



**Opportunities To Improve  
Administration Of The Research  
Program At The National Radio  
Astronomy Observatory B-133338**

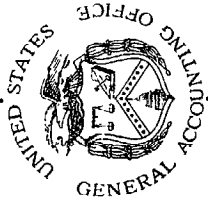
National Science Foundation

~~1-26-04~~

7-11-20



LMD095629



~~1.26.04~~

7-11-20



LM095629

**Opportunities To Improve  
Administration Of The Research  
Program At The National Radio  
Astronomy Observatory B-133338**

National Science Foundation



UNITED STATES GENERAL ACCOUNTING OFFICE  
WASHINGTON, D.C. 20548

CIVIL DIVISION

B-133338

Dear Dr. McElroy:

This is our report on opportunities to improve administration of the research program at the National Radio Astronomy Observatory by the National Science Foundation and Associated Universities, Incorporated.

In this report we have recognized your comments on a draft of this report and the actions taken or contemplated by the Foundation.

Your attention is invited to section 236 of the Legislative Reorganization Act of 1970 which requires that you submit written statements of the action taken with respect to the recommendations. The statements are to be sent to the House and Senate Committees on Government Operations not later than 60 days after the date of this report and to the House and Senate Committees on Appropriations in connection with the first request for appropriations submitted by your agency more than 60 days after the date of this report.

We shall appreciate being advised of the actions taken by the Foundation on these matters.

Copies of this report are being sent to the Director, Office of Management and Budget; the Director, National Radio Astronomy Observatory; the President of Associated Universities, Incorporated; and to appropriate committees and subcommittees of the Congress.

Sincerely yours,

*A. T. Samuelson*

Director, Civil Division

The Honorable William D. McElroy  
Director, National Science Foundation

D I G E S T

WHY THE REVIEW WAS MADE

The National Science Foundation (NSF) is the principal Federal agency responsible for supporting ground-based radio astronomy. The National Radio Astronomy Observatory, with its main observing facilities at Green Bank, West Virginia, was established as a center where astronomers of the Nation could perform specialized research and obtain the use of large expensive radio telescopes not otherwise available.

The Observatory is operated for NSF by Associated Universities, Incorporated, under a cost-reimbursable contract. Federal funds provided for the construction and operation of the Observatory totaled about \$62.1 million through December 31, 1970.

Because of the expenditure of substantial funds under the contract, the General Accounting Office (GAO) has examined into the policies, procedures, and practices for administering the research program at the Observatory.

FINDINGS AND CONCLUSIONS

Allocation of telescope observing time

The Observatory's policy is to allocate observing time for research studies on the basis of the scientific merits of the proposed research and of the availability of the telescopes. Both staff and visiting scientists desiring to use the telescopes are required to submit written proposals describing the research, the time required, and the equipment needed. The Observatory approves the proposals on the basis of evaluations by independent referees and Observatory scientists. (See p. 17.)

The Observatory has, over the years, made improvements in its evaluation procedures. Further improvements could be made in the procedures for review by independent referees by

Tear Sheet

- establishing a pool of referees to obtain a wider range of views and more expert opinions in highly specialized areas of research and to expedite the review process (see p. 18);
- soliciting referees' evaluations of updated requests, which may involve significant amounts of additional observing time or other changes in the scope of ongoing research to ensure that the additional time requested is commensurate with the scientific merits of the research (see p. 19); and
- obtaining referees' pertinent narrative comments on the scientific merits of proposed research projects to make the ratings more useful in allocating telescope observing time (see p. 20).

Also, improvements could be made in the approval and scheduling of research studies by maintaining formal and complete records, including original rating data by referees. Such records, in GAO's opinion, are necessary to document the approval and evaluation of research studies involving the use of costly federally owned facilities and would be of assistance in the orderly management and in surveillance of observatory activities. (See p. 23.)

#### Evaluation of levels of research efforts

The contractor has established two review committees to assist it in determining the appropriateness of the Observatory's concentration of research efforts and the quality of the research program. The Observatory maintains basic records of the monthly use of each telescope and prepares narrative reports on research activities but does not summarize the observing time devoted to individual projects or significant research areas. Such data should assist management and the review committees in their evaluation of the adequacy of levels of research efforts. The Observatory has begun to maintain summaries by individual users for one of its telescopes.

Although this additional information should be helpful in the review of research activities, it should be supplemented by appropriate summaries of observing time used on all telescope systems to enable an effective overall evaluation of the direction of research efforts. Such supplemented information could be helpful to the Director of the Observatory in exercising his responsibility for maintaining research programs of the highest quality and for being alert to needed changes in research emphasis. (See p. 28.)

#### Use of telescopes by visitors and staff

The Observatory's policy provides that visitors be allocated 60 percent or more of the observing time on the telescope systems and that the remainder of time be for use by the resident staff. GAO's review of the manner in which this policy has been carried out raises certain questions regarding the allocation of observing time between resident staff and visitors because:

--The Observatory classifies its temporary employees as visitors and on this basis considers that visitors have used about 54 percent of observing time during the Observatory's 11 years of operations through fiscal year 1969. However, if temporary employees are classified as staff, which GAO believes to be a more appropriate classification, visitors' use has averaged only 34 percent of total observing time during this period. (See p. 30.)

--The average telescope time used by each visitor during the 11-year period has declined significantly compared with the average time used by each staff observer. (See p. 30.)

In GAO's opinion the present policies and practices followed in allocating telescope time may not be adequate to ensure that the Observatory fully serves its mission as a national center primarily for the benefit of visiting scientists.

#### RECOMMENDATIONS OR SUGGESTIONS

In accordance with the above findings, GAO is making recommendations designed to improve the system for allocating telescope observing time and for evaluating levels of research efforts. (See pp. 23 and 29.) GAO is further recommending that NSF, in cooperation with the contractor, undertake a study of visitors' use of the Observatory's telescopes to determine what action, if any, is needed to ensure that the Observatory fully serves its mission. (See p. 41.)

#### AGENCY ACTIONS AND UNRESOLVED ISSUES

NSF agreed in general with GAO's recommendations for improving the procedures for review of research by the independent referees and pointed out that the Observatory had already increased the number of independent referees. (See p. 24.)

NSF stated that, although opinions differed as to what constituted formal and complete records on the approval and scheduling of research studies, opportunities for improvement in this area may exist.

NSF stated that the potential usefulness of additional information for evaluation of levels of research efforts merited consideration and that it would explore with the Observatory the possibility for accumulating such data.

NSF indicated that the Observatory's classification of its temporary staff as visitors was appropriate and did not consider that a study of visitor participation as suggested by GAO was necessary. In support of this view, NSF explained that the Observatory's permanent staff supported projects requiring long-term research whereas temporary staff generally supported projects requiring a more limited amount of time and that it

was not intended that visitors function as staff or even as a complement to the Observatory's permanent staff.

GAO noted that, although temporary staff may generally be concerned with projects requiring a more limited amount of time, several 1-year appointments to temporary staff were extended to 2 years and that temporary staff, in some cases, complemented the permanent staff in its research efforts. Therefore, in GAO's view, it does not seem appropriate to classify all salaried temporary staff as visitors for purposes of determining compliance with the 60 to 40 user policy.

C o n t e n t s

		<u>Page</u>
DIGEST		1
CHAPTER		
1	INTRODUCTION	5
2	OPERATIONS OF THE OBSERVATORY	7
	Brief description of radio astronomy	7
	Functions and achievements	8
	Location and facilities	10
	Administrative and financial operations	15
3	PROCEDURES FOR ALLOCATING TELESCOPE OBSERVING TIME	17
	Review by independent referees	17
	Establishing a pool of referees	18
	Updated research proposals not reviewed by referees	19
	Rating information requested from referees being expanded	20
	Approval and scheduling of research studies	22
	No formal approval record maintained	23
	Recommendations to the Director of NSF	23
	Agency comments	24
4	EVALUATION OF LEVELS OF RESEARCH EFFORTS	26
	Potential for improved information on research performed at NRAO	27
	Recommendation to the Director of NSF	29
5	USE OF TELESCOPES BY VISITORS AND STAFF	30
	Intended use of NRAO telescopes	30
	Actual use of NRAO telescopes	32
	Limited use of 36-foot telescope	32
	Use by staff and visitors	33
	Classification of temporary staff as visitors	36
	Decrease in average visitor use of telescopes	37



CHAPTER		<u>Page</u>
	Proposal, agency comments, and our evaluation	39
	Recommendation to the Director of NSF	41
6	SCOPE OF REVIEW	42
APPENDIX		
I	Letter dated December 18, 1970, from the Di- rector, National Science Foundation, to the General Accounting Office	45

#### ABBREVIATIONS

AUI	Associated Universities, Incorporated
GAO	General Accounting Office
NRAO	National Radio Astronomy Observatory
NSF	National Science Foundation

GENERAL ACCOUNTING OFFICE  
REPORT TO THE DIRECTOR,  
NATIONAL SCIENCE FOUNDATION

OPPORTUNITIES TO IMPROVE  
ADMINISTRATION OF THE RESEARCH  
PROGRAM AT THE NATIONAL RADIO  
ASTRONOMY OBSERVATORY  
National Science Foundation  
B-133338

260 95  
126 01186  
716 02481  
D. W. C. 2/11/70

D I G E S T

WHY THE REVIEW WAS MADE

The National Science Foundation (NSF) is the principal Federal agency responsible for supporting ground-based radio astronomy. The National Radio Astronomy Observatory, with its main observing facilities at Green Bank, West Virginia, was established as a center where astronomers of the Nation could perform specialized research and obtain the use of large expensive radio telescopes not otherwise available.

The Observatory is operated for NSF by Associated Universities, Incorporated, under a cost-reimbursable contract. Federal funds provided for the construction and operation of the Observatory totaled about \$62.1 million through December 31, 1970.

Because of the expenditure of substantial funds under the contract, the General Accounting Office (GAO) has examined into the policies, procedures, and practices for administering the research program at the Observatory.

FINDINGS AND CONCLUSIONS

Allocation of telescope observing time

The Observatory's policy is to allocate observing time for research studies on the basis of the scientific merits of the proposed research and of the availability of the telescopes. Both staff and visiting scientists desiring to use the telescopes are required to submit written proposals describing the research, the time required, and the equipment needed. The Observatory approves the proposals on the basis of evaluations by independent referees and Observatory scientists.  
(See p. 17.)

The Observatory has, over the years, made improvements in its evaluation procedures. Further improvements could be made in the procedures for review by independent referees by

- establishing a pool of referees to obtain a wider range of views and more expert opinions in highly specialized areas of research and to expedite the review process (see p. 18);
- soliciting referees' evaluations of updated requests, which may involve significant amounts of additional observing time or other changes in the scope of ongoing research to ensure that the additional time requested is commensurate with the scientific merits of the research (see p. 19); and
- obtaining referees' pertinent narrative comments on the scientific merits of proposed research projects to make the ratings more useful in allocating telescope observing time (see p. 20).

