mmA Antenna Memo No. 6

National Radio Astronomy Observatory
Tucson, Arizona
19 June ,1992

MEMORANDUM

To: Bob Brown, Dick Thompson, mmA Antenna Memo Series

From: James Lamb

Subject : MAN Proposal

MAN Corporation are very interested in the mmA proposal and would like to be involved at an early stage. On 15 June, 1992 Dr H J Kärcher and Mr E E Dollmeyer visited the Steward Observatory in Tucson in connection with the Sophia Project and also visited NRAO while they were here. Jeff Kingsley and myself spoke with them briefly. They have come up with an unsolicited draft proposal for a reflector study which is included as an annex to this memo. I think that it is too early to act on it, so I will enter it in the mmA Antenna Memo Series for future reference. Obviously other companies will be interested and we should contact them at some appropriate time.

MAN has a good history in the antenna design and construction field and have also had involvements in optical telescope designs with very high pointing accuracy requirements. Dr Kärcher agrees with our assessment that the thermal design is the main obstacle to be overcome. He has indicated an interest in studying a design which does not use a hub which would have a different thermal time constant from the backing structure, which I think could be a good line of study.

Annex: "Proposal for a Feasability Study on Telescope Reflector Concepts", MAN GHH

cc D T Emerson
J M Payne
J S Kingsley

NRAO National Radio Astronomy Observatory

Proposal

for a

Feasibility Study

on Telescope Reflector Concepts

DRAFT
6-12-92 Kä

Project No.

prepared by

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Table of Contents:

1. Introduction

The present offer for a Feasibility Study on Reflector Concepts for NRAO's Millimeter Array project is based on "The Millimeter Array", Proposal to the National Science Foundation, R. E. Hughes, July 1990, where the principle ideas for the Millimeter Array are described, and on personal communications between J. Lamb, H. J. Kärcher and E. E. Dollmeyer in March 1992 and previous contacts and discussions of ideas in Jan. 1990.

The offer has been prepared with special emphasis to the following points:

- Contribution of MAN GHH's experience with regard to design, manufacture and commissioning of telescope systems, particular radio telescope and communication antenna reflectors. We would like to especially mention the design and erection of the 30 m millimeter-wavelength radiotelescope MRT on Pico Veleta, Spain, for MPG, the system design, manufacture and erection of the 15 m carbonfibre reflectors on Plateau de Bure, France and La Silla, Chile, for IRAM and ESO, the design of telescope mechanics and structures for ESO's New Technology Telescope NTT in La Silla, Chile, the design, manufacture and erection of the 32 m MERLIN radiotelescope in Cambridge, UK, for the University of Manchester and feasibility studies for the reflectors and telescope concepts and enclosures for the Submillimeter-Wavelength Telescope Array of the Smithonian Astrophysical Observatory, Cambridge, MA.

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- Contribution of MAN Technologie's experience in the field of carbonfibre reinforced materials and structures. The full know-how in design, material properties, manufacture and lifetime properties of CFRP will be available for the study and compared with the use of more conventional materials like aluminium or stainless steel.

- Close restriction on NRAO's conceptions for the telescope system itself, content and periods for studies and realization of the project and a realistic assessment of a German contribution to an United States national project.

- Detailed description of the investigations and calculations carried out in the frame work of the study.

The processing of the complex problems of the study within a specified scope of costs and time is only possible by fast access to the existing know-how. Only specialists with long years of experience with telescope construction will be allowed to work on the study, viz. Dr. Kärcher (overall system engineering), Dr. Kühn (structural and thermal optimization), Mr. Denker (design) and Mr. Muser (carbonfibre materials).

The result of the study will be presented in a study review at NRAO. We are convinced we are able to contribute, within the cost limits, a step toward the realization of NRAO's Millimeter Array and we would be glad to contribute further steps, e. g. the manufacture and test of a reflector prototyp.

