NATIONAL RADIO ASTRONOMY OBSERVATORY

PROGRAM PLAN 1983

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 1983 PROGRAM PLAN

Amended 02/24/83

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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. The Observatory operates major telescope systems for research in radio astronomy and carries out research and development in related fields of advanced technology and data processing.

The four major telescope systems operated by the NRAO are: the 27-element Very Large Array telescope (VLA) located on the Plains of San Augustin, near Socorro, New Mexico, the 12-m millimeter wavelength telescope on Kitt Peak, Arizona, and the 140-ft telescope and the 300-ft meridian transit telescope in Green Bank, West Virginia. Demand for observing time remains high at all telescopes. The newly resurfaced 12-m telescope will resume operations during the first quarter of the year with a large proposal oversubscription. As new technology is exploited, new receiver developments and operating systems retrofits will continually improve the observing potential of all of the telescopes. No fall off in demand is foreseen. The size of the NRAO user community has increased by 60% since 1980 and by nearly threefold in the last decade as more and more non-traditional radio astronomers exploit the available opportunities. During 1983, approximately 70% of the observing time that is available on the NRAO telescopes will be used by visiting investigators, and their planned research is summarized in Section II of this Program Plan.

Section III of the Plan presents a program for the development of new research instrumentation for use on the telescopes and for computing software to handle the increasing demands for telescope control, data acquisition, signal and image processing, and data analysis. A dynamic electronics research and development effort is one of the driving forces behind the application of technological advances to astronomical instrumentation and therefore is a vital part of the NRAO. Highlights of this effort will include continuing development of millimeter-wave receivers in order to better exploit the new 12-m telescope surface and improvements in VLB recording and processing techniques. During 1983, the NRAO will begin to implement an integrated computer plan for the following five-year period.

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 §VIII, 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, and a list of various committees associated with the NRAO.

II. SCIENTIFIC PROGRAM

Throughout 1983, 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 1983 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 - During 1982 a record number of scientists made use of the VLA, and the prospects for a continuing demand for time in 1983 are high. Many programs requiring as little as a few hours can easily be accommodated and many routine observations are now handled under an absentee observing option which does not require visiting astronomer presence during the observation, calibration and editing procedures. This observing mode is not expected to exceed 20% of the overall observing time for 1983. Gradual improvement of the system's spectral-line capability in terms of the number of spectral channels and telescope baselines supported will occur as demand for spectral-line observations increase. Mid 1983 will see the completion of a 2-cm receiver retrofit program which will provide a factor of three sensitivity improvement on all antennas. Pointing improvements will continue through the year as the thermal insulation of antennas progresses. Two VAX systems are currently in operation at the VLA site for further processing the data into source maps. Travel to either the VLA or Charlottesville for VLA data processing will continue to be supported.

As in the past, there is hardly any subdiscipline of astronomy which will not benefit greatly from programs carried out with the VLA. Solar physicists will continue to relate high-resolution radio features on the solar disk to optical observations of well-known features, such as solar flares. Radio studies of the solar transition region and corona will determine the density-temperature structure of this little understood region. Observations of several other solar system objects that have been proposed include the rings of Saturn and Uranus, minor planets, the Galilean satellites, Pluto and Venus. Target of opportunity occultation experiments will probe the number-density and spatial distribution of electrons in comet's tails.

Previously successful VLA observations in search of morphological features in the circumstellar shells of supergiant stars have spawned increased interest in other stellar investigations of a broad range of objects from planetary nebulae to dwarf novae. Mass loss phenomena have been the focus of much attention as investigators seek to model the physical properties of the outward flow of matter from massive stars and to better understand its role in the stellar evolutionary process. Spatial structure and temporal variation are important parameters to be sought in such investigations. VLA observations of planetary nebulae in combination with

optical data will, in addition to improving physical models of the objects, provide much needed data on the nebulae expansion rates and derived distances. A direct comparison of high-resolution VLA maps of supernova remnants (including polarization characteristics) with corresponding X-ray and optical images should reveal much about the interaction of the blast wave with the surrounding ambient material of the interstellar medium. Other objects in the Galaxy which continue to draw much attention include HII regions, star-formation regions, molecular clouds, and the Galactic Center. Further observations of the spiral feature at the Galactic Center will be necessary to fully test kinematic models of the phenomenon.

Many studies of extragalactic objects have taken advantage of the VLA's ability to provide equivalent angular resolutions over a broad wavelength range as it is used in its various standard configurations. Programs requiring this capability are on the increase as the instrument spends greater amounts of time on in-depth studies of individual objects. Spectral-index distributions, polarization properties and source variability parameters are all important quantities which require multiple observations if we are to fully investigate the physics of normal galaxies, active galaxies, radio galaxies and quasars. For many of these objects the proposed VLA observations will be supplemented with multi-wavelength data from the optical, X-ray, ultraviolet, and infrared spectral regions. The VLA is heavily involved in programs to investigate clusters and groups of galaxies, including an attempt to detect the effect of clusters on the microwave background radiation.

12-m Telescope - During the first quarter of 1983, the newly installed surface of the NRAO millimeter-wave telescope will come into service for astronomical observations. With rms surface deviations from the ideal parabolic contour no greater than 70 microns, the telescope will extend the short-wavelength range of efficient operation to below one millimeter. Additional improvements in performance will be realized due to minimized thermal instabilities and distortions in the newly designed back-up structure. With the telescope out of service for the last half of 1982 and with the promise of enormously increased operating efficiences and higher angular resolution at short wavelengths, the proposal backlog has grown exponentially.

Although a number of requests are in hand to continue spectral observations in the J = 1-0 CO lines at 3 mm, the attraction of twice the angular resolution in the J = 2-1 lines has given rise to a number of requests to observe extragalactic molecules in a wide variety of galaxy classes ranging from spirals to irregulars to Seyfert galaxies. The distribution of molecular gas is expected to reveal much concerning the star-formation regions of these galaxies.

Many spectral-line studies are planned which focus on nearby star-formation regions and molecular clouds in our own Galaxy. The energetics of bipolar mass outflow will be a particularly noteworthy area of investigation which promises to reveal much about critical phases of stellar formation and evolution. Prospects are also quite good for improving our understanding of the chemistry of the interstellar medium in regions as

diverse as dark clouds, circumstellar shells around evolved stars or in young star-formation regions.

The stability and improved sensitivity of the 12-m telescope are also critical for a number of proposed continuum studies of a variety of objects. Several investigators intend to make a concerted effort to observe the local variation in the character of the cosmic background radiation seen through clusters of galaxies. Several programs aim to establish the short wavelength spectral character of specific classes of extragalactic objects as well as to monitor designated sources for variability. Limited availability of large sensitive instruments in the 1 to 3-mm range has restricted such programs in the past. A direct improvement in models for energy generation and propagation in quasars and galactic nuclei is the ultimate goal of these spectral studies. Other continuum programs will explore the character of circumstellar dust emission, the heating mechanisms in dark clouds and globules, and the surface properties of solar system planets, satellites and asteroids.

