AAS 86-242

JAPANESE CONCEPTS OF TETHER APPLICATION

S. Sasaki*, K-I. Oyama*, M. Nagatomo*

The present paper overviews recent studies on tether application in Japan. Three kinds of concepts are proposed: active, and technology experiment onboard Japanese free-flying space platform, and low altitude sounding by Japanese large satellite.

INTRODUCTION

Two kinds of new scientific space vehicles in the 1990's are now under consideration in Japan. One is a free-flying space platform (MICOS) to be launched and recovered by Space Shuttle. Another is a large scientific satellite launched by Japanese M-series rocket(new generation). For the experiments onboard the new vehicles, several candidates utilizing tethered subsatellite system are under investigation. Microwave transmission experiment with a tethered receiver antenna and electro-dynamic tether experiment are proposed for MICOS experiments. A multiple-subsatellite system by the large satellite is proposed to survey the geophysical parameters of the lower ionosphere.

MICROWAVE ENERGY TRANSMISSION EXPERIMENT(METT)

Microwave energy transmission is an important space technology when space exploitation involves large power generation and consumption (Ref.1). The technology will be applied for electrical power supply between orbital system elements such as orbital space factory, space platform, free-flying orbital laboratory and etc. It can be used even for power transmission from an orbital electrical power plant to the customers on the earth. The development of technology of microwave power transmission, including microwave beam control, microwave reception and conversion and hardware design, is the major research area. The study of possible interaction of microwave energy beam with the ionosphere and atmosphere is another research area of the

* *The Institute of Space and Astronautical Science, 4-6-1 Komaba, 4-chome, Meguro-ku, Tokyo 153, Japan.*

experiment. The objectives of this experiment are:

1. Orbital test of the hardware designed for microwave power transmission,
2. Verification of retrodirective and computer-controlled microwave beam control in space,
3. Accumulation of experience in operation of space power system consisting of several system elements in orbital motion, and
4. Environmental study on interaction of microwave and atmosphere and ionosphere.

The METT experiment will be carried out with support of the MICOS platform and tether systems. The METT system will consist of two main elements: microwave transmitter is onboard the platform and microwave receiver is tethered. A general configuration is shown in Fig.1.

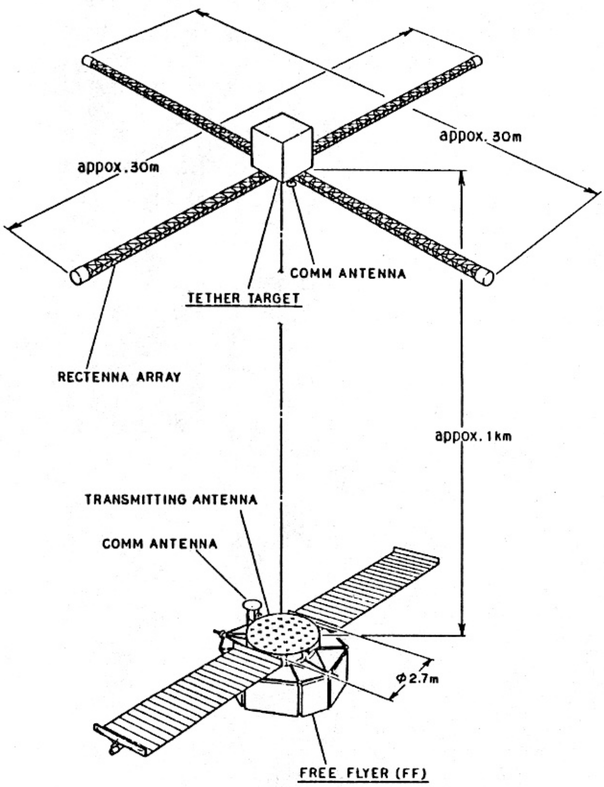

Fig.1 METT experimental configuration

The tethered receiver is deployed upward from the MICOS in an earth oriented attitude. The rectenna is deployed after the tether is extended to a length of 1km. The experiment is conducted in both retrodirective and computer-controlled modes. During the transmission experiment, environmental plasma parameters are measured by various diagnostic

equipment to study the wave-particle interaction.
The characteristics of the experiment are summarized in Table 1.