Also, improvements could be made in the approval and scheduling of research studies by maintaining formal and complete records, including original rating data by referees. Such records, in GAO's opinion, are necessary to document the approval and evaluation of research studies involving the use of costly federally owned facilities and would be of assistance in the orderly management and in surveillance of observatory activities. (See p. 23.)

#### Evaluation of levels of research efforts

The contractor has established two review committees to assist it in determining the appropriateness of the Observatory's concentration of research efforts and the quality of the research program. The Observatory maintains basic records of the monthly use of each telescope and prepares narrative reports on research activities but does not summarize the observing time devoted to individual projects or significant research areas. Such data should assist management and the review committees in their evaluation of the adequacy of levels of research efforts. The Observatory has begun to maintain summaries by individual users for one of its telescopes.

Although this additional information should be helpful in the review of research activities, it should be supplemented by appropriate summaries of observing time used on all telescope systems to enable an effective overall evaluation of the direction of research efforts. Such supplemented information could be helpful to the Director of the Observatory in exercising his responsibility for maintaining research programs of the highest quality and for being alert to needed changes in research emphasis. (See p. 28.)

#### Use of telescopes by visitors and staff

The Observatory's policy provides that visitors be allocated 60 percent or more of the observing time on the telescope systems and that the remainder of time be for use by the resident staff. GAO's review of the manner in which this policy has been carried out raises certain questions regarding the allocation of observing time between resident staff and visitors because:

--The Observatory classifies its temporary employees as visitors and on this basis considers that visitors have used about 54 percent of observing time during the Observatory's 11 years of operations through fiscal year 1969. However, if temporary employees are classified as staff, which GAO believes to be a more appropriate classification, visitors' use has averaged only 34 percent of total observing time during this period. (See p. 30.)

--The average telescope time used by each visitor during the 11-year period has declined significantly compared with the average time used by each staff observer. (See p. 30.)

In GAO's opinion the present policies and practices followed in allocating telescope time may not be adequate to ensure that the Observatory fully serves its mission as a national center primarily for the benefit of visiting scientists.

#### RECOMMENDATIONS OR SUGGESTIONS

In accordance with the above findings, GAO is making recommendations designed to improve the system for allocating telescope observing time and for evaluating levels of research efforts. (See pp. 23 and 29.) GAO is further recommending that NSF, in cooperation with the contractor, undertake a study of visitors' use of the Observatory's telescopes to determine what action, if any, is needed to ensure that the Observatory fully serves its mission. (See p. 41.)

#### AGENCY ACTIONS AND UNRESOLVED ISSUES

NSF agreed in general with GAO's recommendations for improving the procedures for review of research by the independent referees and pointed out that the Observatory had already increased the number of independent referees. (See p. 24.)

NSF stated that, although opinions differed as to what constituted formal and complete records on the approval and scheduling of research studies, opportunities for improvement in this area may exist.

NSF stated that the potential usefulness of additional information for evaluation of levels of research efforts merited consideration and that it would explore with the Observatory the possibility for accumulating such data.

NSF indicated that the Observatory's classification of its temporary staff as visitors was appropriate and did not consider that a study of visitor participation as suggested by GAO was necessary. In support of this view, NSF explained that the Observatory's permanent staff supported projects requiring long-term research whereas temporary staff generally supported projects requiring a more limited amount of time and that it

was not intended that visitors function as staff or even as a complement to the Observatory's permanent staff.

GAO noted that, although temporary staff may generally be concerned with projects requiring a more limited amount of time, several 1-year appointments to temporary staff were extended to 2 years and that temporary staff, in some cases, complemented the permanent staff in its research efforts. Therefore, in GAO's view, it does not seem appropriate to classify all salaried temporary staff as visitors for purposes of determining compliance with the 60 to 40 user policy.

## CHAPTER 1

### INTRODUCTION

The Government-owned National Radio Astronomy Observatory (NRAO), which has its principal observing facilities at Green Bank, West Virginia, is operated for the National Science Foundation under a cost-reimbursable contract by Associated Universities, Incorporated (AUI), a nonprofit corporation formed by nine northeastern universities. We reviewed the policies, procedures, and practices for (1) allocating telescope observing time, (2) evaluating levels of research efforts, and (3) dividing use of the telescopes between visitors and staff.

NSF was established by the National Science Foundation Act of 1950 as an independent Federal agency to support basic research and education in the sciences and to promote the interchange of scientific information among the world's scientists. In carrying out its responsibilities under the act, NSF supports research in various branches of astronomy, including radio astronomy, a relatively new discipline which requires the use of specialized costly equipment. NSF support consists of providing grants to educational institutions for individual research projects and of providing, for the use of all interested scientists, specialized research facilities, including those of NRAO and three other national observatories. For the 5 fiscal years 1966 through 1970, NSF support of research in astronomy totaled about \$113.5 million, including about \$37.5 million for radio astronomy.

In November 1965 NSF was designated the principal Federal agency responsible for support of ground-based radio astronomy by action of the Office of Science and Technology, Executive Office of the President, and by agreement among the Federal agencies supporting research in the sciences.

The need for a national radio astronomy observatory was first discussed at an international conference on radio astronomy held in Washington, D.C., during 1954 which led to a study, undertaken by AUI under a NSF grant of \$85,000, to determine the feasibility of establishing such a research

center. After completion and acceptance of the feasibility study, NSF entered into a cost-reimbursable contract with AUI, effective in November 1956, to organize, construct, operate, and maintain an observatory for research in radio astronomy. Expenditures under this contract amounted to \$47.3 million through June 30, 1968.

A second contract effective in July 1968 provides for the operation of NRAO through June 1973. For the 2-1/2-year period through December 31, 1970, NSF had allocated \$14.8 million to this contract.

## CHAPTER 2

### OPERATIONS OF THE OBSERVATORY

#### BRIEF DESCRIPTION OF RADIO ASTRONOMY

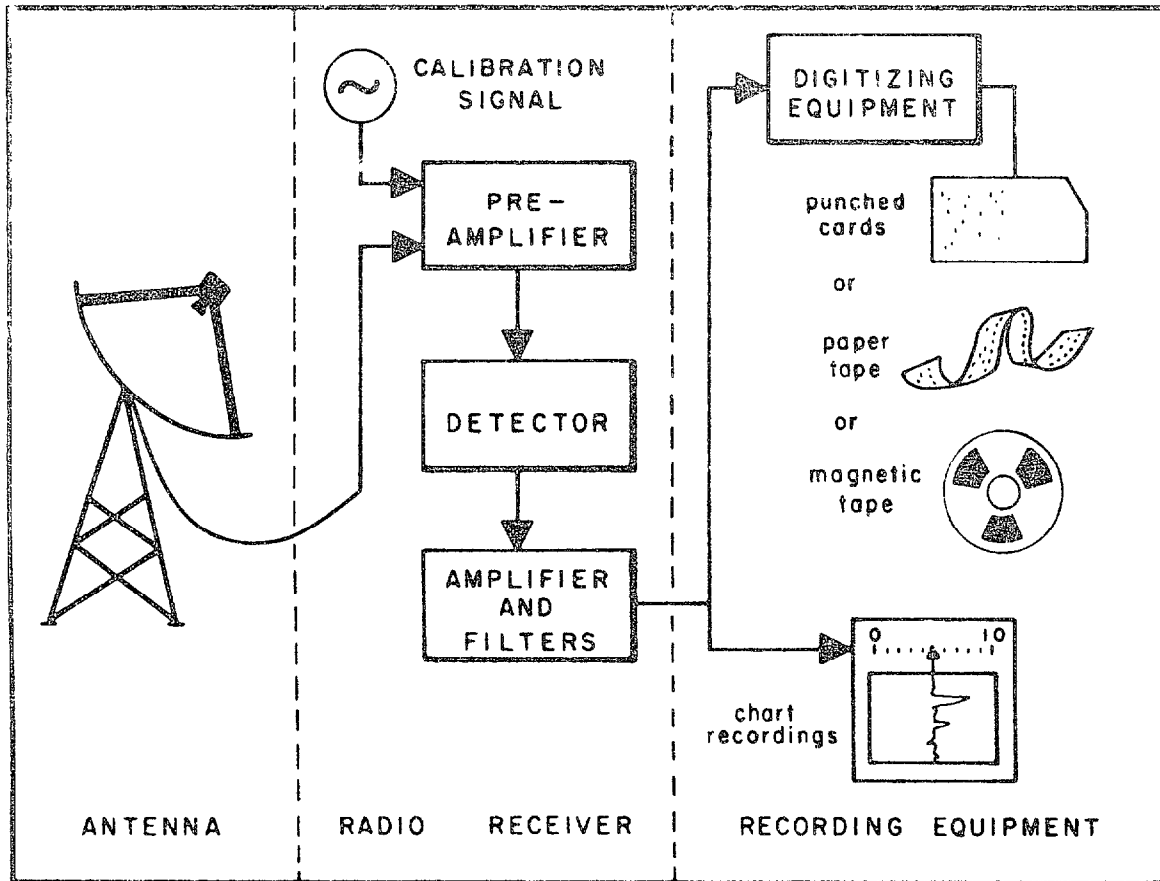
Radio astronomy is a relatively new branch of astronomy that observes and analyzes radio signals received from outside the earth's atmosphere. The purpose of studying these signals is to discover and explain new scientific facts about the universe. Although the results of such research may have ultimate practical value, the main impact is, at present, limited to increasing basic scientific knowledge.

Just as optical astronomers use light waves in making their studies, radio astronomers use radio waves which are collected and measured by radio telescopes. These telescopes can detect many varieties of astronomical objects which are not visible to the optical astronomers. The typical radio telescope consists of a highly sensitive radio receiver connected to an antenna system that can be pointed to different parts of the sky. The antenna system consists of a large reflector surface which reflects the radio waves to specialized equipment mounted at a focal point above the reflector. The radio signals are then carried to the receiver, an electronic device which amplifies, detects, and measures the intensity of the radio signals received.

From the receiver, the signals are processed and recorded by computers as digital data on tapes or cards. The signals are then further reduced, plotted, and analyzed by electronic digital computers for further study by interested radio astronomers.

A diagram (furnished by NRAO) illustrating the functioning of a typical radio telescope follows.





### FUNCTIONS AND ACHIEVEMENTS

NRAO was established as a national center where the astronomers of the Nation could perform specialized research and could obtain the use of large expensive radio telescopes not otherwise available at individual universities and research organizations. It is NRAO's policy that all telescopes and support facilities be available without charge to scientists and students from any institution. NRAO is to promote the utilization of knowledge in astronomy by appropriate means and to disseminate and publish scientific information developed in the course of research work performed at NRAO.

NRAO officials told us that NRAO had made or had assisted in about 200 major accomplishments in radio astronomy. Most of these involved new scientific knowledge, although some involved the development and/or application of new instruments and techniques to study the universe. Following

are some notable examples of achievements cited by NRAO officials.

