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ETS-V, ETS-VI and COMETS Projects in Japan

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Abstract

This paper describes three satellite communication projects now in progress in Japan. The first is a project to establish a telecommunication network for tele-education, TV conference and tele-medicine in the Asia-Pacific region by using the Japan's Engineering Test Satellite-V (ETS-V). The second is a project of the ETS-VI satellite, to be launched in 1993, for inter-satellite communication, mobile and fixed communication and millimeter wave personal communication experiments. The third is a project of the Communications and Broadcasting Engineering Test Satellite (COMETS), to be launched in 1997, for advanced mobile satellite communication, inter-satellite link and advanced broadcasting experiments at higher frequencies.

1. Introduction

In the 21st century, satellite communications systems will become more advanced forms and be extended to the personal level by using higher frequencies than those in existing satellite systems. In the fields of direct satellite broadcasting or inter-satellite communication systems, the use of higher frequencies is expected for high quality and high data rate transmissions.

The Communications Research Laboratory (CRL) has been carrying out mobile satellite communications experiments for ships, aircraft and land-vehicles by using the ETS-V satellite[1]. As a part of the International Space Year's (ISY's) projects, we are planning to establish a telecommunication network using ETS-V in the Asia-Pacific region.

As a challenge to future advanced satellite communication systems such as Ka-band and millimeter wave mobile/personal satellite communications, the ETS-VI and COMETS satellites will be launched by Japan's H-II rockets. This paper presents an overview of these current satellite projects.

2. ETS-V and PARTNERS Project

The ETS-V satellite is now being used in mobile satellite communications experiments for ships, aircraft and land-vehicles. L-band of 1.6/1.5 GHz is used between mobiles and the satellite, and C-band of 6/5 GHz is used between the satellite and the coast/aeronautical earth station. The L-band antenna beams consist of two beams: the North-beam covering the Northern Pacific Ocean and the South-beam covering the South-Western Pacific Ocean. Fundamental communication links are C-to-L and L-to-C links between the coast/aeronautical station, at Kashima in Japan, and mobile earth stations.

The Space Agency Forum on the ISY (SAFISY) in the United Nations has assigned this year, 1992, to the ISY, and has proposed to utilize space technologies to deliver educational programs, medical treatment, space science and technology for developing countries via satellites. At SAFISY #4, held in Moscow May 1991, the Government of Japan has proposed a project of tele-education systems in the Asia-Pacific region by using the Japan's ETS-V, in cooperation with the University of Hawaii. This project is named "Pan-Pacific Regional Telecommunications Network Experiment and Research Satellite (PARTNERS)", and it is planning to be

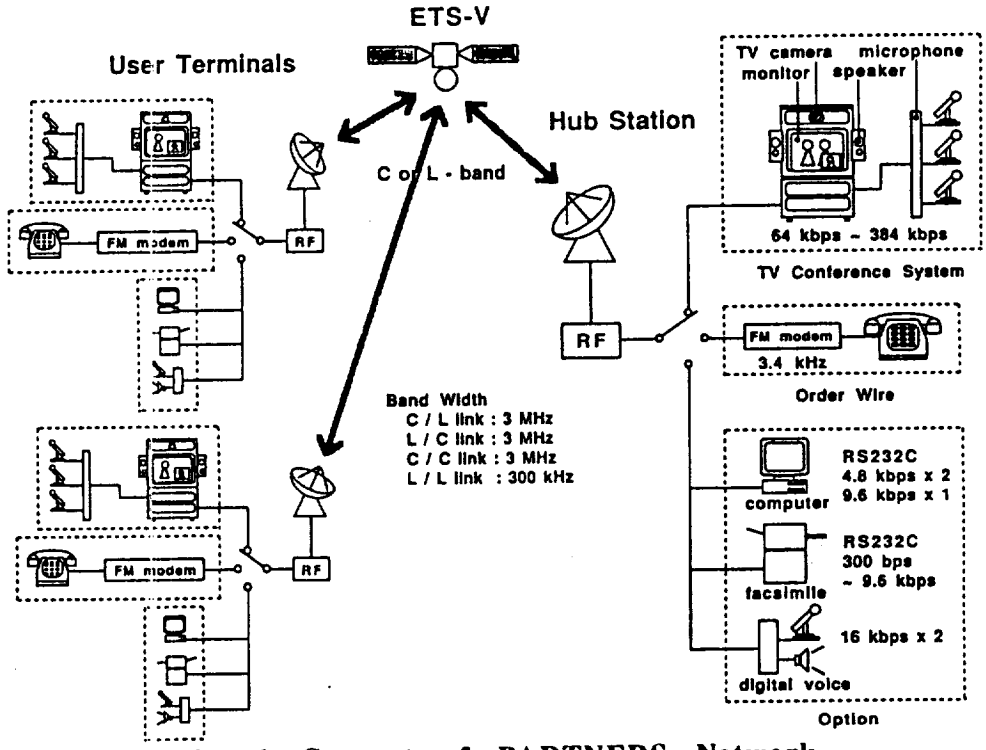

Fig. 1 Concept of PARTNERS Network.

started in August, 1992. CRL, Ministry of Posts and Telecommunications, the National Space Development Agency of Japan (NASDA) and the Science and Technology Agency are carrying forward this project in cooperation with educational institutions, government agencies, organizations in Japan and in Asia-Pacific countries.