Experimental unit(onboard MICOS)			
	a transmitting antenna		
		frequency	2.45 GHz
		power	10 kW
		number of elements	1000(approx.)
		size and weight	2700 mm, 300 kg
	b data processor		
		size and weight	300x300x300 mm, 10 kg
	c control unit		
		size and weight	300x300x300 mm, 10 kg
Experimental unit (tethered system)			
	a rectenna		
		max. receiving power density	230 W/m
		max. incident angle	20 deg.(approx)
		size	30x30 m(cross antenna)
	b measuring unit		
	c control unit		

Table 1 METT characteristics summary

ELECTRO-DYNAMIC TETHER EXPERIMENT

A tethered subsatellite system in which main vehicle and a large conductive structure are connected with an insulated conductive wire has been proposed to conduct a new type of active experiment combined with electron beam emission (Ref.2). By applying a high voltage between the main vehicle and conductive structure through the conductive wire, we can study the responses of ionospheric plasma to the large potential differences. With electron beam emission at negative side, we can control the tether current. By modulating the beam current, low frequency radio waves with long wave length, such as whistler and Alfvén modes, will be excited in a well-controlled manner.

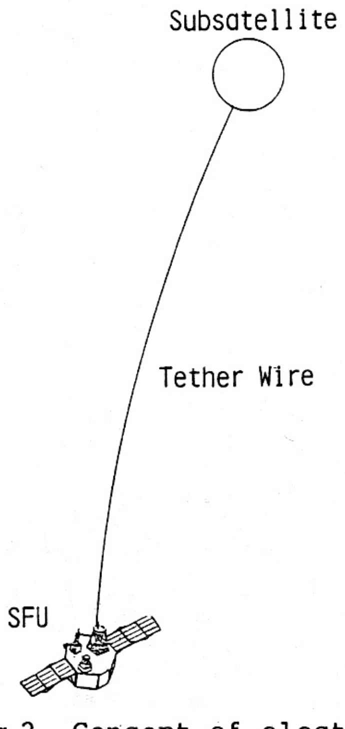

Fig.2 Concept of electro-dynamic tether experiment

The system of the electro-dynamic tether experiment onboard the MICOS mission will extend a conductive balloon up to 10 km above the MICOS with 10 mm diameter wire. Figure 2 illustrates the experimental configuration.

The purposes of the experiment are:

1. Study of wave generation by modulated tether current,
2. Measurement of ionospheric conductivity,
3. Study of beam-plasma physics, and
4. Accumulation of experience in operation of tethered satellite system in orbital motion.

The system can also be used to study the interaction of Jupiter with Io satellite crossing Jupiter's magnetic field.

The characteristics of electro-dynamic tether experiment onboard MICOS are summarized in Table 2.

Tether Deployment System		
	tether length	10 km
	diameter	10 mm
	deployment/recovery mechanism	
	wire dynamics stabilizer	
	telemetry to subsatellite	
Electron Gun System		
	beam current	1 A
	beam energy	5 keV
	batteries	
Diagnostic Package		
	plasma probes	
	charge probes	
	particle energy analyzer	
	wave receivers	
	optical detectors	
Subsatellite		
	solar power system	200 W
	batteries	10 AH
	telemetry to MICOS	
	plasma probes	
	particle energy analyzer	
	wave receivers	

Table 2 Characteristics summary of electro-dynamic tether experiment

MULTIPLE SUBSATELLITE MISSION (TETHER SUBSATELLITE-J)

Multiple subsatellite mission is aimed to get geophysical parameters at different altitudes at the same time in the lower ionosphere where a satellite can not keep its orbit due to the strong drag force. In the multiple subsatellite mission utilizing a Japanese large scientific satellite, more than 4 subsatellites will be tied together vertically by a thin long tether of diameter 1 mm and of length 100 km below the main satellite. Figure 3 shows the experimental concept.