The 140-ft Telescope - Demand for time on NRAO's most versatile single-dish instrument remains high as a result of instrumentation improvements over the past few years. Encouraging results from the initial programs carried out with the upconverter maser receiver in the 5-26 GHz range have brought in even more proposals to exploit the telescope's new-found power. Typical spectral-line programs will investigate the chemistry and excitation properties of molecular clouds by searching for methyl cyanide and its isomer methyl isocyanide or various of the cyanopolyynes. Understanding the peculiarities of interstellar sulfur chemistry is the goal of a study of several sulfur-bearing molecules, such as OCS. The detection, variability and polarization properties of SiS and HC_3N around carbon stars will be investigated.

Extragalactic neutral hydrogen-line observations will explore numerous aspects of galaxy morphology and dynamics. It is hoped that an HI study of active galaxies will provide clues to the connection between normal galaxies and quasars. For a selected sample of irregular galaxies, a study will be made of the structure and evolution of low-density galaxies in which spiral arms are not a significant factor.

About 25% of the observing time on the 140-ft telescope will be devoted to VLBI experiments, partly in concert with the VLBI Network, partly with European VLB stations, and partly in independent VLB experiments. VLB extragalactic programs will focus on the smallest size-scale features in quasars and the nuclei of galaxies in order to understand the mechanisms of energy generation and transport in these sources. A subset of these programs continue to monitor superluminal sources. Within the Galaxy, VLB experiments will probe regions of maser activity in circumstellar shells and star-formation regions for direct dynamical clues to the evolution of these objects. VLB experiments for terrestrial applications, including precision geodesy, crustal dynamics and polar-motion studies, will also continue.

The 300-ft Telescope - As a transit instrument, the 300-ft telescope is ideally suited for observations of a large number of sources on a daily

basis as they cross the antenna's meridian. It has limited flexibility to integrate on individual objects over many observing sessions in an efficient manner. Consequently, it is programmed for several large survey programs during 1983, and minimal support is given to programs requiring in depth analysis of individual sources. The travelling feed does, however, extend the integrating capability of the telescope-receiver system sufficiently for some work on individual sources. Large surveys are underway involving pulsars, low-frequency variables and generally suspected variables.

Monitor programs attempting to establish source variability characteristics as a function of time and spectral range are being carried out by groups from VPI & SU, Massachusetts, and Michigan. These are extremely time-consuming programs which are critically dependent on calibration procedures and long-time baselines. The resulting correlations will provide strong constraints on our understanding of the physical mechanisms and evolutionary processes at work in these sources. In several cases the 300-ft programs are matched by auxiliary monitoring programs at other wavelengths by other non-NRAO telescopes.

A search for low-luminosity pulsars within a kiloparsec of the sun will be carried out with the 300-ft telescope and the new low-frequency receiver. Improved pulsar statistics should dramatically improve our knowledge of pulsar birthrates and their galactic distribution. Other pulsar observations of timing and polarization characteristics will explore the structure of the neutron stars themselves and the nature of the intervening interstellar medium.

Continued observations of a large number of galaxies in the HI line are planned in order to establish redshifts and thereby determine galaxy clustering properties. Such observations will better delineate voids, filaments, and clusters in the overall galaxy distribution in order to provide constraints on evolutionary models of the universe. Other HI studies will investigate the hydrogen content and dynamics of small compact galaxy groups in comparison to the established characteristics of rich clusters.

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 12-m telescope, and (4) the Very Large Array.

The 1983 program for new instrumentation has three categories, with budget allocations as follows (in thousands of dollars):

Item 1.	Other Observing Equipment.....	$1,253
Item 2.	Research Equipment.....	225
Item 3.	Test Equipment.....	50
Total Available.....		$1,528

Item 1. Other Observing Equipment (in thousands of dollars)

	1982 Plan	1983 Plan			1983 Total Estimate
		Est. to Complete	Est. Cont. Development	Est. New Development	
1. Research & Test	$ 235.0		$ 275.0		$ 275.0
2. 140-ft Telescope					
5-26 GHz Rx	10.0		$ 30.0		30.0
New Subreflector				$ 30.0	30.0
3. 300-ft Telescope					
2-5 GHz Rx	25.0		55.0		55.0
Pulsar Signal Processor	20.0		80.0		80.0
Modcomp	25.0	$ 20.0			20.0
Lateral Focusing Device				30.0	30.0
4. 12-m Telescope					
mmλ Device Development	85.0		60.0		60.0
New Receivers	60.0		60.0		60.0
Inductosyns	5.0	10.0			10.0
Computer Upgrade	20.0		40.0		40.0
5. VLA Electronics					
300 MHz Rx	15.0		70.0		70.0
FET Amplifiers	120.0		105.0		105.0
Antenna Pointing Improv.	25.0		40.0		40.0
Module Improvements				25.0	25.0
Water Vapor Radiometer				30.0	30.0
6. VLA Computing					
Sync. Computer Upgrade	35.0		220.0		220.0
DEC 10 System	125.0				
Pipeline	85.0		90.0		90.0
AIPS	85.0		150.0		150.0
7. VLBI	195.0		68.0		68.0
8. Other	66.0		40.0		40.0
Total	$1,236.0*	$ 30.0	$1,383.0	$ 115.0	$1,528.0

* 1982 Plan excludes $192k for 12-m resurface program.

A. Other Observing Equipment: Items to Complete.

1. ModComp. The old DDP-116 control computer at the 300-ft telescope will be replaced by a ModComp. The resultant increased memory available will increase capabilities of the telescope.

2. Inductosyns. Replacement of encoders by inductosyns at the 12-m telescope for improved accuracy and reliability.

B. Other Observing Equipment: Continuing Development Items.

1. Research and Test. Covers cost of small electronics projects (typically less than $20k) and test equipment at all sites.

2. 5-26 GHz Rx. The second channel of this receiver will be completed in 1983.

3. 2-5 GHz Rx. This receiver will cover 2-5 GHz and will be used on the 140-ft and 300-ft telescopes and will result in a very low system temperature in this frequency range.

4. Pulsar Signal Processor. Multifrequency channel back-end capable of fast sampling for pulsar observing.

5. Millimeter-Wavelength Device Development. Covers contract with University of Virginia to supply NRAO with Schottky diodes used in millimeter-wave receivers. Also covers fabrication of superconductor-insulator-superconductor (SIS) junctions for low-noise mixers for future millimeter-wave receivers.

6. New Receivers. New 1, 2, and 3-millimeter cooled mixer receivers for the resurfaced 12-m telescope.

7. Computer Upgrade. Upgrade of DEC-11/40 control computer.

8. 300-MHz Rx. 300-MHz prime focus receivers for the VLA.

9. FET Amplifiers. Cooled GASFET amplifiers for 1, 2, and 21 cm for improved systems performance at the VLA.

10. Antenna Pointing Improvements. Modifications to VLA antennas to improve pointing.

11. Sync Computer Upgrade. Upgrade critical items on on-line system to enhance performance and replace some non-maintainable components.

