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June 14, 1955

Minutes
Steering Committee for the Radio Astronomy
Facility Study
Saturday, May 28, 1955

1. The Steering Committee met in the AUI Conference Room in the Empire State Building at 9:30 a.m. Dr. Hagen presided. The members and alternates present were: B.J. Bok, A.J. Deutsch, Leo Goldberg, W.E. Gordon, F.T. Haddock, and J.P. Hagen. Also present were C.F. Dunbar and R.M. Emberson.
2. The Committee had met on May 27 with invited guests to discuss electronic problems in radio astronomy. The groups met for dinner through the courtesy of Mr. Lloyd V. Berkner, and there were informal discussions in the evening. A record of the May 27 symposium will be separately prepared and distributed. At the luncheon break on May 27, the Steering Committee members present held a short meeting in Mr. Berkner's office. The points made at that time will be incorporated in the minutes that follow.
3. An Atlas for Radio Astronomy. As Dr. Goldberg was flying from Boston and had not arrived at 9:30 on May 28, the Committee did not take up the items in the order on the agenda. The first matter considered was the need for atlases in radio astronomy and, specifically, for the proposed national facility. In a letter dated April 25, Dr. Meinel had noted that both Ross and Barnard atlases were difficult items to obtain. He proposed a modern atlas of about 100 regions that would sell for about \$12.00, provided initial support of \$3,000 could be obtained.

The Committee expressed interest in the atlas proposed by Dr. Meinel and estimated that a considerable number of copies would be purchased by radio astronomers, if the price could be held to \$12.00. The Committee presumed that the initial \$3,000 support was being sought of the National Science Foundation or perhaps private sources.

The Committee believed that a Palomar atlas would be needed at the national facility. Dr. Deutsch agreed to proceed informally to determine if one of the three "reserve" copies might be set aside for this purpose. Dr. Emberson was advised to earmark \$2,000 of the present study funds for the purchase of a Palomar atlas and to proceed with the purchase if a copy were still available, provided the National Science Foundation did not object to this expenditure.

4. Frequency Allocations. The Committee noted the FCC notice, dated April 21, 1955, requesting comment on this matter. Dr. Hagen reviewed the recommendations of Commission V, URSI, which he had distributed by a memorandum dated May 13, 1955 to many persons interested in radio astronomy. A copy of Dr. Hagen's memorandum and of the Commission V recommendations are attached as Appendix 4A. It will be noted that the Commission V recommendations are based primarily on the harmonics (and sub-harmonics) of the hydrogen line at 1420 Mc/s.

The Committee agreed that it was advisable for each member to write individually to the FCC. In addition, Dr. Emberson was to write on behalf of the national facility study, indicating the status of the study, the region in which a site was being sought, and similar matters. All agreed that the fullest possible support should be thrown behind Dr. Hagen, who has been serving as an especially designated member of the NSF Panel on Radio Astronomy.

5. Performance Specifications. With reference to draft specifications prepared by Mr. Karelitz and the ad hoc panel designated at the March 26 meeting, the following companies were being contacted with respect to either or both the construction of a small (140-foot) radio telescope and studies for larger (300-, 450-, and 600-foot) telescopes: Allis-Chalmers, American Machine & Foundry, Bethlehem Steel Shipbuilding Division, Blaw-Knox, Collins Radio, General Electric, Geodesics, Inc. (R. Buckminster Fuller), Goodyear Aircraft, Gray Scientific Division of the Remler Co. (W.W. Salisbury), Hughes Aircraft, Husband & Company, D.S. Kennedy, Kuljian Corp., Newport News Shipbuilding Corp., Warner and Swasey, and Westinghouse. A number of these were showing some interest in the work; to date none had indicated that they would want to undertake the entire job and a few had already indicated that they would want to work on only a part. Mr. Husband predicted that we would have the difficulty here that he had had in England in trying to locate a prime contractor. If the present trend continues, the large radio telescopes will have to be constructed on a project basis, with various tasks contracted to appropriately interested and able companies.

The draft specifications were reviewed. Dr. Bok reported that he had heard criticism from some of the members of the NSF Panel that the specifications were not sufficiently precise. The Committee discussed this point. If detailed materials and construction specifications were prepared, a manufacturer would strive to give only what might conform to the specifications without regard to whether the completed instrument would perform as desired. Thus it seemed preferable to continue with the use of performance specifications. The Committee made certain revisions in the specifications. A copy of the revised specifications has been prepared and are distributed herewith.

