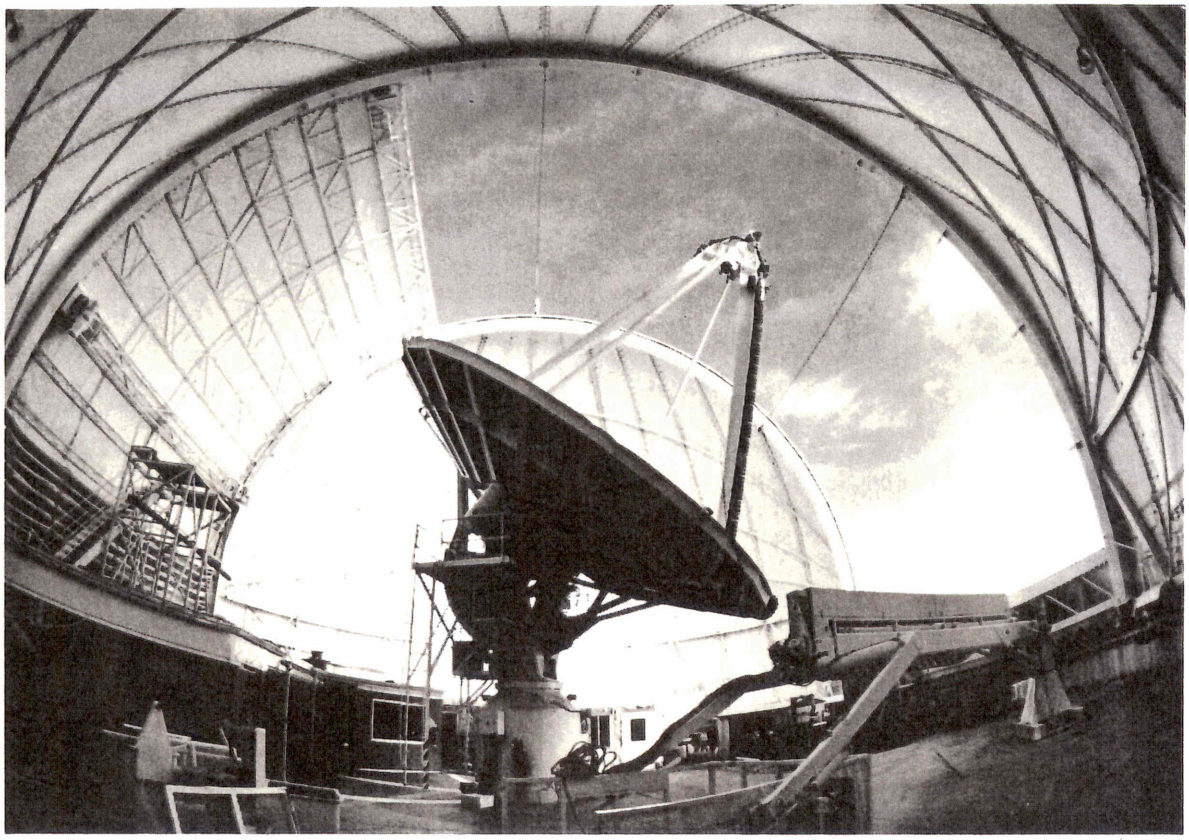
NATIONAL RADIO ASTRONOMY OBSERVATORY



PROGRAM PLAN

1975

NATIONAL RADIO ASTRONOMY OBSERVATORY

CALENDAR YEAR 1975 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 four major radio telescopes and by research and development in the fields of advanced electronics and data processing systems.

The next section of this Program Plan summarizes the research that is planned for the 300-foot meridian telescope, the 140-foot fully steerable telescope, the four-element interferometer, and the 36-foot millimeter-wave telescope during the calendar year. More than 60 percent of the observing time required for this research will be used by visiting investigators.

Section III of the Program Plan describes the new research instruments which will be acquired during 1975. Subsequent sections give the detail of the expenditures required for operations and maintenance of the Observatory. A summary of the allocation of funds is given in Section VII, the financial plan.

Appendices to this Program Plan include a summary of the scientific program of the NRAO permanent staff and an organizational chart for the NRAO.

II. SCIENTIFIC PROGRAM

The scientific program for 1975 will include investigations of a wide range of objects, from the planets and the sun to distant radio galaxies and quasars. It is anticipated, however, that observing pressure will be particularly heavy in three fields: radio stars, interstellar molecules, and the radio structure of radio galaxies and quasars.

It is now known that radio emission arises from stars associated with X-ray sources and with certain binary systems. The binary nature of the stars appears to be a necessary condition, since the maximum power radiated at radio wavelengths is directly proportional to the energy gained by circumstellar gaseous material during its free-fall to the surface of the secondary component in the system. Further observations will be used to investigate the physical conditions leading to the generation of radio waves in circumstellar envelopes, and to find new classes of stars that are radio emitters.