1. Discovery of interstellar formaldehyde. Formaldehyde is the first complex molecule ever detected in space and its widespread distribution is expected to provide important information about the chemical processes of galaxies, i.e., large bodies of gas, dust, stars and their companions held together by their mutual gravitational attraction, such as the Milky Way, which includes the earth.
2. Detection and measurement of the magnetic field of the Milky Way, the study of which is considered essential to the understanding of how stars are formed in the Milky Way.
3. Development and application of very long base-line interferometry. Under this technique two or more telescopes, placed at long--possibly intercontinental--distances, study the same radio source and achieve very precise measurements. In addition, this technique can be used to study irregularities in the earth's rotation, continental drifts, and temperature expansion and contraction of the earth's surface.
4. First use of autocorrelation receivers. This type of receiver, although designed and built elsewhere, was first used extensively for radio astronomy at NRAO. The large number of receiving channels built into this receiver--as many as 413--has significantly reduced the time necessary to carry out certain research projects.

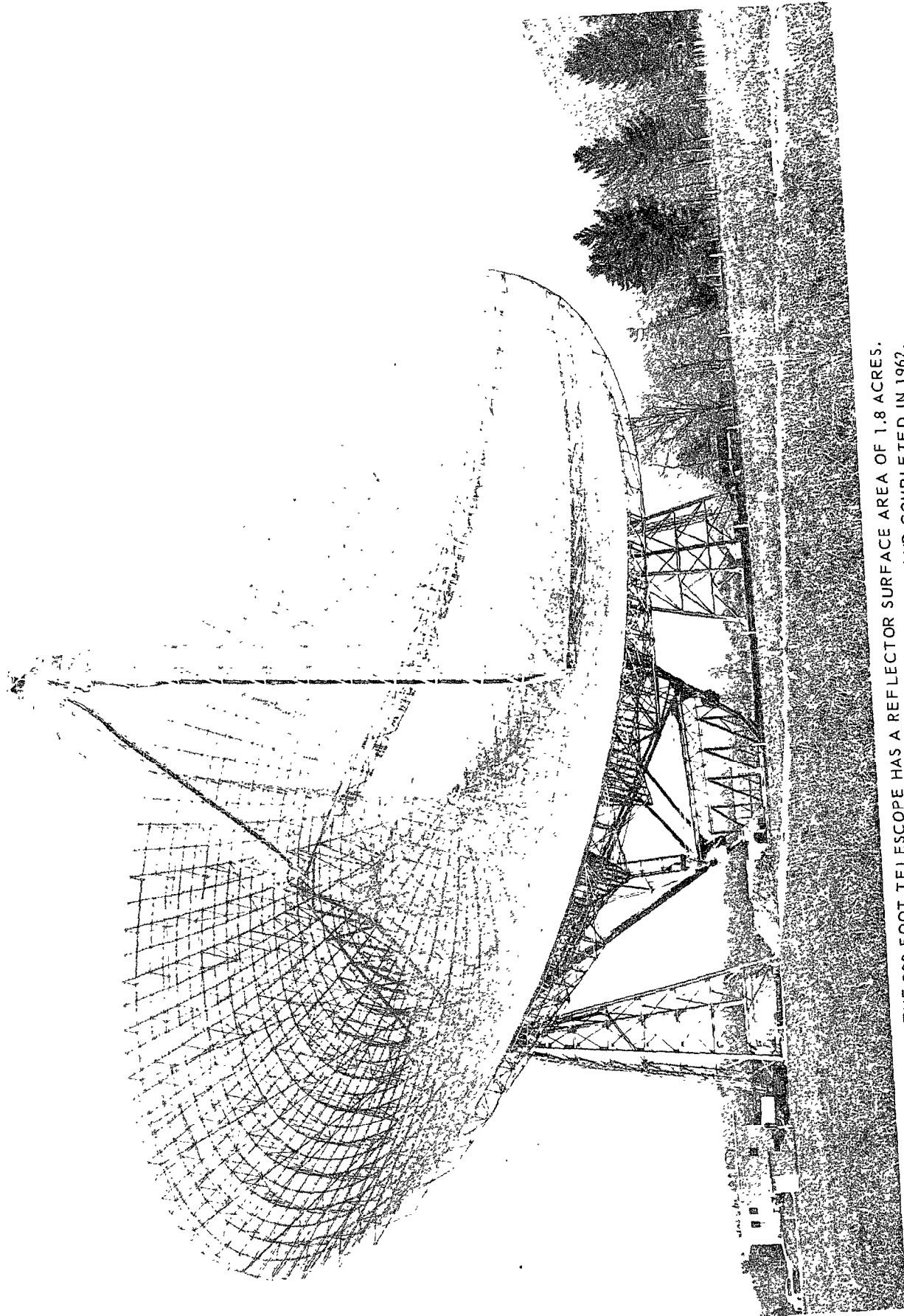
## LOCATION AND FACILITIES

NRAO has its principal observing site at Green Bank, West Virginia, and has additional facilities at Tucson, Arizona. Its administrative and scientific headquarters are located in Charlottesville, Virginia.

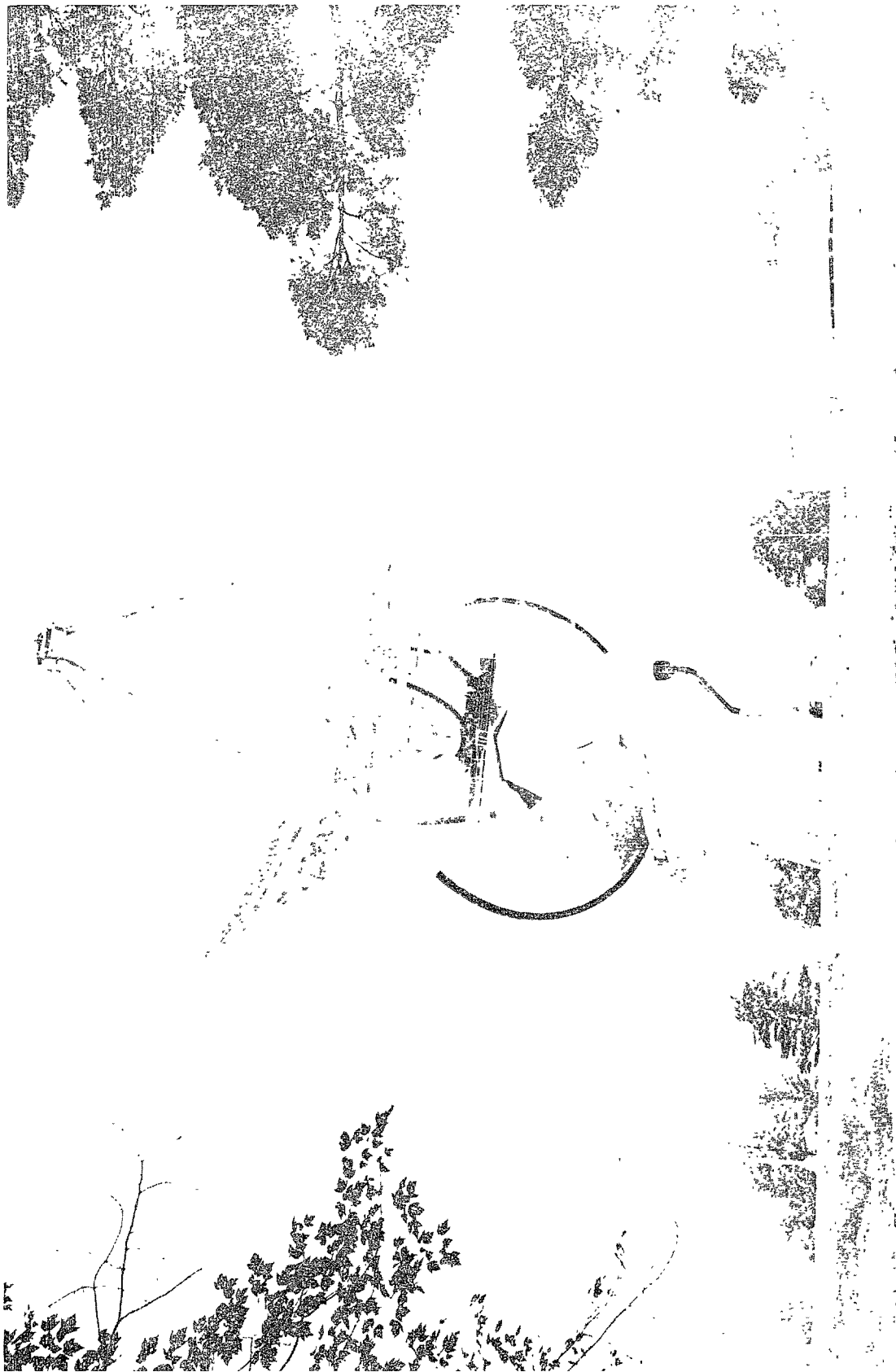
At Green Bank, the observing site covers 2,700 acres. This site was selected because it is isolated from man-made radio interference. Mountains rise to more than 4,000 feet in multiple folds in all directions shielding the observatory from extraneous radio signals and against high winds which might damage the instruments. Major radio telescopes at the Green Bank site include a 300-foot-diameter telescope movable in a north-south plane, a 140-foot-diameter fully steerable telescope, and an interferometer consisting of three 85-foot-diameter telescopes. (See photographs on pp. 11, 12, and 13 furnished by NRAO.)

At Tucson, a 36-foot-diameter highly precise telescope is located at the Kitt Peak National Observatory, a national research center for optical astronomy sponsored and supported by NSF. This site was selected because the operation of this instrument requires a high, dry location to reduce absorption of the signals by water vapor in the atmosphere.