Subsequent to the meeting, a letter has been received from Mr. Husband, answering questions concerning the 250-foot reflector at Jodrell Bank and commenting on our draft specifications. Two paragraphs from Mr. Husband's letter are quoted here as being particularly relevant.

"In spite of the apparent simplicity of the finished job I think there is as much work in preparing a design for a large radio telescope as in designing a new type of large aircraft. I do not think that any firm should be asked to produce a design in sufficient detail to be used as the basis of a contract in under 12 months. Due to a general stiffening up of the operational specification since we prepared the first design for the Jodrell Bank instrument we have tended to carry out improvements to the design as actual constructional work proceeded. For many reasons this is not a good thing to do, but I am quite sure that the alterations we have made will prove to be very valuable."

"I think you would save a great deal of money by preparing a design in considerable detail before inviting bids, as an alternative to inviting "bid proposals". Quite apart from radio telescopes this is usually the case in many branches of engineering because contractors cannot afford the time to get down to bid proposals for novel projects in sufficient detail to avoid including a large contingency item in their tender. I appreciate that I am biased as a consulting engineer, but from time to time we do collaborate with contractors in preparing bid proposals and feel that the alternative of the client being responsible for producing the design is practically always the more economical in the long run."

It may well be that we are fast approaching the date that a full-time consulting engineer must be brought into the work.

As the sky-coverage is very critical in an equatorial design, the Committee devoted some time to this question. Dr. Goldberg and Mr. Haddock stressed that low altitudes would be highly desirable for some solar work, lunar occultations, and eclipses; and Dr. Gordon stressed that atmospheric and ionospheric problems required access to very low altitudes at all azimuths, particularly to the north.

The Committee suggested that the question of alt-azimuth vs. equatorial mount be met at present by requesting two bid proposals, one for each type of mount. In the meantime, it was suggested that in addition to other studies, we might undertake a special study on mounts, including the drives,

computers, and any other appendages; the study should cover both design and construction problems as well as cost estimates. In this connection, Dr. Hagen noted that the alt-azimuth mount requires more complex computers and servo-mechanisms and that maintenance would therefore be more costly and time consuming.

The Committee formulated preliminary plans for a report to the NSF by July 16 that would cover, among other things:

- I. Recommendations concerning the erection of a radio telescope of 140-foot aperture; and
- II. Recommendations concerning detailed studies of design and erection problems for much larger radio telescopes, of 300-, 450-, and 600-foot apertures.

(In addition, the report will discuss site problems and the organization for the national facility). With the above date in mind, all companies should have proposals in by July 8 in order that the Committee may consider them at the July 11-12 meeting.

6. Organization for a National Radio Astronomy Facility. This subject was discussed under headings of content: the instrumental program and the staff organization; and headings of history and budgets. On May 28, the significant portions of the short noon-time session of May 27 were repeated; they are covered here with no attempt to distinguish them.

History. In view of certain misunderstandings that have occurred, it seemed desirable that the events leading up to the AUI proposal and the NSF grant for the present study be placed clearly in the record. Subsequent to the Washington Conference on radio astronomy in January 1954 and some exploratory conversations among representatives of Harvard, M.I.T., and NRL, two meetings were held at the invitation of Dr. Menzel and attended by Dr. Bok from Harvard, Drs. Stratton and Wiesner from M.I.T., and Dr. Hagen from NRL. The subject of discussion was the possibility of a Harvard-M.I.T.-NRL combination to acquire and operate a large research tool for radio astronomy. It seemed clear that a larger and more expensive radio telescope could thus be obtained than any of the institutions would be likely to afford. Dr. Stratton first suggested the possibility of AUI undertaking the job of creating and operating a research facility, and pointed to the similarity of Brookhaven. In accordance with the discussion at this Cambridge meeting, Dr. Menzel called Dr. Berkner and soon thereafter they and Dr. Emberson met (in Washington), at which time preliminary plans were made for an organizing meeting to be held in May; a provisional list of persons known or thought likely to be interested in radio astronomy was prepared and thus constituted the ad hoc organizing committee.