12. Pipeline. Additional hardware to aid in development of pipeline, especially in the area of spectral-line mapping.

13. AIPS. Addition of new features and facilities to existing image processing system at Charlottesville and the VLA site.

14. VLBI. Improvements to Mk III VLBI equipment at NRAO.

15. Other. Covers development of cooled GASFET amplifiers for frequencies to 22 GHz for all NRAO sites.

C. Other Observing Equipment: New Development Items.

1. New Subreflector. Covers new deformable subreflector for 140-ft telescope.
2. Lateral Focusing Device. Translation of receiver box in N-S direction in order to improve efficiency of 300-ft telescope at its higher operating frequencies.

3. Module Improvements. Modifications to various modules to improve reliability and performance.

4. Water-Vapor Radiometers. Water-vapor radiometers mounted on a few antennas to allow corrections for phase fluctuations caused by atmospheric water vapor.

IV. EQUIPMENT

The distribution of funds (in thousands of dollars) in the various equipment accounts is as follows:

1.	Maintenance, Shop and Repair Equipment	$ 10.0
2.	Office and Library Furnishings and Equipment	8.0
3.	Living Quarters Furniture	2.0
4.	Building Equipment	5.0
5.	Scientific Services and Engineering Equipment	5.0
6.	Other Equipment	120.0
		$150.0

Item

1. Maintenance, Shop and Repair Equipment

Funds planned in this account provide for the replacement and/or acquisition of items for the shops and maintenance divisions. Items included in this account are: tractors and mowers, replacement trucks and other vehicles, machine shop equipment, and 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 communications equipment, typewriters, business data and text processing equipment, copying machines, and other major office furnishings.

3. Living Quarters Furnishings

These funds provide for replacement of household appliances and furnishings used in site living quarters.

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 Enginneering Divisions. Items such as cameras, film

processing units, projectors, measuring equipment, etc., are included in this amount.

6. Other Equipment

An amount of $120k is required to replace one of the passenger busses at the VLA.

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 geographic distribution of personnel in these six units is given in §VII.

A. General and Administration

Serving the needs of the entire Observatory, this unit is comprised of the Director's Office, Fiscal Office, and Business Office. For the first time in 1983, following the construction of the VLA, the Socorro Fiscal Office has been included in this unit. Total Materials, Supplies and Services (MS&S) funding will be $170k. Further major budget items, such as the rent and maintenance of the Charlottesville buildings, communications and utilities, will require $380k. The management fee paid to Associated Universities, Inc., will be $315k.

B. 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 the instrumentation. In 1983, the NRAO summer student program will be resumed in full force as a vital element in NRAO's commitment to the training of future radio astronomers.

The Research Support unit also includes the Charlottesville support persons who maintain the central library and the technical illustration and drafting services for the entire Observatory. In 1983, Material and Supply (M&S) budget of $130k for this group is earmarked primarily for publication support (page charges) of papers based on data obtained with the NRAO telescopes as well as for the book and periodical expenses of the three major NRAO libraries. Printing costs for a new NRAO Public Education brochure are also included in this budget.

Nearly one-half of the overall NRAO travel budget will be expended in the Research Support group ($275k) primarily for travel by all staff and visitors from U. S.-based institutions to carry out observing programs at NRAO telescopes or to use Charlottesville's data analysis facilities. During 1983, $25k is planned for foreign travel by the staff and $20k is available for qualifying U.S. scientists who need travel support to observe at unique foreign telescopes.

C. Technical Support

Several groups providing Observatory-wide technical research and development support are concentrated in Charlottesville. Work at the Central Development Laboratory on radiometer improvements and the exploration of state-of-the-art techniques for expanding wavelength capabilities insures that the Observatory will have forefront instrumentation in the foreseeable future. A subgroup at the Central Lab is heavily involved in the development of VLBI techniques and correlator improvements. The Computer Division operates the NRAO IBM 4341 central computer and the VLB MkII processor and assists in the development of programs for computers at the telescopes. A major responsibility of the Computer Division is the development and maintenance of an astronomical image processing capability, which is currently operating in Charlottesville and at the VLA as well as at a number of institutions world-wide. The Engineering Division provides engineering assistance for the design of new facilities and telescopes. During 1983, $415k is budgeted for MS&S for the above three groups. The major portion of this sum ($300k) will be used for computer rental.

D. Green Bank Operations

The six divisions at Green Bank are responsible for maintaining and operating the 300-ft telescope, the 140-ft telescope, and the interferometer (for the USNO). New instrumentation specifically for the single dishes is developed on site. Some workshops, electronics, and graphics support is also provided for Observatory-wide activities. These six divisions and their 1983 budgets for MS&S are: Telescope Services ($131k), Electronics ($120k), Shops ($20k), Plant Maintenance ($110k), Administrative Services ($110k), and Scientific Services ($25k). An additional $318k will be spent on communications and utilities. It is also estimated that food services and housing will bring in revenues of about $85k. The operation of the Green Bank interferometer for the USNO affects the Green Bank Operations budget as a credit of $521k (see §VI).

E. Tucson Operations

Two divisions in Tucson are responsible for the maintenance and operation of the newly resurfaced 12-m millimeter wavelength telescope at Kitt Peak. The Electronics Division will be devoting a major portion of their 1983 effort to packaging new receivers which will take full advantage of the improved short wavelength potential of the new surface. The Operations and Maintenance group handles all visiting astronomer logistics and observing support, which for 1983 will include continued software

development for improved data acquisition. The two Tucson subgroups will require the following M&S budgets for 1983: Operations and Maintenance ($140k) and Electronics ($100k). An additional $58k is programmed for communications and utilities. Miscellaneous revenue will total about $12k.

F. Socorro Operations

Activities surrounding the VLA are coordinated through seven divisions which differ in detail from those in Green Bank due to the special requirements of array operations and geographic isolation. The VLA Site Management group will require a M&S budget of $74k. The Computer Division (including several Systems Scientists), Electronics Division, Array Operations Division, and the Antenna Maintenance Division, which are most critical to the mechanical functioning and data collecting capabilities of the telescope, will require M&S budgets of $390k, $117k, $5k, and $97k, respectively. Other services related to the efficient functioning of the operation and their M&S budgets are: Plant Maintenance ($136k) and Administrative Services ($261k). Communications, utilities, and building rent (in Socorro) will amount to $725k, while miscellaneous revenue of $75k is expected. Included in the above sums is $265k for computer rent and maintenance. A significant part of the communications expenditures will be devoted to remote observing costs.

