The Surface of the 12-m Telescope

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1. Introduction

This memorandum is intended to summarize our present plans for procuring, measuring and setting the telescope surface. It is, naturally, an interim plan. It assumes that we shall procure a surface of suitable shape and accuracy, build a back-up (BU) structure to support this surface, pre-assemble, set and test the surface and BU and finally erect it all on the elevation bearings of the Kitt Peak telescope. It will then be re-aligned and tested.

2. Reflector surface choice

The whole spectrum of possible ways of making mm-wave surface plates was reviewed by me in the survey paper given in Grenoble and published as a 25-meter telescope report No. 8 with the title: "Surface Panels and Measurements".

It might be of value here, however, to list the ways which are being adopted throughout the world for other telescopes.

(a) The MPI/IRAM 30-meter telescope

Panels are made of a 40 mm thick Aℓ honeycomb core with 4 mm Aℓ surface plates. They are formed on a mold. The expected manufactured RMS is not known for sure. Nor do I know yet the chosen contractor. The telescope is expected to work at 1.2 mm, so the RMS of the panels should be ~50 μ.

(b) The French/IRAM 15-meter telescopes

As might be expected, the present French plan is original (and in my opinion impractical). The surface will be small hexagons of Aℓ honeycomb, each mounted like a flower/mushroom on a single central stalk. I comment no further!

(c) The UK 15-meter telescope

This will use a formed Aℓ honeycomb - with a fairly clever forming process. They aim for an RMS of the manufactured panel of 20-30 μ. No company has yet been selected, to my knowledge, though the project is funded.

(d) The Japanese 45-m and 10-m telescopes

The Japanese are well-ahead in this project, but are quite modestly only working towards a 3.5 mm performance for the 45-meter telescope (RMS = 200 μ). They plan panels, however, of manufactured accuracy of 60 μ and include 160 μ as contingency in their error budget.

The 10-m telescope panels of Aℓ skin have been built to a 50 μ RMS. Some achieved 25 μ.

The 45-m will use carbon fiber reinforced panels. They have made panels to an RMS of 57 microns. The chosen contractor is unknown to me.

(e) The cast Aℓ machined panels

These are our choice for the 25-meter telescope. They are expensive and slow to manufacture. We hope for a manufacturing accuracy of 40 μ or better.

(f) The ESSCO surface

This surface is well-known to us. It is essentially a formed-Aℓ skin connected by epoxy to a transverse rib support structure. The following seem to me to be our reasons for preparing this surface for the 12-m. I will state the reasons without elaborate justification.

(i) It is clear from my survey of foreign telescopes that we should not look outside the US for a surface.

(ii) Within the US we believe from our considerable work over many years that the cast-machined panels are the ideal solution for the 25-meter. But they are expensive and slow.

(iii) ESSCO is the only commercial company in the world making and selling mm-wave telescopes. Some have, I believe, been sold for defense tasks, but for RA I list:

Our 45-foot, bought 10 years ago. Not for mm-waves, but is OK.

Four 45-foot telescopes in radomes in Brazil, Finland, Amherst and Spain.

One 20-m telescope in a radome at Onsala Space Observatory.

(iv) We believe that ESSCO could supply us with a surface which could meet our accuracy requirements. We are not completely certain of this. We plan to explore with ESSCO their measurement techniques, data reduction, etc., so that when we accept an RMS figure from ESSCO we know what it means. We note that ESSCO has its own 3-D measuring machine of good accuracy.

(v) We suggest that we accept the ESSCO surface panels at their plant, as measured on their machine with the agreed measurement plan and the operations monitored by us.

(vi) We will ship the panels to Green Bank and pre-assemble the whole BU and panels. We shall set the panels to ensure we can achieve the overall telescope accuracy and to validate our system.

3. Measuring and setting the surface

Let us note at once that no ESSCO surface has yet been set on a telescope to give an overall RSS error budget of 70 microns. So why do we think it is possible for NRAO to do it? In order, I suggest these reasons:

(a) See 2(f)(iv) above. We believe that ESSCO has improved on its tooling, methods and measurement over recent years. If we can buy from them we shall be in parallel with the surface manufacture for a 45-foot Lincoln Lab radar of high performance.

