DEVELOPMENT OF A PRECISION LARGE DEPLOYABLE ANTENNA

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1. INTRODUCTION

It is recognized that large antennas (5-100 meters) will be necessary for many future space missions such as space VLBI observations and mobile communications. The large antennas are forced to be stowed compactly in launch phase and lightweighted due to the launch vehicle constraint. They will be usually constructed by use of mesh deployable structures.

This paper describes the feasibility study of the mesh deployable antenna using the tensioned truss concept[1][2]to the assumed space VLBI requirement as shown in Table 1.

Table 1. Space VLBI Requirements (Preliminary)

Aperture diameter	: 10m
Surface accuracy	: <0.5mm rms
Max. diameter in stowed configuration	: 2.2m
Antenna efficiency	: >60%
Frequency	: L/C/Ka band

2. ELECTRICAL DESIGN

Reflector Design

The displaced axis Cassegrain antenna [3]shown in Fig.1 was selected for space VLBI antenna from the gain maximized point of view by reducing the gain loss due to sub reflector blockage among the axi-symmetrical antennas.

In this antenna, the design parameters are D,F,Ds,Db,Dh and Rh as shown in Fig.1 These design parameters were optimized for the required frequency bands of L band to Ka band for maximum gain considering the mechanical constraints,such as allowable fairing space and subreflector extension. The F/D ratio and Db was determined by the mechanical constraints,and the minimum blocking condition,respectively. Ds and Dh were determined from the relationship shown in Fig.2. Rh is optimized for maximum gain for the given Dh. Consequently, antenna parameters are determined by considering not only the mechanical constraints but also gain maximization.

The estimated antenna efficiency including the primary feed horn loss will be approximately 60% at Ka band.

Mesh Development

For Ka band,the fine mesh with small opening is required for reflector surface. The different net meshes have been investigated concerning RF transmission loss. As a result the fine tricot mesh made of gold plated molibdenum wire with the transmission loss of less than -18dB at Ka band was developed.

3.MECHANICAL DESIGN

Construction

As shown in Fig.3 and 4 of the conceptual model,the antenna structure consists of the supporting hub, the feed support column which deploys vertically from the hub, the six extendible column which radially deploy from the hub, the cable assembly which is tensioned by the above six columns,and the reflective metal mesh which is installed to the cable assembly.

The truss cable, the side and rear backup cables, and tie cables 1 constitute the primary cable assembly to form a paraboloidal reflector surface.This assembly is stretched between the terminal ends of radial columns and the central hub, as shown in Fig.5. As the truss cable system is designed to be statically determinate, its configuration is not affected by the value of the above stretching force of column[1][2] and keeps the stable paraboloid.

Each cable net module, as shown in Fig.6,consists of the cable net, tie cables 2 and support cables, and is stretched by the above primary cable assembly in each triangle formed by the truss cable system.

Surface Accuracy

The cable net is made by the fine triangular lattice and each lattice point is designed to form the aforementioned paraboloidal surface. The side length L of this triangle is directly related to the total surface error δrms as follows[4];

$$L^2 = 62 \cdot \delta rms \cdot F$$

where F is the focal length of the paraboloid. From this equation, it is easily found that the sufficient surface accuray δrms (= 0.2mm) is obtained at the realistic L(= 200mm). Fig.7 shows the reflector configuration at L= 200mm.

Deployment Sequece

At first, the reflector deploys, then the telescopic mast does. The image of the reflector deployment are shown in Fig.8 and 9.

4. CONCULDING REMARKS

Electrical and mechanical design of a mesh deployable antenna intended for use of space VLBI is performed. The design will be verified by the engineering model under construction.

REFERENCES

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2. K.Miura et al, Research and Development of the Tension Truss Antenna, IAF-87-317(1987)
3. W.Rotman et al, Compact Dual Frequency Reflector Antennas for EHF Mobile Satellite Communication Terminals, IEEE, APS-20-4 (1984)
4. P.K Agrawal et al, Preliminary Design of Large Reflectors with Facets, IEEE Trans., AP-29-4(1981)