Research in the area of interstellar molecules will strive for a better understanding of the chemistry of interstellar gas through searches for new species and for new transitions from recently discovered molecules such as ethyl alcohol and N_2H^+. The detection of interstellar molecules not known on earth will also of course contribute to the theory of molecular structure. From observations of the distribution of some of the common molecules inferences can be drawn about the physical conditions in dense interstellar clouds, and about the relationship of these clouds to star formation.

Recent observations with four or five antennas using the techniques of very long baseline (VLB) interferometry have enabled the first crude maps of quasistellar radio sources to be made, with an effective resolution of about 10 milliarcseconds. In the next year more such VLB "array" observations will be made, to determine the angular structure of a larger number of sources and to measure how this structure changes with time.

Studies of radio galaxies will be continued with the four-element interferometer, using angular resolutions between 0.5 and 50 arcseconds. A number of theories about the origin and evolution of such objects have been presented in the last two years, and detailed maps of the distribution of intensity, polarization, and spectral index for a number of "typical" galaxies will be compared with the predictions that the various theories make. The four-element interferometer will also be used in the search for compact radio components associated with the optical counterparts of radio galaxies.

As in the past, more than 60 percent of the observing time devoted to this scientific program will be used by guest investigators. All proposals for telescope observing time, whether by visitor or staff, are sent for

appraisal to referees who are not on the NRAO staff. The programs that are run on the telescopes represent the best of those proposals. Approximately 250 separate observing programs will be undertaken in 1975, by more than 200 guest scientists and students from more than 50 other institutions in the U.S., and by the approximately 25 members of the NRAO staff, and by a smaller number of scientists from other countries.

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

III. RESEARCH INSTRUMENTS

The primary research instruments at the National Radio Astronomy Observatory consist of: (1) a 140-foot telescope; (2) a 300-foot telescope; (3) an interferometer, consisting of three 85-foot telescopes and a 45-foot transportable telescope; and (4) a 36-foot telescope. With the exception of the 36-foot telescope, all NRAO research instruments are located at Green Bank, West Virginia. The 36-foot telescope is located on Kitt Peak, near Tucson, Arizona. The following two tables summarize the funds needed to equip NRAO research instruments.

Item 1.	Other Observing Equipment.....	$510.0
Item 2.	Research Equipment.....	170.0
Item 3.	Test Equipment.....	30.0
	Total.....	$710.0

The estimated funds for research instruments will provide auxiliary instrumentation and equipment to maintain and improve the capabilities of the telescopes, including a 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 following 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, new development, and funds for items of continuing and general development.

Item

1. Other Observing Equipment

(see attached table, page 5)

A. Other Observing Equipment: Items to Complete.

The items expected to be completed in 1975 include:

1. 140 Foot Cassegrain Improvements - This expenditure will be used to make improvements in the new 140 foot Cassegrain receiver as deemed necessary after late CY 1974 tests.

1. Other Observing Equipment (in thousands)

	Estimate to Complete	Estimate for New Development	Estimate for Continued Development	General Development	Total
140-foot Telescope					
Cassegrain	30.0				30.0
Low-noise receiver		50.0			50.0
Correctable subreflector		20.0			20.0
On-line computer		65.0			65.0
300-foot Telescope					
21/6-cm receiver	20.0				20.0
36-foot Telescope					
9-mm Cassegrain receiver	30.0				30.0
120-160 GHz receiver		25.0			25.0
33-50/80-120 GHz receiver		100.0			100.0
Josephson junction			10.0		10.0
Other					
Diode development			40.0		40.0
Satellite experiment	25.0				25.0
Autocorrelator		80.0			80.0
General				15.0	15.0
TOTAL	105.0	340.0	50.0	15.0	510.0

2. Completion of 9-mm Cassegrain Receiver - A dual-beam, dual-polarization (four receivers) 700° K, 500 MHz bandwidth continuum receiver will be provided.

3. Satellite VLBI Experiment - This is to fund NRAO contribution to a Green Bank-Algonquin Park VLBI experiment which will use a satellite for data transmission (in place of tape recorders).

4. Completion of 21/6-cm Receiver - Funds are required to complete the (1000-1450)/(4500-5000) MHz receiver started in CY 1974.

B. Other Observing Equipment: New Development Items.

The following new items are planned for 1975:

1. 140 Foot Very-Low Noise Front-End - The improved short-wavelength performance provided by a correcting sub-reflector plus the additional flexibility of the Cassegrain mode must be matched by high-performance receivers in the 1 cm to 3-cm range. These will be provided by either masers or cooled parametric-amplifier preamps added to the present cooled-mixer system. This choice will be investigated and a receiver expected to cost a total of $200K will be started with $50K in CY 1975.

