Inter-office

National Radio Astronomy Observatory

Charlottesville, Virginia

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From: S. Weinreb

25 METER - MILLIMETER WAVE TELESCOPE

MEMO # 5

Subject: Brief Report on Joint European Millimeter Observatory

.15mm 60μ 24.μ

Representatives from England, France, and Germany agree that a 30 meter dish with 15 mm rms and a 4x10 meter array with .06 mm rms should be built on a common site. The strategy seems to be to get scientific agreement first in the hope this will ease future financial agreements. In fact, Mezger stated that it would be easier to get funding for a joint project than for individual projects. The Observatory may be supported by a European Science Foundation which is due to be formed next year.

The English representatives (Hewish, Croom, Davies) were very non-committal due to internal controversies as to where the UK should put its reduced funds. However, the Germans seem to be willing to fund the design of the 30 meter telescope. They have a proposal from Krupp/MAN for this; a short description is attached. In its first stage, the study will consider both with and without radome designs. Trial manufacture of three different types of panels is underway. This design is expected to take 20 months and cost 25% of the construction cost.

The most difficult open question is that of site selection. A site at ∿3000 meters in the Pyrenees in Southern France is favored but it has heavy snowfall and it is doubtful if the water-vapor stability will permit aperture synthesis at λ=2 mm and 250 meter baseline. Tests utilizing infra-red hygrometers will be started soon. A removal hangar-on-wheels type structure, wind control nets, enclosed back-up structure, and heated panels were discussed to protect the 30 meter telescope.

The favored mode of operation of the Observatory is to have an autonomous director and site-staff reporting to a governing board from the three countries. Other Observatories and Laboratories would carry out electronics development tasks but the site staff would perform system design and integration.

A shaped-reflector Cassegrain with F/D=0.35 seems to be favored. The spectral line baseline deviation in a Cassegrain system is M (Magnification) times worse than in prime focus. However, it can be greatly improved by placing a spoiler cone at the subreflector vertex whereas the corresponding idea for prime focus (cone at reflector vertex) can only give ∿2 times improvement. (I am greatly indebted to Richard Hills and David Morris for educating me on this point.)

Remarks on the Planning of Radiotelescopes for the mm Wave Range

1. Latest Technical Achievement

The design concept of the 100 m radiotelescope largely fulfills the prerequisites to a homology-corresponding structure by separating the elevation supporting frame with sub-reflector and the rotation-symetrically designed reflector supporting structure. Therefore, it was obvious to use this approved concept also for the design of radiotelescopes for the mm wave range. In this case, however, a systematic optimization of the reflector supporting structure had to be performed in order to essentially improve the reflector accuracy due to the load of deadweight by one decimal power at least. This, among other things, was one of the targets of the two studies prepared by Krupp/MAN in 1971 and 1973. On account of these studies an improved supporting structure for a 30 m reflector was found out for which a theoretical rms value of mere deadweight deformations of almost ~0 was the result. In practice this value may of course not be achieved since tubes of standard dimensions are used, and on account of the manufacturing tolerances of tubes and supporting structure. Considering these aspects, however, a value of max. 0.05 mm rms will surely be reached. The studies furthermore proved that the influence of a wind load (wind velocity of 30 km/h) on the rms value may nearly be neglected. The influence of sun rays on the rms value of the reflector is quite another thing. For an extreme

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temperature which was chosen (oblique sun ray on the reflector and reflector supporting structure, temperature difference between the parts exposed to the sun and those lying in the shadow 10° C) a considerable deterioration of the rms value was the result (approx. 0.6 mm rms for deadweight + wind + + sun ray). This result showed that in future special attention will have to be paid to the development in order to solve the problem of deformations due to temperature. Panel and adjustment accuracies are in these studies no subject of investigation. Only those values were mentioned (panel accuracy 0.09 rms, 3.6 µ adjustment accuracy 0.08 rms) which are to be adhered to in 3.2 µ order to achieve the required reflector total accuracy (0.14 rms).

