

ASSOCIATED UNIVERSITIES, INC.
350 Fifth Avenue
New York 1, New York

April 24, 1956

Dr. Raymond J. Seeger,
Assistant Director
National Science Foundation
1520 H. Street, N. W.
Washington 25, D. C.

Dear Ray:

Attached hereto is a statement that reflects the results of our feasibility study on the establishment of a National Radio Astronomy Facility. I am sorry that there was some misunderstanding after the meeting on April 2 as to what you wished from us, and it was indeed fortunate that you joined us on April 19 and clarified the matter.

The intervening weekend reduced the time available to assemble material for you, and I have resorted to the device of extracting relevant paragraphs from draft chapters of the Planning Document, from Dr. Berkner's speech before the American Astronomical Society, and from similar sources. Hence, there may be variations in the style and format among the various parts, but these will not detract from the validity of the contents. I have appended the letter Dr. Berkner left with Dr. Waterman on April 2, but have deleted the original table of cost estimates and substituted a recent letter to Mr. Sheppard.

I trust the above material will meet your requirements, and to save you time in getting it distributed, we are enclosing 25 copies.

Sincerely,

/s/

Richard M. Emberson
Assistant to the President

ASSOCIATED UNIVERSITIES, INC.
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New York 1, New York

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Statement on the Establishment and Operation of A
National Radio Astronomy Facility

Before setting down the principles essential to the effective organization of the Facility, the basic philosophy underlying its creation and the implications of the word "national" as they relate to this philosophy should be set out. The use of the word "national" in the title of the Facility refers not to the character of the organization of its management, but to the guiding policy under which it operates. The broad implication of the word "national" is that the Facility operates fundamentally in the interests of research scientists throughout the Nation by providing without institutional prerogatives unusual facilities and opportunities to any scientist from any institution based on his capabilities and the quality of his problem. Therefore, the basic policy under which the Facility operates must stem from a national source, and this source can only be the sponsoring Federal agency, which in this case is the National Science Foundation.

To assist the Foundation in establishing the broad basic policies that provide the guiding philosophy for a "national" facility, we believe that the Foundation might establish a "National Radio Astronomical Advisory Board". The purpose of such an Advisory Board would be to provide to the Foundation whatever assistance it may need in creating basic policies calculated to establish a broad and fundamental national philosophy and in reviewing the general performance under these policies to insure that the implications underlying the word "national" are being fulfilled.

The existence of such an Advisory Board can have a most beneficial effect on the Facility through its independent evaluation of, and advice to the Foundation, on the proposals for the support of research at the Facility. Such a Board, of course, would not pass judgment on these research proposals without joining with the Foundation in hearing their formal presentation. Moreover, it would have to be scrupulously careful not to interfere with the operation of the Observatory in any way. Full responsibility for capable management must reside in the parent operating agency.

It would seem wise that such a Board also should not enter into direct consideration of the Foundation's educational grants for radio astronomy. To do so might involve, or seem to involve, some conflict of interest between the financial requirements for advancement of science beyond the vanguards of knowledge on the one hand, and the needs for educational training and university research on the other. These two interests should not be competitive, or subject to "pie-cutting" within the Foundation's advisory committees.

groups, or panels, but each should stand on its own feet in the presentation of their needs to the Congress. Therefore, the Advisory Board could best be charged with responsibilities that permit a wholly objective attitude toward the Facility.

The word "national" can never refer to the character of the operating agency or parent management entity itself. If, for example, the operating agency were a Government agency, the Facility would not be "national" in the sense that civil service procedures and other Government restrictions would inevitably affect adversely the academic atmosphere essential to the university-type research laboratory. Likewise, no private group, however selected or organized, could in themselves be completely "national" in the sense of representing all interests in establishing and maintaining a basic philosophy. To endeavor to apply the word "national" to the managing entity would severely limit the selection of a suitable managing agency, without compensatory advantage. The implications of the word "national" can only stem from the policies and philosophy of the Foundation itself.

The requirements for the manager of the Facility should be quite different. The manager must be an organization that inspires confidence in its ability to carry out the national policies established by the Foundation in consultation with its Advisory Board. It must provide an atmosphere within the academic tradition from which inspired and creative research will flow. It must provide the enthusiasms and management skills that underlie all effective research operations. It must provide a stable base for its permanent staff. Finally, it must provide that measure of responsibility that can attract the kind of personnel needed for successful creative research.

The management organization must be responsible for making the Observatory "national" in accordance with the basic philosophy laid down by the Foundation. But since the management organization can never itself be "national", it should be selected by the Foundation as the organization most likely to succeed in operating a "national facility" in the most creative sense.

The word "national" should not be preclusive as applying to any one laboratory, since there may be in the future more than one facility operated under a "national" philosophy. It is under this basic philosophy that the general principles for the National Radio Astronomy Facility are set down below.

We believe that several important requirements must be stressed.

1. The National Radio Astronomy Facility should not be considered as an independent activity, but as a means of supplementing the local facilities of competent radio astronomers with large scale and adequate facilities.