Main purposes of this project are to support the peoples in various areas including education, health, marine resource management, and environment and communications, and to promote international collaboration for space activities in the Pan-Pacific region through a low-cost satellite communications network, as shown in Fig. 1. Contents of this project are summarized as follows.

(1)Transfer of Space Technology
- -Cooperative researches on radio-wave propagation characteristics in satellite paths with researchers in the Asia-Pacific countries.
- -Education programs on space technologies for the people in developing countries.
- -Cooperative research on the optimum satellite communications systems for remote rural areas.
- -Cooperative research on satellite tele-education systems for rural areas.

(2)Exchange of Information
- -Earth environment.
- -Space development related activities.
- -Education programs, medical treatment and researches: demonstrations of a tele-education system, a tele-medicine system.

(3)Interchange between Organizations
- -Various events, for example, an open forum on space science for young generations.
- -TV conference via satellites.
- -Cooperative events with another ISY projects.

Now, we are now constructing a TV conference network using ETS-V with simple and low-cost earth stations at

about six places in the Asia-Pacific region.

3. Advanced Communications Satellite Projects

Early in the 21st century, needs for personal communications will rapidly increase in fixed and mobile satellite communications services. A mobile satellite system will provide communications services for not only airplanes, ships and land-mobiles but also hand-held terminals and portable VSATs. Furthermore, demands for various high quality satellite broadcasting services such as HDTV and high quality sound broadcasting will also increase. Therefore, development of elementary technologies for a hand-held terminal, a large satellite antenna and beam interconnecting is required to realize low-cost and user-friendly terminals.

In Japan, to develop these advanced technologies, two engineering test satellite projects are in progress. One of the satellites is ETS-VI and another is COMETS.

3.1 ETS-VI Project [2][3]

ETS-VI is a two-ton class, three-axis-stabilized geostationary satellite as shown in **Fig. 2**, and is scheduled to be launched in 1993 by a Japanese H-II rocket. One of main missions is to develop fundamental technologies for advanced inter-satellite communication systems.

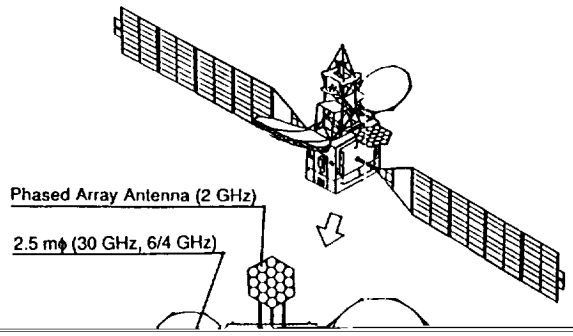

Table 1 Features of ETS-VI.

Bus System	
Shape	Rectangular body with deployable solar paddles
Weight	Approx. 2 tons (beginning of life)
Payload capacity	660 kg
Attitude Control	3-axis-stabilization
Life	10 years for satellite bus
Electric Power	4100 W (end of life at summer solstice)
Launch Vehicle	H-II rocket
Launch Date	Summer, 1993
Orbit	153.8 degrees East
Communication Experiment Mission	
-Ka-band Multibeam Fixed Satellite Communications	
-S-band Mobile Satellite Communications	
-S-band Inter-satellite Communications	
-Ka-band Inter-satellite Communications	
-Millimeter-wave Satellite Communications	
-Optical Satellite Communications	

The major characteristics of ETS-VI and experimental communication payloads are summarized in **Table 1**. ETS-VI is equipped with two large antennas for fixed (Ka and C band) and mobile (S band) satellite communications, a S-band phased array antenna, a Ka-band and a millimeter wave band gimbaled antennas and an optical telescope for inter-satellite communications.

CRL is planning to start the following experiments in late 1993 after the initial check-out of the satellite and continue experiments about three years. The concept of the experiments is shown in **Fig. 3**.

(1)S-band Inter-Satellite Communications

The S-band (2.3/2.1 GHz) Inter-Satellite Communication payload (SIC) has a multibeam phased array antenna in co-operation with NASDA to establish the future Japanese Data Relay and Tracking Satellite System (DRTSS).