Meanwhile measurements were carried out by KIS at a re-adjustable, unpainted , high-precision cassette-type panel. With this kind of panels a minimum accuracy of 0.05 mm may be obtained; this signifies an improvement 2.0 µ by nearly the double as compared to the value mentioned in the study. Investigations on the behaviour of this panel type under extreme temperature cycles are still outstanding, furthermore the available information on long-time behaviour is only insufficient. The investigations are being carried on.

Latest achievable accuracies:

reflector accuracy (wind + deadweight)	rms 0.05 mm	2.0 µ
panel accuracy (total)	rms 0.05 mm	2.0 µ
adjustment accuracy	rms 0.08 mm	3.2 µ

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If for a 30-m radiotelescope a value of a total of 0.14 mm rms is to be adhered to, the influence of temperature on the accuracy of the reflector is to be kept to a minimum (max. 0.08 mm rms).

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2. Further investigations

As the technical risk with the construction of a 30- radiotelescope is particularly high on account of the great demands on the mechanical portion, further investigations would be indispensable. This involves:

1) Study of panel (provided by MPI in cooperation with ARGE), testing and measuring of various types of panels in a test stand under different environmental circumstances.

   Selection of the best suited types of panels regarding accuracy, long-time behaviour, costs.

2) Study of the influence of temperature on reflector and pointing accuracies.

   Measuring of temperatures in the supporting structure of a 30-m antenna (Helios Command station).

   Ascertainment of the absolute temperature deformations and reflector and pointing accuracies, comparison with high-frequency technical measurings.

3) Measuring study

   Kinds of measuring in accordance with the latest technical status.
   Selection of the best suited measuring procedure.

4) Study of the dynamic behaviour and the drive control system (in cooperation with a firm of driving techniques).

Setting-up of a dynamic model, determination of main data (stiffnesses, masses, mass moments of inertia, translation, dampenings, etc.), ascertainment of the natural frequency, setting-up of the control system, simulation on analog and digital computers, prove of the pointing and tracking accuracies required, behaviour of stability, determination of the control concept.

5) Study of the position data acquisition

Selection of the best suited method of acquiring position data, putting-out of effects, which may be of influence on the position data acquisition, setting-up of simulation model.

3. Proposals for further project planning

In order to comply with the high specification demands and adhere to costs and deadlines for a task of such complexity as is the construction of a 25/30-m radio-telescope for the mm-wave range, project planning as detailed as possible would be required. So, prior to the fabrication phase proper, in a combined study, definition, and development phase, for which a separate contract would have to be concluded, the system-technical concept of the radio-telescope including the main design and a project structure plan of the most important assemblies including drive control, interfaces, cost analysis, etc. should be determined. At the end of this study and definition phase it has to be clearly decided whether, for example, in order to adhere to the high specification demands, the radiotelescope would have to or may be executed with or without a radome. In the development phase, after this decision, the main assemblies for the respective type of radiotelescope chosen will be determined.