2. Correcting Sub-Reflector - The 140-foot telescope will be improved for operation in the 1 to 3-cm wavelength range by installation of a sub-reflector which is programmed to correct astigmatism.

3. 140 Foot Central Control Computer - A central control computer will be provided for the 140-foot telescope. It will have the necessary speed, memory and reliability to handle all control and data collection functions for the 140-foot telescope.

4. 120-160 GHz Receiver - Cooled mixers for a 120-160 GHz receiver will be designed in a similar manner to the presently available 80-120 GHz receiver. These mixers will be incorporated in a receiver in CY 1976.

5. (33-50)/(80-120) GHz Cooled Mixer Receiver - A Cassegrain receiver covering these frequencies will be constructed in CY 1975. It will replace the present 80-120 GHz receiver which will be updated to include 120-160 GHz in CY 1976.

6. 1024-Channel Autocorrelator - The present 413-channel autocorrelator at the 140-foot telescope is one of the most heavily used instruments at NRAO. It will be replaced with a unit providing 20% more sensitivity (thru 3-level quantization), 2.5 times more channels, and a larger bandwidth.

C. Other Observing Equipment: Continuing Development Items.

1. Josephson Junction - This relatively small sum will be used to continue development of a 3-mm mixer receiver.

2. Diode Development - This amount will be contracted for development of Schottky diodes for improvement of millimeter-wave mixers and for use in a new 120-160 GHz receiver.

Item

2. Electronic Research Equipment

Items funded under this part of the program are the numerous smaller experiments and development projects--usually costing less than $10K 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 the laboratories and also for monitoring and testing the complex observing systems on the telescope.

Millimeter-Wavelength Instrumentation

All the items listed under the 36-foot telescope are part of the Observatory's continuing effort to develop instrumentation in the millimeter-wave region. Millimeter-wave electronics has developed rapidly during the last years. Of special note is the cooled Cassegrain system for the 36-foot telescope, which not only has provided considerable improvement but also presents the opportunity for future low-noise radiometers. The planned 33-50/80-120 GHz receiver is an example of this.

The successful operation of the 36-foot telescope has led to a rapid advance in millimeter-wave astronomy. This field now clearly requires a larger telescope with a more accurate surface. In response to this need, the National Radio Astronomy Observatory started in 1974 the design of a millimeter-wave telescope of diameter 25 meters with an r.m.s. surface accuracy of 0.07 mm.

The design of the telescope used as a basis the concepts developed for the 65-meter homology telescope, and detailed studies of such problems

as wind and temperature deformation and surface panel tolerance have been made. The main back-up structure and intermediate structure under conditions of no wind contribute errors which are under the design tolerance. However, to achieve the necessary temperature uniformity across the structure, an enclosure may be required. Such an enclosure could be a standard large space-frame, although an investigation is being made of a novel form of astrodome containing a large opening over which low-loss material is placed.

The design group is evaluating a number of possible sites for the telescope. The three principal selection criteria are the quality of the atmosphere, the difficulty of supporting operations at the site, and the cost of developing the site.

The design of the telescope and its drive systems will be completed in 1975. The investigations of the enclosure and of the sites will be continued. Approximately $50,000 is allocated for miscellaneous design studies in these areas.

IV. EQUIPMENT

No major equipment acquisitions are planned for 1975. The distribution of funds (in thousands of dollars) in the various equipment accounts is as follows:

Item 1.	Maintenance, Shop and Repair Equipment.....	$ 32.0
Item 2.	Office and Library Furnishings and Equipment.....	15.0
Item 3.	Living Quarters Furniture.....	5.0
Item 4.	Building Equipment.....	10.0
Item 5.	Scientific Services and Engineering Equipment.....	15.0
	Total.....	$ 77.0

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, welding guns, milling machines, 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, chairs, tables, lamps, draperies, carpets, etc., used in the residence hall and furnished houses in Green Bank.

4. Building Equipment

These funds provide for items that are generally attached to and become a part of the buildings. Includes are such things 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.