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2. Technical Discussion

The reflector system is the central structural component of each telescope and accounts for its performance as a millimeter-wavelength telescope. The reflector system must control the influences of the outside environment as gravity, wind, isolation and radiation to the cold sky. As mentioned in NRAO's proposal "The Millimeter Array", for reflectors under 8 m diameter - which is for radiotelescopes a rather small size - gravity and wind deformations can be kept under control by an adequate stiff design of the reflector trusswork, where as the temperature deformations need also for this small sizes special treatment.

MAN GHH has some experience with different concepts for controlling the temperature effects on radiotelescopes, e. g.

- a fully passive control principle, using conservative materials (steel for the trusswork, aluminium for the reflector panels) and a thermal "fast", laticed lay-out of the structural system (e. g. the 32 m-MERLIN telescope in Cambridge, UK, which is not a millimeter telescope)

- a passive principle, but using low-temperature-expansion materials as carbonfibre reinforced plastics (e. g. the 15 m IRAM reflectors on Plateau de Bure, France and La Silla, Chile)

- a fully active thermal control system (e. g. the 30 m MRT on Pico Veleta, Spain).

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According the needs of the MMA project with its large number of telescopes, the big impact of the telescope costs and the possibilities of cost reduction using the advantages of a serial typ of production - there is a strong demand to look on passive lay-out criteria, using conservative materials as far as jusifiable by adequate design and analysis. The serial typ of production has the further advantage making it possible to check the lay-out by prototyping and testing.

For a passive lay-out the emphasis of the design work under thermal aspects lies on an adequate balance between thermal protection and thermal behaviour, e. g. the right balance between thermal radiation (solar and infrared), convection and thermal transmission, which can be influenced by

- structural system lay-out (filigree, laticed for fast thermal time constants)

- insulation (surface treatment, optional claddings or covers)

- semi-passive convection (forced ventilation)

This considerations result in the idea, to investigate alternatively to a more conventional lay-out with an (expensive) central hub (like the 15 m IRAM, the 10 m SMT or the 8 m SAO reflectors) a **"hubless"** lay-out, which is, from the viewpoint of thermal behaviour more homogenious and cheaper (see figures).

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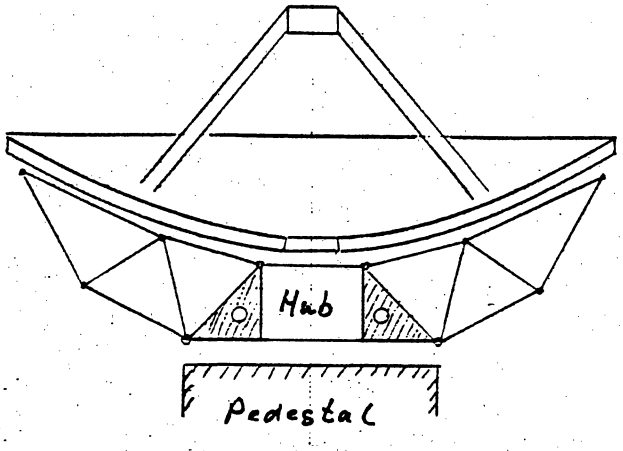
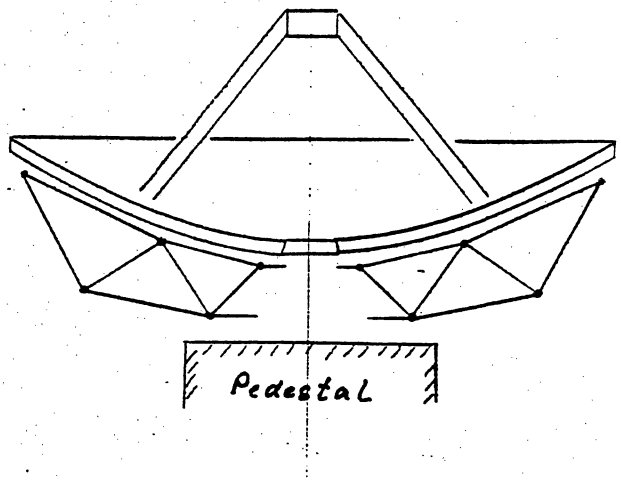


