Interoffice

National Radio Astronomy Observatory

Charlottesville, Virginia

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To: H. Hvatum, John Payne, W. Horne, Mark Gordon

From: John. W. Findlay

Subject: The 11-meter Telescope

1. Payne, Ralston and I have just completed the first draft of our report on the 36-foot stability measurements. This seems to confirm our long suspected fears - that the telescope behaves badly when exposed to different, though fairly stable, ambient temperatures. Hein tells me that he intends to ask a small group to consider seriously what course NRAO should follow. There are many choices open to us; in this memorandum I propose to outline the steps in one of our many choices. Please read this brief paper as an attempt at a 'gedanken' experiment. It is not meant to be definitive, but it is a good exercise to work through a full plan, even though it almost certainly will be not the one followed. I will try to set it out as a sort of flow chart, showing the choices we may have to make.

2. May we accept as a fact that our long experience of the 36-foot, combined with the surface measurements made in 1974 and 1975, combined with the recent Findlay, Payne & Ralston (FPR) results show that the telescope is essentially unusable at 1.2 mms wavelength ? The first question to be answered is whether any substantial part of this bad behaviour can be attributed to those parts of the structure below the elevation axis. We should look at this in a simple way at once. I suggest that a good tilt sensor (A TALYVEL or my Schaevitz sensor) be mounted to record tilts of the telescope at the level of the elevation bearings. Whenever the telescope is stationary, the tilt shoud be read, along with the azimuth reading and a few representative temperatures. This can be interposed during observations, and in a week or two we should know whether there are any unpleasant glitches here which are temperature-related. This is so simple it may already have been done. If so I should like to be reminded of the results.

3. This is a branch-point in our flow chart. If we feel there are no major problems due to temperature, I wish to clear a further point. What is the sort of maximum dead-weight load the present tower and azimuth bearing can support? The need for this comes later, but I shall assume that our engineers know the answer and can easily confirm whether my proposed load changes can be followed.

4. At this point I propose to replace the entire structure from the elevation axis upward with a new dish surface, support structure and feed legs. Before describing this structure I must look at the main branch points which arise when I consider the nature of the telescope reflector surface. There are several possible choices here and I propose to discuss only four of them.

(a) Machined cast Al plates A tried and effective surface. Will be slow to make, and expensive. Either or both of these facts may hold (or even prevent) our improving the telescope. Thus we must look at alternatives.

(b) ESSCO plates ESSCO have made plates for 45-foot mm-wave telescopes, with an F/D ratio of about 0.4. Such plates on a 36-foot telescope would yield an F/D of 0.5. This would be entirely acceptable. I shall not discuss in detail the fact that we are fairly sure that ESSCO would (or might) have difficulty in reaching 60 microns RMS in their plates. I shall note that we have at Green Bank a machine which can quickly and easily measure such plates to about 10 microns. Even if we have to accept a 60 micron figure to our error budget, we should remember that other contributions can be reduced below our 25-meter budget figures. So I believe we must (quickly) look at ESSCO as a possible surface plate supplier.

(c) Use 25-meter plates This is "far-out", but at this stage we should give it a thought. We accept a change in the 25-meter design to an F/D of about 0.4 from its present 0.42. The inner 36 feet of the 25-meter now has F/D = 0.94. Could we live with something near this ? If so we build the new 36-foot and put on it the plates as in (a) which subsequently we use on the 25-meter. This is just the sort of scheme Bill Howard might like. We start building and testing the most vital part of the 25-meter and, if it never gets built, nothing is wasted. Indeed, if inflation goes on, we save money.

(d) A Leighton dish I need not discuss this. But it is urgent that the question be put to rest by a firm choice. Can someone do this ?

5. It must be clear that I consider the choice of the surface to be an important branch-point in our plans. Without discussion, I am going to choose 4(b) above. But this choice must be given serious thought and work. I only make my choice so that I can continue to describe my 'gedanken' experiment.

6. The next step is easier. We design an 11-meter telescope from the elevation axes up, with the F/D determined by our choice in paragraph 4 above. We have had more than one such design over the years. It may be noted here that I have passed over a possible branch-point; that we might buy from ESSCO a reflector support structure at the 36-foot size to carry their surface plates. I do not believe this possibility, rather than mine, represents a very serious choice. I shall not discuss it further; the working group will surely want to. Since I have control of my telescope design, I shall ask for the following points to be considered-

(a) We should watch carefully how to reduce possible thermal effects. Would it be better to use steel rather than Al ?. Re-read S. von H on thermal time constants. Can we have equal and small time constants over the back-up structure and the feed legs. Study again the Bonn 30-meter thermal work. Can we keep the option of enclosing the back-up structure so that active air could be used if needed for the structure and the feed legs ?

