Interoffice

VLB ARRAY MEMO No. 290

National Radio Astronomy Observatory

Socorro, New Mexico

November 3, 1983

To: John Findlay

VLBA Antenna Memo No. 3

From: W. Horne

Subject: VLBA Memo 255 Aug 17, 1983
Setting the VLBA Antennas

I was quite relieved to receive your memo #255 dated Aug. 17, 1983 on setting the surface panels for the VLBA antennas. In developing a design for VLBA antennas and preparing cost and construction estimates the panel installation and adjustment is one portion of the program which has not received very much attention.

On the premise that an exchange of viewpoints will be beneficial I would like to list some of the questions and possible approaches which have occurred to me.

(1) How do we accept the surface from the antenna supplier and to what accuracy do we require the surface to be set at this time? At th e time of completion of the antenna suppliers work (and here I assume that we will require the contractor to install the surface , nels and make the initial alignment) NRAO will not have installed any receiving equipment, control computers, electronic cabling, cryogenic equipment or local data sets. If a similar procedure is followed as we normally follow we will be some eight weeks or so away from being able to make any sort of radiometric measurements. This seems to imply that the acceptance criteria will have to be some form of mechanical measurement.

The accuracy to which the panels will finally have to be set is determined by the observing frequency to be used. While the ultimate objective of the highest frequency may be 86 GHz it is fairly certain that it will be several years after completion and initial operation of the VLBA before 86 GHz operation is attempted. I am not aware of the order in which either the receiver group will want to place frequencies in operation or in which the scientific group will want to use them but would anticipate that among those frequencies most in demand very early in initial operation of the VLBA would be 6 cm(5GHz) 2 cm(15 GHz) and 1.3 cm(22 GHz) because of the experience of those frequencies at the VLA and because of the existence of those frequencies of the VLA. This would indicate that the initial setting accuracy required of the antenna .ontractor should be at least to an RSS of 0.015 inches (0.38 mm).

(2) What setting capabilities can we expect from an antenna contractor?

Perhaps I should ask what setting capabilities could we expect from the contractor without asking them to develop more sophisticated techniques and procure more accurate equipment (at higher price) than the antenna contractor's present best practice?

All of the presently foreseen possible antenna contractors are familiar with and utilize the theodolite and drill tape method of final alignment of panels and are experienced and capable of setting panels to the required 22 GHz RMS accuracy of 0.015 inches (0.381 mm). To the best of my knowledge none of them are experienced at setting an antenna of the size of the proposed 25 meter VLBA antenna to the required 43 GHz RMS accuracy of 0.008 inches (0.200 mm) with the probable exception of ESSCO should they be one of the bidders. This might tend to imply that to require the antenna contractor to align panels to an RMS of 0.008 inches (200μm) would increase considerably their price for the panel setting over the price for 0.015 inches RMS. (380μm)

(3) What mechanical systems are capable of and most convenient (cheaper) to use to accomplish setting to the required accuracies for 22 GHz, 43 GHz and 86 GHz frequencies?

A. For 22 GHz frequency a setting accuracy of RMS 0.015 inches (0.381 mm) is required including residual setting deviation, reading error, distance error and instrument error. This accuracy can be achieved by the theodolite and drill tape method fairly comfortably as shown by our experience on the VLA antennas in which the RMS (as read) was indicated as ranging for the various antennas from 0.008 inches to 0.014 inches with an average for (200-360μm) the 28 antennas of 0.0106 inches. This method is (270μm) convenient for th panel installer, quite economical in time consumed and generally consisted of a 3 cycle operation; (1) the first cycle being the installation of the panels with all alignment controlled by the theodolite reading the radial edge for radial alignment, measurement to the inside edge of the first intersel panels and then a plug gauge to set distance and an angle reading to the circumferential edges to set elevation; (2) The arc drill tape to drill the target holes (tape is controlled radially by theodolite) installation of targets and one cycle of reading and adjustment; (3) A final theodolite reading of all targets. Efficiency measurements confirm that this method was able to set panels to the desired accuracy.

B. For 43 GHZ frequency a panel setting accuracy of 0.008 inches (0.200 mm) RMS would be required. While some of

the readings achieved on the VLA antennas would indicate the possibility of using the tape and theodolite method for this accuracy I would consider it marginal because of instrument and operator error and had given thought to the use of the pentaprism system considered for the 65 meter millimeter wave antenna. It will be recalled that the report on the 65 meter predicted a setting accuracy of 0.005 inches (0.125 mm) RMS for the 65 meter diameter surface. With the 25 meter diameter VLBA antenna instead of the 65 meter it would appear that the required accuracy for 43 GHz could quite easily be achieved by the pentaprism method. An added advantage of the pentaprism method is that its similarity to the theodolite and drill tape method might make it possible to persuade the antenna contractor to use this system in the last stage of alignment procedure with NRAO providing the pentaprisms, rotary table and alignment telescope to the antenna contractor. As an alternate NRAO itself could make the final setting using this method after acceptance of the antenna from the contractor.

C. For the 86 GHz frequency more consideration are involved than the preceding 2 highest frequencies and more alternatives are possible. Some of these considerations are:

1. It appears that possible 86 GHz operation would occur (if at all) some 2 or 3 years after the array is initially in full operation.

2. The manufacturing accuracy of the panels to be initially installed has not been established. Chapter III - The Antenna Elements projected a panel manufacturing accuracy of 0.008 inches (200μm) and the cost estimate for the panels ($31.40/ft^2) and antennas was based on this. As pointed out in that chapter the desirable manufacturing accuracy for panels for 86 GHz would be 0.003inches and panel costs were (76μm) estimated at approx. $162.00/ft^2 which would have placed antenna costs beyond a present budget. For this reason any 86 GHz operation would have required an additional capital budget project of some later date. Since the time of that report the <u>possibility</u> of securing 0.005 inches RMS for the initial (125μm) installation led to Memo No. 285 which projects <u>limited</u> 86 GHz operation without resurfacing.

3. <u>If</u> it turns out to be possible to get panels manufactured to 0.005 inches accuracy within (125μm)

the budget for the antennas we would probably prefer to set the panels initially (probably a combination of contractor setting and NRAO touch-up) to an accuracy useable at 86 GHz.

Possible options for procedure are:

I. Antenna contractor sets panels initially to RMS accuracy of 0.015 inches (380μm) (suitable for 22 GHz) using theodolite and drill tape method. NRAO shortly thereafter, using the pentaprism system, would adjust the panels to an RMS accuracy of 0.005 inches. The (125μm) holographic system could be used at a later date to achieve any necessary verification and touch-up.

II. Antenna contractor using first the theodolite and tape method rough sets panels, then fine sets panels to 0.008 (200μm) inch RMS using the pentaprism method. When 86 GHz operation becomes imminent NRAO makes final alignment using holographic method.

III. Antenna contractor using the theodolite and tape method sets panels to RMS accuracy of 0.0015 inches. NRAO using (38μm) the template method fine sets panels to 0.005 inch RMS. The holographic method (125μm) is used for verification of results and if necessary fine tuning.

It is quite probable that some of the above may not be logical considerations or approaches. We have not considered for a number of years the pentaprism method because of the initial cost but with ten antennas the initial cost may be offset by ease of handling and speed of setting as compared to some other method.

WH/bmg