Scenario on Orbital Experiment System Using Small Satellites of NASDA

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Abstract

This paper presents the scenario on orbital experiment system using small satellites of the National Space Development Agency of JAPAN (NASDA). On this scenario, the main missions of the small satellites are the experiment of the earth observation, the satellite communications, and the others on orbit. And the small satellites will be launched by the small launch vehicle J-I of NASDA.

As the first mission of this scenario, NASDA had studied the Optical Inter-orbit Communication Engineering Test Satellite (OICETS) system, and has started its development from the spring of 1993. Through this study, the small common satellite bus had been studied for the OICETS mission and other future missions.

As the second mission, the Maneuvering, Rendezvous, and Docking Technology Experiment (MATEX) mission is studied now.

1.Concept of this scenario

1.1 Characteristics

The purpose of the scenario on orbital experiment system using small satellites of NASDA is to conduct the missions that are categorized as shown in Table 1. In order to realize this purpose, the scenario has the following characteristics:

(1)Mission field

The mission fields are the earth observation, the satellite communications, and the others is shown as Table 1.

(2)Satellite

The satellite system must be developed quickly and low-cost.

(3)Launch vehicle

The low-cost launch vehicle of NASDA, or J-I.

The assumed common characteristics of the satellite system on this scenario is shown in Table 2.

Table 1 Mission category of the small satellites

	earth observation	communications	other mission
experiment (main purpose of the small satellites)	(1)experiment of advanced technology	(1)experiment of advanced technology (2)confirmation of new communications system	(1)establishment of RVD technology (2)test of new components and subsystems for satellite bus
validation	(1)observing by small instruments	(1)communication system using LEO satellites	(1)small OTV (2)space environment monitor

Table 2 Assumed Common Characteristics of the Satellite System

launch vehicle	J–I (3–stage type)
orbit	altitude; 300 – 600km inclination; 30 – 45deg.
weight	total; 400 – 700kg mission equipment; 100 – 200kg
mission period	less than 1 year

1.2 Background

NASDA has been developing and operating many satellites for experiment and for validation. The NASDA launch vehicles had become larger as the growth of these satellites. NASDA has developed and used the launch vehicle series and the next heavy–lift launch vehicle H–II will be used from early of 1994[1].

The large satellites have some merits about the capacity of mission equipments and the ability of satellite resource (that is, the electric power supply, the capacity of communication links, the attitude stability, etc.). On the other hand, the large satellites have some demerits as shown below:

- The large satellites need the long period for development, therefore some missions of them may be commonplace.
- The interfaces between mission equipments in large satellite system are more complicated.
- The mission damage will be large, in the case of the system failure.

This scenario will compensate these demerits of the large satellites. NASDA has started the development of the small launch vehicle J–I, and the first flight of J–I is planned to be launched in 1996. By using J–I launch vehicle in this scenario, NASDA will get two grades of satellite systems.

The large satellites launched by H–II will be used for the validation missions of large scale and long period, and the small satellites launched by J–I will be used for experiment missions which require quick and low–cost development. This concept is shown by Fig. 1.

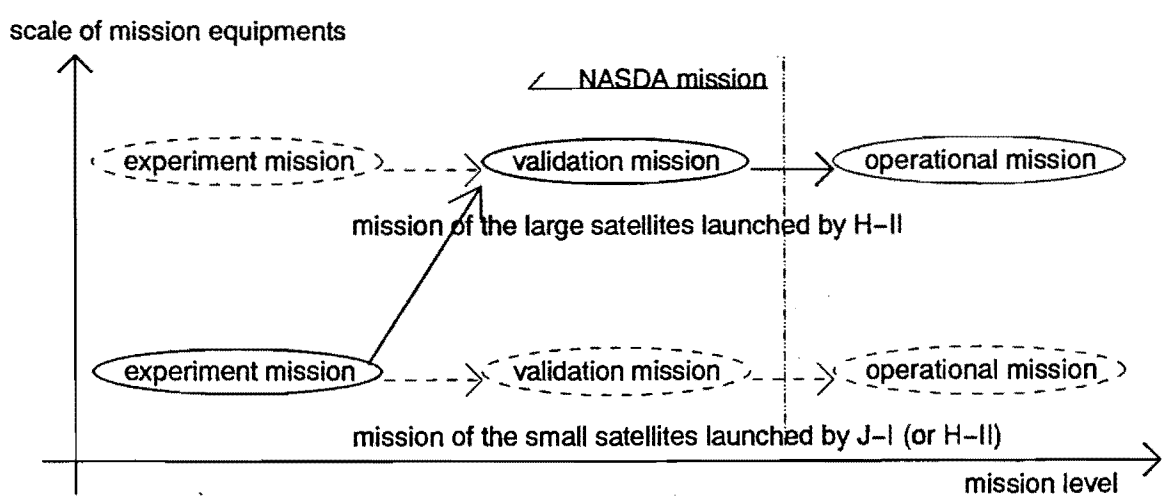

Fig. 1 A concept of use of large satellites and small satellites of NASDA

2.Small satellite system

The phase-A study of OICETS that will be the first satellite of this scenario had been completed in March of 1993. Through this study, the small common satellite bus had been studied for the OICETS mission and other future missions. In this study, its system design had been studied as shown below:

- The mission life is limited to 1 year.
- The remaining probability of the satellite bus at the end of life is about 0.7.
- Almost the components of satellite bus should be flight proven.
- The interfaces between mission equipment and the satellite bus should be simpler.

The each subsystem design of OICETS had been studied as shown below:

(1)Communication and data handling subsystem

Use of the dual standard S-band transponders (for USB and inter-orbit links of NASDA) and the solid state data recorders had been studied.

(2)Attitude control subsystem

Both the zero-momentum attitude control system and the bias-momentum attitude control system had been studied.

(3)Electrical power subsystem

Use of NiMH battery cells had been studied.

The block diagram of the satellite bus for OICETS on phase-A study is shown in Fig. 2.

3.OICETS mission

3.1 Mission concept

The OICETS mission is the experiment of the optical Inter-Orbit Links (IOL) technology between Low Earth Orbit (LEO) and Geostationary Earth Orbit (GEO). OICETS will carry the optical inter-orbit communication equipment, and will be launched into LEO. ARTEMIS, the geostationary technology communication satellite of ESA, will be GEO station of this experiment. The assumed cooperative experiment system with ARTEMIS is shown in Fig. 3. The outline of the OICETS mission is shown Table 3. A candidate of the OICETS configuration is shown Fig. 4.

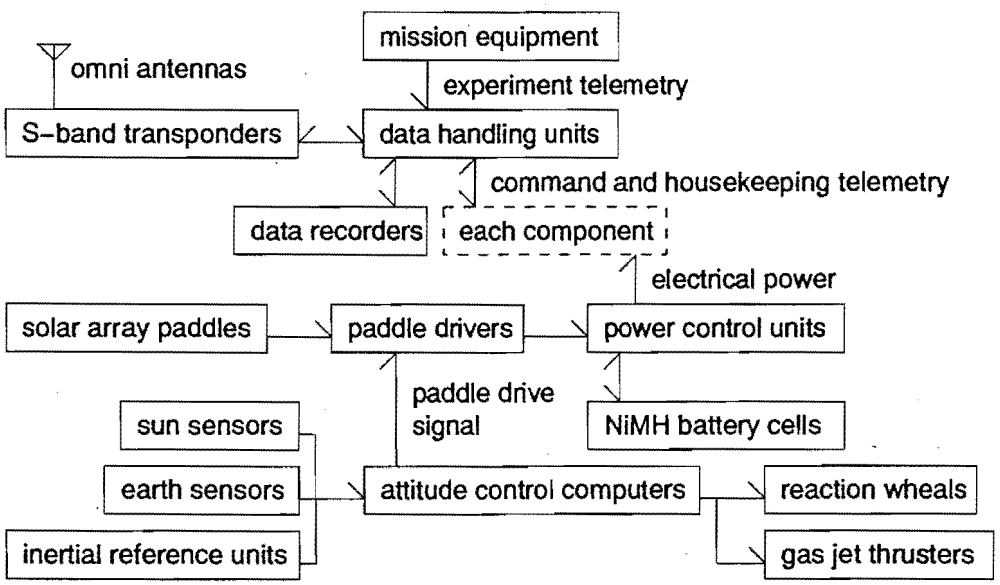

Fig. 2 The block diagram of the OICETS bus on the phase-A study

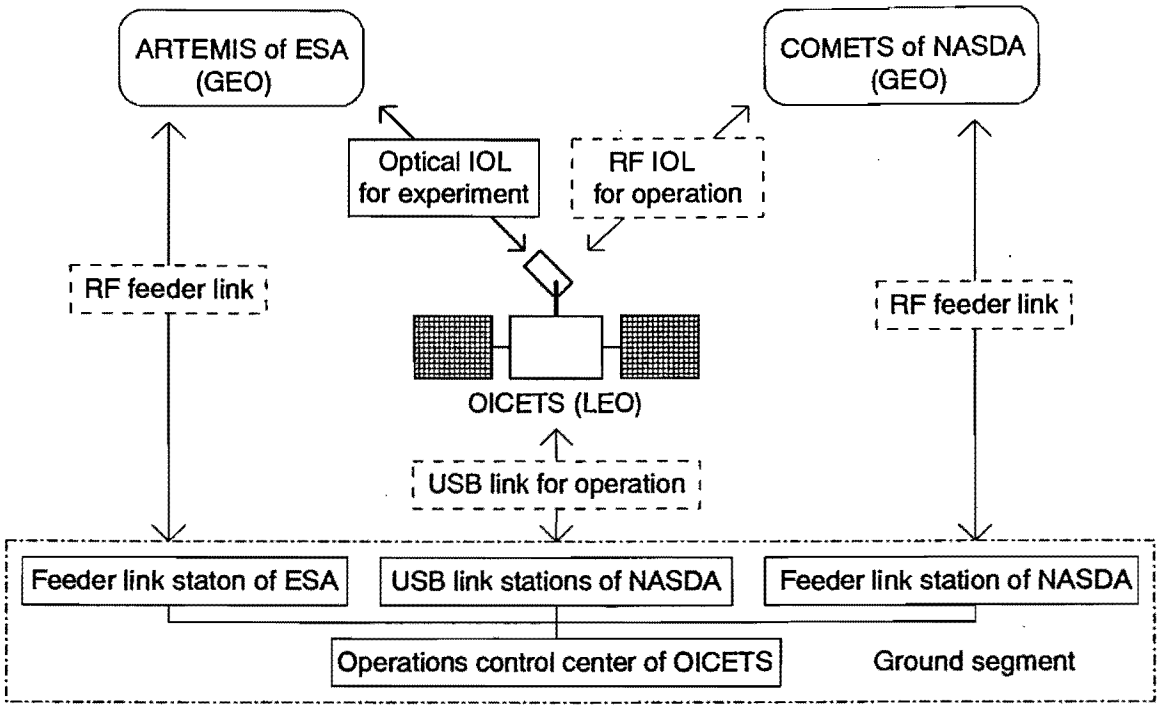

Fig. 3 The assumed cooperative experiment system with ARTEMIS

Table 3 Outline of the OICETS mission

launch date	early of 1998
orbit	altitude; 500km, circular orbit inclination; 45deg.
weight	total; 500kg mission equipment; 140kg
mission equipments	1.optical inter-orbit communication equipment 2.micro vibration noise measuring devices