(b) The structure should be quasi-homologous. This does not mean it must be like the 25-meter, only that its contributions to the RMS should be below about 20 microns. Make it stiff enough to support light plates, such as ESSCO, or the heavier cast Al plates. (I am not going back on my choice, but I think I can have this option for nothing)

(c) I do not define what loads the feed legs must hold. But this must be chosen. Is it still a Stirling mount ?

(d) Can I have a design where I can set up the whole reflector support on mock-up elevation bearings, test it, even mount the surface on it ? Then I wish to take it into 4 pieces, transport it and re-erect it with good accuracy. Leighton does this, so I suppose we can.

(e) I need the design to be complete, so that no details of joints, for example, need to be worked out.

All these points seem to me to be easy, and well within the skills we have in NRAO. I return to man-power later, but it must be clear that I imagine this design work being done within NRAO. I hope we shall follow our normal course of having designs checked independantly; again I believe we can do this ourselves.

7. I am now ready to buy and build the reflector. For the back-up structure I can either go to a small steel fabricator or use the Green Bank shop. I do not know the total steel weight yet, but guess at 15 - 20 tonnes. Whichever way I go, I have the complete structure erected at Green Bank, mounted in the zenith position on mock-up elevation bearings. Before going further I carry out simple zenith-deflexion tests to confirm the correctness of the engineer's analysis. The surface plates are delivered from ESSCO to Green Bank and re-measured on the existing measuring machine. If they fail to meet specifications we have three options:-

(a) Return them to ESSCO to be reworked at no cost

(b) Insist on a new plate from ESSCO

(c) Pay a reduced cost to ESSCO and rework the plates ourselves.

As the plates are approved we mount and set them. We have all the instrumentation and skill to do this. As we do so, we check on the thermal behaviour of the whole reflector. When all is well, we ship the reflector to the telescope. I leave open for the present whether to demount the plates for shipment or not.

8. When the reflector arrives at the mountain, it is re-assembled and lifted into position on the telescope. The final plate alignment is repeated. I need not deal with these final stages at present, since they will be essentially independant of any plan we follow.

9. I should like to see a plan such as I have outlined looked at from the important aspects of time, manpower and money. It might almost be worth putting the major items into a simple PERT chart. This could also show the points at which money is needed, and its amount. But at this point let me leave the idea that this is just a thought-experiment, and in a final paragraph discuss briefly why I believe some such plan, where we essentially do the work ourselves, must be given very careful thought.

10. I wish to refer briefly to the manpower and time used almost 20 years ago to build the 300-foot telescope. We cannot expect costs to be comparable, but surely we can expect manpower and time requirements not to have grown. (Except of course in places where administrative decisions are needed; but here a do-it-yourself plan does permit a lot to be achieved without the detailed approvals large projects need) That telescope was built when Green Bank was small. Our two engineers, Smith and Ralston contributed much. Bob Hall and five others worked for six weeks in his house and made a design from nothing. Faelten then worked about 3/4 time for 18 months as engineer. Bristol did all the steel fabrication and erection. Spencer Greenwood reviewed all the machinery design and made it work. Fred Crews cabled the telescope and with Frank Drake and others put it on the air. After Smith and Ralston had surveyed the steel the somewhat heavy but twist-dancing student from Fred Hoyle computed the lengths of every surface mounting stud. And she got them all right. We were going to put the surface on ourselves, but because the Union was at the 140-foot they forced me to use Bristol to put on the surface. And from the point of just an idea to the first drift curve at 1400 MHz. was 23 months. I hope that is sufficient comment to say that this present task should not take <u>too</u> long.

Just a word on manpower. I suggest that this task deserves a high priority in its needs for manpower. It should for some time have all the 25-meter effort without question. Except at the VLA it should have strong support if it requests assistance from staff members. Some of our Scientific Staff might be willing to help for short times in such a project. It must be evident that I should be glad to work for it. It must also be remembered that it can often be cheaper and better to buy for brief periods the help that is needed, rather than to contract out an entire task. Two possible cases as examples. The detailing of the joints in our design must be done well, and should be reviewed with care by our designer. I believe we have the skills in NRAO to do this, but if in doubt let us supplement them. Similarly, I believe we have the skills in Green Bank to fabricate the reflector support. (See, for example the recently completed travelling feed for the 300-foot) But if we need extra manpower, why not try hiring it temporarily ?

Again, however, if we do consider the kind of attack described here, it is easy to spell out the actual manpower needed and to see that we have it within the NRAO and are willing to make it available.