The specification of the SIC is

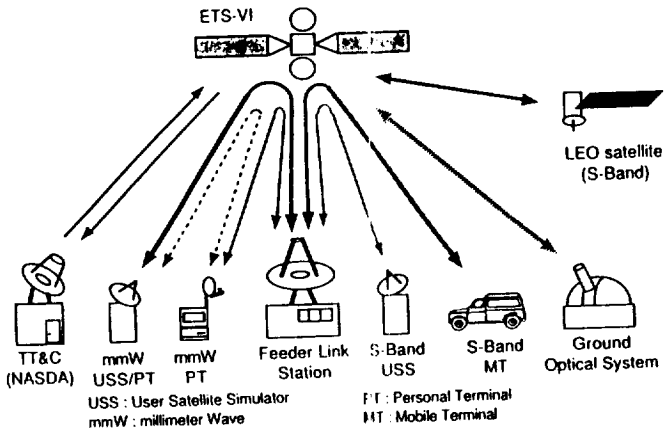

Fig. 3 Concept of ETS-VI Experimental System.

satellites. Candidates of user satellites are the ADvanced Earth Observing Satellite (ADEOS) to be launched in 1996, and the Japanese Experiment Module (JEM) of the International Space Station.

(2)Millimeter Wave Satellite Communications

The millimeter wave transponder has the frequency of 43/38 GHz. These frequencies have been selected, considering the atmospheric attenuation allowable in personal satellite communications and the achievable technology level of millimeter wave devices. The major specifications of the millimeter wave transponder are summarized in **Table 3**. Two high power GaAs FET amplifiers are equipped in the ETS-VI satellite: One has the output power of 0.8 Watts and another has 0.5 Watts. The noise figure of a low-noise amplifier of HEMT is 5.2 dB. The objectives of this mission are to develop high data rate inter-satellite communication technology and to study the feasibility of personal communication systems.

Table 2 System Performance of SIC.

Frequency	2106.4 MHz ±3 MHz for forward 2287.5 MHz ±2.5 MHz for return
Antenna	Onboard beam forming multi-beam phased array antenna
No. of Beams	1 for forward 2 for return
Tracking Range	10 conical (covering LEO satellites below 1000 km in altitude)
G/T	> -4.4 dB/K
EIRP	> 34.1 dBW

Table 3 Major Specifications of ETS-VI Millimeter-Wave Transponder.

Frequency	38 GHz 30 MHz for forward 43 GHz 30 MHz for return
Amp. Type	SSPA (GaAs FET)
Output Power	0.8 W (SSPA1), 0.5 W (SSPA2)
Noise Figure	5.2 dB (HEMT)
Freq. Stability	$1.7\ 10^{-7}$

(3)Optical Inter-Satellite Communications

The onboard optical communication payload (Laser Communication Equipment, LCE) has fundamental optical communication functions with a telescope of 75 mm in diameter, which has a beam pointing, acquisition and tracking mechanism with a gimbal mirror, an aluminium-gallium-arsenide laser diode transmitter at a wavelength of 0.83 microns, a silicon avalanche photo diode receiver at a wavelength of 0.51 microns, modulator/demodulator for 1.024 Mb/s pulse modulation. These features are summarized in **Table 4**. This optical communications system is expected to be much smaller, to consume less power and to be able to carry more information than the radio frequency inter-satellite systems.

3.2 COMETS Project [4]

In 1990, the Government of Japan has authorized the COMETS project. COMETS is a three-axis-stabilized geostationary satellite with three deployable antennas for Ka- and S-band inter-satellite links, millimeter wave and Ka-band mobile communication links, and Ka-band broadcasting links, as shown in **Fig. 4**. COMETS will be launched by a H-II rocket at the beginning of 1997 to develop key technologies of advanced

Table 4 Major Specification of LCE.

Wave Length	0.83 mm for down link 0.51 mm for up link
Telescope	75 mmf (Magnification:15)
Laser Source	AlGaAs LD
Output Power	13.8 mW
Detector	Si-APD
Data Rate	1.024 Mb/s
Weight	22.4 kg

satellite communications and broadcasting. **Table 5** shows features of COMETS. Three mission payloads are shown below.
(1)Advanced Mobile Satellite Communications

Advanced mobile satellite communications payloads using Ka-band and millimeter wave is being developed by CRL to develop key technologies for future advanced satellite communications systems at higher frequencies. **Figure 5** shows a service concept of the advanced satellite communications system.

The two-meter Ka-band antenna for mobile communications links has one spot beam for millimeter wave links and two spot beams for Ka-band links. These beams are interconnected onboard with an IF filter ban method or baseband processing of a regenerative transponder. The specification of this payload is shown in **Table 6**. In the filter bank method, signals from an up-link beam are divided by the IF filter bank and sent to its destination beam. In the baseband processing, SCPC signals in up-links are demodulated to baseband signals and are switched and multiplexed to TDM signals on its destination beam. Onboard channel assignment is achieved by baseband switching.