V. OPERATIONS AND MAINTENANCE

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

Category	1974			1975		
	Level	Salaries	Benefits	Level	Salaries	Benefits
Scientific and Engineering	59	$1,065,000	$214,000	64	$1,303,000	$261,000
Technical	77	945,000	190,000	77	1,041,000	208,000
Administrative and Clerical	57	803,000	163,000	60	906,000	181,000
Operations and Maintenance	57	527,000	106,000	56	562,000	112,000
Total - Operations and Maintenance	250	$3,340,000	$673,000	257	$3,812,000	$762,000
VLA Construction	57	674,157	139,355	83	1,182,000	237,000
Total Personnel	307	$4,014,157	$812,355	340	$4,994,000	$999,000

OPERATIONS AND MAINTENANCE

A. Personnel Levels at December 31, 1975

Category	Green Bank	Charlottesville	Tucson	New Mexico	Total
Operations					
Scientific & Engineering	22	37	5	-	64
Technical	48	17	12	-	77
Administration & Clerical	31	25	4	-	60
Operations & Maintenance	54	2	-	-	56
Total, Operations	155	81	21	-0-	257
VLA Construction					
Scientific & Engineering	-	7	-	17	24
Technical	-	20	-	17	37
Administration & Clerical	-	3	-	14	17
Operations & Maintenance	-	2	-	3	5
Total, Construction	-0-	32	-0-	51	83
Total Personnel	155	113	21	51	340

B. All Other Materials, Supplies and Services (in thousands of dollars)

1.	Directors Office	$ 2.0
2.	Research Group	2.0
3.	Scientific Services Includes planned expenditures for library books, periodicals and other supplies for the Green Bank and Charlottesville libraries and also includes cost of preprints and reprints, darkroom and scientific drafting materials and supplies.	70.0
4.	Electronics Division Includes expenditures for general electronics and laboratory supplies at Green Bank, Charlottesville and Tucson, including receivers and electronics equipment maintenance, materials and supplies, e.g., helium, wire, tubes, resistors, small tools, special parts, etc., and radio noise control and suppression costs.	340.0
5.	Computer Division Includes cost of tapes, cards, paper, maintenance agreement, outside programming assistance for the computer division.	55.0
6.	Engineering Division Includes cost of engineering and drafting supplies, small A/E studies.	55.0
7.	Tucson Operations Division Includes reimbursement to KPNO for services, general maintenance of telescope, office upkeep, vehicle rental and supplies, postage, telephone, etc.	150.0
8.	Fiscal Division Includes cost of audit service, tax assistance, general office supplies, e.g., blank checks, records, cards, tapes, paper, etc.	22.0
9.	Business Management Division (CV) All Charlottesville general office supplies, freight (in and out), Xerox rental, office machine service agreements, GSA auto rental, legal services, outside printing, personnel recruitment, etc.	105.0
10.	Telescope Operations Division (GB) Includes costs of maintaining the telescopes, e.g., painting, cryogenics, oil, grease, spare parts, special cabling and wiring, etc.	68.0
11.	Plant Maintenance (GB) Includes cost of maintaining the Green Bank physical plant, e.g., electrical, water and sewer systems, materials and supplies for the auto shop, paint shop and carpentry shop and general equipment maintenance. Costs of maintaining the buildings, houses, control	145.0

buildings, grounds, roads and airstrip. Also includes cost of materials and supplies for safety and security and cost upkeep of the ambulance and fire-fighting equipment.

12. Central Shops..... $ 30.0
Includes costs of general machine shop supplies, metals, welding materials, etc.

13. Adminsitrative Services (GB)..... 115.0
Includes cost of operating the cafeteria and residence hall, e.g., food for resale and other cafeteria supplies, linen and laundry service, freight and express (in and out), office machine service agreements, Xerox rental, GSA vehicle rental, purchasing office supplies, warehouse supplies (not stock items), darkroom and printing supplies, office supplies, etc., all for Green Bank.

VI. CONSTRUCTION

The construction of the Very Large Array (VLA) will accelerate in 1975, with new funds in the amount of $13,000,000. A detailed description of this program will be found in the VLA Project Plan submitted separately.

A new electronics laboratory, approximately 1500 square feet in area, will be constructed adjacent to the 36-foot telescope on Kitt Peak, for a cost estimated at $60,000. The building will be large enough to permit storage of the millimeter-wave front-end boxes when they are not on the telescope. The present NRAO buildings on the mountain are too small to support the increased electronics activity in an acceptable fashion. For example, the new cryogenic receivers require substantial laboratory and storage space on the mountain; their size and weight preclude their transport to the downtown laboratory on a regular basis. Even the room-temperature receivers, although somewhat lighter and more rugged, should be prepared on the mountain immediately prior to their installation, in order to minimize loss of telescope time arising from box malfunctions. The new laboratory, of modular design, will provide both needed laboratory facilities for the receivers, and warehouse space for active receivers which are temporarily off the telescope. Offices will be included for the technical staff and engineers working on the mountain.