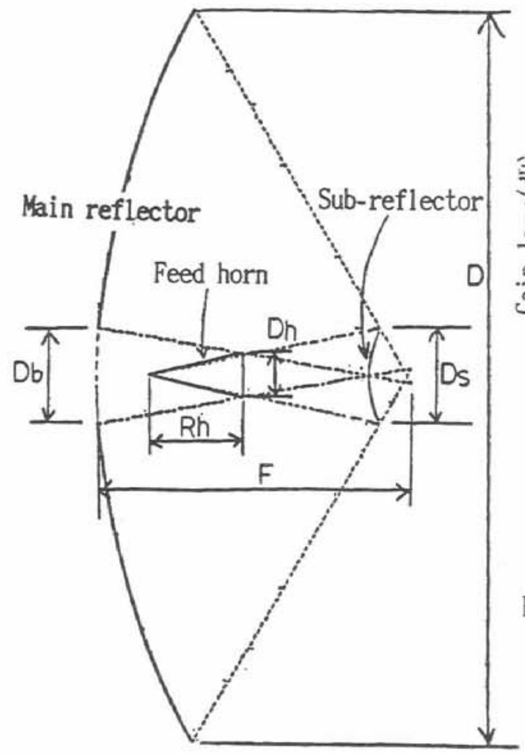

Fig.1 Disign parameter of displaced-axis cassegrain antenna

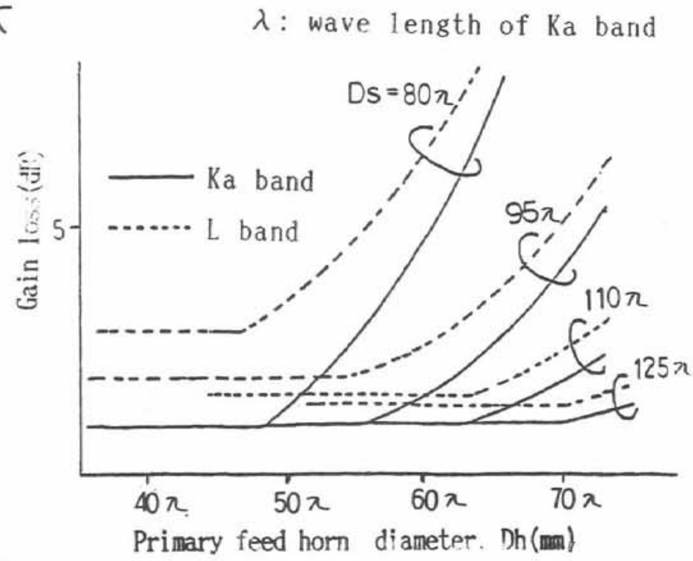

Fig.2 Relationship between sub-reflector diameter Ds, primary feed horn diameter Dh and gain loss

