DESIGN AND DEVELOPMENT OF A LARGE DEPLOYABLE MESH ANTENNA STRUCTURE MODEL

Koryo Miura
Institute of Space and Astronautical Science,
Yoshinodai, Sagamihara 229, Japan

Fumihiro Kuwao, Masaharu Tsushima, Tatsuo Katoh, Kazuaki Kawabata
Toshiba Corporation, Komukai, Toshiba-cho, Saiwai-ku, Kawasaki 210, Japan

Kenichi Takahara
Toshiba Corporation, Ukishima-cho, Kawasaki-ku, Kawasaki 210, Japan

1. Introduction

Communication and radioastronomy satellites increasingly require large deployable antennas to satisfy future mission requirements. Because of launch vehicle payload envelope constraints, antennas have to be stowed compactly in launch phase. Table 1 shows one of requirements for large deployable antennas.

Generally speaking, deployable reflectors can be divided into three types: a solid reflector type, an inflatable reflector type and a mesh reflector type. Table 2 shows characteristics of these reflector types and their characteristics. In the case of inflatable type, shaping of the reflector is performed by heat on orbit. It is impossible to verify shaping of the flight model(FM) reflector by heat in ground test, because the shaped reflector by heat can not be stowed again for launch. Though some means for reduction of surface error are required, in order to satisfy the requirements shown in Table 1, a mesh reflector type is selected.

A structural function model of the mesh reflector was designed and fabricated to verify the feasibility of high surface accuracy. The deployment function test, the surface accuracy measurement/adjustment test and the modal survey will be performed in 1989.

Table 1 Requirements for large deployable antenna

Reflector Diameter	: 10 m
Surface Accuracy	: 0.5 mm rms
Launch Vehicle Faring Diameter	: 2.2 m

Table 2 Trade-off of reflector types

Solid Reflector Type	: Large dimension in stowed configuration Heavy weight High surface accuracy
Inflatable Reflector Type	: Many research and development items Impossibility of the ground test for FM
Mesh Reflector Type	: Small dimension in stowed configuration Larger surface error than solid type

2. Structural design of reflector

A mesh reflector consists of a back-up structure, a secondary structure and a mesh surface. Table 3 shows two candidates of large deployable mesh reflector. In the case 1, the back-up structure is Hoop/Column type, and in the case 2, the back-up structure is adaptive deployable truss type. Hoop/Column type has very high packaging efficiency, and can be applicable to center feed antennas. Adaptive deployable truss type has high stiffness and uniformly distributed hard points on reflector surface. A secondary structure is connecting structures between back-up structure and mesh surface, and generally consists of cable network. The cable tension truss , which is statically determinate structure, when all members are in the tension condition, is adequate concept for secondary structure of mesh reflector. The surface error in fabrication is theoretically reduced to zero by changing cable length of the cable tension truss.

Surface error can be divided into three types: geometrical error due to approximate a curved surface by small planes(facet), Manufacturing error especially due to small difference of member length and error due to operating environmental load such as thermal distortion, dynamic distortion and zero gravity effect on orbit. Table 4 shows the budget of surface error.

The geometrical error due to approximate a curved surface by small planes is shown in Figure 1, as a function of member length of regular triangle, in case that the spherical surface which is similar to the paraboloid surface approximates by regular triangle planes. If F/D (Focus/Diameter) is 0.4, then the geometrical error is approximately 0.16 mm rms in case that the member length of regular triangle is 200 mm. Figure 2 shows the example of cable tension truss. The manufacturing error will be less than 0.2 mm rms by adjusting member length of the cable tension truss. If the error due to operating environmental load on orbit is greater than 0.4 mm rms, active shape control of surface is performed.

