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Plan of Advanced Satellite Communication Experiments using ETS-VI

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Abstract--In 1992, an Engineering Test Satellite VI is scheduled to be launched by an H-II rocket. The missions of ETS-VI are to establish basic technologies of inter-satellite communications using S-band, millimeter waves and optical beams and of fixed and mobile satellite communications using multibeam antenna on board the satellite. This paper introduces a plan of the experiments.

1.Introduction

An Engineering Test Satellite VI (ETS-VI) is a 2-ton class, three axis stabilized satellite as shown in Figure 1, which is scheduled to be launched in 1992 by an H-II rocket. One of main missions of the ETS-VI is to develop basic technologies for advanced satellite communication systems in the future. This paper presents brief introduction for a plan of propagation and communication experiments using the ETS-VI.

2.Experimental system

The major characteristics of the ETS-VI and experimental communication payloads are summarized in Table 1. The ETS-VI has basic missions to establish advanced technologies such as inter-satellite communications, mobile satellite communications and fixed satellite communications (Shiomi et al, 1988) (Nakagawa et al, 1988)(Kitahara et al, 1989). Communications Research Laboratory (CRL) has three missions, and these are summarized as follows.

(1)S-band inter-satellite communications

CRL develops S-band (2.3/2.1GHz) inter-satellite communication payload (SIC) with a multibeam phased array antenna in cooperation with National Space Development Agency of Japan (NASDA). The specification of the SIC is summarized in Table 2. The SIC is compatible with the S-band Multiple Access (SMA) system of NASA's TDRSS. CRL and NASDA plan to conduct fundamental tracking and data relay experiments between ETS-VI and low orbit satellites. The SIC can also be used for the data relay of TDRSS SMA's user satellites. Figure 2 shows a concept of an S-band inter-satellite communication system.

(2)Millimeter wave satellite communications

CRL develops a millimeter wave (43/38GHz) transponder on the basis of research through the ETS-II (1977) and Japanese ECS (1979) satellite programs. The frequencies 43/38GHz are selected considering the atmospheric attenuation allowable in personal satellite communications and the achievable technology level of millimeter devices. The major specifications of the millimeter wave transponder are summarized in Table 3. The objectives of millimeter wave mission are to develop high data rate inter-satellite communication technology and to study the feasibility of personal satellite communication system. Figure 3 shows a concept of this mission.

(3)Optical inter-satellite communications

CRL develops an optical communication system with a telescope of 75 mm in diameter, which has a beam pointing/tracking mechanism with a gimbal mirror. The onboard optical communication payload (Laser Communication Equipment, LCE) has fundamental optical communication functions with a laser diode transmitter of wave length 0.83 micron, a beam point-ahead mechanism, a receiver of wave length 0.51 micron, modulator/demodulator subsystems, and so on. These feature are summarized in Table 4, and a concept of this mission is shown in Fig. 4.

3.Frequency bands available for propagation experiments

The following frequency bands, which are used for corresponding missions, can be used for the propagation experiments.

2.3/2.1GHz	S-band inter-satellite communications
2.6/2.5GHz	Mobile satellite communications
30/20 GHz	Feeder links for the ETS-VI
32/23 GHz	Ka-band inter-satellite communications
43/38 GHz	Millimeter wave satellite communications
590/360THz	Optical inter-satellite communications

4.Conclusion

Experiments on advanced satellite communications will start in 1992 using an ETS-VI satellite. Propagation experiments are scheduled to carry out with several frequency bands such as 2GHz, 20GHz, 40GHz and 590THz.

References

Shiomi, T. et al, "Plan of Advanced Satellite Communications Experiment Using ETS-VI," International Symposium on Space Technology and Science (ISTS), Sapporo, May 1988.

Nakagawa, K. et al, "Fixed and Mobile Multibeam Communications Experiment Payload for ETS-VI," ISTS, Sapporo, May 1988.

Kitahara, H. et al, "An Overview of Japan's Engineering Test Satellite VI (ETS-VI) Project," ICC'89, 52.3, Boston, June 1989.