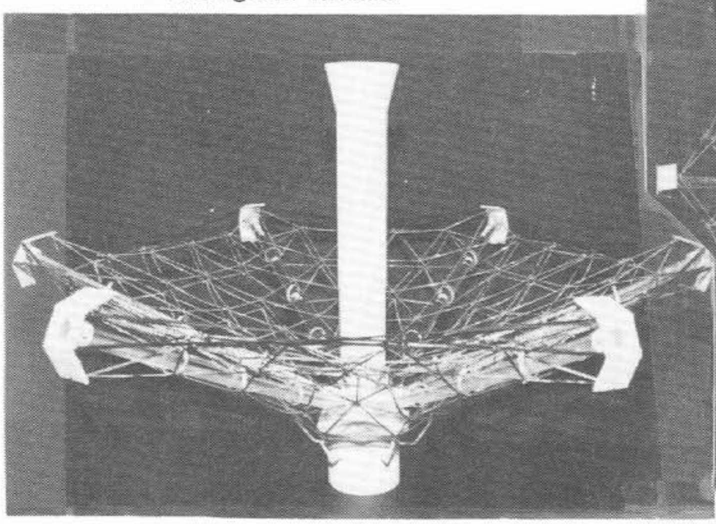

Fig. 3 Side view

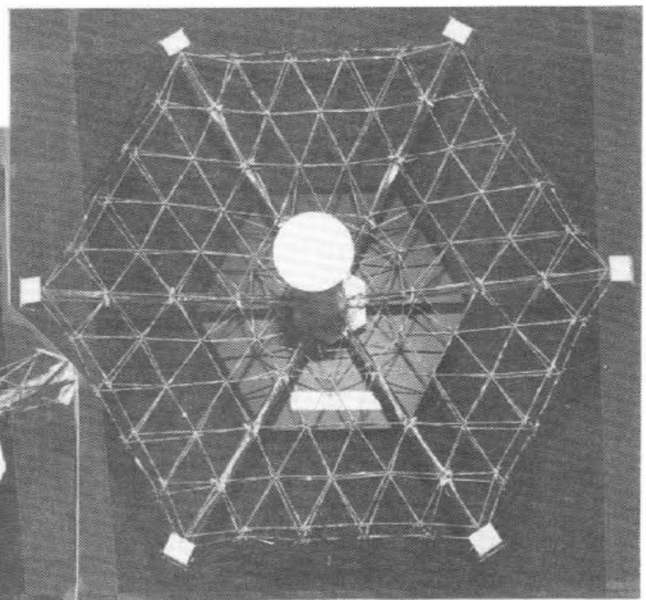

Fig. 4 Top view

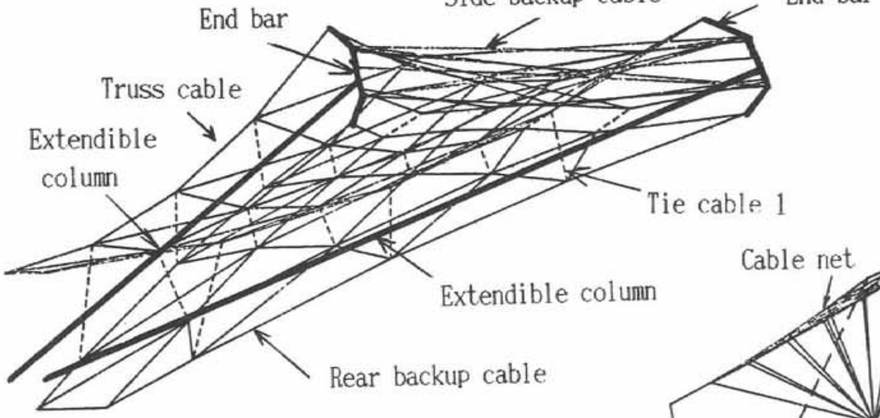

Fig. 5 Primary cable assembly

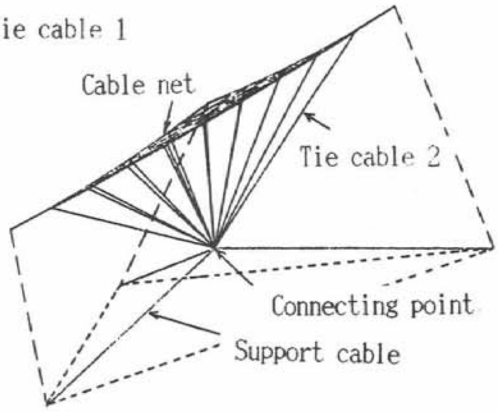

Fig. 6 Cable net module

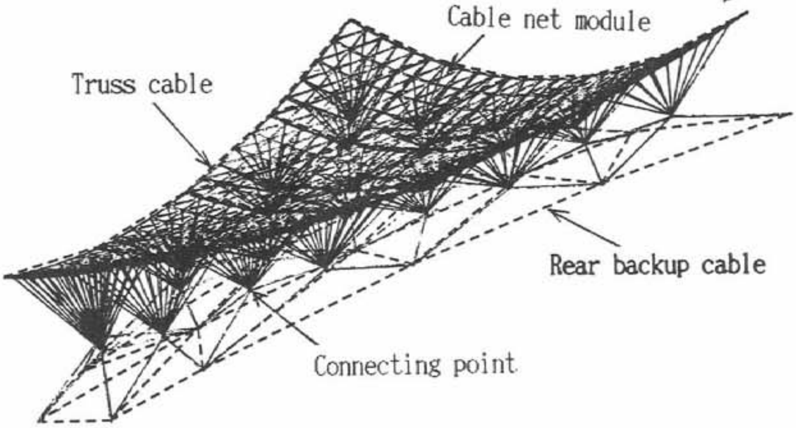

Fig. 7 Cable net assembly

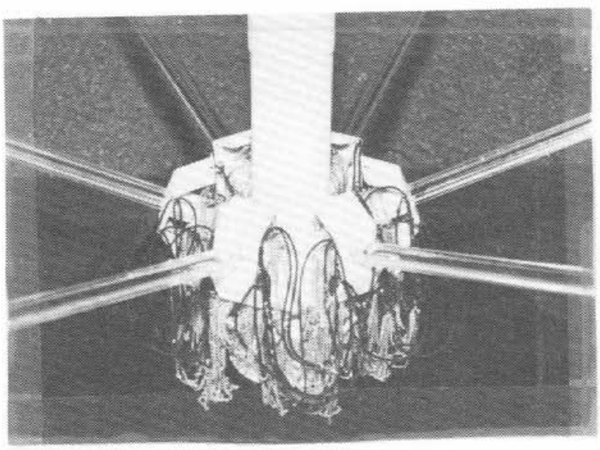

Fig.8 Stowed configuration image

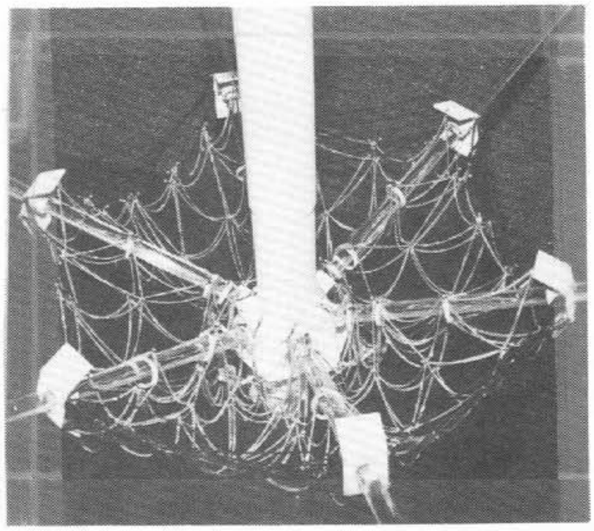

Fig.9 Deploying configuration image