Dr. Menzel prepared a memorandum on the status of radio astronomy in the U.S., "Survey of the Potentialities of Cooperative Research in Radio Astronomy", dated April 13, 1954, on the basis of which AUI extended invitations to the ad hoc organizing committee to meet on May 20, 1954. Dr. Menzel presided at the meeting. As the discussion proceeded, it became clear that there was a genuine desire by the radio astronomers to join forces to achieve a large research facility. It was the consensus that such an undertaking was compatible with the objectives of the National Science Foundation and might have its support. Presented with this mandate, AUI initiated steps leading to the present feasibility study: The present Steering Committee was formed; a meeting was held July 26, 1954; and on July 26, 1954 a study proposal was submitted to the NSF. The NSF granted \$85,000 to support the study on feasibility of a national radio astronomy facility and the effective date for the start of the study was March 1, 1955.

7. Content of the Study Program. The AUI proposal included the following major items in the feasibility study:
- A. A Site Survey, to be limited to a 300 mile radius of Washington, D. C.
 - B. Determination of the feasibility of constructing very large and precise radio telescopes.
 - C. Examination of buildings and other construction necessary to develop a functional research facility.
 - D. Development of an organization and staff plan.
 - E. Exploration of means of financing the facility.

Dr. Bok noted that in discussion by the NSF Panel, doubt had been expressed that AUI was putting enough emphasis on the intermediate (140-foot) telescope. Mr. Berkner clearly stated that every effort was being made to conduct the study in a manner to meet the objectives of the AUI Steering Committee, the NSF Panel, and of radio astronomers generally. When it became apparent that early construction of an intermediate size telescope was desired, a major shift of emphasis to this task had been made (ref. Item 5 of these minutes). Dr. Hagen referred to the report planned under Item 5 and explained that it should recommend in detail what is appropriate for a 140-foot reflector.

8. Budgets and Programs. The Committee next discussed the radio astronomy budgets suggested by the NSF Advisory Panel on Radio Astronomy and how these figures were related to the overall estimates for the five-year construction and operating plan included in the AUI statement to the NSF dated May 6. Dr. Hagen pointed out that the NSF Panel's budget for the first

year or so was not greatly different from that envisaged under the AUI plan. Dr. Emberson noted that the total AUI figure was large because everything that might be considered for the facility had been worked into the provisional construction plan; for example, four radio telescopes were included: a small (25-50 foot) test and research instrument mounted on the laboratory roof, and three large reflectors of 140-, 250-, and 600-foot apertures. It was further noted that AUI had prepared and submitted the overall estimates in response to requests from the NSF. These preliminary estimates were in advance of necessary detailed studies and at no time should be considered as the final AUI budget estimates. Dr. Bok noted also that the NSF Panel was thinking in terms of a much smaller staff and overall operation than the AUI statement had indicated. The Committee then undertook an examination of what might be done within the limitations of the budget suggested by the NSF Panel.

9. The NSF Panel Budget. Discussion revealed that there was not a clear understanding of the content of the Panel budget. The consensus was that a total of \$300,000, perhaps apart from general funds for the support of radio astronomy, had been earmarked for FY 57-60 feasibility studies and the development of engineering and detailed construction drawing for a large (600-foot) telescope. For the period of FY 1957-1960, a total of \$3.3 million was suggested, to cover operations of the National Facility for four years as well as all construction and other necessary developments in connection with the 140-foot precision reflector. It was noted that an additional \$1.2 million was tentatively earmarked, perhaps to include some part of the aforementioned \$300,000 for studies of very large telescopes, and to support research in radio astronomy and the construction of equipment at places other than the National Facility. It was recalled that some Panel members had suggested an operating budget of \$75-100,000 per year for the Facility. The Committee discussion indicated that this budget would almost certainly be too small by a factor of two. The following table estimates the staff required for the 140-foot reflector: The first column is the staff suggested during informal discussions after dinner on May 27; column two is the very minimum austerity staff; column three was Dr. Bok's suggestion of minimal salaries, which he emphasized should not be taken as careful estimates.