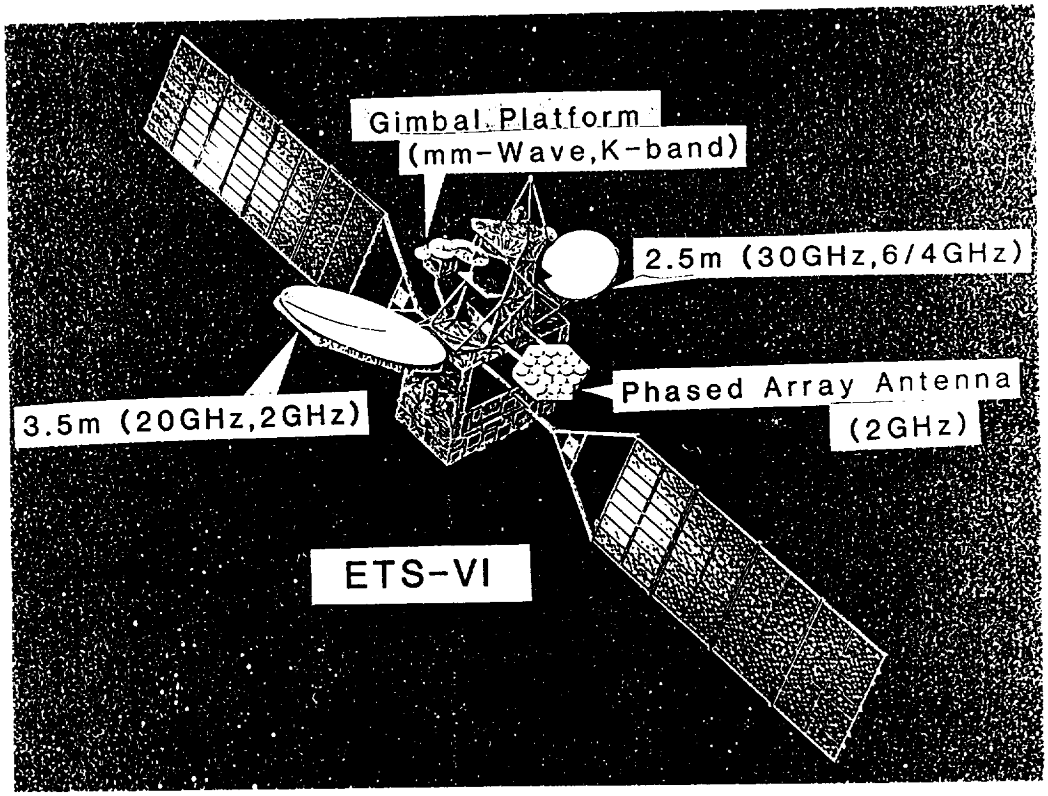

Fig. 1 ETS-VI

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 1992
Payloads for Communications Experiment	
Fixed and Mobile Satellite Communications	
S-band Inter-satellite Communications	
K-band Inter-satellite Communications	
Millimeter-wave Satellite Communications	
Optical Satellite Communications	

Table 2 System performance of SIC

Frequency (GHz)	Forward 2.1034-2.1094 Return 2.2845-2.2905	
Data Rate	Less than 1.5 Mbps	
Modulation	PCM-PSK/SSMA	
Bandwidth	6 MHz	
Antenna	Multibeam Phased Array	
Field of View	20 degrees (covering satellites below 1000 km altitude)	
Return Link	Number of Beams	2
	Minimum Gain	27.4 dB (FOV)
	Polarization	LHC
Forward Link	Number of Beam	1
	Minimum Gain	27.1 dB (FOV)
	EIRP	35.5 dBW
	Polarization	LHC