(b) We plan to pre-assemble the BU and first set the surface on the ground in a large building in Green Bank. We shall probably use more than one method of measuring (see later). If difficulties arise, we have all the facilities and expertise of Green Bank and are not under extreme time pressure.

(c) NRAO is expert in mm-wave surface measuring. Over the past eight years we have:

(i) Invented and tested the modulated laser distance measurer--now adopted by MPI and to be developed in Switzerland by Kern. (Payne, Rev. Sci. Inst. 44, 304, 1973).

(ii) Invented and tested two novel methods of measuring surfaces--The "cart" and "stepping" methods.

(iii) Used the cart to measure (3 times) the 36-foot. (Payne et al. Rev. Sci. Inst. 47, 50, 1976).

(iv) Used the cart on the U. British Columbia reflector to demonstrate its value.

(v) Used the stepping method to measure twice more than 2000 surface points on the 140-foot telescope. (Findlay and Ralston, Eng. Div. Memos Nos. 127 and 129, 1979).

(vi) Used the stepping method on the Algonquin telescope to demonstrate its value.

(vii) Used edge methods to measure the stability of the Onsala 20-m telescope (Elldér, Findlay and Hansson, 25-m Report No. 9, 1981).

(viii) Used edge and stepping methods to show the 36-foot instability (Findlay, Payne and Ralston 12-m Memo No.11, 1981).

(ix) Designed, built and tested a 25-m plate measuring machine. (This work is not yet complete--see various reports by W.-Y Wong).

(d) With this record, it can be fairly concluded that NRAO has a skilled and experienced team for the task of setting the 12-m telescope.

4. The measuring methods

(a) The gravity referenced system

We shall establish an (x, y, z) coordinate system with z measured upward with respect to local gravity. The origin 0 (see Figure) is a fixed, well-defined reproducible point near the surface vertex. We establish this system by mounting a Wild N III level with its horizontal sight line a known (and measurable) distance above 0. The x and y axes lie in the gravity horizontal aimed at convenient points on the BU structure or surface targets.

We establish a ring of 48 or 96 "edge" targets at equal distances from 0 around the edge of the dish. These targets can all be observed by the N-III. Such observations give:

(i) The tilt of the target plane (the edge) with respect to gravity.

(ii) The Δz departures of the edge targets from this tilted plane.

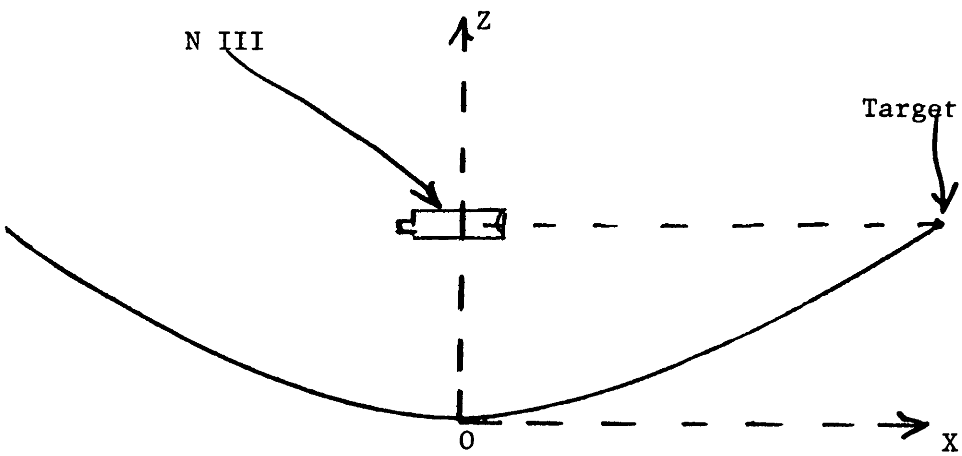
(iii) The elevation of the center of the tilted plane above 0.

(b) The radial profiles

We shall determine the radial profiles either by stepping from 0 to the edge targets, or by using a template method or perhaps by both methods. These possibilities are still being considered.

(c) Accuracy

We believe that either method should give a measurement accuracy of 25 μ as its contribution to the error budget for the complete surface.



Figure