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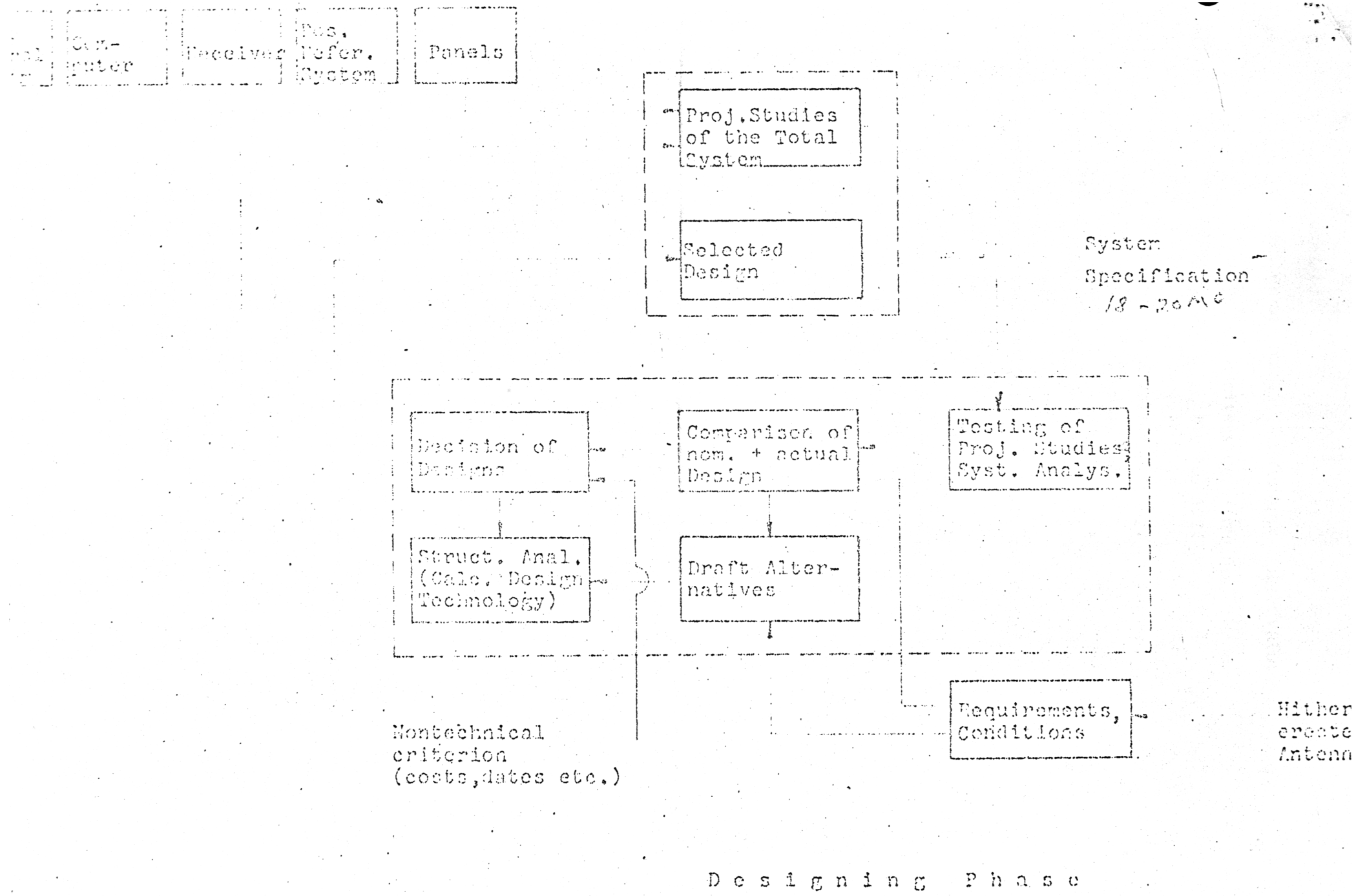
The procedure of the combined study, definition and development phase may be noted from the attached scheme. It will be of importance that a list of the demands and conditions with regard to a mm-telescope would be prepared by a group of scientists. So the erection site with its environmental conditions would play a significant role. First, various design alternatives can be dispensed with; as a design two radome-less radiotelescopes to the Effelsberg principle with diameters varying in size will be taken as a basis. Should the detailed system analysis show that the high demands make it necessary to have an execution with radome, then only another type of telescope with radome would be developed. It is suggested that ARGE, for this first projecting phase, would prepare a detailed project structure plan with the individual activities inclusive of the drive-technical portion, and a time schedule and an estimate of cost. The duration of the projecting phase is estimated to be about 18 to 20 months.

Considerations would have to be made further whether, in this projecting phase the 10-m radiotelescope of the Arrays and the 25-m radiotelescope should be dealt with in parallel, as, apart from that, a series of detailed studies for both sizes of telescopes could be used.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