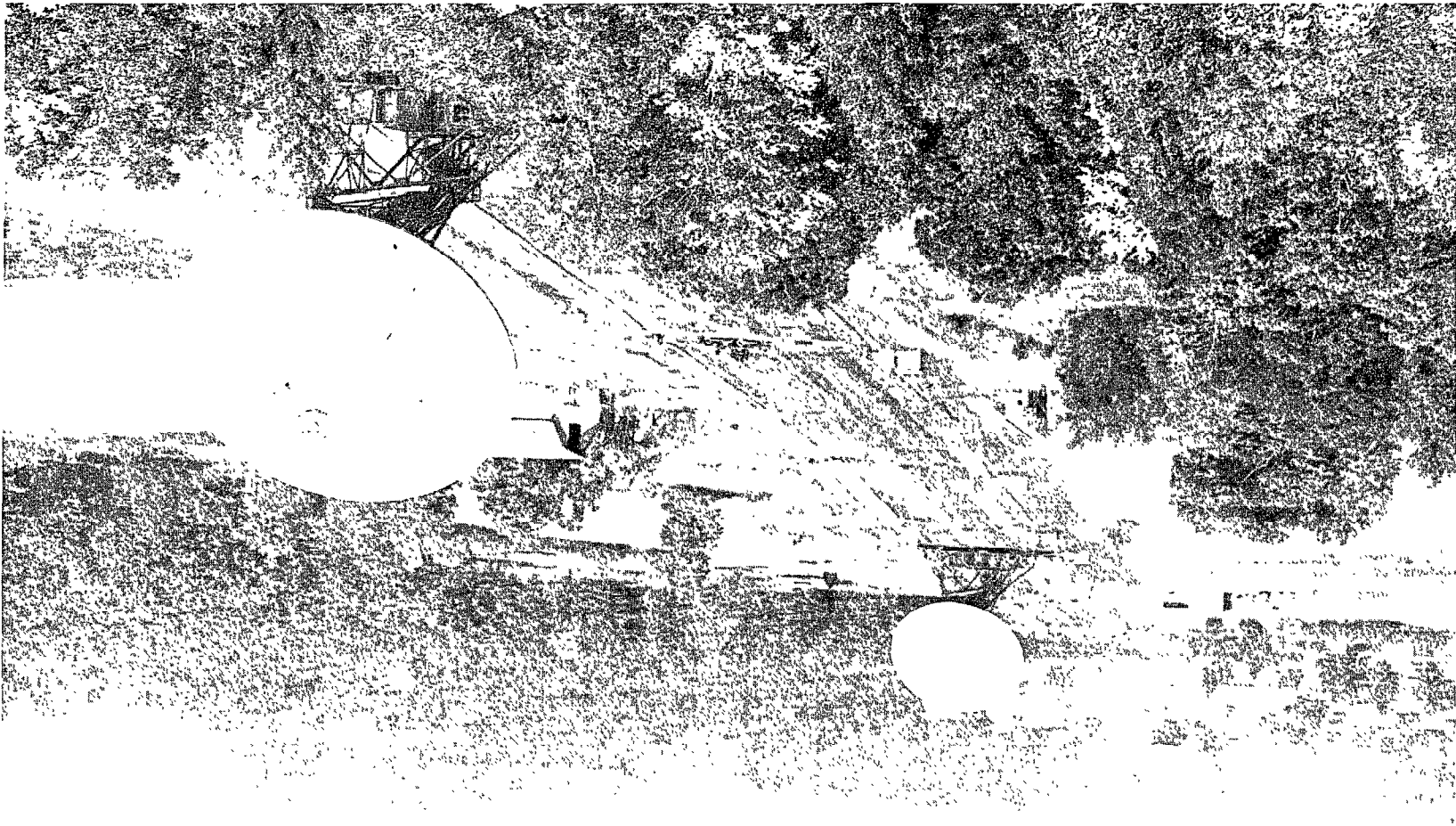
The original plans for NRAO called for all administrative and scientific functions to be performed at the Green Bank site. Due to the remoteness of the area, NRAO found it difficult to hire and retain high-quality personnel. Therefore, beginning in 1966 NRAO moved most of its major administrative offices, library, analytic computers, and scientific staff to the campus of the University of Virginia in Charlottesville, Virginia. The Charlottesville center was built and is owned by the University of Virginia and is occupied by NRAO under a lease agreement providing for rent payments during the first 5 years intended to cover the University's cost of construction including interest, totaling about \$702,000. In addition, NRAO pays for building maintenance and utilities; these payments will continue after the initial 5-year period. Because of additional space requirements, NRAO has proposed an expansion to the Charlottesville center at a cost of about \$1 million. The arrangements for ownership and financing of the expanded



THE 300-FOOT TELESCOPE HAS A REFLECTOR SURFACE AREA OF 1.8 ACRES.  
IT WAS BUILT AT A COST OF ABOUT \$1 MILLION AND COMPLETED IN 1962.



THE 140-FOOT TELESCOPE DESIGNED AND BUILT AT A COST OF ABOUT \$14 MILLION OVER  
A PERIOD OF 7 YEARS WAS COMPLETED IN 1965.



THE INTERFEROMETER SYSTEM, BUILT AT A COST OF ABOUT \$1.6 MILLION, USES THREE STEERABLE 85-FOOT RADIO TELESCOPES, TWO OF WHICH ARE PORTABLE ALONG A BASELINE. THIS SYSTEM IS CONTROLLED FROM ONE CONSOLE IN THE INTERFEROMETER CONTROL BUILDING.

building would be similar to those for the existing building. NSF has not yet approved these expansion plans.

In connection with the exploration of new types of research equipment in radio astronomy, NRAO has made studies for the design of a very large array radio telescope and a 213-foot-diameter high-precision antenna. The costs incurred by NRAO in conducting these studies through fiscal year 1970, exclusive of staff salaries, totaled about \$939,000 for the array and about \$118,000 for the high-precision antenna.

The array, proposed for construction in the Southwestern United States, would consist of 27 antennas arranged on a Y-shaped configuration of railroad tracks. Each arm of the "Y" would be 13 miles long. The cost of developing and constructing the array has been estimated by NRAO at \$60 million. The high-precision antenna was in the preliminary planning stages and was estimated to cost about \$10 million.

An advisory panel convened by NSF to make recommendations and establish priorities on proposals for design and construction of large radio telescopes favorably recommended these two projects in its report of August 1969.

In its fiscal year 1971 budget presentation, NSF stated that design work on the two systems would continue with existing funds and that no funds had been requested for the construction.

## ADMINISTRATIVE AND FINANCIAL OPERATIONS

As of December 31, 1970, NSF had provided about \$62.1 million for the financial support of NRAO's construction. As of June 30, 1970, expenditures of NSF contract funds totaled about \$58.3 million. This amount included \$28.2 million for land, buildings, and equipment, of which \$20.2 million was for the construction of observing facilities.

Under the terms of the operating contract, AUI is paid a management fee which is intended to defray AUI's normal operating expenses associated with its corporate being but are not directly related to the work under the contract. AUI accumulates the portion of the fees not required for operating expenses as a corporate reserve. The fees paid to AUI from inception of the contract through June 30, 1970, totaled \$1.3 million. Fees were paid at the following annual rates.

<u>Fiscal year</u>	<u>Annual fee</u>
1957	\$ 40,000
1958	45,600
1959	55,400
1960	60,000
1961 and 1962	65,000
1963-67	125,000
1968-70	100,000

The annual funding of NRAO's operating expenses during the last 5 fiscal years follows.

<u>Fiscal year</u>	<u>Amount (millions)</u>
1966	\$ 2.8
1967	3.5
1968	3.8
1969	4.0
1970	<u>4.3</u>
Total	<u>\$18.4</u>
Average	<u>\$ 3.7</u>



About 60 percent of the operating expenses were for salaries and related benefits of NRAO scientific and administrative staff.

The following table shows NRAO's total staff as of June 30, 1970, at the three locations. Temporary staff includes 50 students who were participating under NRAO's summer student program.

	<u>Permanent</u>	<u>Temporary</u>	<u>Total</u>
Charlottesville, Virginia	69	37	106
Green Bank, West Virginia	151	41	192
Tucson, Arizona	<u>7</u>	<u>3</u>	<u>10</u>
Total	<u>227</u>	<u>81</u>	<u>308</u>

## CHAPTER 3

### PROCEDURES FOR ALLOCATING TELESCOPE OBSERVING TIME

It is NRAO's policy to allocate telescope observing time for research studies on the basis of the scientific merits of the proposed research and of the availability of the telescopes. Both visitors and staff desiring to use the telescopes are required to submit written proposals describing the research to be undertaken, the observing time requested, and the type of equipment needed. NRAO has developed a system of approving these requests on the basis of evaluations by both independent expert reviewers and scientists on the staff of NRAO.

NRAO has, over the years, made several improvements in its review and evaluation procedures to properly implement its stated policy. Our review showed opportunities for certain additional improvements.

#### REVIEW BY INDEPENDENT REFEREES

Prior to 1966, the review of proposals for research was handled by the NRAO management without advice of outside experts. In June 1966 the NRAO Visiting Committee<sup>1</sup> recommended an improved review procedure as follows:

"It was obvious \*\*\* that problems are beginning to arise in the matter of scheduling and project priority. \*\*\* There was unanimous agreement among members of the Committee that a scheduling committee with outside members should be set up. It is recommended that this committee be advisors to the Director on science and that it have regularly scheduled meetings. Final authority and responsibility for scheduling and project priority should remain with the Director."

---

<sup>1</sup>A review committee established by AUI to evaluate the scientific activities of NRAO. (See p. 26.)

Subsequently, in 1966 NRAO established a system of sending requests for observing time to independent referees who were noted astronomers connected with universities active in the field of radio astronomy. The referees serve for an unspecified period and without compensation. Initially NRAO appointed three referees from different universities; one has served continuously since inception and two have been replaced.

The referees furnish their evaluations independently of each other through the mail on rating sheets supplied by NRAO. The referees do not meet as a group or individually with the Director of NRAO in their capacity as referees. Therefore they do not function as part of a scheduling committee as was recommended by the NRAO Visiting Committee, but the Visiting Committee has expressed its general approval of the referee system as satisfying its 1966 recommendation.

Our review indicated that improvements could be made in the referee system by (1) establishing a pool of referees to obtain a wider range of views, (2) soliciting referees' evaluations of updated requests involving significant additional observing time, and (3) expanding the rating information being requested from referees.

#### Establishing a pool of referees

We believe that increasing the number of referees would permit NRAO greater flexibility in assigning research proposals for evaluation and obtaining expert advice in specialized areas of research.

During fiscal years 1968 and 1969, NRAO was using only two referees to evaluate the majority of research proposals instead of obtaining the evaluation by three independent reviewers as originally contemplated. We were informed that appropriate comments could not be obtained from the third referee during this period. A replacement appointed during fiscal year 1970 made it possible to resume the general practice of soliciting the views of three referees. The use of a minimum of three referees appears to be desirable to obtain a consensus when the views of two referees concerning the merits of a proposal significantly differ. We noted several such cases.

Also, the use of a larger number of referees appears to be desirable since the field of radio astronomy includes several specialized areas of research--such as solar studies and galactic studies--and NRAO could refer research proposals to those reviewers most expert in the particular area.

An additional advantage of establishing a pool of referees is that it would be possible to expedite the review process, particularly in the event that the number of research proposals should increase beyond the present annual volume of about 100 as a result of a larger demand for the use of the observing facilities as expected by NRAO.

In response to our suggestion that NRAO consider expanding the number of referees used, NRAO officials told us that on a few occasions proposals had been submitted to other outside referees when the present referees were not expert in the proposed research area, but they agreed that this practice could be expanded.

#### Updated research proposals not reviewed by referees

Requests to update an initial proposal to do research generally are not referred for review and evaluation by the referees, even though significant changes may be involved in the research method employed, the equipment used, or the observing time required. Initial proposals may be updated for one of the following reasons.

