VLA. Its particular concern is with the broad elements of the operation 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 to assist the Director and the project staff in assuring that the scientific and technical specifications are met and that the VLA is 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 non-NRAO 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 meets once a year.

The current membership of the Committee is:

Brouw, W. N.	Dwingeloo, Netherlands
Johnston, K. J.	U. S. Naval Research Laboratory
Kronberg, P. P.	University of Toronto
Moffet, A. T.	California Institute of Technology
Palmer, P.	University of Chicago
Rogstad, D. H.	California Institute of Technology
Rudnick, L.	University of Minnesota
Swenson, G. W.	University of Illinois
Zirin, H.	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:

Bignell, R. C.
Brown, R. L.
Clark, B. G.
Condon, J. J.
Hjellming, R. M.
Owen, F. N.
Reid, M. J. (Center for Astrophysics)
Rudnick, L. (University of Minnesota)
Sramek, R. A.
Wade, C. M.
Walker, R. C.

APPENDIX E

INTERFEROMETER PROGRAM STATUS @ 10/01/80

Funds obligated to the NSF by the U.S. Naval Observatory for transfer to the NRAO for operation of the Green Bank interferometer on behalf of the USNO.

	Through 12-31-79	1980	1981	Total
Funds Provided:				
Actual	$456,520	$476,185		$ 932,705
Estimated		20,000[1]	$518,000	538,000
Total	$456,520	$496,185	$518,000	$1,470,705
Funds Expended:				
Actual	$477,576	$357,334[2]		$ 834,910
Estimated		117,795	$518,000	635,795
	$477,576	$475,129	$518,000	$1,470,705

1 For the preparation of a feasibility study to add an east-west baseline to the Green Bank interferometer.

2 Includes commitments of $37,500 for the installation of commercial power to the 45-ft telescope site.