NLSRT Memo No. 1

National Radio Astronomy Observatory
Charlottesville, Virginia

February 2, 1988

To: Scientific and Engineering Staff

From: K. Kellermann KIK

Subject: New Large Steerable Radio Telescope (NLSRT)

During the past year there has been considerable enthusiasm from some NRAO staff members as well as several outside scientists about the possibility of building a new large steerable radio telescope. I have agreed to investigate the possible characteristics of a modern large steerable filled aperture antenna, and prepare a report for the Director discussing the options that might be available to us.

Among the topics which need to be addressed are:

1. Scientific Justification: Is there a need for a new instrument? What are the major scientific problems which will be addressed? In what way will a new instrument be an improvement on existing facilities? Some of the major scientific uses which have been discussed are:

   a. Ground support for space VLBI, other VLBI;
   b. Pulsars and other variable sources;
   c. Atomic and molecular spectroscopy, particularly large scale features and highly redshifted lines;
   d. Microwave background studies;
   e. Other large scale phenomenon such as the distribution of galactic HI and HII;
   f. Extragalactic HI;
   g. Extragalactic source surveys and other studies;
   h. SETI;
   i. Provision of low spatial frequencies for synthesis observations;
   j. Planetary Radar.

2. What is the optimum size, cost, and wavelength limit? Clearly there is no simple answer to this; different people will have different emphases. Do we want a (more expensive) general purpose instrument that will, in line with NRAO tradition, do everything for everyone? Or, as some have argued, do we want to build a (cheaper) more specialized instrument that might be more likely to be funded? The type of instrument we will want to consider will probably be in the range of 30 to 130 meters with wavelength limits of 1 mm to 6 cm. So far most of the interest has been expressed in 70 to 100 m class dish working to 3 or 7 mm wavelength. How important is it to reach CO at 2.6 mm?

3. What novel design features might significantly enhance the performance and/or reduce the construction or operation costs? Some items which have been discussed are:

a. Off-axis designs;
b. Very low sidelobe level to reduce interference from space born transmitters;
c. Spherical primary;
d. Three mirror system;
e. Limited sky coverage;
f. "Permanent" installation of most frequently used receivers and feeds;
g. Focal Plane Arrays for multi-beaming and the correction of surface errors;
h. Remote observing and unattended operation;
i. Active Surface.

4. What is the optimum location? This will depend to an extent on the answers to question (2). Emphasis on the shorter wavelengths might favor a high dry site, but otherwise the existing infra-structure, technical staff, and favorable RFI environment appear to make Green Bank a very attractive location.

5. <u>Funding</u>: We are probably talking of a price tag in the range of 50 to 100 million dollars for a major general purpose instrument; probably much less for a no frills long wavelength antenna. Krupp has estimated that it would cost 80 MDM ($50M) to replace the German 100 m telescope today, in Europe. NRAO is committed to completing the VLBA and to the Millimeter Array as the next NSF funded major project for NRAO. If we want a new large filled aperture telescope in this century, alternative sources of funding need to be investigated? What are they? Is there any support for an international project?

It is likely that any new telescope would probably replace the 140 and/or 300 foot (depending on size and wavelength limit). Thus, there might truly be no new operating costs involved, and we need to find only one-time construction costs. This is perhaps the only bright light in an otherwise apparently bleak funding picture.

6. What do we call it? The VLBA went without a name for years, and we were asked by the NSF to change the name twice during the final preparation of the proposal. I am tentatively using NLSRT because that is so bad that there is no danger that it will, by default, become the final name (as did happen with the VLBA!).

It is not my intention to begin a long drawn-out (e.g., never ending) design study, but rather to establish by the end of this year, or earlier, a conceptual design that can, if appropriate, be used to seek funding. Nor do I plan to organize extensive meetings or workshops, although I do anticipate two or three teleconferences over the course of the year to help organize our thoughts. Most of the work can be, and some already has been done by interested individuals. In order to keep those of us who are working on the study informed, I am reluctantly giving in to the NRAO tradition of starting a memo series. Those of you who wish to receive copies of the NLSRT Memo series should contact S. Mason (804 296-0224). Contributions to the memo series should be sent initially to me. Material which may be suitable for a draft report will be most conveniently received in machine readable form, preferably a Word Perfect floppy, or by E Mail to KKELLERM at NRAO.

At this time I would especially like to hear your initial reactions on the need for a modern large steerable dish at NRAO which may replace the aging 140-foot and/or 300-foot antennas. Specifically we need brief descriptions of the scientific need in various areas. In particular, how will the new instrument impact the scientific problems described in Section 1 (or other problems)? What are the alternative solutions? Can existing facilities satisfy, or be modified to satisfy our requirements? Would such an instrument do anything new? Is it necessary for it to do anything new? Anything being done now on the 140-foot, the 300-foot, Haystack, and the Bonn 100 m would be done much better with a modern well supported 100 m dish.

As many of us are aware, NRAO has developed, over the years, several concepts for antennas of various sizes and wavelength limits. Regrettably, none of these were ever built, but they do form a source of material that will be valuable in evaluating our present requirements and capabilities. The following reports, which may be found in the NRAO libraries, may be of interest:

J. W. Findlay, Design Studies of Radio Telescopes, February, 1965.
J. W. Findlay, et al., Progress Report on the Design of the Largest Feasible Steerable Radio Telescope (LFST), January 1966.
A 300 Foot High Precision Radio Telescope, May 1969.
J. W. Findlay and S. von Hoerner, A 65 Meter Radio Telescope, April 1972.
A 25 Meter Radio Telescope for Millimeter Wavelengths, September 1975.
A 25 Meter Radio Telescope for Millimeter Wavelengths II, July 1977.
A 25 Meter Radio Telescope for Millimeter Wavelengths III, February 1982.

Also of interest is the CAMROC proposal for a "Large Radio-Radar Telescope," (1967, 1968) and a Caltech-Berkeley-Michigan proposal for a 300 foot radio telescope. Lovell (The Jodrell Bank Telescopes, Oxford Univ. Press, 1985) gives an interesting account of their unsuccessful attempts to build the MK IV (1000 foot), MK V (400 foot) and MK VA (375 foot) antennas.

Further background and discussions of the need for a large fully steerable radio telescope is given in the Whitford (1964), Greenstein (1972), and Field (1983) Reports of the National Academy of Science, as well as the two reports of the Dicke Committee (1967, 1969). All of these studies concluded that there is a convincing need for a large fully steerable radio telescope working down to short centimeter wavelengths, but as far as I have been able to determine there have been no proposals to build such an instrument since the mid-1960's.