1. New developments in the research area occur between the date of the initial proposal and the start of the project.
2. Similar proposals are received from more than one researcher requiring coordination or other changes of the individual proposals.
3. The project cannot be completed within the initially approved time.

For example, of the 28 projects carried out on the 300-foot telescope during fiscal year 1969, eight involved updated requests, some of which were for significant amounts of additional observing time.

One of these requests called for an increase in total observing time from 120 to about 1,800 hours. The referees were asked to comment only on the original request for 120 hours, and in their evaluation they expressed some reservations as to its merit. NRAO approved and scheduled most of the updated request, without further consultation with the referees.

We believe that updated requests should be submitted to the referees to ensure that the additional time requested is commensurate with the scientific merits of the research. In our discussion of this with NRAO officials, we were told that it was NRAO's intended policy to submit updated requests to the referees when significant additional time was requested. Since this policy apparently was not followed, the officials agreed that attention should be given to its implementation.

Rating information requested  
from referees being expanded

The NRAO Visiting Committee commented in its May 1969 report that "The system for outside review of proposals is considered excellent, but further effort should be made to ensure responsive reviewers."

For research proposals evaluated by referees prior to fiscal year 1969, rating information requested from referees was limited to an overall project rating, designated "good," "average," or "poor," and to optional comments on the merits of the project. Referees were not requested to assign priorities and to evaluate the length of the observing time requested. The extent of narrative comments furnished varied from proposal to proposal, and such comments were only very brief and general in nature. For example, for the 28 projects carried out on the 300-foot telescope during fiscal year 1969 when NRAO was using only two referees, we found:

	<u>Number of projects</u>
No comments made by either referee	8
Comments made by one referee only	14
Comments made by both referees	<u>6</u>
Total	<u>28</u>

In April 1969 NRAO added a new category designated "priority" on the rating sheet which the referee may choose in the event that a proposal should be given preferential treatment displacing, if necessary, other proposed projects. In October 1969 NRAO further revised the rating sheet to include the referee's evaluation of the observing time that should be approved for the project.

We believe that these revisions in the rating sheet will make the referee's evaluation more meaningful and useful to the Director and the staff of NRAO but that consideration should also be given to obtaining, in all cases, pertinent narrative comments on the scientific merits of proposed research projects to supplement the basic rating data.

## APPROVAL AND SCHEDULING OF RESEARCH STUDIES

Research proposals in most instances are approved and scheduled on a tentative basis several months in advance of the date the project is to be performed. All proposals are first referred to the NRAO Director. The proposals are then forwarded (1) to designated staff scientists according to the telescope for which they have been assigned responsibility, (2) to the independent referees, and (3) to several NRAO technical divisions which will be concerned with the technical requirements of the project. After the referees' evaluations and any comments by the technical divisions have been received and considered, the projects are tentatively entered on monthly schedules which set forth, for each telescope, the dates of all proposed projects to be performed during the month. At that time, informal notice is given to the interested astronomer that his project has been tentatively approved.

Changes in the tentative schedules are made from time to time, as considered necessary, to accommodate competing proposals, the availability of supporting equipment, or any other developments affecting the use of the telescopes. Final approval of the allocation of telescope time is made at the monthly meeting of the scheduling committee composed of the Director and key scientific and technical officials of NRAO. The scheduling committee, after considering the availability of facilities and equipment, in particular receivers, computers, and other electronic instruments, decides on a final monthly schedule for each telescope. Such schedules are circulated within NRAO and are furnished to the astronomers whose projects have been approved.

In the process of approving and scheduling individual projects, the dates and length of time of a project's performance may be adjusted several times and may be spread over several months. As a result, the observing time actually scheduled for a project has varied significantly in many instances from the time requested. For example, of the 28 projects carried out on the 300-foot telescope during fiscal year 1969, one project was scheduled for the same period of time that was requested, 15 projects were scheduled for more time than requested--the scheduled hours ranging up to 426 percent of requested hours--and seven projects were

scheduled for less time than requested--ranging between 89 and 13 percent of requested hours. For the remaining five projects, the record was not clear as to the number of hours requested.

We were told that some projects had been granted more time than requested because vacant time had occurred on the telescopes and it had been determined that these projects could productively use the additional time.

#### No formal approval record maintained

NRAO's procedures for approving and scheduling research projects do not require the maintenance of a formal record showing, for each proposal, the telescope observing time requested, NRAO's approval or disapproval of the request, the total observing time authorized, and the reasons for any significant differences between the time requested and the time authorized. Also, the ratings received from the referees are not made a part of the permanent record of reviewing research proposals. To protect the anonymity of the referees, the adjective ratings and any narrative comments are abstracted and transcribed onto the proposal document and the original rating sheets are discarded.

In our opinion, a formal and complete record, including the original rating sheets submitted by the referees, is necessary to document the evaluation and approval of research studies to be undertaken on NRAO's telescopes because these are important management decisions involving the use of costly federally owned research facilities. Also, we believe that a formally documented approval is needed to assist the Director and his staff in the orderly management of NRAO and to assist the review committees appointed by AUI in their surveillance of NRAO's activities.

#### RECOMMENDATIONS TO THE DIRECTOR OF NSF

We recommend that, to ensure that NRAO's telescope facilities are allocated in the most effective manner and for the most deserving research studies, NSF bring to the attention of AUI the several opportunities which exist--as discussed in this chapter--for improving NRAO's system of using independent referees in the evaluation of proposed research studies. We recommend also that NSF bring to AUI's attention



the need for more adequate documentation of NRAO's management actions regarding the evaluation and approval of research proposals.

#### Agency comments

The Director, NSF, in a letter dated December 18, 1970, advised us that NRAO had taken steps to improve the implementation of the referee system. He stated that NRAO now received reviews from three regular referees, that appropriate members of the resident staff provided expert advice whenever there were differences of opinion among the referees, and that NRAO had two additional referees for solar proposals, an area that is outside the field of two of the three regular referees. He also pointed out that, although NSF was opposed to the establishment of a large pool of referees, it would consider with NRAO the desirability of appropriate additions to the pool of referees, particularly in specialized areas of research such as had been done for proposals involving solar studies.

The Director agreed that updated proposals requesting significant amounts of additional observing time should be reviewed by the referees. He noted that NRAO followed the policy of resubmitting to referees updated proposals in cases where the scope of the work had significantly changed. He pointed out, however, that a decision to resubmit was one that required scientific judgment in each case and that, if the judgment of the referees regarding a particular request was known through prior comments of the referees, the updated proposal may not be resubmitted. Because our review showed that this policy was not always followed even in a case where it was known that the referees had reservations concerning the merits of the initial proposal, we believe that this matter is in need of further attention.

Also, the Director agreed that narrative comments by reviewers on the scientific merits of proposed research projects were valuable supplements to the basic rating data. He stated that, although NRAO considered the comments by referees to be adequate, this did not preclude the consideration of means to encourage expansion of such data.

With respect to our recommendation concerning the need for more adequate documentation of NRAO's management actions

regarding the evaluation and approval of research proposals, the Director stated that, although opinions differed as to what constituted formal and complete records, he agreed that opportunities for improvement in this area may exist. Although he pointed out that NRAO maintained a record on such management actions, he agreed further, however, that there was a need for improvement in documentation.

In elaborating on the Director's statement, agency officials informed us that NRAO's record of these actions did not consist of a single consolidated record providing complete information related to the pertinent management actions but that most of this type of information could be developed from various records, documents, and memorandums which were kept at NRAO. The Director advised us that NSF would review with AUI and NRAO appropriate means of accomplishing the report recommendation for more adequate documentation, including retention of the referees' original rating sheets.

## CHAPTER 4

### EVALUATION OF LEVELS OF RESEARCH EFFORTS

AUI has established two review committees to assist its president and board of trustees in their task of determining the appropriateness of NRAO's concentration of research efforts and the quality of its research program.

One of the review committees is the Trustees Committee for NRAO which is composed of three members of the board and the president serving ex officio. The AUI policy manual provides that one of the major areas of interest to the committee be an "evaluation of the present and prospective balance of effort among the fields of research concentration of the resident staff." This committee is required to report to the board annually on its findings. We have been told that the committee presents its findings informally to the full board of trustees without preparing a formal record of its report.

The other review committee is the NRAO Visiting Committee made up of one AUI trustee and six distinguished scientists selected from other public and private institutions, most of whom are radio astronomers. This committee is expected to make an expert examination of the scientific activities at NRAO and, in its annual report thereon, make recommendations with respect to the research program, including whether efforts in any area should be increased, diminished, or discontinued.

In our review of the Visiting Committee's reports for the last 5 years, we noted that on several occasions the committee had commended NRAO for both the quantity and quality of the scientific output and that only one specific recommendation had been made. The committee's report of May 1966 proposed that increased use be made of the 140-foot telescope in the investigation of the variability of radio sources which, according to NRAO, was subsequently accomplished. The committee, however, apparently was not fully satisfied with the information presented for its review of NRAO's research activities, since it requested in its 1968 report that a listing of all scientific programs in progress

be submitted to members of the committee in advance of their meeting to help them plan the most efficient coverage of NRAO's activities. Such a list was submitted, as requested, for the committee's review starting in 1969.

POTENTIAL FOR IMPROVED INFORMATION ON RESEARCH PERFORMED AT NRAO

Our review of the type of information at NRAO available to evaluate the direction of its research efforts indicated a potential for certain improvements which, we believe, would be useful to the review committees. NRAO maintains basic records of the monthly use of each telescope and prepares narrative reports on research activities on a quarterly basis and an annual basis but does not summarize the total hours of telescope time spent on individual projects and does not accumulate them by significant research area.

We proposed to NRAO officials the desirability of a cumulative record, possibly on an annual basis, of the observing hours spent by all astronomers classified by individual research area considered significant by NRAO management. For example, the 28 projects that were carried out during fiscal year 1969 on the 300-foot telescope, which used a total of 7,669 observing hours, could be classified according to the research categories used in NRAO's annual reports as follows:

<u>Research area</u>	<u>Number of projects</u>	<u>Hours used</u>	<u>Percent</u>
<u>Pulsars</u> --Searches for and studies of astronomical objects which emit a strong, rapidly pulsating radio signal	9	3,240	42.25
<u>Neutral hydrogen lines</u> --Studies of neutral hydrogen gas of a specified wavelength in the Milky Way and other galaxies	7	1,732	22.58
<u>Source surveys</u> --Survey to identify sources of radio signals in the universe for the purposes of establishing maps, catalogues, and number counts of them	4	1,458	19.01
<u>Ionized hydrogen regions and recombination lines</u> --Studies of regions around very bright stars where hydrogen gas is electrically charged	2	641	8.36
<u>Hydroxyl molecules</u> --Studies of radio signals emitted by molecules composed of one atom of hydrogen and one atom of oxygen	1	359	4.68
<u>Supernova remnants</u> --Studies of the gases remaining from a star which has exploded	2	138	1.80
<u>Spectral studies and time variations</u> --Studies of variable radio sources and their physical properties	2	98	1.28
<u>Exterior galaxies</u> --Studies of the physical properties and characteristics of galaxies beyond the Milky Way	<u>1</u>	<u>3</u>	<u>.04</u>
Total	<u>28</u>	<u>7,669</u>	<u>100.00</u>

We obtained the above information by analyzing the monthly summary of telescope utilization and by correlating the number of hours used on specific projects during the entire fiscal year 1969 with the description of significant research activities contained in NRAO's annual report for the year. In our analysis, we were assisted by NRAO personnel who generally agreed with the proposed classification of telescope projects.