experiment subjects	1.experiment in acquisition and tracking 2.experiment of optical inter-orbit communication 3.evaluation of optical performance characteristics 4.evaluation of OICETS bus
mission period	1 year

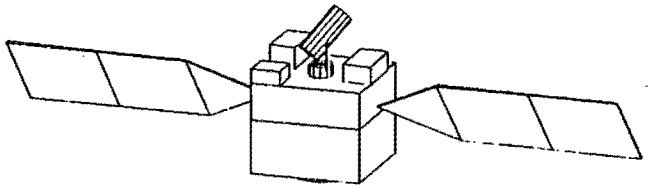

Fig. 4 A candidate of the OICETS configuration

3.2 Status of OICETS program

A part of the budget of the OICETS program has been admitted, NASDA has started the phase-B study of OICETS since April of 1993. Besides the phase-B study, NASDA is discussing with ESA about the memorandum of understanding of this cooperative experiment.

4.MATEX mission

4.1 Scenario using platform

NASDA has two kinds of the scenarios on orbital experiment system as shown below:

(1)The orbital experiment system using small satellites

(2)The orbital experiment system using platform

The scenario (2) is newer concept which will consist of an unmanned large platform, unmanned logistic transfer vehicles, unmanned retrieval vehicles. This system concept is shown in Fig. 5.

NASDA is studying the MATEX mission for the basic experiments about this unmanned logistic transfer technology, as second mission of the scenario on orbital experiment system using small satellites.

4.2 Mission concept

The MATEX will be launched by the J–I launch vehicle into lower earth orbit. After separation from J–I, MATEX will automatically experiment maneuvering, rendezvous, and docking to the Engineering Test Satellite–VII (ETS–VII) of NASDA as the target.

ETS–VII will be planned to be launched by H–II in 1997. ETS–VII system consists of the target satellite and the chaser satellite, its mission are the basic experiments of rendezvous and docking technology on co–orbit and robotics technology[2].

The MATEX mission will link the ETS–VII technology to the orbital experiment system using platform. The assumed experiment plan of MATEX is shown in Fig. 6.