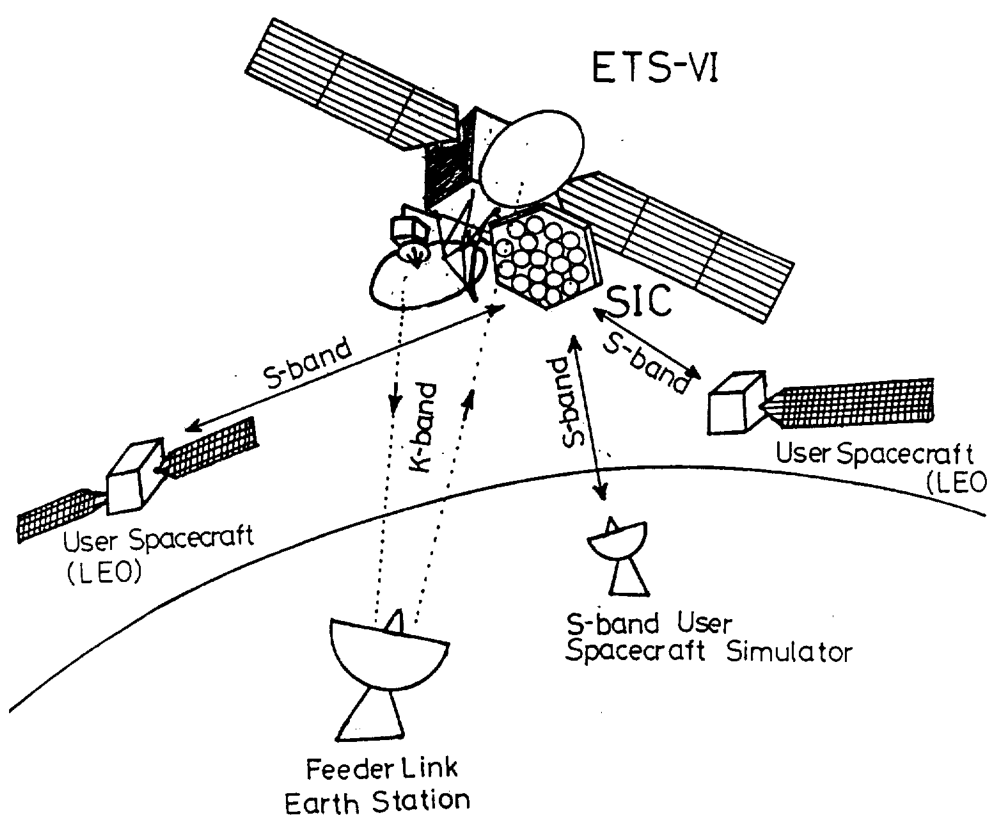

Fig. 2 S-band inter-satellite communications

Table 3 Specifications of ETS-VI millimeter-wave transponder

Frequency		
Receive	43.0	GHz
Transmit	38.0	GHz
IF	1.98	GHz
Receiver NF (LNA front-end)	6.0	dB
Transmit Power (SSPA)	0.5	W
Local Oscillator		
Stability	3×10^{-7}	(-10 to +40 deg C)
Phase Noise	-75	dBc/Hz