VII. PRELIMINARY FINANCIAL PLAN - 1975
(in thousands of dollars)

SCIENTIFIC RESEARCH	(a) Actual Exp. 1974	(b) Comm. Carried to 1975	(c) Uncomm. Funds Carried to '75	(d) New Funds 1975	(e) Exp. & Comm. (b,c,d) 1975
A. Operations					
Personnel Comp.	$3,340.0			$ 3,812.0	$ 3,812.0
Personnel Benefits	672.6			762.0	762.0
Travel-Domestic	183.3			215.0	215.0
Travel-Foreign	6.0			17.0	17.0
Comm.& Utilities	196.0			217.0	217.0
Computer Rental	435.0			470.0	470.0
Bldg. Rent & Maint.	155.0	$ 10.0		150.0	160.0
Mgmt. Fee	125.0			125.0	125.0
Other Mat., Supp. & Serv.	1,162.3	190.0		1,159.0	1,349.0
Misc. Revenue	(85.0)			(85.0)	(85.0)
Subtotal	$6,190.2	$200.0	-0-	$ 6,842.0	$ 7,042.0
B. Equipment					
Research Inst.	$ 859.5	$220.0	$175.0	$ 535.0	$ 930.0
Operating Eqpt.	94.9	40.0	2.0	75.0	117.0
Subtotal	$ 954.4	$260.0	$177.0	$ 610.0	$ 1,047.0
TOTAL SCIENTIFIC RES.	$7,144.6	$460.0	$177.0	$ 7,452.0	$ 8,089.0
CONSTRUCTION					
Very Large Array	$2,301.8	$4,000.0	-	$13,000.0	$17,000.0
Other	0.3		$ 12.0	48.0	60.0
TOTAL CONSTRUCTION	$2,302.1	$4,000.0	$ 12.0	$13,048.0	$17,060.0
TOTAL	$9,446.7	$4,460.0	$ 189.0	$20,500.0	$25,149.0

Note: This is a preliminary plan based on estimated 1974 figures. The final Financial Plan, reflecting actual year-end figures, will be submitted early in 1975.

APPENDIX A

NRAO SCIENTIFIC STAFF PROGRAMS

The following scientific program presents a summary of the research planned by the NRAO permanent staff for 1975. Some of the work will be done in collaboration with visiting scientists.

A. Galactic Studies

1. Hydrogen Line

The relationship between the observed neutral hydrogen distribution and that predicted in the two-component model of the interstellar medium will be examined. This will require rediscussion of a number of the conclusions regarding the large-scale hydrogen distribution which have depended on the one-component hypothesis, in order to properly account for optical depth effects occurring because there are cold opaque clouds embedded in a hot background intercloud medium. Further information on this point may be obtained from a program designed to detect scale lengths in the range 0.01 to 1 parsec. Should such short scale lengths be found to be common, substantial revision in the present understanding of the thermal balance of the interstellar medium will be required.

Searches will be made for characteristics in the observed hydrogen distribution which might be attributable to the galactic shock predicted by the density-wave theory, and observations of the velocity structure in the nuclear disk will be continued.

2. Non-thermal Continuum

A study to determine the non-thermal volume emissivity in the galactic disk on a scale of less than 300 parsecs, out to a distance of approximately 3 kpc from the sun, is in process. Observations of brightness versus galactic latitude will be made with the 300-foot telescope and converted via a simple model to yield volume emissivity as a function of distance from the sun. Any structure which is revealed using this approach will be examined for correlation on a scale that could be expected if the non-thermal emission regions are associated with spiral features.

An absolute measurement of the brightness of a strip of sky, including a portion of the galactic plane, will be made at 820 MHz.

3. Radio Stars, Novae, Pulsars and Supernovae

Studies of such well-known radio stars as Cyg X-3 and Sco X-1 will be continued, often as part of international campaigns to gather simultaneous radio, infrared and X-ray data. Searches will be made for radio-emitting binary stars and for newly-appearing counter-parts of X-ray sources.

An analysis of the data showing the evolution at centimeter wavelengths of the novae HR Delphini and FH Serpentii during the years 1970 to 1973 will be completed.

A series of observations have been completed which measure the spectra of pulsars over one and one-half decades of frequency at two epochs one year apart. These observations will be used to determine the effects of interstellar scintillation as well as the relative stability of pulsar spectra over long periods of time.

An attempt will be made to understand the general classes of magnetic field configurations within the remnants of supernovae, by means of a theoretical study of the hydrodynamics of the late stages of these objects. The study will be based on recent radio data which provide information about the plasms and magnetic fields within remnants.

Further observations of the change in flux density of the remnant Cas A will be made, at frequencies near 1400 MHz.

4. HII Regions and Dust Clouds

Aperture synthesis observations of the interstellar hydrogen lying between the sun and several HII regions will be undertaken, in an effort to identify the hydrogen associated with, and affecting the development of, the HII regions. The absorption profiles obtained during the course of the program can also be used to improve the distance estimates for these regions.

