Green Bank Telescope

Project Summary

February 20, 1989

Following the collapse of the 300-Foot Telescope on November 15, 1988, the Observatory staff and user community worked to define the scientific requirements and technical specifications of a replacement telescope. It is clear that there is a compelling scientific case for a fully steerable, high performance, large aperture radio telescope and that new technology makes it possible to build such a telescope, superior to any existing fully steerable antenna, at reasonable cost. The estimated budget for the entire project is 75 M$ (1989). The telescope will begin operations in late 1994/early 1995.

Science

The scientific program for the telescope and the implied technical requirements were discussed in a workshop held in Green Bank, December 2–3, 1988, and subsequently refined by the Observatory staff (*A Radio Telescope for the Twenty-First Century — Scientific Considerations for the Design of a Replacement for the 300-Foot Radio Telescope*). The telescope will make major contributions to the study of the structure of the universe, the gaseous content of galaxies, solar/stellar phenomena, molecular clouds and star formation, evolution of galaxies, the solar system, the nature of radio galaxies and quasars, fundamental catalogs, as well as applications to space VLBI. Despite the diversity of scientific needs, a telescope design has been specified which offers major advances over existing instruments to every relevant area of research.

At longer wavelengths the new telescope will have more effective collecting area compared with the 300-Foot Telescope, as well as full steerability and access to the galactic center. At shorter wavelengths the sensitivity of the new telescope will exceed by a substantial margin that of any other fully steerable telescope in the world, including the MPIfR 100-meter telescope in Effelsberg, Germany. At wavelengths of a few millimeters the telescope could exceed the performance of the Nobeyama Observatory 45-Meter Telescope if dynamic control of the panel setting can be achieved.

Technical Specifications

The technical issues and tradeoffs in the design of the new telescope were studied by a group of NRAO engineers and scientists (*A Study of Technical Issues and Tradeoffs in the Design of the New Green Bank Telescope*). Their major finding is that the cost of the telescope is only weakly dependent on the high-frequency operational limit. Refinements in panel manufacturing techniques allow for the routine assembly of panels with r.m.s. surface accuracy of about 70 micrometers, so that the performance of the new telescope at short wavelengths is dependent on the setting of the panels and compensation for gravitational, thermal, and wind deformations of the support structure. By supporting the panels on motorized adjusters and controlling the settings according to a pre-determined lookup table, the gravitational deflections can be cancelled so that the surface r.m.s. is $\lambda/16$ at $\lambda = 7$ mm or better. Further refinement of the lookup table and the addition of compensation for thermally induced deformations will eventually allow efficient operation at shorter wavelengths, perhaps to 2.6 mm.

Their report also discusses pointing considerations and methods for reducing aperture blockage. All of the options provide improvements on existing telescopes and increased protection from interfering signals—natural and man-made. The best-performance option, a totally unblocked aperture, requires detailed structural analysis to evaluate its feasibility. An unblocked design costs more for a given diameter than a conventional axisymmetric design. A decision to build an unblocked design for the cost estimate given below would imply a telescope of less than 100-m but more than 70-m diameter.

Site Considerations

Green Bank, West Virginia, is the obvious choice of site for the new telescope. A substantial infrastructure already exists in Green Bank, together with a skilled staff that has many years of experience on single dish radio astronomy. The fact that Green Bank is in the National Radio Quiet Zone and enjoys protection from certain forms of radio interference is a major consideration. The NRQZ, plus minimization of blockage in the new telescope, will make this facility the most powerful in the world for projects sensitive to interference. For VLBI applications the east coast location complements the large collecting area available with the VLA and the 100-m Effelsberg antennas. Finally, the site is acceptable for observing at several millimeters wavelength. Analysis of radiosonde data (F. R. Schwab, "Analysis of radiosonde data from Huntington WV, Pittsburgh PA, and Albany NY", NLSRT Memorandum No. 52, NRAO) shows Green Bank to be equivalent to the FCRAO site, in Massachusetts, where there are years of experience in millimeter wavelength observing.

Estimated Cost (M$ — 1989)

Preliminary design	0.5
Design contract	2.7
Construction contract	53.1
Project management	1.9
Instrumentation	4.3
Subtotal	62.5
Contingency (20%)	12.5
Total	75.0

Estimated Cost (M$ — 1989), by Year

	1989	1990	1991	1992	1993	1994
Preliminary design	0.5					
Design contract	2.7					
Construction			20.0	13.0	13.0	7.1
Project management	0.1	0.4	0.4	0.4	0.4	0.2
Instrumentation		1.0	1.0	1.0	1.0	0.3
Subtotal	3.3	1.4	21.4	14.4	14.4	7.6
Contingency (20%)	0.7	0.3	4.3	2.9	2.9	1.4
Total	4.0	1.7	25.7	17.3	17.3	9.0

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