NRAO officials agreed with us that additional information on research projects would be useful and informed us that, since completion of our field work, NRAO had begun maintaining summaries of the observing time of each user of the 140-foot telescope and that these summaries would be made available to the review committees. These officials also told us that similar summaries would be maintained for the other telescopes when increased demand for their use would make such records desirable.

NRAO officials further pointed out that the field of radio astronomy was still relatively limited in scope so that balance among research areas could be achieved without additional formal use records.

We believe that the additional information that is being accumulated by NRAO on the use of the 140-foot telescope will be helpful in the review of research activities but that, to enable an effective overall evaluation of the direction of research efforts, it should be supplemented by appropriate summaries of observing time used on all telescope systems, according to research projects and significant areas of research.

We believe also that such supplemented information could be helpful to the Director of NRAO in exercising his responsibility for maintaining research programs of the highest quality and for being alert to needed changes in research emphasis.

The NSF Assistant Director for Administration, with whom we discussed this matter, told us that a summary record showing levels of research efforts at NRAO would provide useful information for NSF's astronomy support program and that NSF believed such an expansion of NRAO's program records would be feasible and desirable.

Recommendation to the Director of NSF

We recommend that the Director, NSF, bring to the attention of the board of trustees of AUI the desirability of improving the information available on the levels of research efforts at NRAO and that the board require NRAO to make such improvements to its records as may be most useful to AUI review committees and to NRAO management.

- - - -

The Director, NSF, informed us that:

"NRAO management had reservations about the need to expand the present information systems, believing that scientific management should seek to foster and encourage the very best proposals for telescope time that are submitted to it by scientists, but it should rarely attempt to manage the scheduling by research area."

He also advised us that NRAO's management also believed that, as long as the visitors and staff that used the facilities were first-rate, the proposals submitted would indicate where the interesting research areas lay and that the proportion of time spent observing in various research areas should be determined through the process of trying to promote research in specific areas. The Director stated that NSF agreed in general with this philosophy; however, NSF believed that the potential usefulness of additional information merited consideration. He stated also that NSF would explore with NRAO the possibility of accumulating data in such a manner that the time and effort involved would not outweigh its usefulness.

## CHAPTER 5

### USE OF TELESCOPES BY VISITORS AND STAFF

NRAO was established as a national research center to be used primarily by visiting scientists. Since NRAO's establishment, both NRAO and NSF have publicly stated on several occasions the policy that visitors will be allocated 60 percent or more of the observing time on NRAO's telescope systems and that the remainder of the time will be for use by the resident staff.

Our review of the manner in which this policy has been carried out raises certain questions regarding the allocation of observing time between resident staff and visitors because:

--NRAO classifies its temporary employees as visitors and on this basis considers that visitors have used about 54 percent of observing time during NRAO's 11 years of operations through fiscal year 1969. However, if temporary employees are classified as staff--which we believe to be a more appropriate classification--visitors' use has averaged only 34 percent of total observing time during the 11-year period.

--The average telescope time used by each visitor during the 11-year period has declined significantly compared with the average time used by each staff observer.

Also, there has been only minimal use of the 36-foot telescope located at Kitt Peak National Observatory because of problems connected with atmospheric conditions which have limited actual observing time in 1969 to less than 12 percent of total available time. We have been informed that remedial actions have been taken by NRAO to increase the usefulness of this telescope.

### INTENDED USE OF NRAO TELESCOPES

In the original plan for establishing NRAO, prepared in 1956, AUI pointed out that the support of a national

research center by NSF seemed to offer the only way whereby radio astronomers in this country would have access to large telescopes. In response to questions raised in the fiscal year 1958 Senate appropriation hearings regarding the purpose of the new observatory, the Director of NSF pointed out that AUI was only the constructing and managing agent for NRAO and that its instruments were for the use of all astronomers of the country.

In 1959 the NRAO Director explained NRAO's user policy as follows:

"\*\*\* We believe that about 60% of the research activity at the NRAO should be by visitors, and 40% by the permanent staff of the Observatory. This ratio of visitor to staff activity is based on the experience of other institutions with similar aims. It is felt that a higher ratio of visitor activity does not allow a staff of sufficient size and diversity to maintain productive staff research and still provide necessary services to visitors, while a lower degree of visitor activity would not be consistent with the principal objective of the Observatory as an institution for all scientists.

"The 60/40 ratio cannot of course be rigidly adhered to on an hour by hour basis in the scheduling of observing time and other activities at the Observatory. It is, however, a basic premise that is used as a guide in determining the size and nature of the Observatory staff."

The policy that visitors be allocated 60 percent or more of the observing time has been stated in such publications as NRAO's annual reports and in NSF's budget justifications to the Congress. Certain other public statements by NSF and NRAO have referred to a policy of allocating about 70 percent of telescope observing time to scientists not on the NRAO staff.



ACTUAL USE OF NRAO TELESCOPES

In contrast with optical telescopes which generally can be used during nighttime only, most radio telescopes can be used for some type of observation by both day and night. Our analysis of actual usage of NRAO's four major telescope systems for fiscal year 1969 showed that, with the exception of the 36-foot telescope located at Kitt Peak National Observatory, the systems were used for observing most of the time after allowing for testing, maintenance, bad weather, and similar factors as follows:

	<u>Percent of telescope time used</u>				
	<u>Interfer-</u> <u>ometer</u>	<u>300-</u> <u>foot</u>	<u>140-</u> <u>foot</u>	<u>36-</u> <u>foot</u>	<u>Aver-</u> <u>age</u>
Actual observing	74.08	87.54	78.58	11.52	62.93
Testing	14.94	1.76	2.73	7.47	6.72
Time not sched- uled	.82	.84	1.08	57.32	15.01
Maintenance	4.62	5.51	5.98	-	4.03
Equipment changes	.85	2.46	3.39	1.00	1.93
Lost time	<u>4.69</u>	<u>1.89</u>	<u>8.24</u>	<u>22.69</u>	<u>9.38</u>
Total	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

Limited use of 36-foot telescope

The 36-foot telescope located in Tucson, Arizona, was constructed at a cost of about \$1 million and was placed in operation in April 1967. This is a highly precise instrument specially designed to study radio signals of millimeter lengths which can not be studied on other NRAO telescopes. Although NRAO had intended that the telescope would be fully used for both daytime and nighttime observing, in fiscal year 1969 actual observing time was limited to about 11.5 percent of total available time.

We have been informed by NRAO officials that the utilization of the 36-foot telescope has been low because the reflector surface has deformed due to the sun's heat, which has limited the instrument's effective use to nighttime observing, and because the millimeter radio waves have been absorbed by water vapor in certain rainy seasons, which has

further limited the telescope's use to periods of dry weather.

At the time of our field review, NRAO technicians were studying means to increase the utilization of the 36-foot telescope. NRAO utilization records showed that during the period January to June 1970 the 36-foot telescope was used for observing about 50 percent of the total available time. NSF advised us that it had reviewed the observing time of the 36-foot telescope for the months of September, October, and November 1970 to determine current utilization. The review showed that actual observing time, as a percentage of maximum possible observing time in a 24-hour period, was 72 percent for September, 53 percent for October, and 61 percent for November, of which use by visitors averaged 56 percent, and that NSF expected that actual observing time would continue at a comparable rate in the months ahead.

The Head of the NRAO Tucson Division advised us that the 36-foot telescope was an experimental instrument and initially its performance capabilities were not fully understood. He stated that added experience had provided a better understanding of the functional and technical capabilities of the 36-foot telescope which had made possible reasonably accurate predictions of the effect that deformities of the reflector surface had on the results of the scientific data collected. This, according to the Head of the NRAO Tucson Division, was the principal reason that permitted increased use of the telescope, particularly for daytime observing.

#### Use by staff and visitors

The following table shows the use of NRAO's four major telescopes during the 11 fiscal years, 1959 through 1969, by the three classes of users: permanent staff, temporary staff, and visitors.

	<u>Percent of telescope observing time used</u>				
	<u>Interfer-</u> <u>ometer</u>	<u>300-</u> <u>foot</u>	<u>140-</u> <u>foot</u>	<u>36-</u> <u>foot</u>	<u>Aver-</u> <u>age</u>
NRAO staff:					
Permanent	63.96	30.79	39.14	54.88	46.28
Temporary	<u>19.63</u>	<u>25.21</u>	<u>11.49</u>	<u>6.39</u>	<u>19.61</u>
	83.59	56.00	50.63	61.27	65.89
Visitors	<u>16.41</u>	<u>44.00</u>	<u>49.37</u>	<u>38.73</u>	<u>34.11</u>
Total	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>	<u>100.00</u>

Depending on the classification of temporary staff-- which NRAO considers to be visitor, whereas we believe that the temporary staff should be more appropriately classified as staff (discussed on p. 36.)--different percentages result when seeking to determine compliance with the 60 to 40 ratio established for visitor-staff usage. According to NRAO's classification, the 60-percent goal for visitor use was attained for the 300-foot and the 140-foot telescopes but not for the interferometer (36.04 percent) and the 36-foot telescope (45.12 percent); overall, visitor usage was 53.72 percent. By excluding temporary staff from visitors, the 60-percent goal was not met for any of the four systems; visitors' overall use of all telescopes was 34.11 percent.

During this 11-year period, the visitor participation varied considerably for individual years and for individual telescopes, as shown in the following table.

Percent of Telescope Observing Time Used by Visitors  
(note a)

<u>Fiscal year</u>	<u>Interfer-ometer</u>	<u>300-foot</u>	<u>140-foot</u>	<u>36-foot</u>	<u>Average</u>
1959	40.18	-	-	-	40.18
1960	15.62	-	-	-	15.62
1961	.14	-	-	-	.14
1962	45.77	-	-	-	45.77
1963	18.29	39.08	-	-	28.58
1964	-	29.27	-	-	21.99
1965	1.27	34.86	-	-	22.11
1966	15.87	56.89	39.35	-	36.57
1967	100.00	72.59	49.16	-	59.36
1968	8.93	36.16	63.06	61.72	37.11
1969	11.99	51.97	44.98	14.67	36.36
Average	<u>16.41</u>	<u>44.00</u>	<u>49.37</u>	<u>38.73</u>	<u>34.11</u>

<sup>a</sup>Excluding temporary staff.