Studies of carbon radio recombination lines in dark clouds will be compared with existing observations of ^{12}CO and ^{13}CO, in order to delineate the structure of the ionized component of the gas in such clouds. A search for compact continuum sources in dark clouds will be continued, since such sources may arise from highly compact HII regions surrounding stars embedded in the cloud; in this case the radio flux can be used to reliably establish both the spectral type and luminosity class of the exciting star.

Theoretical analyses of dark clouds will be undertaken, to determine the level populations of ionized carbon in a cold, dense gas and to examine the processes of formation, excitation, and destruction of interstellar molecules in these clouds. The formation and destruction of molecules in the dust shells surrounding infrared objects will also be studied.

5. The Galactic Nucleus

The gas both in hydrogen clouds and in molecular clouds which lie within 3 kpc of the galactic nucleus has been shown to have a complex velocity structure, perhaps as a result of explosive events in the nucleus itself.

In order to separate rotational and radial velocities, and to obtain more detailed data on the pattern of radial velocities over a very wide range of velocities, observations will be made of hydrogen, OH, formaldehyde, carbon monoxide, and ammonia. These surveys will be made with a very fine grid, and for the most part will be confined to regions within two degrees of the galactic center.

6. Molecular Line Studies

The recent discovery of interstellar N_2H^+ has given support to ion-molecule reactions as the dominant source of interstellar molecules. Observations of N_2H^+ in a new type of interstellar cloud, in which linewidths are unusually narrow but excitation conditions are high, have permitted a study of higher order coupling effects between atoms in molecular ions of this type; such studies are generally not possible on earth because of the broader linewidths. These studies will continue in additional interstellar sources. They will include a determination of the relative distribution of their related molecules, in particular HCO^+ and HCN, to show what pathways the ion-molecular processes may take.

Other line studies will include the investigation of galactic structure using the carbon monoxide lines near 2.6 mm wavelengths, further exploration, including observations for time variations, of the close connection between the maser emission from the molecule SiO and infrared stars, and searches for new molecules, including those containing atoms of chlorine and magnesium.

B. Studies of Extragalactic Sources

1. Flux Densities of Radio Galaxies and Quasars

A program of monitoring about 40 radio sources for variability at frequencies lower than 1 GHz will continue at half year intervals. Certain variability is seen in two sources and possible changes seem to exist in at least three others. Because of the implications of low-frequency variability on radiation mechanisms, it is important to study variability over a wide range of frequencies (300-1000 MHz).

A survey of selected regions of the sky at a wavelength of 6 cm will be continued. The new radiometer at 3 mm will enable the measurement of the flux density of compact components found in extended radio sources.

2. Angular Structure of Radio Galaxies and Quasars

The four-element interferometer will be used to map the polarization distribution in a number of objects, to study the nature of the compact

components lying in the nuclei of the elliptical galaxies associated with extended radio sources, and in a study of the relationship between angular size and flux density of radio sources. Observations of the radio structure of 500 sources identified with elliptical galaxies will be continued in an effort to distinguish amongst different theoretical models by comparison of the orientation of the radio and optical axes.

Low-frequency observations of the cluster of galaxies Abell 2256 will be made to determine if the X-ray emission from the cluster is caused by the inverse-Compton scattering of the microwave background or by thermal bremsstrahlung from the hot gas within the cluster.

Very long baseline (VLB) interferometers comprised of a number of antennas both in the USA and in Europe will be used to detect compact components associated with extended radio galaxies and to determine the angular structure and time variation of that structure in the compact components of both radio galaxies and quasistellar sources. Initial attempts will be made to measure with the VLB technique the visibility phase and the polarization distribution of selected sources.

3. Theories of Radio Galaxies

In an extensive series of detailed calculations concerning extended extragalactic radio sources, the time-dependent behavior of various source models will be examined using numerical hydrodynamic techniques. It is hoped that the resulting computed brightness and polarization distribution, when compared with observations, will provide useful distinctions to be made among the various models. Another hydrodynamical calculation will address the question of whether highly collimated oppositely-directed beams of relativistic particles can be produced from a gradual flux of such particles.

A new type of model of compact radio sources, in which the magnetic field energy density is much higher than the particle energy density, will be explored. This model allows the possibility of coherent synchrotron radiation from electrons with small pitch angles.

4. Normal Galaxies and the Intergalactic Medium

The surveys of the neutral hydrogen content of approximately 2500 spiral, irregular, and dwarf galaxies will be continued. For the large galaxies, including the neighboring spiral M31, the hydrogen distribution and rotation curves will be determined. For the others, the data serve as a basis for the description of the integral properties of normal galaxies and also give, in many cases, the first measurement of radial velocity. The sample is large enough to give new information on such problems as the space density of dwarf systems near the Local Group of galaxies, the possible difference

between barred and regular spirals, the intrinsic scatter in the integral properties of a subset of field galaxies, and the isotropy of the Hubble expansion of the universe.