A summary of the CY 1983 budget for these operations units is provided in the following table:

CY 1983 Budget - Operation Units
($ thousands)

Operation Unit	Personnel Ceiling	Salaries, Wages & Benefits	Material, Supply, Service	Travel	Total
A. General and Administrative	27	$ 974.9	865.0	$ 83.0	$ 1,922.9
B Research Support	37	1,624.0	130.0	298.0	2,052.0
C. Technical Support	43	1,547.0	415.0	55.0	2,017.0
D. Green Bank Operations	94	2,588.0	749.0	38.0	3,375.0
E. Tucson Operations	22	747.0	286.0	30.0	1,063.0
F. Socorro Operations	112	3,140.0	1,730.0	80.0	4,950.0
Total Operations	335	$10,620.9	4,175.0	$584.0	$15,379.9

Notes: 1. Does not include commitments carried forward from 1982.
2. General and Administrative includes $83.9k carried over for special severance pay and $315k for management fee.
3. Green Bank Operations includes $521k for USNO interferometer support.

VI. INTERFEROMETER OPERATIONS

The NRAO operates and maintains the 4-element interferometer at Green Bank for the U. S. Naval Observatory. Funds for interferometer operations and upgrading are transferred from the Office of Naval Research to the National Science Foundation on a quarterly basis and subsequently made available to NRAO by contract amendment from the NSF. The 1983 cost estimate for the interferometer is $921,802, as follows:

1. Operations	
Salaries, Wages, Benefits, Burden	$299,747
Material, Supplies, Purchased Services	77,800
Overhead and Other Indirect Charges	144,255
Subtotal	$521,802
2. Construction*	$400,000
Total	$921,802

*E/W baseline addition: Funds provided prior to 1983 = $1,220,000.

VII. PERSONNEL

The following table compares the Personnel Services and Benefits (level = full time at December 31) at the Observatory according to employment classification for 1982 and 1983:

	1982			1983		
Category	Actual Level	Salaries	Benefits	Est. Level	Salaries	Benefits
Operations*						
Scientific & Engineering	95	$3,047.9	$ 673.3	102	$3,553.0	$ 790.2
Technical	109	2,131.2	470.8	112	2,363.0	525.5
Administrative & Clerical	67	1,704.3	376.5	68	1,814.0	403.4
Operations & Maintenance	51	801.0	176.9	53	890.0	197.9
Total Personnel	322	$7,684.6	$1,697.5	335	$8,620.0	$1,917.0

* Includes approximately 10 man years charged to Interferometer Operations.

The following table shows the geographic distribution of NRAO personnel according to job function. Although the personnel ceiling level for 1983 is 335, there are 13 unfilled positions at the start of the year in agreement with the actual level of employment in the table above.

Full-Time Employment by Location

	Estimated Distribution				
	GB	CV	TUC	SOC	Ceiling
General and Administration					
Director's Office		6			6
Fiscal Office	8			5	13
Business Management		8			8
Subtotal	8	14		5	27
Research Support					
Basic Research	2	21		9	32
Scientific Services		5			5
Subtotal	2	26		9	37
Technical Support					
Central Lab		16			16
Computer		21			21
Engineering	4	1		1	6
Subtotal	4	38		1	43
Green Bank Operations					
Telescope Operations	24				24
Central Shops	8				8
Electronics	21				21
Plant Maintenance	18				18
Administrative Services	13				13
Scientific Services	10				10
Subtotal	94				94
Tucson Operations					
Operations/Maintenance			12		12
Electronics			10		10
Subtotal			22		22
Socorro Operations					
Site Management				7	7
Antenna Maintenance				20	20
Computer				16	16
Electronics				30	30
Array Operations				11	11
Administrative Services				16	16
Maintenance				12	12
Subtotal				112	112
Total NRAO	108	78	22	127	335

VIII. 1983 Financial Plan
Expenditures and Commitments by Classification

	1981	1982		1983			
	Actual Expend.	1982 Actual Expend.	New Funds 1983	Uncomm. Funds From 1982	Avail. for Comm. 1983	Comm. From 1982	Avail. for Exp. 1983
1. Operations							
Personnel Compensation	$ 7,674.9	$ 7,684.6	$ 8,620.0		$ 8,620.0		$ 8,620.0
Personnel Benefits	1,550.5	1,697.5	1,917.0		1,917.0		1,917.0
Travel	538.0	458.7	584.0		584.0		584.0
Material & Supply	3,550.9	3,577.0	3,860.0		3,860.0	$ 242.7	4,102.7
Subtotal	$13,314.3	$13,417.8	$14,981.0		$14,981.0	$ 242.7	$15,223.7
Management Fee	$ 235.0	$ 295.0	$ 315.0		315.0		$ 315.0
Special Insurance Credit	(107.7)	-	-		-		-
Special Severance Pay	307.9	9.1		$ 83.9	83.9		83.9
Total Operations	$13,749.5	$13,721.9	$15,296.0	$ 83.9	$15,379.9	$ 242.7	$15,622.6
2. Equipment							
Research Equipment	$ 1,172.9	$ 1,173.0	$ 945.0	$ 583.2	$ 1,528.2	$ 371.6	$ 1,899.8
12-m Resurface	21.0	365.8		102.1	102.1	11.1	113.2
Operating Equipment	264.6	189.9	150.0	10.8	160.8	30.0	190.8
Total Equipment	$ 1,458.5	$ 1,728.7	$ 1,095.0	$ 696.1	$ 1,791.1	$ 412.7	$ 2,203.8
3. Construction							
Very Large Array	$ 1,913.1	$ 221.5	-	-	-	-	-
Interferometer Expansion	39.9	872.3	$ 400.0	$ 350.7[1]	$ 750.7	$ 44.7	$ 795.4
Total Construction	$ 1,953.0	$ 1,093.8	$ 400.0	$ 350.7	$ 750.7	$ 44.7	$ 795.4
Total NRAO	$17,161.0	$16,544.4	$16,791.0[2]	$1,130.7	$17,921.7	$ 700.1	$18,621.8

Notes: [1] Includes $87.2k from USNO Operating Funds.
[2] NSF Funds = $15,870.0; USNO = $921.0.

1983 Financial Plan
Operating Expenses by Major Function

	1981	1982	1983				
	Actual Exp.	Actual Exp.	New Funds 1983	Uncomm. Funds From 1982	Avail. for Comm. 1983	Comm. From 1982	Avail. for Exp. 1983
Operations							
General & Administrative	$ 1,428.1	$ 1,392.7	$1,524.0	$83.9	1,607.9	$ 6.0	$ 1,613.9
Research Support	1,589.3	1,598.6	2,052.0		2,052.0	20.2	2,072.2
Technical Support	1,981.3	1,976.6	2,017.0		2,017.0	11.2	2,028.2
Green Bank Operations	3,541.6	3,002.8	3,375.0		3,375.0	63.9	3,438.9
Tucson Operations	994.8	991.2	1,063.0		1,063.0	15.7	1,078.7
Socorro Operations	4,087.1	4,465.0	4,950.0		4,950.0	125.7	5,075.7
Subtotal	$13,622.2	$13,426.9	$14,981.0	$83.9	$15,064.9	$ 242.7	$15,307.6
Management Fee	235.0	295.0	315.0		315.0		315.0
Special Insurance Credit	(107.7)						
Total Operations	$13,749.5	$13,721.9	$15,296.0	$83.9	$15,379.9	$ 242.7	$15,622.6

APPENDIX A

Research Programs for the NRAO Scientific Staff

During 1983 the permanent staff of the NRAO will be working in a number of research areas as described below. Some of the research will be carried out in collaboration with visiting scientists.