Provisional Estimates of the Staff Operating Budget for a 140-foot Telescope

<u>Staff Requirements</u>	<u>Minimal Staff</u>	<u>Dr. Bok's Minimal Staff Salaries</u>
5 Astronomers (Including director)	³ Astronomers	\$25,000
5 Electronic experts 3-2 engineers 2-3 technicians	2 Electronic experts	18,000
3 Computers 1 mathematician 2 operators	2-3 Scientific assistants including computers	12,000
2 Engineers 1 mechanical engineer 1 assistant	2 Engineers	10,000
5 Machinists	4 Machinists	18,000
15 Housekeeping Staff Business Manager Secretaries Grounds keepers Power House, water supply, etc.	7 Housekeeping Staff (no business mgr.)	25,000
		\$108,000

In the discussion that followed, Dr. Emberson noted that academic salaries were usually based on a 9 or 10 month period, and as the Facility salaries were for a 12 month basis they should be proportionately larger. During the discussion, it was suggested that \$50,000 be added to Dr. Bok's figure, which would mean \$632,000 for staff salaries for the four year period. The consensus was that total operating expenses, including salaries, for the first four years might be held to an average close to \$200,000 per year. In addition, there will be some visitors. At the start, most of the time initially will be devoted to the final testing and adjustment of the radio telescope. During the next few years, it was estimated that perhaps three visitors with specific research projects would be in residence at the Facility at any one time. This number might be expected to grow in subsequent years. In this connection, it was noted that there had been some concern that AUI would plan a self-contained research laboratory not a truly inter-university cooperative affair; it was evident from the discussion that this was not a widely held view. On the other hand, Dr. Deutsch indicated that the contenders believed their position was borne out by an analysis of data from Brookhaven. Discussion brought out that the statistics could be very misleading; that the actual time of visitors on the Brookhaven site was not a good indication of the amount of participation. Dr. Goldberg suggested that a study of the published papers might give a more reliable indication. It was agreed that the Committee be in a better position to judge for itself after its visit to Brookhaven on July 11-12.

Dr. Hagen mentioned that some of the NSF Board members had shown apparent concern over a continuing commitment by the NSF for such large operating budgets. The Committee agreed that it would be most desirable for the July report to include a statement on outside support.

10. Site Development. The Committee did not attempt to formulate a position with respect to the number and kinds of buildings that would be required at the site for the operation of the 140-foot reflector. It was suggested that any construction should be part of an overall plan sufficiently flexible to provide for future growth and with the possibility constantly in mind that a 500-or 600-foot reflector may be erected at the site at some future time. The Committee members agreed to furnish Dr. Emberson information concerning the larger optical observatories for possible guidance in drafting a site development program for the 140-foot reflector: Dr. Deutsch concerning the Mt. Wilson and Palomar Observatories; Dr. Goldberg concerning the Michigan Observatories; Dr. Emberson was to write to Dr. Meinel for data of Yerkes and MacDonald Observatories.

11. Future Emphasis in the Study. Drs. Bok and Hagen reported that the NSF Panel had formally recommended to the NSF Board that the remainder of the study effort be devoted primarily to the bid proposals for a 140-foot telescope and to feasibility studies on larger sizes. Present undertakings would appear to be in harmony with this recommendation.
12. Site Survey. Dr. Emberson described briefly the status of the site survey. The Committee examined some of the available maps and noted that some site possibilities offered very favorable cultural environments while others were extremely isolated. All agreed that first priority in the site selection should be the observing quality (i.e. very low radio noise level); we should not compromise in the selection of a site and thus avoid the erection of a large radio telescope at a site, the selection of which might be regretted at a later date. We should, in other words, profit by past mistakes made by our official colleagues. The site selection panel is to meet in Washington on June 10, at which time it is hoped that the present list of 19 site possibilities may be placed in some priority order for more intensive studies. It was the opinion of some that noise surveys could be conducted without raising the interest of local inhabitants; on the other hand, access to the various properties would be needed for geological surveys.
13. National Electronics Convention. The Committee was advised of a proposed symposium on radio astronomy to be held at the National Electronics Convention in Chicago, October 3-5. The members individually expressed no interest in participating in the proposed symposium. (Dr. Kraus advised, by telephone, that he had been approached directly on organizing the symposium, and he had taken a similar position.)
14. Proposal for Continued Studies. The study under the present grant will have run its course in the fall of 1955. In view of discussions earlier in the meeting, a general basis for a proposal for continuing the feasibility study is available, i.e. to proceed at a rate of at least \$100,000 per year on the large reflector design. The Committee members suggested that they would assist individually on this as on other matters and that a draft might be ready for discussing at the July meeting.
15. Plans for the July Meeting. Dr. Emberson outlined tentative plans for the Monday-Tuesday, July 11-12, meeting at Brookhaven. It was agreed that the first day should be devoted to inspections and discussion of Brookhaven activities, particularly those bearing on the organization and operation of the radio astronomy facility. The second day should be devoted solely to the various items of business before the Committee.