We discussed with NRAO the reasons for the wide variations in the visitor participation shown above. We were told that the interferometer had the lowest overall visitor utilization primarily because the use of this system required the scientist to remain at NRAO for considerable lengths of time and thereby made it more difficult for visitors to use this system. The low rate of visitor use of the interferometer in 1960 and 1961, which at that time consisted of only one telescope, was attributed to the lack of demand because NRAO was relatively new.

NRAO stated that it believed that statistics for visitor usage of the interferometer in 1964, 1965, and 1967, of the 300-foot telescope in 1967, and of the 36-foot telescope are not meaningful. It was NRAO's view that these statistics were affected by the fact that the total available observing time on these instruments during those years was significantly reduced below normal amounts because of major alterations or additions of equipment to the telescope systems. The limited available observing time coupled with NRAO's policy to allot available time to the most deserving projects, whether visitor or staff, has resulted, in NRAO's opinion, in the wide variances in visitor participation.

Classification of temporary staff as visitors

The temporary staff includes research associates, scientists on leave from their home institutions, and students. Temporary staff employed by NRAO in June 1969 were receiving salaries at annual rates ranging from about \$4,300 to \$14,400. The number of temporary staff and the percent of their observing time on all telescopes during fiscal year 1969 were as follows:

	<u>Number</u>	<u>Percent of time used</u>
Research associates	12	13.51
Scientists	5	9.71
Students	<u>13</u>	<u>4.96</u>
	<u>30</u>	<u>28.18</u>

According to AUI policies, research associates are appointed for 1 year and their appointments are normally renewable for an additional year. About one third of the research associates later accepted positions on the permanent staff.

We have been told by NRAO that temporary staff are considered visitors because they are permitted to work on research work of their own choosing and because their research work benefits the scientific community as a whole rather than NRAO alone. We have been told also that research associates, during their 1-or 2-year stay at NRAO, are gaining valuable knowledge and training that will benefit the outside community when they leave NRAO and join another institution. Other salaried visitors, according to NRAO officials, may be on leave from a particular university, perform work at NRAO, and then return to the university; thus they primarily benefit the outside community. In summary NRAO

staff as visitors was proper and that temporary staff should be included in the 60 percent of observing time intended for use by visitors.

The Kitt Peak National Observatory, which is also operated by a contractor for NSF, has a 60 to 40 telescope usage

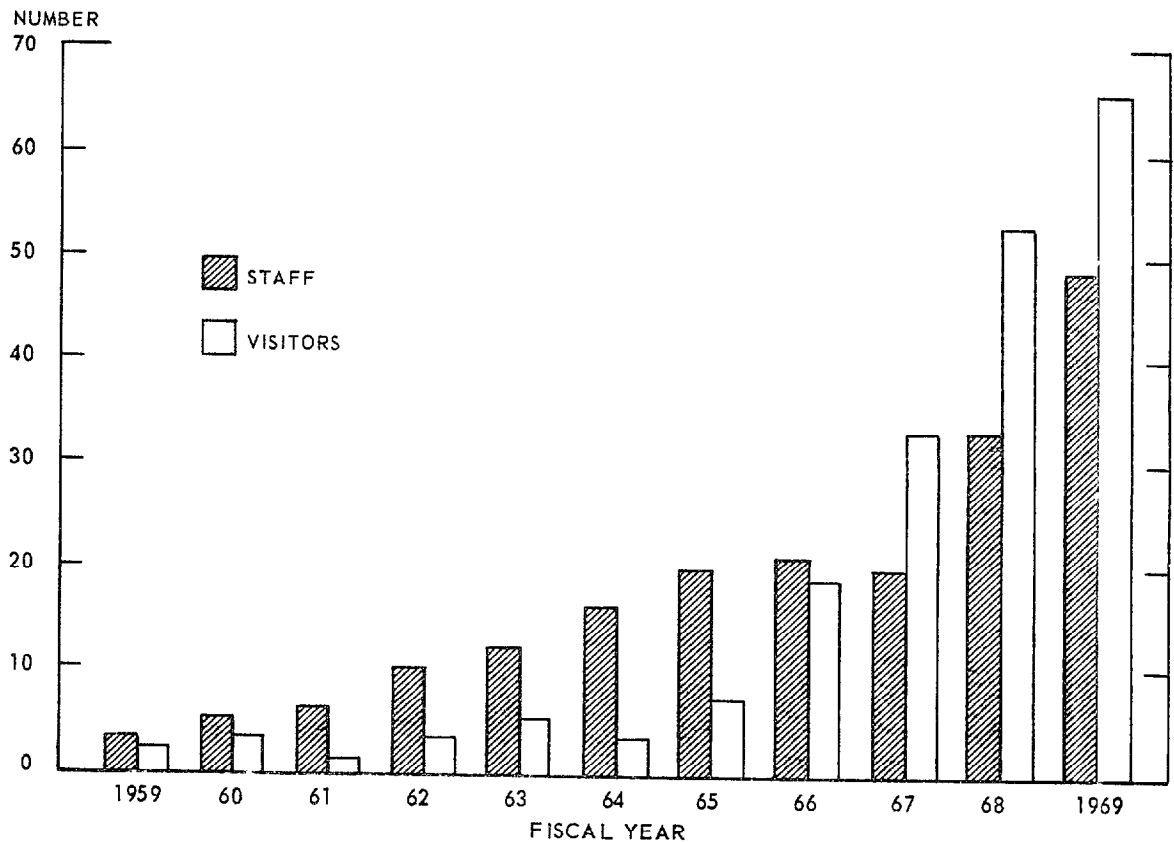
policy similar to that of NRAO. We have been told by a Kitt Peak official that all observers who are on the Kitt Peak payroll, whether for a short term or a long term, are considered part of the staff, whereas all observers not on the payroll are considered visitors.

### Decrease in average visitor use of telescopes

The number of visitors using the NRAO telescopes has increased substantially over the years; however, the amount of observing time used by them has not increased proportionately. As a result, the average use time by visiting observers has declined significantly.

Our observation is based on an analysis of the utilization of the four telescope systems from the time of their installation through fiscal year 1969. In our analysis we considered visitors to be persons not on NRAO's payroll and classified temporary employees as staff.

The number of visiting scientists has increased from two in 1959 to 66 in 1969 and for the past 3 years has exceeded the number of staff observers, as shown below.



The average number of telescope hours used by staff observers has varied considerably during the 1959-69 period. However, since 1962 the number of hours used by visitors has steadily declined, as shown in the following table.

<u>Fiscal year</u>	<u>Average number of telescope hours used by</u>	
	<u>Staff members</u>	<u>Visitors</u>
1959	68	68
1960	344	106
1961	840	7
1962	350	983
1963	604	580
1964	311	468
1965	458	368
1966	525	335
1967	201	178
1968	406	149
1969	287	122

- - - -

We discussed our observations regarding the declining trend in visitors' use of telescopes with NRAO officials. The officials expressed their belief that observing time had declined for both staff and visitors, primarily as a result of increased pressure for observing time and a tendency for larger research groups to collaborate on the average research project. However, in response to our proposal, they agreed that a study would be useful regarding visitors' use of the telescopes and that NRAO would undertake such a study.

In addition, they informed us that NRAO had begun sending explanatory information on the use of NRAO's facilities and on how to apply for observing time to all potential users of NRAO's telescopes.

Proposal, agency comments, and  
our evaluation

In a draft of this report, we indicated that NRAO may not be fully serving its mission as a national research center primarily for the benefit of visiting scientists and proposed that a study be undertaken of visitors' use of NRAO's telescopes.

In commenting on our proposal, the Director, NSF, stated that he did not believe that such a study was necessary at this time. He noted that, as a matter of policy, NSF, NRAO, and AUI had striven for a 60 to 40 ratio in the allocation of observing time between visitors and permanent staff, respectively, and that the ratio was but an operating goal which NSF, NRAO, and AUI all felt had been both satisfactorily and substantially met. He explained that, as a result of information developed during regular monitoring by NSF of NRAO activities which included the visitor program and telescope usage, NSF believed that NRAO was fulfilling its mission as a national research center.

He agreed, however, that during the 11-year period 1959-69 the average telescope use time for visitors, compared to average use time for staff, had declined. He attributed the decline to a number of reasons, such as (1) the use of receivers with lower noise temperatures (background noise) that permit the same observing program to be completed in much less time than previously and (2) the teaming up of observers on an observing program due to increased pressure for telescope time and increased complexity of observing preparations and procedures. The differential decline of telescope time for each user, with the result that permanent staff users are assigned more telescope time on the average, according to the Director, is caused principally by permanent staff undertaking long-term programs, whereas visitors tend to work on problems having shorter observational times.

Regarding classification of users, the Director has informed us that NSF believes that NRAO's classification of temporary staff as visitors is appropriate because:

1. NRAO's permanent staff appointments take into consideration the staffing required to provide the



needed services to visitors and the requirements to support research projects of long-term continuity.

2. Visitors from other institutions and students, whether they are paid by NRAO or their own institutions, are generally concerned with research related to specific projects for which the collection of data at NRAO may take only a limited amount of time.
3. The 1-year appointments for research associates do not allow sufficient time for them to contribute effectively toward assisting other visitors in using the facilities.
4. It is not intended that the visitors function as staff or even as a complement to NRAO's permanent staff.

Although temporary staff may generally be concerned with research related to projects requiring only a limited amount of time, we noted that several 1-year appointments to temporary staff were extended to 2 years and that, in some cases, the principal research effort of temporary staff complemented the work of NRAO's permanent staff.

Moreover, AUI's policy manual and NRAO's Appointment Policy for the Scientific Staff, which have been reviewed and approved by NSF, distinguish between salaried and non-salaried visitors. These policies provide that salaried appointments to visitors, which include scientists classified by NRAO as temporary staff, be given to individuals who take leave from their home institutions primarily to assist in advancing NRAO's own program. Nonsalaried appointments to visitors, according to these policies, are made to scientists who come to NRAO primarily to carry out their own research projects.

Therefore, in our view, it would not seem appropriate to classify, in all cases, salaried temporary staff as visitors for purposes of determining compliance with the 60 to 40 user policy. Furthermore, salaried appointments made by NRAO to temporary staff whose primary effort is to carry out their own research projects rather than to assist in advancing NRAO's own program appears to be inconsistent with the

appointment policies of AUI and NRAO and may indicate the need for NSF to examine into NRAO's practices of hiring temporary staff.

RECOMMENDATION TO THE DIRECTOR OF NSF

We recommend that the Director, in cooperation with the board of trustees of AUI, make the necessary arrangements for undertaking a study of visitors' use of NRAO's telescopes and of NRAO's practices of hiring temporary staff to determine what action, if any, is needed to ensure that NRAO fully serves its mission as a national research center primarily for the benefit of visiting scientists.