Reflector system
with central hub



Hubless reflector

According these considerations, the main emphasis of the study will lay on the following

- comparison of CFRP-panels versus costed, machined aluminium panels
- comparison of a hubless reflector versus a reflector with central hub
- estimation of gravity and wind influences
- lay-out and analysis of a passive thermal central system (surface treatment, baffles and claddings) versus a semi-passive system (forced ventilation)
- manufacturing aspects CFRP-versus aluminium panels, trusswork in CFRP versus aluminium and steel

- assembling, adjustment and testing
- reliability, maintenance, quality asurance
- cost estimates
- development, prototyping

The **task of the study** is the recommendation for a final reflector system by soberjudgement of the results of the investigations and a proposal for a next step in development and prototyping of the system.

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Feasibility Study on Reflector System

WORK PACKAGE DESCRIPTION	WP REF. NO. 10 000

WP No.	Title **Project Definition**
11 000	Specification - Check of specifications for the reflector system and requirement for supplementary data
12 000	Interface Definition - Definition of interfaces to subsystems, which are not concerning the reflector system itself (i.e. pedestal etc.)
13 000	Statement of Work - Setting up a work package plan and description for the development phase
14 000	Time schedule - Listing of development and manufacturing steps. Time schedule with bar and milestone-plan for development, prototyping, testing, serial production.

Delivery Items	Report approx. 10 pages

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Feasibility Study on Reflector System

WORK PACKAGE DESCRIPTION	WP REF. NO. 20 000

WP No.	Title **System Concepts**
21 000	Reflector Panel Concepts - aluminium panels - CFRP panels - listing, comments on lay-out parameters and material properties
22 000	Reflector Trusswork Concepts - system with central hub - hubless system - listing, comments on lay-out parameters and component properties
23 000	Thermal Control System - passive system - semi-passive system - listing comments on lay-out parameters and component properties
Delivery Items	Approx. 6 concept drawings, report approx. 20 pages

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Feasibility Study on Reflector System

WORK PACKAGE DESCRIPTION	WP REF. NO. 30 000

WP No.	Title **Analysis**
31 000	Reflector Panel Analysis - establishment of calculation models for aluminium and CFRP-panels - calculation of gravity and wind deformations - evaluation of thermal behaviour incl. radiation, convection and heat transmission effects - calculation of thermal deformations - optimization of panel lay-out and size resp. the calculation results
32 000	Reflector Trusswork Analysis - establishment of a finite-element-model for two reflector systems (hubless and withhub) - optimization under gravity loads - evaluation of wind influences - calculation of thermal deformations using temperature dato of WP 33 000 - comments, recommendaties
33 000	Thermal Analysis - establishment of a calculation model for thermal effects - analysis and optimization of a passive and semi-passive thermal control system for both reflector lay-outs - comments, recommendations

Delivery Items	Report approx. 40 pages including figures, plots and data sheets of the calculation results

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Feasibility Study on Reflector Systems

WORK PACKAGE DESCRIPTION	WP REF. NO. 40 000

WP No.	Title **Conclusion**
41 000	Comments on manufacturing aspects
42 000	Comments on assembling, adjustment, testing
43 000	Comments on reliability, maintenance, quality assurance
44 000	Recommendations
45 000	Revised specifications

Delivery Items	Report approx. 10 pages

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Feasibility study on Reflector Systems

WORK PACKAGE DESCRIPTION	WP REF. NO. 50 000

WP No.	Title **Cost Estimates**
50 000	Development: Cost estimates for - reflector design - reflector prototyping - testing of prototyp
51 000	Serial production - comments & ideas
52 000	Time schedule - bar chart
Delivery Items	Price lists, comments, reports approx. 10 pages