TRIAL AND ERROR AT THE 12-METER. A GREEN BANK TALK, OCT.28th 1985

(John W. Findlay)

1. Early History.

The desire to make a better telescope goes back to 1973. Measured by "cart" in 1974 (twice) and 1976. JMP tries foil in 1976. Bobby Ulich made structure changes 1978. MAG proposed a Leighton dish or a 100 micron ESSCO dish in 1980. WGH memo 1981 discusses this and a machined panel dish. In March 1981 JWF and JMP reported on the poor thermal behaviour of the dish. On March 7 1981 JWF wrote a definitive memo (it became 12-m Memo #12) and HH set up a W.G to plan a project. The project essentially began on April 1st 1981 when JWF visited ESSCO and concluded we could work with an ESSCO surface.

2. Results as of August 24th 1985

The telescope surface has not been changed since Nov 28-30 1984. Performance shown in slides of aperture efficiency and beam shape at 345 GHz. Mechanical measure of surface made August 15 '85 but no holographic data since the November '84 re-set. Results speak for themselves. Original intent was for "adequate" performance at 1.2 mms wavelength - this has been achieved. There are indications that some further surface shape improvements are possible.

3. The main milestones in the work.

The project was carried out with two constraints in mind. First, the telescope should be out-of-use for as short a time as possible, starting, of course, at the start of a summer shut-down. Second, costs should be contained within the budget (which was $450,000 in August 1981, and was increased to $0.5 million when we decided to add holography to the project cost).

Date	Milestone
April 1st 1981	JWF meets with Al Cohen - panels look OK
August 18th 1981	Contract for panels let to ESSCO
September 1981	Design of back-up-structure (BUS) complete
March 1st 19821	Tests of Reference Jig (RJ) and Template start in the warehouse at Green Bank
April 24th 1982	First pieces of BUS arrive at Green Bank
May 1982	Work on BUS - changes to make panels fit.
June 1982	Testing thermal behaviour of BUS in warehouse.
July 1982	Three panels set on BUS. Tests of measuring system started.
July 25th 1982	Released BUS from Green Bank. Go-ahead to start dismantling 36-foot dish. VLA crew to Kitt Peak.
August 4th 1982	First load BUS steel arrived at Kitt Peak
August 1982	Old dish removed and new BUS down to elevation axis installed
September 7th '82	Remaining measuring equipment shipped from G.B
Sept. 11-28th '82	Thermal tests. Setting and measuring 144 edge-balls
Oct..1st-11th '82	Lifting and placing surface panels
Oct 12th-19th '82	Realized all panels placed systematically wrong. Made a first measure of the surface as a check.
Oct 21st-31st '82	First attempt to set the surface correctly.
November 1st '82	Found telescope counter-weight (CW) too small.
Nov.1st - 24th '82	Time-out to fix counter-weight. Saw the moon at 3.5 mms on night of Nov. 24th. Estimate RMS about 140 microns.
Nov. 29-Dec.2nd '82	Second surface setting ("ADJUST #2")

December 7th '82	Measure the surface (MEASURE #2). This suggested that the RMS was improved to about 80 microns.
Dec.7th 1982 - Feb.1st 1983	During this time aperture efficiency and focus curves at 1.33 mms were not consistent with the MEASURE #2 value for the RMS. Many aspects of measuring system were reviewed.
February 2nd 1983	Found that the RJ in its tilted position did NOT have the profile derived by computation from its horizontal position.
Feb. 8th-14th '83	Surface re-set using re-measured shape of RJ
February 17th '83	Aperture efficiency now about 17% at 240 GHz at prime focus.
March 1st 1983	12-meter starts use for observing.
April 8th 1983	JWF and JMP meet with A.N.Lasenby at Jodrell Bank
July 21st 1983	First trial Holographic (H) run attempted
July 26th 1983	Run MEASURE #5. Mainly needed to study the "Sensor #6" problem prior to starting "Unbend"
August 1983	Efforts to remove the "Sensor #6" low points.
September 1983	Successful H runs. Still working on surface low points. Comparing H and Mechanical (M) results
October 17th '83	At end of work on low points, ran MEASURE #6
October 21st '83	After MEASURE #6 the computed RMS was 71 microns, but there were clear discrepancies between H & M
Nov.3rd-5th 1983	Re-set radii #135 thru #1 based on H data
Nov. 6th 1983	After several attempts got a good full data set on the edge-ball (EB) values.
Nov.7th - March 10th 1984	Telescope in use for astronomy. Plans made for H and M runs close together in March
March 9th-12th '84	Two M maps made together with 40x40 and 64x64 H maps. The two M maps are very similar.
Mar 12-May 4th '84	Telescope in use for astronomy.
May 4th-8th 1984	Adjusted about 1/4 of the dish area, mainly outer panels, based on March H data. Checked performance improved using prime focus aperture efficiency
May 9th-July 1984	Telescope in use for astronomy
July 15th 1984	Program on EB heights, checking surface and edge deflections started, in search for EB errors.
July 26-27th 1984	A good 56x56 H map obtained.
August 1984	JMP made a "wheel-on-edge" experiment which suggested M measures were wrong on some radii.
November 1984	Planned a full re-adjust (except for Sensor # 12) to be based on the July H map.
Nov.27-30th '84	Carried out full re-adjust. Estimated the adjusted surface might have an RMS about 75 microns.
August 11th - 24th 1985	Located the cause of the EB errors and corrected March '84 M map. Re-measured surface using correct EB values.

4. Discussion of Errors.

Look at some of the main errors in the M measurements as examples. Note that H got its first trial in July 1983; we will not deal with problems in H. (Those involved were JMP, ANL, Betty Stobie and later Fred Schwab). It was not until about March 1984 that H was really trustworthy.

(a) December '82 - February '83.

The RJ shape was found to be wrong. Fairly easy to locate error. Correction involved developing new measuring methods, Tri-lateration, H-P Interferometry, NIII levelling etc. Once corrected this did not have great influence on the other aspects of the project.

(b) The EB uncertainties

Several errors contributed to this problem, some just because of the doubts raised about the assumptions made in the measuring plan.

(i) The plan only allowed the EB's to be measured before the surface was emplaced.

(ii) The BUS was fabricated quite badly out-of-shape (May 1982)

(iii) Unexpectedly large additions had to be made to the CW (November 1982) which could have distorted the dish edge.

(iv) It proved quite difficult to devise methods to check the EB values with the surface in place.

(v) Doubts were raised as to the integrity of the BUS in giving "well-behaved" support for the surface. Deflexion measures were devised and tested before the facts were known.

(vi) The troubles were found to lie in (ii) above and in a small fabrication error at the end of the template.

(c) The low points near Sensor #6.

From early December 1982 it became clear that many panels were showing consistently low values at the radius of Sensor #6. At first it was feared that the original panel placement (Oct.1st -11th 1982) might have put a "permanent set" into the panels. Later it became clear that the problem arose from the mounting screws. It has not been fully overcome, but extra light structure has been put in to give extra panel adjustments at some points under Sensor #6.

5. Lessons ?

Lessons to be learnt may best be left for informal discussion. However, one might suggest that a post-mortem review of some projects might reveal points to look out for in the future.