2. The National Radio Astronomy Facility must be more than a collection of research instruments; it must be organized and main-

tained by a small and competent staff who also carry on research and who aid in providing an exciting intellectual atmosphere for conduct of research.

3. The National Radio Astronomy Facility must be organized to provide easy movement of senior research workers, together with graduate students and post-doctoral fellows between their regular posts and the Facility for widely varying intervals of time. About half of the research should be done by visiting scientists.

4. The welcome of a visiting scientist should be based solely on his competence, the quality of his problem, and its suitability to the Facility. Any system of supporting-institutional membership in the Facility should be avoided since it implies a preference benefiting scientists in the supporting institutions.

5. The Facility should not be operated as a Government laboratory, but by a university-type contractor on a non-profit basis under the National Science Foundation to emphasize the university atmosphere of inquiry and penetration.

Finally, we should mention the place of the public visitor that will certainly be interested in the Facility if only as a spectacle. Experience at other observatories shows that he cannot be ignored, and that the opportunity for public education can be exploited. Therefore, provision should be made to take advantage of such itinerant visitors without interference to the research.

We recommend the prompt organization of the National Facility under an appropriate contractor. The organization of an operating staff will be one of the first steps then to be taken. The character of the operating staff will be strongly influenced by the fact that the staff functions of the parent contractor must be clearly separated from the management direction of the Observatory. Therefore, the Director and his staff will bear direct operating responsibility for the Facility subject only to the policies, controls, and supervisory functions of the parent organization. Since the Director and his staff will bear full responsibility for final decisions with the structure of policies and controls specifically defined by the management contractor, the successful functioning of the Observatory depends on a staff adequate to assume this responsibility. The extent of this responsibility should be clearly understood in considering a tentative organization, since the number of responsible posts must be sufficient to discharge fully the several operating responsibilities delegated to the staff.

A final organization for the operating staff cannot, of course, be specified without a full knowledge of the skills and capabilities of the key individuals who are finally selected. It is possible, however, from a knowledge of the extent and kind of responsibility involved to outline a typical organization sufficient to assume adequately the basic responsibilities involved. For the basic operation management of the National Radio Astronomy Facility, four

key persons appear necessary for good management of such a Facility. On these four persons the success of the Facility will depend. The training and experience of these individuals must be supplementary, so that the total responsibilities outlined below are suitably distributed. Depending upon the training and experience of the particular individuals selected, the various designated responsibilities can be reshuffled as deemed most appropriate to their skills and capabilities.

The Observatory should be departmentalized, probably into three Departments, each under a Department Head reporting to the Director. Tentatively, we specify these Departments as the Research Department, the Engineering Department, and the Department of Business Administration. In outlining this organization, we must remember that during the early years of the Observatory, construction will play an important part in the total functions of the Facility, and it cannot be ignored in establishing the organization. If and when the time comes when construction diminishes to a smaller part of the total responsibility, it may be desirable to modify the organization. But in the initial phases both construction and research must be taken into consideration.

The Director bears overall responsibility for the Facility. He must not only be a research scientist of recognized ability, but he must have proven capability in administering scientific operations and a special aptitude for the selection and supervision of scientific personnel. Experience of this sort will be particularly essential during the early life of the Facility.

The Director must be responsible for every phase of the operation of the Facility. This will include not only the normal internal functions relating to the general direction of the Observatory itself, involving personnel, budgets, financial control, and research and construction planning, but also a great many external functions as well. Since the site will inevitably be isolated, it will be necessary that the Director make frequent trips away from the site to discharge his external functions, since he will find it difficult to delegate many of these. These external functions will include contact with universities in stimulating cooperative research arrangements, as well as public relations with the surrounding community and the State, planning for large numbers of casual visitors, communications with and formal presentations to the National Science Foundation, and meetings with the Science Foundation's "Advisory Board", possible appearances at Congressional hearings, and contact with the parent organization and its officers and Board of Trustees. Consequently, a great measure of responsibility for the day-to-day functioning of the Facility must be delegated to Department Heads whose skill and judgment are of sufficient calibre to insure effective operations.

The search for a suitable site was dominated by the requirement for a low radio noise level. Radio astronomy is concerned with the region of the spectrum between 10 and 35,000 mc/s, and perhaps even up to

100,000 mc/s. For the lower part of this spectrum the basic minimal level of radio noise will be approximately constant over the whole country and produced by ionospheric and tropospheric scattering arising from irregularities in the atmosphere. Such scattering does not reduce very fast with distance and, in the case of ionospheric scattering, becomes strongest from 1500 to 2000 kilometers from the transmitter. Protection from this basic minimum of interference in the continental United States can only be obtained by the clearing of channels through cooperation with the FCC, the Government agencies, and the International Telecommunications Union. The clearing of suitable channels was initiated some years ago on representations by the URSI, and action is now proceeding rapidly in our own Government to insure the availability of a few entirely clear channels. In addition to nation-wide minimal levels for the lower frequencies, one is faced with direct or diffracted propagation at the very high frequencies, and with a kind of white noise produced by man-made interference in the utilization of all sorts of electrical machinery and devices. Here the only protection is to get into a mountain valley surrounded by many successive mountain ranges and containing the lowest possible population. Having once found such a site, it must be proclaimed as an agreed "zone of avoidance" insofar as the licensing and installation of any sort of transmitter is concerned. Such measures preclude establishment of more than one or two or perhaps three such especially protected sites in the whole Country and add emphasis to the need for one or two national sites where excellent "seeing" can be preserved. Consequently, in the search for the site certain specifications, some of which, of course, contain some mutually contradictory requirements, must be resolved in favor of the more essential.