A. Planetary Studies

An attempt will be made to resolve the long-standing uncertainty about Pluto's surface temperature. Sensitive 2-cm measurements will be made with the VLA, and the bolometer will be used at 1 mm on the 12-m telescope. Previous attempts to detect Pluto's thermal radio emission have proven unsuccessful. Given the current best estimates of the planet's size and albedo, the predicted radio emission should be well within the range of these instruments. Unexpectedly low values of the radio flux could have implications for the solar heating models of the planet's surface.

The long-term program of astrometric measurements of the largest minor planets will continue. Not only does the study reveal physical properties of the asteroids, but its main objectives are a refined location of the vernal equinox and an absolute calibration of the VLA in right ascension without reference to any optically determined standards.

B. Galactic Studies

1. Stars and the Stellar Environment

Recent surveys with the VLA have discovered three faint sources coincident with three previously identified but spectroscopically undistinguished K dwarf stars. The radio-optical position agreements are within 1 arcsec. Further observations of the radio spectra, sizes, and time variations of these sources will be made in an attempt to reveal additional physical characteristics of this apparently new class of radio star.

Three years of high-resolution, multi-frequency maps of the evolving SS433 radio sources will be analyzed in order to study the time-dependent evolution of its radio jets in the context of existing models. Further modelling will be needed before the relationships between different source structures are understood. It is hoped that scaled-up models of this nearby stellar source in our own Galaxy will provide clues to the mechanisms operating in extragalactic radio jets. Similar regular observations of the triple source Sco X-1 should greatly improve our knowledge of how it evolves with time.

A selected group of radio binary stars continues to be monitored with the VLA in an effort to measure their absolute parallaxes and proper motions.

A number of stellar sources have been resolved with the VLA, and programs are underway to analyze the structural information thus obtained. In the Antares binary system, a study of the outer structure of the stellar wind by mapping and modelling the ionized portion of the wind around the B4V companion star will be pursued. For the wind-driven extended atmosphere of the Wolf-Rayet star γ Vel, multiwavelength observations will be made in order to sample the run of temperature with distance from the star. Other Wolf-Rayet stars will also be probed in this manner.

Observations of the Crab Nebula, the remnant of the supernova of AD 1054, will be completed, using all four of the VLA configurations at 20-cm and 6-cm wavelengths. The data will be used to study the magnetic field properties of the filaments, to study the relationship between the radio and optical filaments, and to study the region where the pulsar wind interacts with the nebula. A search will be made for the radio counterpart of the optical jet.

Early high-resolution (0.1 arcsec) observations of some ultra-compact HII regions have shown that a high proportion of these sources present ring-like configurations. The detailed analysis of these sources seems to favor a stellar wind origin as placental material is blown away from the region of a recently formed star. Further observations of many additional candidates are planned in order to determine how common the incidence of such shells is as well as to gather additional morphological specifications in order to test competing theories.

The envelopes of evolved stars, such as IRC 10216, provide excellent laboratories for the study of photochemical processes and the excitation of molecular lines. With the high-resolution capability of the 12-m telescope at high frequency, it should be possible to resolve photochemically induced layering of molecules in the outer circumstellar shell regions of IRC 10216. The same object exhibits SiS emission which either arises from maser action or is pseudo-thermal in nature. Theoretical models of the conditions for maser excitation will be pursued and other similar objects will be searched for equivalent vibrationally excited states in a situation analogous to that of SiO maser emission in evolved stellar envelopes.

Parallel investigations of molecular-line spectroscopy will be carried out in the circum-nebular shells of planetary nebulae. Observations of the carbon and oxygen fine-structure lines in the submillimeter will be coordinated with IUE observations of the ultraviolet resonance lines.

2. The Interstellar Medium

The structure of star-forming clouds is normally substantially altered by the formation of a star. Material ejected from centers of star formation can be gravitationally unbound. High-resolution observations can determine the flow mass and velocity as a function of radius, which can in turn be interpreted to measure the history of the rate of momentum injection into the outflow and related quantities, such as the luminosity history of the star-forming cloud core. A program to meet these goals is

underway using the millimeter-wave telescopes at the NRAO, Onsala, and Texas. Observations of the J = 2-1 CO lines will be obtained to augment the already existing data from the J = 3-2 lines of HCO^+ and $H^{13}CO^+$ and the J = 1-0 lines of CO and ^{13}CO. Comparison of the density and chemical structure of these star-forming clouds to a set of cold clouds, which are chemically and dynamically well-developed but have not formed stars, is the aim of another study involving comprehensive spectral-line observations and detailed models of line formation. Highly excited high-frequency lines, relatively unaffected by foreground absorption, are an important element of this study. The improved capabilities of the 12-m telescope will be particularly useful in this respect.

Photochemistry plays an important role in determing the physical conditions at the periphery of interstellar clouds. Observations in the 610 μ fine-structure line of neutral carbon are planned in a collaborative effort between workers at NRAO and Caltech in order to probe these regions. Clues to the relationship between metal abundance and ionization structure will be sought in clouds exhibiting both carbon recombination lines and DCO^+ lines.

The expanded power of the 12-m telescope should help to place limits on the abundance of O_2 below those that are currently inferred from CO observations of dense clouds. Two previous attempts to find O_2 in dense clouds have failed. A search is planned for the elusive NH_2 radical, of considerable importance in models of gas-phase ion-molecule chemistry of interstellar clouds. NH_2 has no suitable transitions at wavelengths longer than ~ 1.3-mm wavelength but has two highly suitable groups of transitions (the 2_{20} - 3_{13}, J = 3/2 → 5/2 and J = 5/2 → 7/2 transitions) which have been recently measured accurately in the laboratory and lie at ~ 229 and 242 GHz, respectively. Some preliminary evidence for a signal at the 242 GHz lines has already been obtained, but may be spurious.

A confirmation of vibrationally-excited HCO^+ and a search for vibrationally-excited HCN and HNC is planned. Recent laboratory measurements of the rotation constants for the (1,0,0), (0,0,1), and (0,2°,0) states of HCO^+, HCN, and HNC have been made elsewhere. In the case of HCO^+, coincidence of the J = 1-0 transitions in both the (1,0,0) and (0,0,1) states occurs with the two U-lines seen in the NRAO survey toward Ori (KL). The search to confirm the identification for HCO^+ and to seek vibrationally-excited transitions of HCN and HNC will feature the J = 2-1 lines in the 1.2-mm wavelength spectral region.