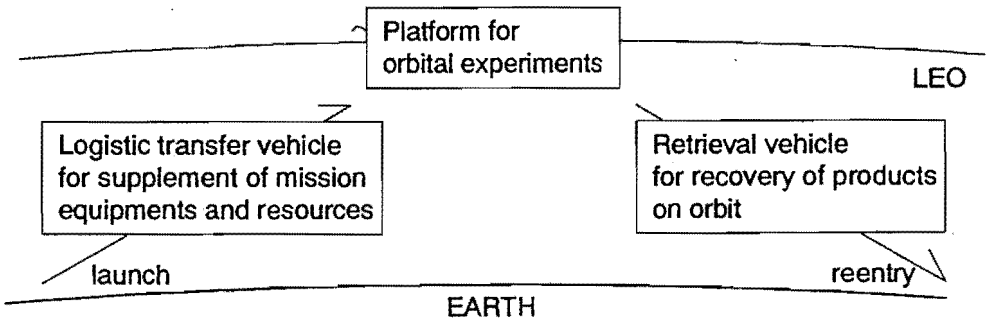

Fig. 5 The concept of the orbital experiment system using platform

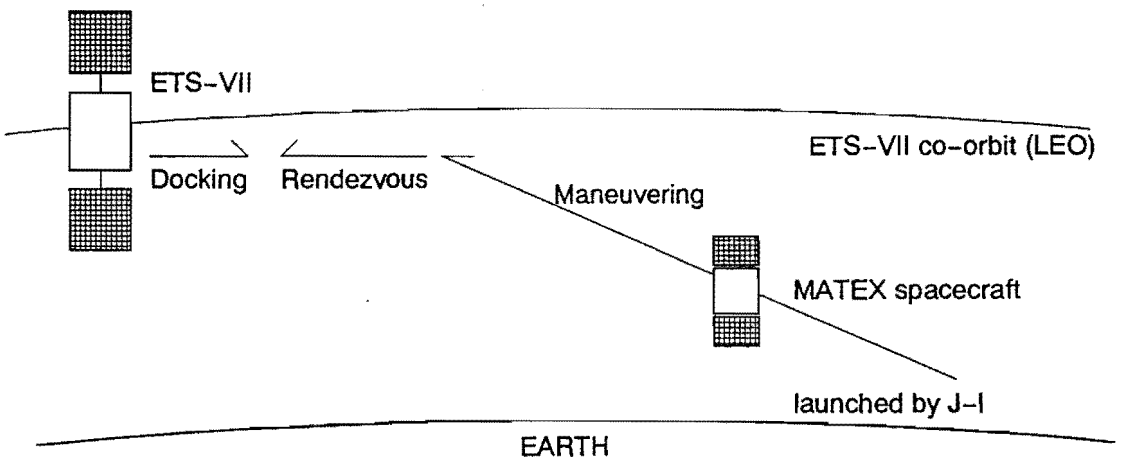

Fig. 6 The assumed experiment plan of MATEX

5.Advanced scenario

5.1 Share of mission

The orbital experiment system using platform of NASDA will be realized in ten years, and NASDA will have two kinds of the orbital experiment system for LEO. After that, these two system will be used as:

(1)The orbital experiment system using small satellites

It will be used for small scale mission with unique requirements of orbit or resources.

(2) The orbital experiment system using platform

It will be used for long term mission without unique requirements of orbit and resources.

Therefore, future small satellites will be needed adaptability to unique requirements.

5.2 Launched by H–II

With some modifications, the small satellites for J–I can be launched by the H–II launch vehicle. In this case, the small satellite will be launched with main payload of H–II. The orbit of the small satellite will be limited by the requirement of the main payload. But, if the orbit requirement is matched between the small satellite and main payload, the small satellite will be able to carry more mission equipments and be launched into the orbit of a higher inclination.

5.3 Adaptation to validation mission

With some modifications, the small satellite for J–I can be used for validation missions. An example of validation missions is the earth observing system using a cluster of small satellites. If the small satellites cluster will be launched into a same orbit plane and different orbit phases, this system will be able to observe the earth atmosphere and the earth surfaces frequently.

5.4 Improvement of the satellite bus

The OICETS satellite bus will be almost assembled by the components of flight proven to develop quickly and to be low–cost. This conservative design philosophy can't be adopted for more cost reduction and more weight reduction of the satellite bus to carry more mission equipments. Therefore, the satellite bus of this scenario need to be improved through future missions.

6.Conclusion

Since a part of the budget of the OICETS program has been admitted, NASDA has started the development of the small satellite of this scenario. In the future, the orbital experiment system using small satellites will be used for many missions of NASDA, which will be launched by J–I and H–II.

7.Reference

1.M.Miyazawa, "Homegrown technology for Japan's heavy–lift launcher", IEEE spectrum, pp51–55, March 1989.

2.M.Oda et al., "ETS–VII the world first telerobotic satellite", the 2nd i–SAIRAS, Sept. 1992.