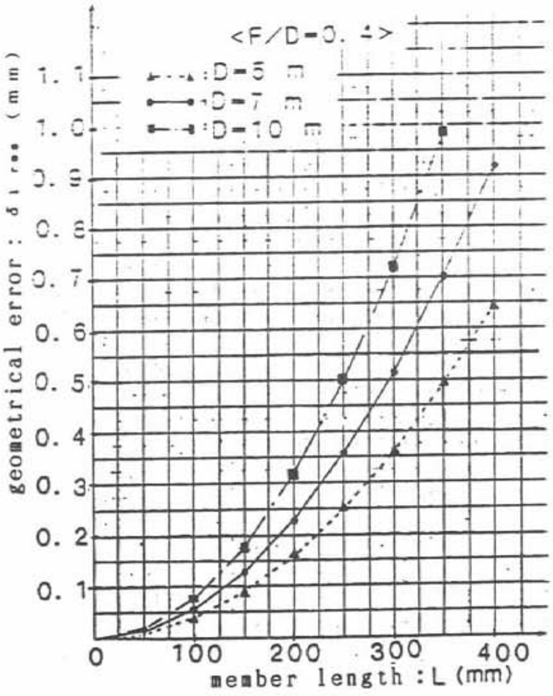


Figure 1 Geometrical error

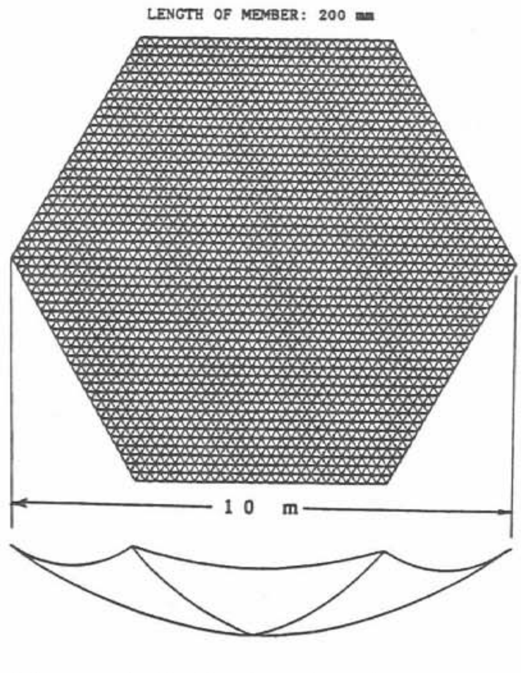


Figure 2 Cable tension truss

Table 3 Candidates of mesh reflector

	Case 1	Case 2
Back-up Structures	Hoop/Column type	Adaptive deployable truss type
Secondary Structure	Cable tension truss	
Mesh Surface	Gold-plated molybdenum wire	

Table 4 Budget of surface error

Geometrical error	: 0.16 mm rms
Manufacturing error	: 0.2 mm rms
Error due to operating environmental load	: 0.4 mm rms
Total (RSS)	: 0.47 mm rms

3. Structural function model

A structural function model of the mesh reflector was designed and fabricated to verify the feasibility of high surface accuracy. The Hoop/Column type(case 1) was selected because of its high packaging efficiency. The objectives of the structural function model are the following items.

(1) verification of the feasibility for high accuracy mesh reflector
 - surface adjustment in fabrication
 - shape control on orbit

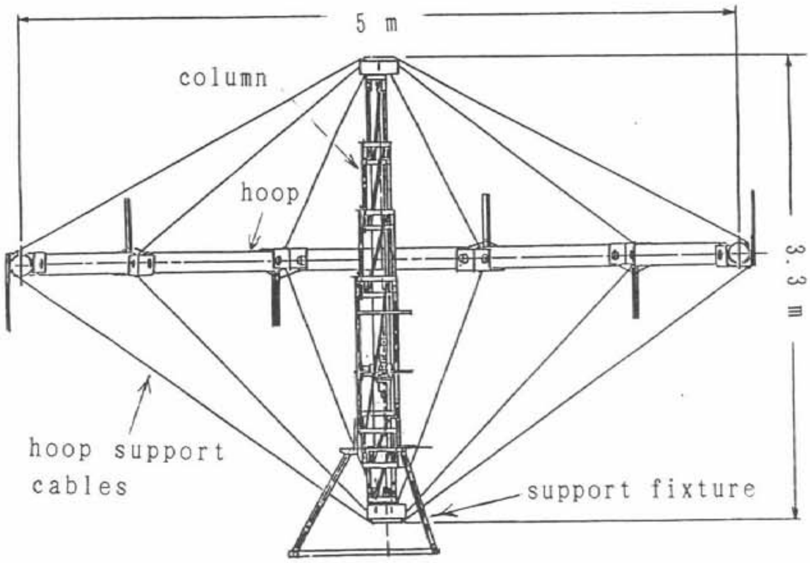
(2) verification of deployment
 - repeatability of surface accuracy

(3) evaluation of structural dynamic characteristics
 - evaluation of mathematical model

Figure 1 shows the deployed configuration of structural function model without secondary structure and dummy mesh, and Figure 2 shows the stowed configuration.