## CHAPTER 6

### SCOPE OF REVIEW

Our review was directed toward an evaluation of the policies, procedures, and practices followed by NSF and AUI in the administration of NRAO. Our review was conducted at NSF headquarters in Washington, D.C.; NRAO's administrative headquarters at Charlottesville, Virginia; and NRAO's operational site at Green Bank, West Virginia.

We reviewed pertinent contracts, files, and other records of NSF and NRAO for fiscal years 1959-69. Also, we had discussions with NSF and NRAO officials concerning various aspects of the NRAO operation.

APPENDIX

NATIONAL SCIENCE FOUNDATION  
OFFICE OF THE DIRECTOR  
WASHINGTON, D.C. 20550

DEC 18 1970

Mr. Lloyd G. Smith  
Associate Director, Civil Division  
United States General Accounting Office  
Washington, D. C. 20548

Dear Mr. Smith:

This is in response to your letter dated October 15, 1970, requesting comments on the GAO Draft Report entitled "Opportunities to Improve Administration of the Research Program at the National Radio Astronomy Observatory, Green Bank, West Virginia." The report has been reviewed by representatives of the Foundation, Associated Universities, Inc., and NRAO. As a result of this review, questions have been raised with respect to some of the information presented and exceptions have been taken to some of the conclusions and recommendations of the General Accounting Office. The exceptions center around the fundamental difficulty in evaluation of research management and related questions which do not readily lend themselves to letter responses such as this. Therefore, we believe that before a final report is issued it might be in the best interest of GAO and the National Science Foundation to discuss the draft report and this letter reply in more detail concerning areas in which there does not appear to be sufficient understanding. [See GAO note 1, p. 50.]

Procedures for Allocating Telescope Observing Time - (Chapter 3)

Review by Independent Referees (Pages 10-14) [17 to 21]

GAO suggested that improvements could be made in the referee system by (1) establishing a pool of referees to obtain a wider range of views, (2) soliciting referees' evaluations of updated requests involving significant additional observing time, and (3) expanding the rating information being requested from referees.

Concerning the recommendation to establish a pool of referees, NRAO has taken steps to improve the conditions existing in fiscal years 1968 and 1969 as described in the report. For example, NRAO now consistently receives reviews from three regular referees, and appropriate members of the resident staff provide expert advice whenever there are differences of opinion among the referees who are, and should be, in an advisory capacity. In addition, NRAO

## APPENDIX I

now has two additional referees for solar proposals, an area that is outside the field of two of the three regular referees. There is, in our opinion, a distinct advantage in keeping the number of referees relatively small, since the reviewers are better able to advise NRAO when they are able to see nearly all, rather than a small fraction of the proposals. Accordingly, we are opposed to the establishment of a large pool of referees. However, we will consider with NRAO the desirability of appropriate additions to the pool of referees, particularly in specialized areas of research such as has been done for proposals involving solar studies.

We agree that updated proposals requesting significant amounts of additional observing time should be reviewed by the referees. NRAO follows the policy of resubmitting to referees updated proposals in cases where the scope of the work has significantly changed. The decision to resubmit is one that requires scientific judgment in each case, and if the judgment of the referees regarding a particular request is known through prior comments of the referees, the updated proposal may not be resubmitted.

We agree that narrative comments by reviewers on the scientific merits of proposed research projects are valuable supplements to the basic rating data. Although NRAO considers the comments by referees to be adequate at present, this does not preclude the consideration of means to encourage expansion of such data.

### Approval and Scheduling of Research Studies (Pages 15-17) [22 and 23]

GAO suggested the need for more adequate documentation of NRAO's management actions regarding the evaluation and approval of research proposals. In particular, examples were cited of adjustments in the observing time scheduled for individual projects, and the absence of the original rating sheets submitted by referees.

Although opinions differ as to what constitutes "formal and complete records," we agree that opportunities for improvement in this area may exist. However, NRAO does maintain a record showing, for each proposal, the telescope time requested, NRAO's approval or disapproval of the request, and the amount of observing time granted, including the dates of telescope use. Also, data from the referees' original rating sheets are transcribed on the proposal. We agree that there is need for improvement in documentation. We will review with AUI and NRAO appropriate means of accomplishing the report recommendation for more adequate documentation, including retention of the referees' original rating sheets.

Evaluation of Levels of Research Efforts - (Chapter 4) (Pages 18-21) [26 to 29]

GAO suggested that the information available on the levels of research efforts at NRAO should be improved, and recommended that NRAO "make such improvements to its records as may be most useful to AUI review committees and NRAO management." GAO expressed the belief that expanded information could be useful in connection with possible changes in research emphasis. NRAO management has reservations about the need to expand the present information systems, believing that scientific management should seek to foster and encourage the very best proposals for telescope time that are submitted to it by scientists, but it should rarely attempt to manage the scheduling by research area. NRAO's management also believes that, as long as the visitors and staff that use the facilities are first-rate, the proposals submitted will indicate where the interesting research areas lie, and the proportion of time spent observing in various research areas should be determined through the process of selecting the best proposals rather than through the process of trying to promote research in specific areas. We agree in general with this philosophy; however, we believe that the potential usefulness of additional information merits consideration, and we will explore with NRAO the possibility of accumulating data in such a manner that the time and effort involved will not outweigh its usefulness.

Use of Telescopes by Visitors and Staff - (Chapter 5) - (Pages 22-23) [30]

The report notes that NRAO was established as a national research center to be used primarily by visiting scientists. It also was noted that NRAO, AUI, and NSF, as a matter of policy, have striven for 60/40 ratio between visitors and resident staff, respectively, in scheduling observing time. The GAO questions the allocation of observing time between resident staff and visitors because (1) NRAO classifies its temporary employees as visitors and, consequently, this increases the percentage of observing time allocated to visitors and (2) the average telescope time used per visitor during an 11-year period has declined significantly as compared to average time used per staff observer. The GAO also observed that there has been only minimal use of the 36-foot telescope located at the Kitt Peak National Observatory because of problems connected with atmospheric conditions.

It was recommended that the Director of NSF, in cooperation with the Board of Trustees of AUI, make the necessary arrangements for undertaking a study of visitors' use of NRAO's telescopes to determine what action, if any, is needed so that NRAO will fully serve its mission as a national research center primarily for the benefit of visiting scientists.

## APPENDIX I

The Foundation agrees that as a matter of policy NSF, NRAO, and AUI have striven for a 60/40 ratio in the allocation of observing time between visitors and resident staff, respectively. The ratio, as I am sure GAO realizes, is but an operating goal and one that NSF, NRAO, and AUI all feel has been both satisfactorily and substantially met.

As indicated by the Foundation's letter to the GAO dated September 4, 1970, the Foundation believes that NRAO's classification of temporary staff as visitors is appropriate. NRAO's permanent staff appointments take into consideration the staffing required to provide the needed services to visitors, and the requirements to support research projects of long-term continuity. Visitors from other institutions and students, whether they are paid by NRAO or their own institutions, are generally concerned with research related to specific projects for which the collection of data at NRAO may take only a limited amount of time. Although both groups perform productive research, it is not intended that the visitors function as staff or even as a complement to NRAO's permanent staff. We also consider it appropriate to classify research associates as visitors since their one-year appointments do not allow sufficient time for them to contribute effectively toward assisting other visitors in using the facilities. For these reasons we reaffirm our previous statement that the present classification of visitors is appropriate and should be continued.

As a matter of interest, some radio observatories have resident requirements for visitors. The visiting observers spend several weeks, and even months, becoming acquainted with the radio telescopes, electronics, and data processing facilities of the observatory. For example, visitors using the new Westerbork array in the Netherlands are required to spend a minimum of two months in residence at the facility. This policy is also pursued for certain observing programs at the 210' Parkes telescope in Australia. NRAO has not placed such requirements on its users, but it has become obvious that users must become familiar with their instruments if they are going to enjoy productive observing runs. For first-time NRAO users, this frequently means spending weeks in Green Bank and Charlottesville. As larger, more complex instruments come into use NRAO may find it necessary to impose minimum residence requirements on visitors.

With respect to the decline during the 11-year period 1959-1969 in the average telescope use time for visitors, compared to average use time for staff, we agree that the average telescope time per user has declined. The decline itself is attributable to a number of reasons, examples of which are (1) the use of receivers with lower noise temperatures that permit the same observing program to be



completed in much less time than previously, and (2) teaming up of observers on an observing program due to increased pressure for telescope time and increased complexity of observing preparations and procedures. The differential decline of telescope time per user, with the result that permanent staff users are assigned more telescope time on the average, is caused principally by permanent staff undertaking long term synoptic and survey observational programs. University users, which make up the bulk of visitors, tend to preferentially work on astrophysical problems having shorter observational times.

Concerning the utilization of the 36-foot telescope which is located at Kitt Peak National Observatory, the telescope is relatively new and it is well established that a new major instrument does not go into full use for many months due to de-bugging and calibration requirements. In the past, extensive daytime usage has not been possible due to thermal distortions caused by telescope exposure to full sunlight. These limitations have been practically overcome and daytime usage is expected to expand significantly.

We have reviewed the observing time of the 36-foot telescope for the months of September, October, and November 1970 to determine current utilization. Actual observing time, as a percentage of maximum possible observing time in a 24-hour period, was 72%, 53%, and 61%, respectively, of which use by visitors averaged 56%. It is expected that actual observing time will continue at a comparable rate in the months ahead.

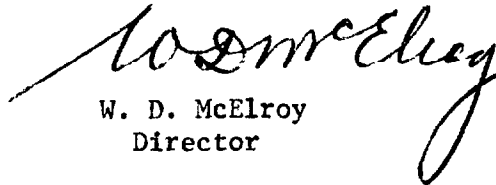
In response to the recommendation to undertake a study of visitors' use of NRAO's telescopes to determine what action, if any, is needed so that NRAO will fully serve its mission as a national research center primarily for the benefit of visiting scientists, we do not consider that such a study is necessary at this time. Under our present organization, we have an Office of National Centers and Facilities under the Assistant Director for National and International Programs which, together with the Astronomy Section under the Assistant Director for Research, monitors activities at NRAO. Also, each year NRAO presents a program review to the Foundation's senior staff at which time activities such as the visitor program and telescope usage are subject to review. As a result of the information developed from the review activities indicated, we believe that NRAO is fulfilling its mission as a national research center.

[ See GAO note 2, p. 50.]

[ See GAO note 2.]

We appreciate the opportunity to comment on the draft report. As indicated, representatives of the Foundation, AUI, and NRAO will be pleased to meet with you to discuss the draft report or any question you may have concerning this letter.

Sincerely yours,



W. D. McElroy  
Director

Enclosure

GAO notes:

1. The views expressed during discussion held with NSF officials on the draft of this report and NSF's letter reply have been considered in the preparation of our final report.
2. Deleted comments refer to material contained in draft report but omitted from final report.