A 1,000 FOOT PRECISION ZENITH ANTENNA FOR RADIO ASTRONOMY

A PROPOSAL, submitted, for consideration, to the National Radio Astronomy Observatory.

November 21, 1957

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Introduction: The scientific capabilities of a truly giant antenna are well known to the radio astronomical community. From the viewpoint of individuals wanting to perform experiments, the availability time scale of a giant antenna in the United States is not impressive. Even granted substantial funds to construct a giant precision steerable antenna, nearly ten years would likely elapse before scientific results were obtained.

It is the purpose of this proposal to call attention to a means of obtaining scientific results with a giant antenna, on a time scale of two or three years, and with the expenditure of a reasonable sum of money.

We propose to eliminate steerability and accept partial sky coverage in return for an immediate opportunity to study part of the universe with the power of a 1,000 foot precision parabola. Specifically, we propose the construction of a 1,000 foot parabolic antenna with a focal length of 500 feet. The main beam of the antenna would be directed toward the zenith. It is imperative that the antenna have a minimum acceptable working wave length of 21 cm, which dictates the surface accuracy of the antenna. Two five-hundred foot towers carry a platform for stabilization and translation of feed systems at the focus. Controlled motions of the feed system permit off-axis scanning of the main beam and limited tracking of sources.

Description of the Zenith Antenna: The vertex of the 1,000 foot antenna will be located approximately at ground level, giving the rim an elevation above ground of 125 feet. Carried by an array of towers, a mosaic of flat panels will compose the antenna surface. Two five-hundred foot towers rising near the central regions of the antenna will support a feed-carriage system at the focus. Stabilization of the feed-carriage platform, to compensate for tower motions, will be accomplished by servo-control. The platform will be referenced to an optical master located at the vertex of the antenna. Both tracking the beam off-axis and stabilization of the beam are accomplished by the optical master.

The antenna surface requires special mention, since we propose a mosaic of flat panels which approximate the desired paraboloid. For the proposed antenna with λ min = 21 cm, panels of an average area of approximately 400 square feet are possible and are a convenient size for fabrication.

We have obtained a cost estimate for a 1,000 foot zenith antenna, based on the above general description, and on material, fabrication and erection quotations from various sources. The proposed form of construction is not necessarily the most suitable for a 1,000 foot zenith antenna. It is a feasible design however, and the estimate serves to indicate the order of magnitude of money needed for an antenna of this size.

Cost Estimates

Towers	$2,652,860
Tower Erection	928,501
Tower Foundations	1,200,000
Feed Towers	150,000
Feed Towers Erection	15,000
Feed Tower Foundation	15,000
Tower Surveys	120,000
Panels	750,000
Panel Erection	100,000
Feed Stabilization Servo-System........	80,000
	$6,011,361

Comparison with other Large Antennas: From the rough cost estimate given above, and the anticipated time scale of construction, the 1000 foot zenith antenna is attractive. However, we wish to compare the zenith antenna to two other giant systems from the viewpoint of scientific programs. Fixing our attention on an aperture of 1000 feet, we consider three systems for which cost estimates exist, viz. a steerable parabola, an array, and the zenith antenna.

Steerable Parabola: From the viewpoint of bandwidth, sky coverage, and tracking, the steerable parabola is, of course, the versatile instrument. However, a steerable parabola of 1000 foot aperture would be extremely costly to design and build. A very long construction time is anticipated.

Zenith Antenna: This system is limited in sky coverage but retains the desirable bandwidth of operation. Cost and time scale of availability are most favorable.

Large Array: A recent report by Van Atta enables an evaluation of the properties of an array. A bandwidth of 25% and about 45° sky coverage is possible, being intermediate in sky coverage between the steerable parabola and the zenith antenna. The array is inferior to both the other systems in bandwidth.

For a given aperture, there are two critical considerations in rating antennas: scientific utility and cost. On this basis, we choose to rate the three proposed 1000 foot antennas in terms of a merit factor:

$$F = \frac{\text{Data Gathering Ability}}{\text{Cost}} = \frac{GfB}{C}$$

where G is the antenna gain (proportional to collecting area), F the fractional sky coverage, and B the bandwidth. The product GfB for a given antenna is a measure of the information inherently available to that antenna. The three types of antennas are compared in the following table. Costs for the steerable parabola and the array are from the Van Atta report.

Antenna	Area (sq.ft.)	f	B	C(millions)	F	T(years)	F/
Zenith	7.85×10^5	0.2	1	$ 6	0.3	3	0.01
Array	"	0.8	0.25	50	0.004	3	0.00
Steerable	"	1	1	200	0.005	10	0.00

Obvious dangers exist when one attempts to "rate" instruments used for basic research. The unpredictable may be expected. Nevertheless, the necessity of a choice forces a rating. We take F, as given in the table above, as a strong argument in favor of the zenith antenna.

We have gone also one step further and attempted to include a rough-time needed for construction, T. The final rating of the three systems is put in the form F/T. Although the quantitative significance of F/T must be regarded cautiously, the zenith antenna emerges worthy of most serious consideration.

Scientific Program: We are deliberately omitting any discussion of scientific justification for a 1000 foot antenna. There are a myriad of interesting and stimulating experiments that could be undertaken. The desire to perform certain specific experiments has motivated the submission of this report.

Urgency: We feel that for a variety of reasons some sort of very large antenna is needed in the United States within the next few years The extreme simplicity of the zenith antenna is an important factor in this regard. The time and money required for design and construct should be, relatively, very small, while the benefits from having in operation within 2 or 3 years a simple antenna of large size should be very great. We hope that action may be taken on this quickly, that it can be pushed vigorously, and that the guiding principals can be simplicity and a short time for completion.