The diameter of the structural function model is approximately 5 m, which is a half size of the requirement. The model consists of a back-up structure, a secondary structure and a mesh surface. The back-up structure consists of a hoop, a column and hoop support cables. The hoop is deployed by twelve DC servo motors, and the Column is deployed by two DC servo motors. The secondary structure consists of a cable tension truss, back-up cables and an active shape control mechanism. The cable tension truss consists of 468 grid points and 1,320 members, whose length is approximately 0.2 m. All members can be changed their length by small screws. The surface error is extremely reduced by changing member length of cable tension truss in fabrication. The active shape control mechanism which consists of twelve DC servo motors and cables can reduce the surface error due to operating environmental load on orbit. The mesh surface is dummy mesh whose mechanical property is similar to the actual mesh surface.

Figure 3 shows deployed configuration of structural function model without dummy mesh.



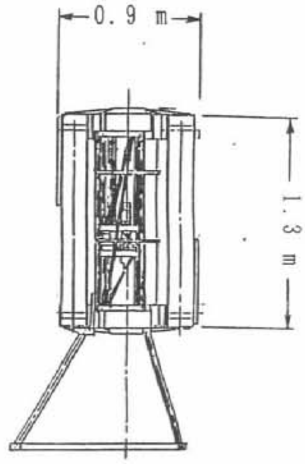


Figure 1 Structural function model (deployed configuration)

Figure 2 Structural function model (stowed configuration)

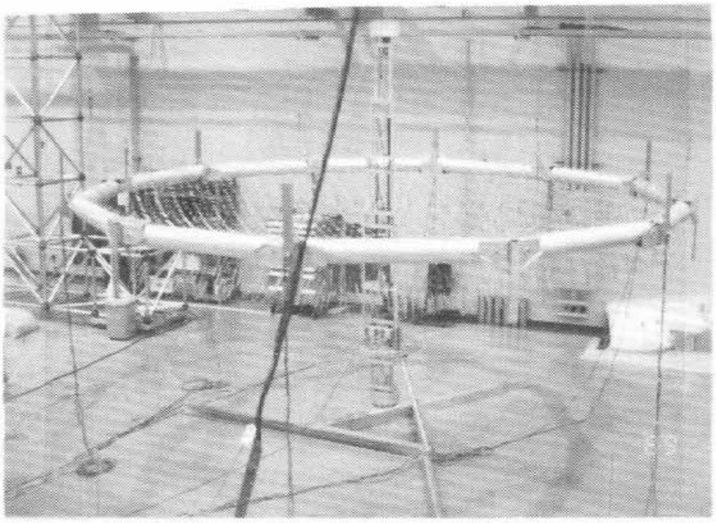


Figure 3 Structural function model (deployed configuration)

4. Concluding remarks

A structural function model of the mesh reflector was designed and fabricated successfully. The deployment function test, the surface accuracy measurement/adjustment test and the modal survey will be performed in 1989.

References

1. K.Miura: Concept of Tension Activated Cable Lattice Antenna, IAF-86-206, 37th Cong. Internalt. Astron. Fed., Innsbruck, Oct. 1986.
2. K.Miura, M.Sakamaki, T.Yasaka, I.Ohtomo, J.Mitsugi, H.Yahagi and K.Okazaki: Research and Development of the Tension Truss Antenna, IAF-87-317, 38th Cong. Internalt. Astron. Fed., Brighton, Oct. 1987.
3. W.K.Belvin, H.H.Edighoffer and C.L.Herstrom: Quasi-Static Shape Adjustment of a 15 Meter Diameter Space Antenna, AIAA-87-0869, AIAA/ASME/ASCE/ASH 28th SDM Conf., Monterey, April 1987.