A project will be started in which Lyman-α measurements are used in conjunction with the large available body of 21-cm absorption statistics to reconstruct the parameters of the diffuse interstellar medium. UV measurements provide information on column densities which the 21-cm results can infer only as the combination of rather precise optical depths and very imprecise spin temperatures. Comparison of the UV and HI absorption data in principle provide sufficient information to deconvolve both the column density and spin temperature distributions of diffuse clouds.

A large area around the Rosette nebula has been fully mapped in HI using the 140-ft and the 300-ft telescopes. Analysis of these data will give the structure and properties of atomic gas in this area of recent star formation.

3. Galactic Structure

Maps of the Sgr molecular clouds at 2' resolution, extending over the inner 1.5° of galactic longitude, show for the first time the detailed disposition of the molecular clouds associated with the Sgr A, B, C continuum sources. They also show a component of gas with the kinematic signature of circular motion but two other unexpected properties: the observed velocity at the longitude of Sgr A (the putative center of the galaxy) is + 80 km s^{-1} and the gas morphology shows a clear and large tilt, rising above b = 0° at $\ell > 0°$. This is approximately orthogonal to the earlier, larger-scale tilted disk description of gas in the range 100-1500 pc from the nucleus, but very recent models of gas flow in triaxial potentials predict the existence of tilted gas planes.

VLA 21-cm HI absorption maps toward Sgr A at 12" resolution extend and greatly clarify previous absorption measurements. By comparison with maps of the CO emission, it is directly inferred that the great majority of gas seen in emission toward the nucleus of the galaxy lies between the Sun and Sgr A. Around this position the emission profile roughly covers the range -200 km s^{-1} to +200 km s^{-1}, and all but the features at $v \geq 150$ km s^{-1} are present in the HI absorption spectra with identical spatial distribution.

Further investigation of the Sgr A region in the galactic center will include VLB observations of the point source and work on the theoretical interpretation of the present observations. Higher resolution observations of the regions surrounding the point source are also required.

The high-resolution (3') CO survey of the galactic equator have been extended to include the full range from 20.5° to -40° in longitude. The observations have been used to derive the one-dimensional cloud-cloud random velocity. (It is found to be 4.2 km s^{-1} on average.) They also show, in comparison with the published CO survey results of Burton and Gordon, a gradient in the $^{12}CO/^{13}CO$ isotopic intensity ratio. Further work on the interpretation of this gradient is underway.

Existing and new 21-cm HI measurements of the inner Galaxy will form the basis of an investigation of the neutral halo of the Galaxy. A combination of 21-cm and UV Lyman-α observations of HI toward bright high-latitude stars should determine the halo's structure in the solar neighborhood. These observations involve removing stray radiation from 140-ft HI spectra, a complicated procedure that relies heavily on the existence of the all-sky HI survey made with the Crawford Hill horn of Bell Labs.

This year two large-scale surveys of ionized gas in the Galaxy will be completed. The first is a 1.4 GHz recombination-line survey that is sensitive to diffuse nebulae and that has been made aiming for uniform

coverage of the inner plane. The second is a 10.6-GHz survey of compact HII regions that will increase the known number of these objects by a factor of more than three. This survey aims for complete coverage of thermal continuum sources in the northern sky above some limiting flux level.

C. Extragalactic Studies

1. Normal Galaxies

A preliminary investigation of the radio properties of a complete sample of 2400 galaxies will be begun. This sample has been extensively investigated at optical wavelengths by Heeschen and colleagues, who call the sample "North Zwicky Forty." Radio data, in conjunction with the existing optical material, should provide valuable new insights into optical/radio correlations in galaxies.

Spiral galaxies with exceptionally bright radio disks often appear "swept back" on VLA continuum maps. A possible explanation is that bursts of star formation are triggered on the leading edges of these galaxies through compression of the interstellar medium by collisions with intergalactic gas. This hypothesis will be tested with VLA maps of the HI mass distributions and velocity fields of such galaxies.

Detection surveys, primarily carried out with the Nancay radio telescope in France, have detected the main lines of OH in absorption in eight galaxies out to a maximum distance of 68 Mpc. Following up on these new detections, the VLA has been used to synthesize the distribution of OH absorption (and maser emission) at high spatial resolutions. For NGC 253, a molecular ring-like distribution of radius ~ 1 kpc in absorption in the main lines is seen. The maser emission is essentially unrevolved and centered on the strong nuclear continuum source. Data reduction, using even more sophisticated self-calibration techniques, will continue on M82, NGC 3079, and NGC 3628. All of these galaxies have been observed in the satellite lines at 1612 and 1720 MHz and show in preliminary reduction P Cygni-type spectra. VLA observations of possibly four other OH galaxies will be made.

Although studies over the years have revealed significant structure in the disk CO component of several galaxies on size scales of ~ 1', spiral arm structure has not yet been established in the molecular component, nor have depressions of the sort that in our own galaxy separate the nuclear from the disk components. Large-scale trends with galactocentric radius have been seen in M31, such as a decrease with increasing R of maximum T_A^* values for CO. Observations at CO J = 2-1 are planned which make use of the 30" resolution of the resurfaced 12-m telescope to try to resolve spiral structure in several galaxies. Depressions ("inner Lindblad resonances") between nuclear and disk components in M51, NGC 6946, IC 342, and other objects will also be sought after. Arm/interarm contrasts in CO in the SW

complex of M31, the one instance where spiral structure seems to be observed, will be refined.

2. Radio Galaxies and Quasars

The VLA 6-cm deep source survey will be extended to reach a source flux density of 25 μJy, and new areas will be surveyed to improve the source statistics in the range 350 μJy to 5 mJy. A sample of the faintest sources will be observed with the KPNO 4-m telescope and possibly other large optical telescopes as well in order to obtain optical identifications and, where possible, redshifts. In addition, the brightest quasars from the Palomar Bright Quasar list and a sample of fainter quasars will be observed with the VLA to determine the rate of occurrence of radio emission from quasars. Some of these will also be studied with the 36-ft telescope at 1-mm wavelength to see if they radiate in this portion of the electromagnetic spectrum. These observations will be combined with the Deep Source Survey to better determine the radio luminosity function of galaxies and quasars and its spatial evolution.

A deep 1465-MHz VLA survey has been used to determine source counts down to 200 μJy and constrain models in which the cosmic microwave background is primarily thermalized radiation from massive pregalactic stars. This survey will be redone with a wider bandwidth and longer integration time to yield an rms map noise of 10 μJy. From the new map it will be possible to make direct source counts down to 60 μJy, statistical counts down to 10-20 μJy, and set limits on the microwave background fluctuations sufficient to eliminate the pregalactic-star model (or to detect the stars!).

Beyond the above deep source surveys, a number of programs have been organized to search for statistically significant relations among large groups of radio sources. A sample of radio galaxies and quasars, previously studied for short-time scale variability, will be observed with the VLA in order to get homogeneous structural data for comparison with the variability results. The same sample of objects will also be reobserved with the 300-ft telescope to determine variability characteristics on various time scales up to four years. For another large group of southern radio galaxies, the existing radio data will be analyzed for correlations between the observed radio parameters as well as intercompared with existing quantitative optical spectroscopic information.