The search for redshifted hydrogen absorption lines in the radio spectra of quasars in the redshift interval $z = 0.4$ to 0.9 will be concluded. The implications of these results (one such line has been found) will be assessed in terms both of the number density of galaxies in the universe and of the probable distance to the quasars.

Continuum observations of spiral galaxies will yield information about their structures and spectra, especially in regard to the source complexes associated with the nuclei of these objects. Observations of recent supernovae in normal galaxies will be used to place limits on the energy density of magnetic fields and relativistic particles in these young remnants.

5. Theoretical Studies of Normal Galaxies and Clusters of Galaxies

The evolution of the nuclei of galaxies will be studied in several ways. Indirect evidence is available from the observations of large, noncircular gas motions in normal galactic nuclei, since such motions might arise because of gravitational perturbations, or because of explosive events in the nuclei; both possibilities will be studied using numerical models. The effects of accretion and ablation of gas from stars moving at high speed through gaseous debris in a dense nucleus will be examined to determine if significant amounts of gas are either produced or removed. Numerical experiments--N-body studies--will determine under what conditions, if any, a dense stellar system undergoes violent relaxation.

Studies of clusters of galaxies will include a determination of the dynamical age of clusters by numerical integration of the equations of motion of an N-body system, a determination of the amount of gas removed from a galaxy in a cluster through its interaction with the intergalactic medium, and an estimation of the amount of heating of the intergalactic medium that such interactions might produce.

6. Accurate Positions and Astrometry

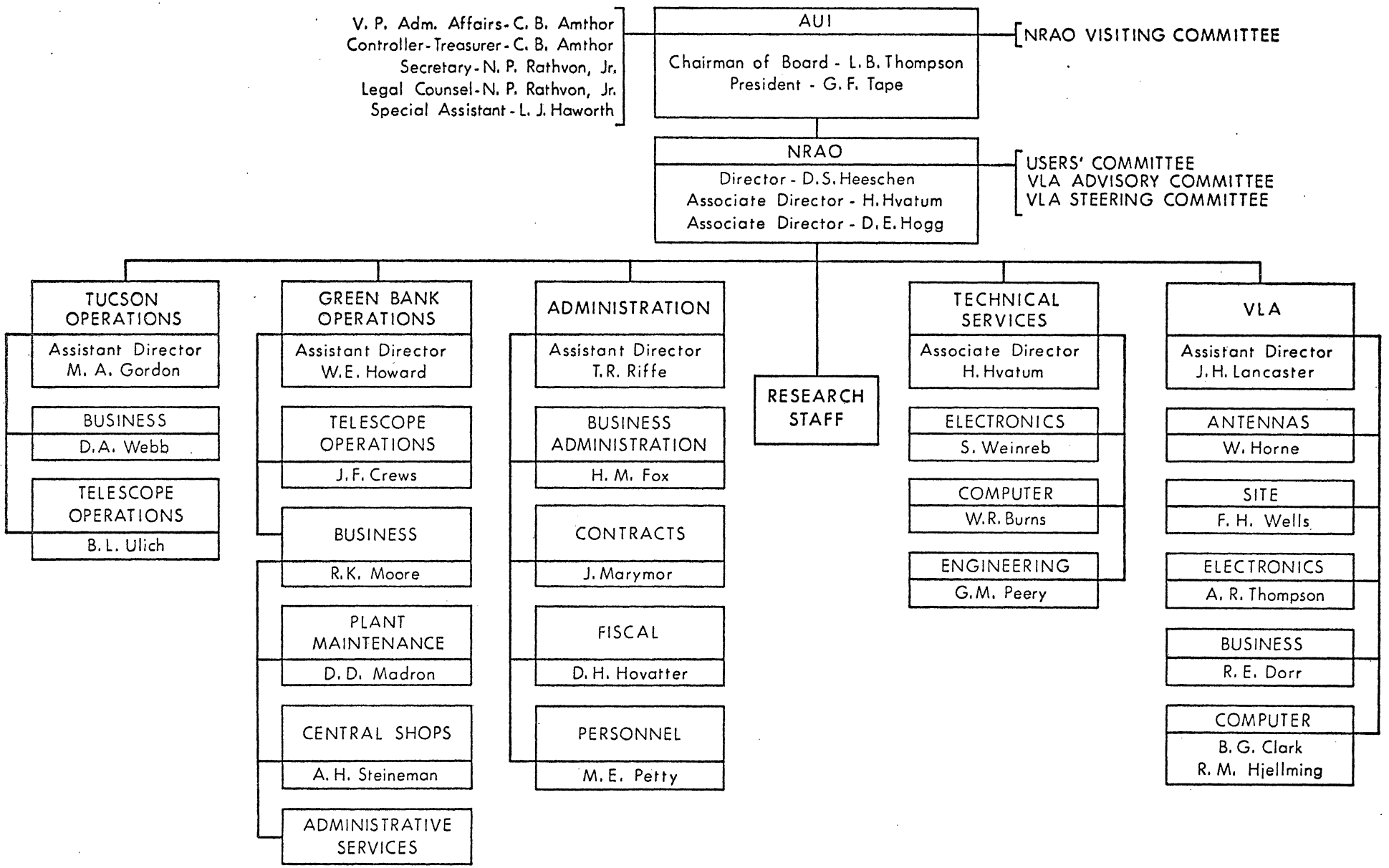
The ability to measure accurate relative positions of radio sources will be used in the measurement of the relativistic bending of radiation due to the gravitational field of the sun.