A. There must be an extraordinary low level of radio noise or interference on wavelengths below 10 meters (frequencies greater than 30 megacycles). To this end:

1. The telescopes should be within the view of the fewest number of surrounding inhabitants who might generate noise in the course of their daily occupations;
2. The telescopes should not view high tension power lines that radiate radio noise through corona discharges or otherwise;
3. The site be in a valley surrounded by many ranges of high mountains in all directions to attenuate direct radio propagation from surrounding radio stations and to reduce diffraction of tropospheric propagation into the valley;
4. The site should be removed at least 50 miles from cities and other concentrations of inhabitants or industries and should be isolated from such concentrations by surrounding mountain ranges;

5. The site should be so situated that it is not on a cross road of commerce involving frequent overflight of aircraft, nor in regions where commerce or industry are likely to intrude and grow in the future. The future quietness of the site must be preservable, through appropriate restrictions on noise generation, exclusion of radio transmitters from the vicinity, and local zoning regulations to permit a control over the installation and use of equipment, devices, or systems of any type that might emit radio noise.
 - B. The site should be as far south as possible with a southern obstruction not exceeding a few degrees to permit observation of the center of the Milky Way and other objectives having southern declinations.
 - C. The site should be in northern latitudes to permit researches involving aurora, ionospheric scintillation, and polar blackouts.
 - D. The site should avoid excessive snow and ice that would create frequent snow and ice loads on the radio telescopes.
 - E. The site should avoid a region of violent winds and possible tornadoes or hurricanes.
 - F. The climate should be reasonably mild and high humidity is undesirable.
 - G. The site should provide adequate space for separate installation of many types and sizes of telescopes and arrays, the latter requiring relatively flat areas of one or more square miles. A total area of as much as 5-10 thousand acres should be available for ultimate use by the observatory.
 - H. Subject to the basic requirements:
 1. The site should provide as many as possible of the attributes of a university campus. Included under this are, of course, the physical means for research -- laboratories, shop, libraries, and conferences. It is also stimulating and helpful if scientists working in related domains of science are nearby - mathematicians, engineers, chemists, and physicists, to name only a few.
 2. The site should provide or have easy access to habitation and other services for visiting scientists, the permanent staff, and their families.
 3. The site should be accessible by easy and frequent transportation by plane, rail or automobile.

In addition, the NSF Advisory Panel recommended that the site should be within 300 miles of Washington, D. C.

We have studied many possibilities and a site at Green Bank, West Virginia comes closest to being the ideal. It has the lowest radio noise level of any site tested; has a minimum nearby population; has maximum mountain shielding; is not involved in commercial or Government installations. One-year options have been obtained for 6000 acres, which is more than half of the total area in the valley, at a total price of \$502,000. Officials of the State of West Virginia have indicated that they would introduce special zoning legislation to protect the site against future encroachment that might spoil the low radio noise level. And a presentation has been made to the Interdepartmental Radio Advisory Committee and the Federal Communications Commission requesting that the site be made a "zone of avoidance" for the future installation of any types of transmitters.

While it is not possible to give an absolute guarantee that no better site exists or that one of equal excellence is not situated on Government-owned land, there is little likelihood of such sites, for the following reasons: (a) The area sought for a site is sufficiently large to stand out regardless of what search procedure is employed; and (b) several independent searches have been made, discovering and rediscovering the same sites, and thus giving a considerable degree of confidence in the thoroughness of the search. Accordingly, we recommend the Green Bank site as the site to be acquired, and we urge, backed by the unanimous vote of the AUI Advisory Committee, that title be obtained to as much of the valley as possible.

Concerning the instrumental program, the first major construction will be a 140-foot radio telescope. The specifications we have set require that the parabolic reflector deviate no more than $\frac{1}{4}$ -inch from a true paraboloid and that the drive and control system be capable of pointing the instrument with an accuracy of 10" of arc.

Three independent designs, all of an alt-azimuth configuration, are being obtained for the structure of the telescope and two of these are accompanied by proposals for a drive and control system. An independent study on this problem is now being concluded by the MIT Servomechanisms Laboratory, and several commercial firms have expressed an interest in developing the system. Meanwhile, a design study on an equatorial configuration has been initiated as requested by the Foundation. This solution would simplify the drive and control problem at the expense of structural problems. Several experts have independently advised that the total cost of an equatorial mount will probably be as large or larger than an alt-azimuth telescope. As there is agreement that larger (300- or 600-foot) telescopes must be alt-azimuth mounts, there are strong arguments for making the 140-foot telescope in this same configuration. Assuming that bids might be requested on the alt-azimuth designs at an early date, the results of the equatorial study will be available before a construction contract would be awarded.