The program to regularly monitor a complete sample of low-frequency variable sources (mostly quasars) will continue. In order to determine the spectral character of the variations, flux density measurements are being made every two months at 318, 430, 606, 880, and 1400 MHz.

An L-band search for interstellar scintillations of compact extragalactic sources will be made with the VLA. It is designed to circumvent any possible intergalactic broadening and consequent suppression of scintillations. Either scintillations will be detected, or it will be shown that strong extragalactic sources do not contain components with brightness temperatures significantly greater than 10^{12} K.

Numerous investigations of individual radio sources and galaxies are planned. For the three interesting radio galaxies, 3C 75, M87, and 3C 465, VLA observations will take advantage of the scaling properties of the standard array configurations. Equivalent angular resolution at several wavelengths will make possible unambiguous studies of the spectral index and polarization distributions in these sources. For M87, in particular, second epoch observations will be crucial for the detection of proper motions in its jets. High dynamic range studies should reveal numerous interesting low-level features which are at the limit of the current best maps of the source. In the case of 3C 75, there are multiple jets to try and interpret.

Two beautiful S-shaped radio sources in which the collimating objects (black holes?) are undergoing forced precession were mapped with the VLA and will be analyzed. One is a $z = 0.128$ QSO with stellar absorption lines in its spectrum; it has a companion galaxy at the same redshift. The other is an elliptical galaxy at $z = 0.073$ with an interesting spiral companion. Both radio sources are well resolved with the VLA, so most of the geometric and kinematic parameters which describe the precessing jets can be determined.

Synthesized VLA maps of the HI distribution in the Seyfert galaxies NGC 1068 and NGC 4151 will be obtained in order to investigate the distribution and kinematics of the neutral interstellar medium. Of specific interest is whether or not the perturbed nuclear gas kinematics can be traced into the disk. The distribution of the neutral gas in comparison with other tracers will be an important diagnostic tool for evaluating the "starburst" and other models for star formation and nuclear activity. For NGC 1068, which appears to be deficient in HI and relatively rich in molecular gas, high-resolution 1.2-mm observations of the $J = 2-1$ CO line with the 12-m telescope will provide information on the bulk of the neutral interstellar medium in the galaxy.

The rapid component motions in the radio nucleus of the Seyfert galaxy 3C 120 are being monitored every four months using 6-cm VLBI observations and using six to ten telescopes. The increased temporal coverage and improved dynamic range available with these observations, compared to those made before 1981, have removed much of the ambiguity that has been associated with this apparently superluminal source in the past. At least two new superluminal components, and maybe more, are evident in the first three maps made under this program. Continued monitoring will provide much information on the history of individual superluminal components and on the relative behavior of different superliminal components in the same source. During 1983, this program will be expanded to include an attempt to measure the absolute motions in 3C 120 to determine which components are moving and which are not.

High dynamic-range VLBI observations (14 stations) at 18 cm will also be used to study the structure and motions in the 3C 120 jet on intermediate scales in an effort to determine the relationship between the inner (VLBI scale) and outer (VLA scale) regions. The transition between the relativistic motions in the case of 3C 120 to the region of the

non-relativistic large bent jet and the diffuse outer radio lobes is not fully understood. Similarly, VLBI observations will be made of the inner regions of the classic VLA jet source NGC 6251 where the jet is probably not subject to the strong relativistic beaming implied by the superluminal motions in 3C 120.

Following up radio recombination-line detections from four high redshift quasars during the past year, a further search for examples of such lines will be undertaken in a carefully selected sample of quasars. Seen in emission, these lines are stimulated by the background quasar continuum radiation and provide an extremely valuable probe of the low density, ionized envelope surrounding quasars. They also have the potential to provide a redshift-independent measure of the distance to quasars.

3. Clusters and Groups of Galaxies

The VLA Abell cluster survey will continue with snapshot observations at 20 cm of about 100 clusters in the B and C configurations. The resulting compilation of a complete morphological picture of cluster radio emission and its correlation to the X-ray emitting cluster gas may lead to a better idea of the origin and evolution of these sources. In some of the clusters the kinematics of the binary nuclei of cD galaxies will be spectroscopically investigated in order to establish the frequency of large velocity differences and their implications for cluster evolution. The goal of another optical program will be the discovery of faint clusters surrounding a select sample of quasars which are known to have peculiar morphologies.

The continuing study of the effect of the cluster environment on the measurable properties of component galaxies is now being carefully evaluated for selection effects and possible inaccuracies in the classifications for magnitudes and angular sizes. Twenty-one centimeter line observations of galaxies in differing environments, varying widely in local intergalactic density, have been obtained and are now systematically being analyzed. Preliminary indications are that the ratio of total mass to luminosity varies from the sparsely populated regions to the centers of rich clusters. It is anticipated that further examination of the HI distribution of galaxies in various environments will provide insight into the causes of gas depletion and how it is affected by the initial conditions of galaxy formation.

Redshift information for a large sample of quasars in the Pices-Perseus region have indicated that the supercluster extends, in a series of filaments, over perhaps twelve hours of right ascension. Further redshifts are being obtained in the zone of avoidance with the 300-ft telescope to see if the Perseus chain does indeed connect up with the Lynx-Ursa Major supercluster on the other side of the galactic plane. The 300-ft is also being used to extend the survey of the Hercules supercluster to the north and south and to investigate a possible bridge to Coma.

D. Miscellaneous

Measurements 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 for the VLA. Secondary objectives include refinement of precessional, nutational, and geophysical constants.

Observations are in progress in which the difference between the outputs of two water-vapor radiometers is compared with the phase measured by two connected elements of the VLA. The water-vapor radiometers, developed at the Jet Propulsion Laboratory, provide an estimate of the path delay introduced by water vapor in the atmosphere. The observations are designed to explore the accuracy with which corrections for atmospheric path fluctuations can be made, either to VLA data or to VLBI data.