A program to determine precise absolute positions of approximately 40 radio sources will be started with the four-element interferometer over a baseline of 35 km. It is expected that these observations will provide a set of first-epoch reference points for a radio determination of the constants

of precession and nutation, a reference frame for the rapid determination of UTI-UTC, a direct tie-in between radio positions and those of the FK4 and FK5 astrometric systems, and a direct measurement of the polar motion from the time-dependent variation of the baseline constants.

APPENDIX B

NATIONAL RADIO ASTRONOMY OBSERVATORY
ORGANIZATION CHART
November 15, 1974



APPENDIX C

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:

E. J. Blum	Meudon Observatory
M. H. Cohen	California Institute of Technology
R. D. Ekers	Kapteyn Laboratories, Groningen
C. E. Heiles	University of California, Berkeley
B. M. Oliver	Hewlett Packard Company
E. E. Salpeter	Cornell University
P. Thaddeus	Institute for Space Studies
D. T. Wilkinson	Princeton University

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:

A. H. Barrett	Massachusetts Institute of Technology
J. J. Broderick	Virginia Polytechnic Institute and State University
B. F. Burke	Massachusetts Institute of Technology
T. A. Clark	NASA Goddard Space Flight Center
J. J. Condon	Virginia Polytechnic Institute and State University
W. A. Dent	University of Massachusetts
J. R. Dickel	University of Illinois
J. N. Douglas	University of Texas

F. D. Drake	Cornell University
W. C. Erickson	University of Maryland
S. J. Goldstein	University of Virginia
C. E. Heiles	University of California, Berkeley
M. A. Kaftan-Kassim	State University of New York, Albany
F. J. Kerr	University of Maryland
H. C. Ko	Ohio State University
M. R. Kundu	University of Maryland
A. E. Lilley	Harvard University
C. H. Mayer	U. S. Naval Research Laboratory
P. Palmer	University of Chicago
K. W. Riegel	University of California, Los Angeles
A. G. Smith	University of Florida
L. E. Snyder	University of Virginia
P. Solomon	State University of New York, Stony Brook
G. W. Swenson	University of Illinois
J. H. Taylor	University of Massachusetts
P. Thaddeus	Institute for Space Studies
G. L. Verschuur	Fiske Planetarium, University of Colorado
J.F.C. Wardle	Brandeis University
J. W. Warwick	University of Colorado
G. Westerhout	University of Maryland
D.R.W. Williams	University of California
R. W. Wilson	Bell Telephone Laboratories
W. J. Wilson	Aerospace Corporation
B. Zuckerman	University of Maryland

VLA Advisory Committee

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

When scientific observing commences, this group may also advise on the observing programs to be carried out.

The Committee is appointed by the NRAO Director. It is composed of scientists whose interests encompass all areas of radio astronomy and technology

of concern to the VLA. An attempt is also to maintain, in the membership, reasonable geographic distribution and representation of the major radio astronomy centers. The Committee generally meets two or three times a year, depending on the nature of current Project activities and their rate of progress.

The current membership of the Committee is:

B. F. Burke	Massachusetts Institute of Technology
J. N. Douglas	University of Texas
F. D. Drake	Cornell University
R. D. Ekers	Kapteyn Laboratories, Groningen
C. E. Heiles	University of California, Berkeley
M. R. Kundu	University of Maryland
A. T. Moffet	California Institute of Technology
A. E. E. Rogers	Haystack Observatory
G. W. Swenson	University of Illinois

VLA Steering Committee

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

The Committee is appointed by the NRAO Director. It is composed principally of NRAO scientists and engineers who are thoroughly familiar, both with the scientific requirements and uses of the VLA and with the techniques and instrumentation employed in the VLA. It meets at least monthly, and more often if needed.

The current membership of the Committee is:

B. G. Clark
J. W. Findlay
E. Fomalont
E. Greisen
R. M. Hjellming
D. E. Hogg
K. I. Kellermann
C. M. Wade