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The Japanese Payloads for the N-Launch Vehicles

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PAYLOADS FOR THE N-LAUNCH VEHICLES

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1. INTRODUCTION

National Space Development Agency of Japan (NASDA), which was established in 1969 as the nucleus of the national space development effort, is promoting a variety of space projects in accordance with the Space Development Programs which are decided and revised annually by the Space Activities Commission in line with the basic space development plan authorized by the Prime Minister.

Since 1975, NASDA has launched the following satellites from Tanegashima Space Center: ETS-I (KIKU), ETS-II (KIKU-2), ISS-a (UME), ISS-b (UME-2), ECS-a (AYAME), ECS-b (AYAME-2), ETS-IV (KIKU-3) and GMS-2 (HIMAWARI-2). The launch vehicles for these satellites are the N-I and the N-II launch vehicles, of which outline has been presented last year at this congress.

At present NASDA is developing the Engineering Test Satellite III (ETS-III), Communications Satellite-2a and 2b (CS-2a and 2b), Broadcasting Satellite-2a and 2b (BS-2a and 2b) and Marine Observation Satellite-1 (MOS-1). It is also planning to develop the Engineering Test Satellite V (ETS-V) and Earth Resources Satellite-1 (ERS-1), which are to be launched by H-I launch vehicle.

The outlines of these satellites are shown in Table 1.

2. METEOROLOGICAL SATELLITES

On August 11, 1981, NASDA launched successfully the second geostationary meteorological satellite "HIMAWARI-2 (GMS-2)" by use of the second N-II vehicle at Tanegashima Space Center.

HIMAWARI-2 was developed five years period by NASDA with the dual objectives of promoting meteorological satellite technologies and improving domestic meteorological operations. Its function is almost the same as for the first Japanese meteorological satellite that had been sending cloud-cover picture signals to the earth for display of global meteorological images in the form of weather forecasts on TV and in newspapers.

HIMAWARI-2 is capable of taking two kinds of earth images in about 30 minutes by means of visible and infrared ray scanning radiometers. The images are received at the ground base at intervals of three hours for monitoring typhoons, low atmospheric pressures and local meteorological phenomena, for observation and analysis of cloud distribution, for observation of temperatures of the clouds and the oceans, as well as for determining wind direction and velocity.

In addition to the image sensors, HIMAWARI-2 has various equipments for accumulating and distributing meteorological data, for relaying data obtained at marine vessels, buoys and aircraft, and for supplying earth images processed at the Meteorological Agency to data utilization stations in the West Pacific region by facsimile transmission. At present, the meteorological images of the earth taken by HIMAWARI are being transmitted by facsimile to thirteen countries, contributing immensely to close international cooperation.

After trial operation, "HIMAWARI-2" will conduct full-scale meteorological operations in April, 1982.

The configuration of the spacecraft is shown in Fig. 1 and Table 2.

3. COMMUNICATION SATELLITES

The communication satellite program with CS-2 intends to establish the first domestic operational satellite communications system in Japan. The space segment of this system is composed of two satellites, CS-2a and

CS-2b; the latter for the back up in the orbit. These satellites are being developed by NASDA, and will be launched in the first and the third quarter of 1983 respectively by N-II launch vehicles.

Nippon Telegraph & Telephone Public Corporation (NTT), National Police Agency, Fire Defense Agency, Ministry of Constructions, Japanese National Railways and electric power companies will use the CS-2. The user's earth stations will be of various types with 2m, 3m, 5m or 10m diameter antennas.

The design of CS-2 is based on the former CS, which is a spin stabilized satellite with a mechanical despun communication antenna. The communication subsystem consists of two microwave transponders (6/4 GHz) and six quasi-millimeter-wave ones (30/20 GHz). The gain of the antenna of the quasi-millimeter-wave band is more than 33 dB at the edge of the Japanese mainland. The gain of the antenna of the microwave band is more than 25 dB over all of Japan. The spacecraft configuration is shown in Fig. 2 and Table 3.