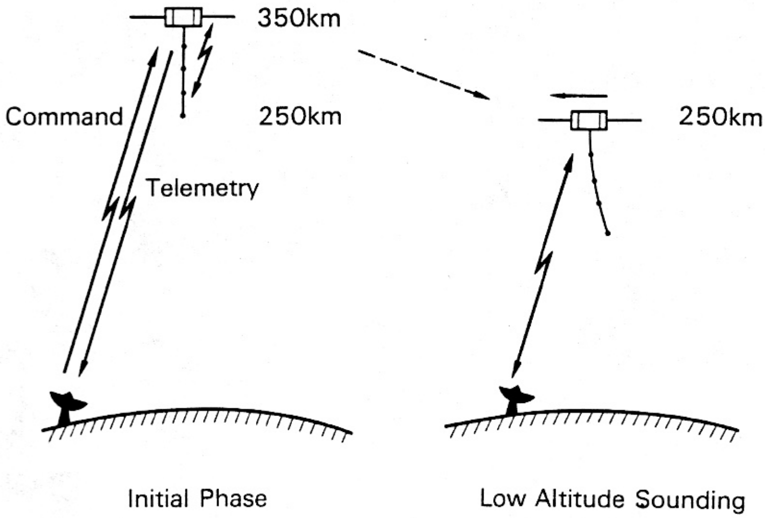

Fig.3 Experimental concept of multiple subsatellite mission

The large satellite will be put into a circular orbit at the altitude of 350 km. Then the tethered subsatellites will be deployed to 100 km down to the earth. The vertical long wire will stabilize the dynamics of the tethered subsatellite system by gravity gradient forces. This system surveys the geophysical parameters at the altitude from 250 km to 350 km (high altitude sounding mode). After several months, the altitude of the main satellite will be lowered down to 250 km keeping the vertical configuration of the tethered subsatellites. For this, a thrusting mechanism onboard the main satellite will be activated. The geophysical parameters from 150 km to 250 km will be studied in this configuration (low altitude sounding mode). In the latter phase, mission life is strictly limited due to the drag force to the subsatellite system. With an aid of thrusting system onboard the main satellite, the low altitude sounding will be continued for another several months until the lowest subsatellite reaches the altitude of 100 km. The geophysical parameters to be measured by the tethered subsatellite system are:

plasma	density, temperature, energy spectrum of low enery electrons
energetic particles	ion/electron energy spectrum
neutral gas	density, temperature, wind
magnetic field	
electric field	
electric current	
waves	electrostatic/electromagnetic
airglow	

The characteristics of the multiple subsatellite experiment are summarized in Table 3.

Tether Deployment System	
tether wire length	100 km
diameter	1 mm
deployment/recovery system	
wire stabilizer	
telemetry	
Diagnostics onboard Main Satellite and Subsatellites	
plasma probes	
particle energy analyzer	
neutral particle detector	
current detector	
electric field probe	
photometers	
magnetometers	
wave receivers	
Bus System onboard Subsatellites	
solar power system	200 W
batteries	10 AH
telemetry to main satellite	

Table 3 Characteristics summary of multiple subsatellite mission

CONCLUSION

The three concepts described here have been studied by the working groups at the Institute of Space and Astronautical Science. They have not been officially accepted by the Japanese government yet, but will be materialized within a couple of years after further active investigations.

REFERENCES

1. N.Kaya, H.Matsumoto, S.Miyatake, I.Kimura and M.Nagatomo, "Microwave energy transmission test toward the SPS using the space station", Space Solar Power Review, 5, 1985, pp.163-169
2. P.M.Banks, P.R.Williamson and K.I.Oyama, "Shuttle orbiter tethered subsatellite for exploring and tapping space plasmas", Astronautics & Aeronautics, Feb.1981, pp.31-33