NLSRT Memo No. 42

Comments on new Green Bank telescope - P. C. Crane

1. One of the design goals of the telescope is to reduce the near-in and far-out sidelobes of the beam pattern of the antenna to reduce the response to interfering signals. An off-axis design offers greater opportunities for reducing the sidelobes than does a standard parabaloid, whether at prime or cassegrain focus; however, much can be down to reduce the sidelobes of a standard parabaloid, based upon lessons learned from the 300', 140', and other radio telescopes.

2. Aside from the advantage the intrinsic advantage of the off-axis parabaloid of having no scattering sidelobes from feed-support legs, some of the other measures for reducing sidelobes include: Reduce number of feed-support legs and reduce scattering sidelobes they produce. Extend surface of parabaloid with ground screen. Enclose off-axis paraboloid in metal enclosure as is Bell Labs millimeter-wavelength telescope (but such an enclosure greatly increases amount of steel and aluminum used without collecting additional photons.)

3. I think the new telescope should replace both the 300' and 140'. The savings in operating costs may help appease the NSF and provide support for the VLBA. A direct replacement for the 140' is unlikely, and I cannot picture the 140'lasting to 2119 A.D. (the end of the nominal lifetime of the new telescope) at which time the 140' would be 55 years old, and its design even older. Many mechanical parts are already difficult to maintain and replace.

4. Whatever the design I do not think the optics should be shaped. An on-axis parabaloid will provide peak aperture efficiencies of 0.55-0.60 for broad-bandwidth feeds, 0.65 for narrow-bandwidth feeds. An off-axis parabaloid provides peak aperture efficiencies factors of 1.10-1.15 greater because of the absence of blockage. Sebastian von Hoerner has shown that shaping the appropriate surfaces in an off-axis antenna can provide a nearly uniform illumination pattern and aperture efficiencies close to one; but such an illumination pattern would have very bad sidelobes. The shaped optics of the VLA and VLBA antennas also have bad sidelobe; the 0 dBi levels are not reached until angular offsets of 40-50 degrees off axis. Shaping the optics would also reduce the size of the focal area. I think that without shaping the optics of an off-axis parabaloid, the additional gain from the absence of blockage will not compensate for the higher construction costs to obtain the same effective area as a standard parabaloid.

5. The new telescope represents an opportunity to develop technologies essential to its best operation that are needed by other NRAO telescopes. The first that comes to mind is the use of electronic levels or other devices to provide the measurements needed to actively correct the antenna pointing for thermal and wind effects. Such techology will be needed to provide the pointing accuracy of 1-2" needed at high frequencies. This technology is also needed for the VLA and VLBA but they lack the resources to develop it.

6. Perhaps the proposal should include the money to provide an optical-fiber connection to nation-wide optical-fiber network. By 1994 the network should be almost ubiquitous except perhaps for some areas like Green Bank. Ken Stetten suggested this to me and will check with AT&T about their closest tie-in and costs of running a connection to Green Bank.

7. I have two comments on George's Appendix D. The first is that III.H.1 and .2 suggest supporting the feed structure with either guy wires or feed legs connected to the edge of the dish. These conflict with one of the advances of the VLBA antenna design - connecting the feed support legs not to the surface backup structure but to the more rigid structure supporting the vertex room. Furthermore, a simple central post supporting the feed would cast a large shadow on the feed, and even if well guyed would still be floppy.

8. The second is that the law of diminishing returns must be important at some point, and will affect the specifications in IV.A. The degradation of an antenna's performance is an exponential process, and my intuition is that attaining the performance specified for 115 GHz is improbable, and even if feasible would cost too much. I think that an upper frequency limit of 50 GHz, with the specifications George gives, is feasible and desirable. Several of the other contributions show that important astronomy can be done in the frequency range 30-50 GHz. 50-70 GHz is a desert because of absorption by atmospheric oxygen. I just do not think that building this telescope to operate at frequencies greater than 50 GHz would be worth either the cost or the lost capabilities at other, lower frequencies.

9. I think the telescope should be designed to allow near simultaneous operations at both the prime and cassegrain foci - e.g., by moving the subreflector to the side, using an opening in the center of the subreflector. The prime focus should be useable at all frequencies; array feeds like the seven-feed 6cm system are most conveniently sized for the prime focus. Use of the cassegrain should be for frequencies of 4-5 GHz and higher, which allows use of a smaller subreflector than if cassegrain operations at lower frequencies are required. Sufficient frequency flexibility at the prime focus may be possible with a system like that at the 100m, with perhaps some kind of turret providing flexibility at the cassegrain focus.

10. The new telescope could be used for solar system studies in many ways, including the following two: As an adjunct to the Deep Space Network for special time-critical missions, as the VLA is being used for Voyager 2's Neptune flyby. Second, as the transmitter of a bi-static radar system at 8 GHz used in conjunction with the VLA (and VLBA?); Goldstone and the VLA have already been used for such experiments; the larger aperture (say 100m vs. 70m) and higher transmitter power now feasible (1 MW vs. 300 kW) would provide >8dB better sensitivity and better time coverage than Goldstone (2 hours east, not 1 hour west, of the VLA).

11. The structure at the prime focus will be massive. If it resembles that of the 100m, the room will be large enough to contain several receivers. The subreflector will be large; I ask whether it should be able to nutate and deform. Perhaps multiple-feed, multiple-receiver systems subtracted digitally (like the seven-feed 6cm system) may eliminate the need for a

nutating subreflector (Rick Fisher might know the feasibility of this idea.) A deformable subreflector may be able to correct for large-scale deformations and allow operations at whatever the high-frequency limit is.