The concept of CS-3, the next generation of CS, is now under study. The CS-3 will be launched around 1988, when the H-I launch vehicle with approximately 550 Kg geostationary launching capability will be available. The mission objectives of CS-3 are considered as follows, a) to continue and extend the satellite communication services which will be provided by CS-2, b) to further specialized satellite communications services (broadcasting mode, digital communications services etc.). The spacecraft is supposed to be 550 Kg in weight and have a 7 year design life. The conceptional design is being carried out at present.

4. DIRECT BROADCASTING SATELLITES

The purpose of the Operational Broadcasting Satellite program with BS-2 is to establish the first domestic operational broadcasting system in Japan. The mission objectives of this program are as follows, a) to provide television broadcasting services by NHK (the National Broadcasting Corporation) over poor reception areas. b) to further the development of technology for the broadcasting satellite.

The system consists of two satellites (BS-2a, BS-2b) and ground segments. Fixed transmitting stations will be located at Tokyo Broadcasting Center and Osaka Broadcasting Hall, and transportable transmitting stations in the field.

The BS-2a and BS-2b are to be launched into geostationary orbit at 110°E longitude with N-II vehicles in the first and the third quarter of 1984 respectively. BS-2a is for actual operation, while BS-2b is for back up in the orbit.

The configuration of the spacecraft is shown in Fig. 3 and Table 4.

The BS-2 design is based on the former BSE, which is a tri-axis stabilized satellite with solar power generation capability of 950 W at beginning. The mission payload consists of two active and one back-up transmitters (12 GHz, 100 W), which enable the broadcasting of two color TV programs to be done simultaneously. The antenna beam is shaped so as to cover the whole of Japan. The BSE operation proved that the TV signal to noise ratio is more than 45 dB at the edge of the Japanese mainland with parabolic receiving antenna of 1.6m diameter and at the border of Japanese territory with an antenna of 2.4 to 4.5m diameter.

BS-3, the next generation of Japanese broadcasting satellite will come in around 1989 due to the end of the design life of BS-2. The launch vehicle will be H-I vehicle and the payload of BS-3 will be transmitters which exceeds that of BS-2 in the number of channels and power of transmission.

5. EARTH OBSERVATION SATELLITES

Japan's first earth observation satellite MOS-1 is an experimental satellite to collect information on earth surface and to establish fundamental technologies relative to earth observation satellites. The satellite which is under development, is scheduled to be launched in 1986 by N-II vehicle into a sun synchronous orbit at an altitude of approximately 900 Km. Its principal missions are as follows:

a) to establish fundamental technologies which are common to both marine and land observation satellites,

b) to observe the state of the sea surface and atmosphere by use of visible, infrared and microwave radiometers.

In MOS-1, Multispectral Electronic Self-Scanning Radiometer (MESSR), Visible and Thermal Infrared Radiometer (VTIR) and Microwave Scanning Radiometer (MSR) are to be installed. MESSR is a visible and near-infrared radiometer with a push-broom scanning sensor using charge coupled devices (CCD's). VTIR is a mechanical scanning type of radiometer used to measure the sea-surface temperature. MSR is a Dicke type used radiometer to measure the content of atmosphere water vaper. MOS-1 is also to carry a transponder for the experimental Data Collection System (DCS), which collects the data acquired by Data Collection Platforms (DCP).

MOS-1 is three-axis stabilized and weighes about 750 Kg. The configuration of the spacecraft is shown in Fig. 4 and Table 5.

Another earth observation satellite is the Earth Resources Satellite-1 (ERS-1) which is the first satellite of Land Observation Satellite Series. The principal mission objective of this satellite is to collect remotely sensed data of the surface of the earth relating to geological survey, land use, agriculture, forestry, fishery, environment preservation, coastal area monitoring. Since 1980, some of the critical hardware for Synthetic Aperture Radar (SAR) has been studied and tested by NASDA. The ERS-1 is planned to be launched by H-I vehicle in 1989. The concept of the spacecraft is shown in Fig. 5.