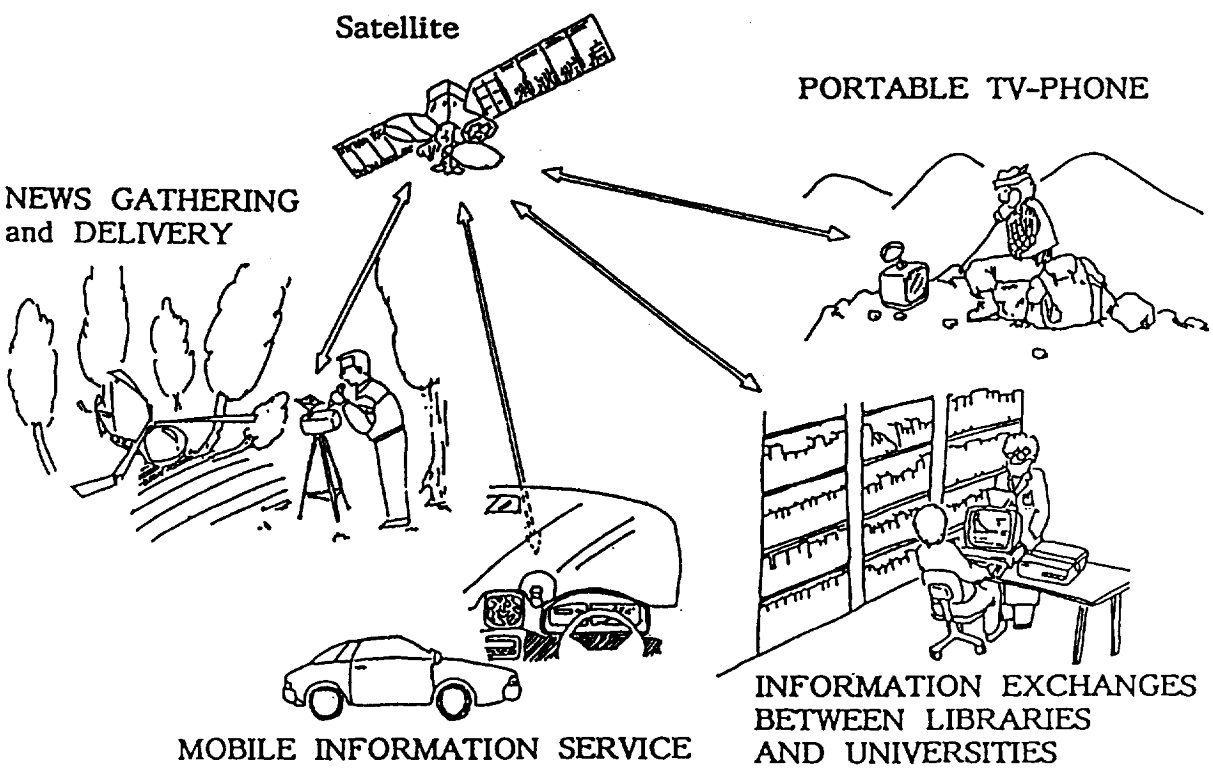

Fig. 3 Millimeter-wave personal communications via ETS-VI

Table 4 Main Features of LCE

Antenna	75 mm diameter telescope FOV 0.46 deg
Tracking and Pointing	
Coarse	Two-axis gimbal mirror and CCD sensor Beam steering angle 3.0 deg
Fine	Fine-pointing mechanism with mirrors and 4QD (FOV: 400 microrad) Pointing accuracy 2 microrad
Point-ahead Mechanism	mirrors on laminate-actuators
Receiver	Wave length 0.51 micron Bit rate 1 Mbps Detection Direct detection by APD (FOV:200 microrad)
Transmitter	Redundant laser diodes(AlGaAs) Wave length 0.83 micron Transmit power 10 mW Bit rate 1 to 10 Mbps
Modulation	Intensity Modulation with Manchester code

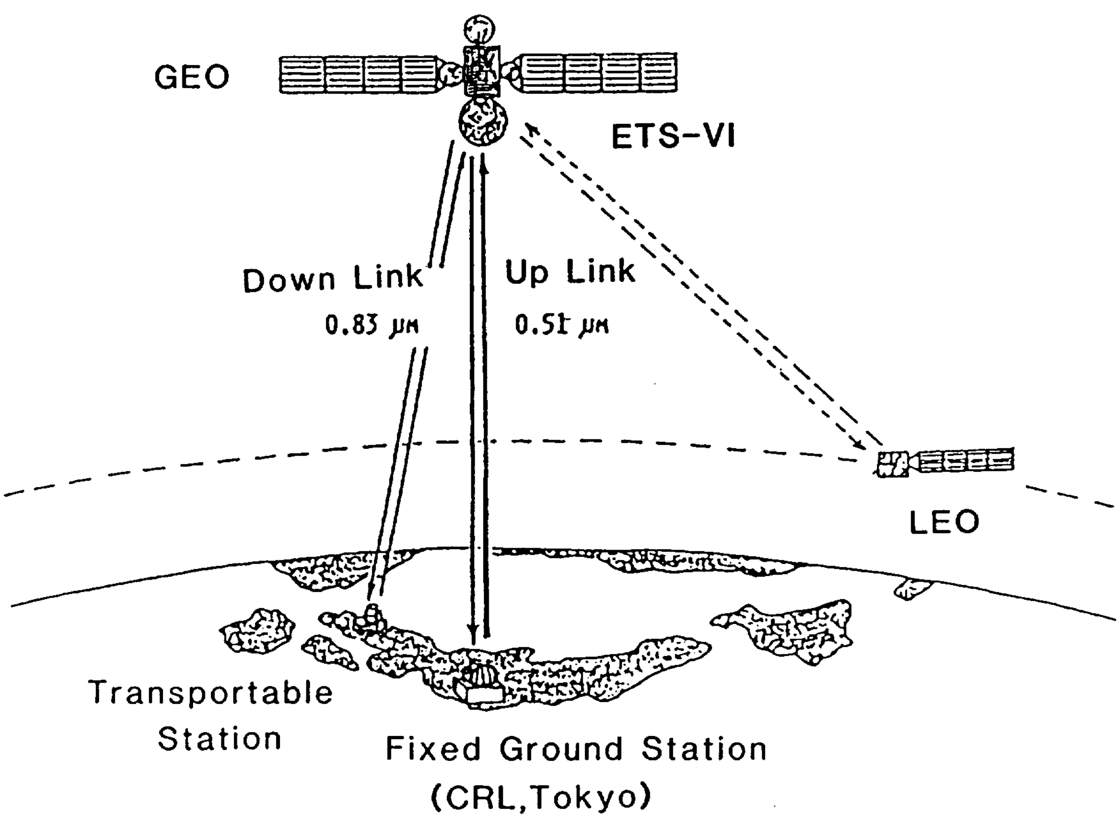

Fig. 4 Experimental system of optical satellite communications