It was suggested that the Committee members plan to arrive at Brookhaven by noon on Monday, July 11. Detailed instructions on routes, for those who will drive in their own automobiles, and schedules of Long Island trains and other connections will be mailed separately. The Laboratory is about 75 miles east of New York and a minimum of two hours should be allowed for a trip from the city to the Laboratory.

After lunch, the group will visit several of the Brookhaven facilities - e.g. the reactor, the cosmotron, and the radiation field; at the meteorological laboratory there will be an opportunity for a report on wind studies that is relevant to radio astronomy telescope problems; there will be discussions by Dr. Haworth and other members of the administrative staff on the various arrangements that are made for the convenience of scientists coming to the Laboratory to undertake research. These discussions will continue informally through dinner and the evening. On Tuesday, July 12, the entire day will be devoted to radio astronomy matters until departure time in the afternoon.

15. The meeting adjourned at 2:30 p.m.

Appendix 4A
to the
Minutes of the May 28, 1955 Meeting
of the
Steering Committee

13 May 1955

To All Users of Frequency Bands for Radio Astronomy

The National Science Foundation Advisory Panel on Radio Astronomy has delegated me, as one of their members, to correlate request for frequency bands for use in radio astronomy and to follow through with any action needed before the bodies authorized to advise upon or to allocate frequencies.

At the recent spring meetings of URSI Commission V, Radio Astronomy, the matter of desired frequency allocation for radio astronomy use was discussed. Preliminary discussions have been had with the Interdepartmental Radio Advisory Committee and with individuals in the Federal Communications Commission which has advised them of the importance of radio astronomy and of the necessity of obtaining cleared channels for radio astronomy use. They were advised of the total effort in the country and the frequencies being used as of the fall of 1954.

You have by now received a form from either the Federal Communications Commission or from the Interdepartmental Radio Advisory Committee asking certain questions concerning your use of frequencies and a statement as to the importance of your work. I am now requesting that you consider the recommendations of Commission V, URSI, given below and make your requests for frequencies compatible with these recommendations. The scheme is based on the necessity of protecting the fixed frequency band around the hydrogen line. Other bands asked for should then be harmonics or subharmonics of 1420.5 mcs. This gives double protection and adequate coverage over the spectrum. Obviously if all requests are originally confined to the same frequency bands success in obtaining protection will be more certain. Any comments or improvements in the plan would be appreciated.

I would request that each addressee fill out the enclosed table as it pertains to his institution. If it is possible for you to move one or two steps up or down in frequency, if that should prove desirable in order to keep the number of requested bands at a minimum, a statement to that effect would also be appreciated.

It was considered feasible to carry the subharmonic scheme only as far as 80 mc, consequently the four frequencies used by DTM are outside the scheme. I would appreciate from DTM a separate statement concerning their use of these frequencies, their ability to change to near by channels if this is indicated and a justification for their use of these frequencies.

13 May 1955

I would appreciate receiving replies within a week. They will be put together in one table and sent on to the Interdepartmental Radio Advisory Committee and the Federal Communications Commission. Each user should also reply directly to the form letter he has received from either I.R.A.C. or F.C.C.

Sincerely,

John P. Hagen

JPH/lmc

	Frequency	Band Width	Area of Protection
	12 Mc	0.04 Mc	Country wide
	15	0.04	" "
	22.7	0.2	" "
	38	1.0	" "
	82	± 1 Mc (2.0)	" "
	109	± 1 (2.0)	" "
	163	± 1 (2.0)	" "
	202	± 2 (4.0)	" "
	236	± 2 (4.0)	" "
	283	± 2 (4.0)	" "
Deuterium Line	325 - 330		" "
	353	± 2 (4.0)	" "
	472	± 2 (4.0)	" "
	709	± 2 (4.0)	" "
Hydrogen Line	1400 - 1427		" "
O H Line	(1668)	(5.0)	" "
	2840	± 5 (10.0)	200 mile radius
	4260	± 5 (10.0)	" " "
	5680	± 7.5 (15.0)	" " "
	8520	± 15 (30.0)	" " "
	17040	± 25 (50.0)	" " "
	34080	± 50 (100)	" " "