Table 5 Features of COMETS.

Bus System	
Platform	Based on ETS-VI
Weight	Approx. 2 tons (in orbit)
Mission Life	3 years
Launch Vehicle	H-II rocket
Launch Date	1997
Communication Experiment Mission	
- Advanced Mobile Satellite Communications in Millimeter-wave and Ka-band	
- Advanced Satellite Broadcasting in Ka-band	
- Inter-satellite Communication in Ka-band and S-band	

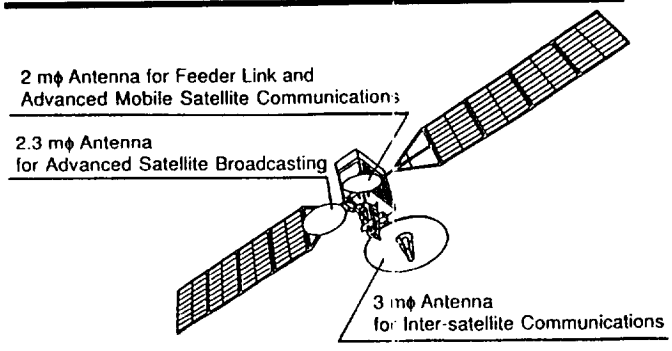

Fig. 4 Conceptual Sketch of COMETS.

Table 6 Outline of COMETS Advanced Mobile Satellite Communications Mission Payloads.

Antenna	
Diameter	2 m (Ka-band/mm-wave)
No. of Beams	3 (2 Ka-band, 1 mm-wave)
Polarization	Circular
Transponder	
Two Ka-band (20W/10W SSPA)	
One millimeter-wave (20W TWTA)	
Operating mode	
- 3 3 Matrix Beam Interconnecting by IF filter bank	
- 8 ch SCPC/TDM Baseband Regeneration	

(2)Advanced Satellite Broadcasting

The Ka-band advanced direct broadcasting payload is developed by CRL and NASDA. Major specifications are shown in **Table 7**. The purpose of this mission is to develop Ka-band HDTV broadcasting technologies which is higher quality than the existing commercial Ku-band satellite broadcasting in Japan. Furthermore, key technologies for various broadcasting services using Integrated Services Digital Broadcasting (ISDB) and multibeam satellite broadcasting experiments for local broadcasting services.

(3)S-band and Ka-band Inter-Satellite Communications

As mentioned in the section of the ETS-VI project, inter-satellite links compatibility at S-band frequencies will achieve among NASA, ESA and NASDA systems. To operate high data rate in inter-satellite links, NASDA is developing Ka-band inter-satellite systems and planning to carry out experiments in the COMETS project. Both S-band and Ka-band inter-satellite payloads are equipped in COMETS to develop key technologies for large satellite antennas, high accuracy acquisition and tracking systems, high data rate inter-satellite systems.

4. Concluding Remarks

In this paper, communications satellite projects of ETS-V, ETS-VI and

Table 7 Outline of the COMETS Advanced Satellite Broadcasting Mission Payloads.

Frequency	22 GHz band
Band Width	120 MHz
Antenna	
Diameter	2.3 m
No. of Beams	2 (two areas in Japan)
Polarization	RHC
Gain	> 44 dBi (field of view)
Transponder	> 200 W (TWTA)

COMETS are briefly reported. Propagation measurements are conducted or planned by these satellites at many different frequencies as well as satellite communications experiments. **Table 8** summarizes available frequencies for propagation measurements, satellites and its missions. The frequencies range from 1.5 GHz to 47GHz. Configuration of the measurement system in the ETS-VI and COMETS experiments is now under consideration. The results of L-band propagation measurements using ETS-V for mobile satellite communications were presented in NAPEX XV(1).

Table 8 Available Frequencies and Satellite for Propagation Measurements.

Frequency bands	Satellite	Corresponding Missions
1.6/1.5 GHz	ETS-V	Mobile satellite com.
2.2/2.1 GHz	COMETS	Inter-satellite com.
2.3/2.1 GHz	ETS-VI	Inter-satellite com.
2.6/2.5 GHz	ETS-VI	Mobile satellite com.
6/5 GHz	ETS-V	Feeder links & sat. com.
26/23 GHz	COMETS	Inter-satellite com.
30/20 GHz	COMETS	Feeder links
28/21 GHz	COMETS	Satellite broadcasting
30/20 GHz	ETS-VI	Feeder links
30.8/21.0 GHz	COMETS	Mobile satellite com.
32/23 GHz	ETS-VI	Inter-satellite com.
43.0/38.0 GHz	ETS-VI	Fixed satellite com.
46.9/43.8 GHz	COMETS	Fixed satellite com.
510/830 nm	ETS-VI	Optical inter-sat. com.

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