APPENDIX B

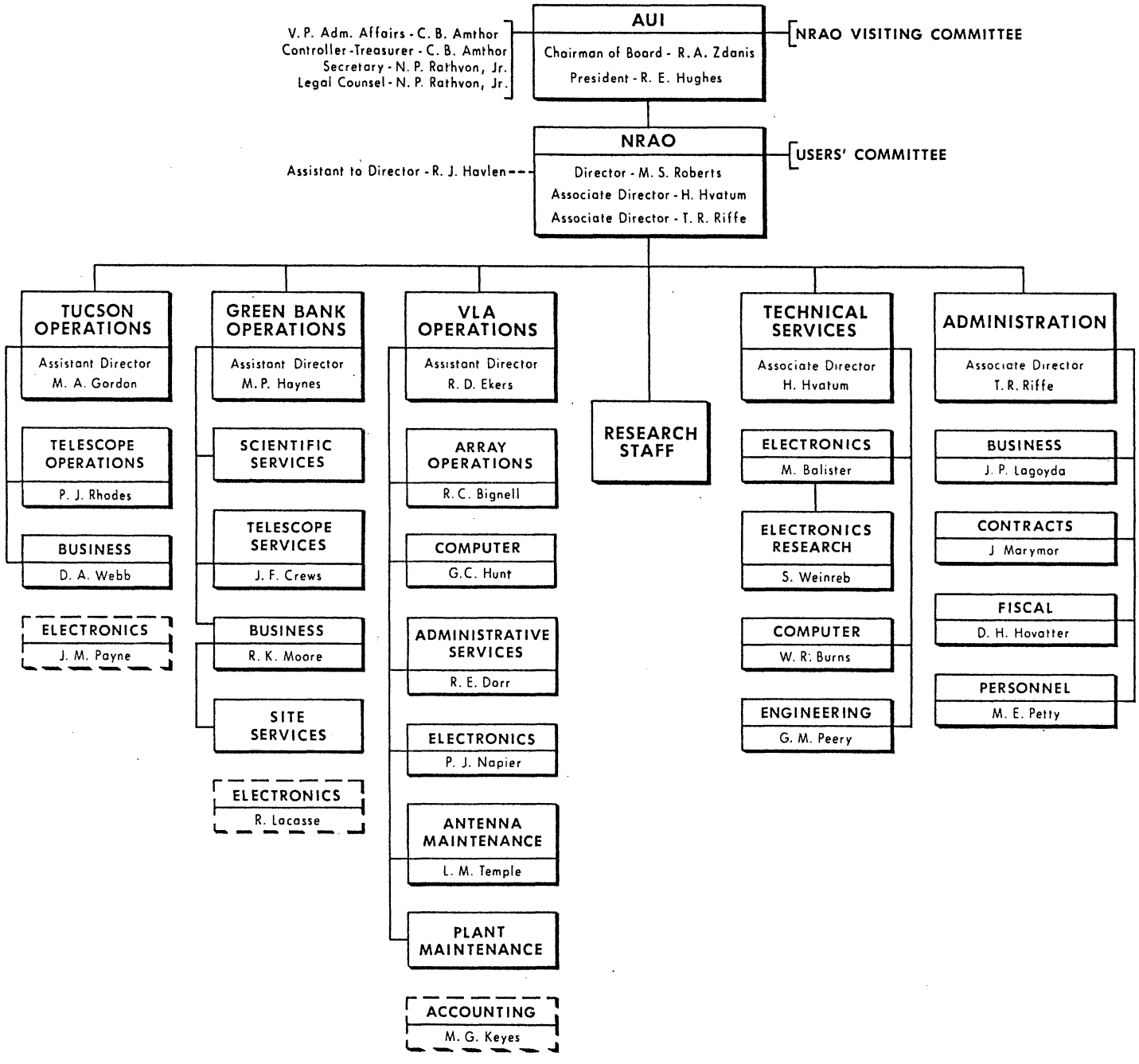
NRAO Permanent Scientific Staff, with Major Scientific Interests

Benson, J. M.	Stellar OH Masers; Compact Galactic Sources
Bignell, R. C.	Polarization and Mapping of Extragalactic Radio Sources; Planetary Nebulae; Supernova Remnants
Bridle, A. H.	Continuum Radio Radiation; Extragalactic Radio Sources; Radio Jets
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
Crane, P. C.	Normal Galaxies; Interferometry
Ekers, R. D.	Synthesis Techniques; Galactic Center; Normal and Radio Galaxies; Cosmology
Findlay, J. W.	Absolute Flux Density Measurements; Telescope Design; Surface Measuring Techniques
Fomalont, E. B.	Interferometry; Extragalactic Radio Sources; Relativity Tests
Gordon, M. A.	CO; Galactic Structure
Greisen, E. W.	Structure of Interstellar Medium; Computer Analysis of Astronomical Data
Havlen, R. J.	Galactic Structure; Clusters of Galaxies
Haynes, M. P.	Normal Galaxies; Clusters of Galaxies; Intergalactic Medium
Heeschen, D. S.	Variable Radio Sources; Normal Galaxies; QSOs
Hjellming, R. M.	Radio Stars; Theoretical Astrophysics; VLA Development
Hogg, D. E.	Radio Stars and Stellar Winds; Extragalactic Radio Sources
Kellermann, K. I.	Extragalactic Astronomy; VLBI Instrumentation
Liszt, H. S.	Molecular Lines; Galactic Structure

Lockman, F. J.	Galactic Structure; Interstellar Medium; HII Regions
Owen, F. N.	Clusters of Galaxies; QSOs; Radio Stars
Payne, H. E.	Interstellar Medium; Low Frequency Variables
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; Stellar Radio Emission; Minor Planets
Weinreb, S.	Millimeter Wave Development
Wells, D. C.	Digital Imaging Processing; Extragalactic Research
Wootten, A.	Molecular Clouds; Circumstellar Shells

NATIONAL RADIO ASTRONOMY OBSERVATORY
ORGANIZATION CHART

January 1, 1983



APPENDIX D

NRAO COMMITTEES

Visiting Committee

The Visiting 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
Hewish, A.	University of Cambridge, England
Richards, P. L.	University of California, Berkeley
Seaquist, E.	University of Toronto
Shapiro, I. I.	Massachusetts Institute of Technology
Strittmatter, P.	University of Arizona (Steward Obs.)
Taylor, J. H.	Princeton University
Vanden Bout, P. A.	University of Texas

NRAO Users' Committee

The Users' Committee is made up of users and potential users of NRAO facilities from throughout the scientific community. It advises the Director and the 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, appointed by the Director, meets twice a year.

The present membership of this Committee is:

Berge, G. L.	California Institute of Technology
Bieging, J. H.	University of California, Berkeley
Blitz, L.	University of Maryland
Briggs, F. H.	University of Pittsburgh
Dennison, B. K.	Virginia Polytechnic Institute and State University
Dulk, G. A.	University of Colorado
Giovanelli, R.	Arecibo Observatory
Goldstein, S. J.	University of Virginia
Gottesman, S. T.	University of Florida
Helfand, D. J.	Columbia University
Ho, P. T. P.	University of California, Berkeley
Lo, K-Y.	California Institute of Technology
Lovas, F. J.	National Bureau of Standards
Marscher, A. P.	Boston University

Mutel, R. L.	University of Iowa
Myers, P. C.	Massachusetts Institute of Technology
Partridge, R. B.	Haverford College
Phillips, R. B.	Haystack Observatory
Price, R. M.	University of New Mexico
Reid, M. J.	Smithsonian Center for Astrophysics
Rodriguez, L.	Observatorio Astronomico Nacional
Rudnick, L.	University of Minnesota
Seaquist, E. R.	University of Toronto
Stark, A. A.	Bell Laboratories
Weisberg, J. M.	Princeton University
Welch, W. J.	University of California, Berkeley
Wilson, A. S.	University of Maryland