6. ENGINEERING TEST SATELLITES

The first engineering test satellite of NASDA was the Engineering Test Satellite-I (ETS-I: KIKU), which was launched in 1975 into a circular orbit at an altitude of approximately 1,000 Km by the first N-I launch vehicle in order to establish the basic technologies of launching, tracking control, and operating a satellite.

The Engineering Test Satellite-II (ETS-II: KIKU-2) was launched by the third N-I vehicle in 1977 in order to acquire launching technologies of geostationary satellite and to test the function of attitude control of a spin stabilized satellite with an antenna despun mechanism. By launching this satellite, Japan became the third country in the world that succeeded in putting a satellite into geostationary orbit.

The Engineering Test Satellite IV (ETS-IV: KIKU-3) was launched in early 1981 into a geostationary transfer orbit by the first N-II vehicle in order to confirm the performance of the vehicle. This satellite weighing 640 Kg was the first heavy satellite manufactured in Japan.

The Engineering Test Satellite III (ETS-III) is scheduled to be launched this coming August by the last N-I vehicle into a circular orbit at an altitude of approximately 1,000 Km. The principal objectives of the satellite are to conduct a series of experiments, including three-axis attitude control, extension of deployable solar paddles, in order to promote technologies common to large-scale satellite which requires large amount of electric power.

The attitude of this spacecraft is stabilized by the attitude control subsystem, which consists of Earth sensor, Sun sensor, gyros, three reaction-wheels and attitude control electronics. The propulsion subsystem was hydrazine monopropellant and it is operated in a blow-down mode. The spacecraft is injected into the orbit in a spinning mode via the solid third stage of N-I vehicle and then it is despun and put in three-axis control. Successful deployment of solar paddles and the operation of ion engine are also of prime importance. The on-board vidicon camera takes pictures of the surface of the earth in order to evaluate the attitude control performance. The configuration of the spacecraft is shown in Fig. 6 and Table 6.

The Engineering Test Satellite V (ETS-V) is planned to be launched by the second H-I vehicle. The principal objectives of this satellite are as follows;

a) to confirm the performance of the H-I vehicle and the apogee motor to inject 550 Kg payload into geostationaly orbit,

b) to acquire technologies to handle a three-axis stabilized geostationary satellite.

The ETS-V is in definition phase at present and is scheduled to be launched in 1987.

CONCLUDING REMARKS

We recognize that the use of application satellites could be enhanced immensely by international cooperation. In this respect, we hope that Japan could participate in international collaboration of space development activities by using its own technologies.

Table 1. Outlines of NASDA satellites

Satellite	Mission	Weight and Dimension	Orbital Parameters	Launch Date/Vehicle	Remarks / Main Experimenter/User
Engineering Test Satellite-I (ETS-I) "KIKU"	NASDA's first satellite launched to confirm vehicle launching technology, acquire satellite tracking and control technology, as well as conduct antenna extention experiment and examine satellite environment.	Weight: Approx. 82.5 kg Shape: 26 sided sphere Dia.: Approx. 80 cm	Type of orbit: circular Period: Approx. 106 min. Altitude: Approx. 1,000 km Inclination: Approx. 47°	September 9, 1975 N-I #1	Mission phase out *1 NASDA
Ionosphere Sounding Satellite (ISS) "UME"	Observation of the ionosphere for improvement of forecasting accuracy and warning systems regarding short-wave Communications. However, the satellite lost contact one month after the launching due to the malfunction in the onboard power system.	Weight: Approx. 139 kg Shape: Cylinder Dia.: Approx. 94 cm Ht.: Approx 82 cm	Type of orbit: circular Period: Approx. 105 min. Altitude: Approx. 1,000 km Inclination : Approx. 70°	February 29, 1976 N-I #2	Lost contact RRL*2
Ionosphere Sounding Satellite (ISS-b) "UME-2"	Back up of UME, mission of which is the same as above.	Weight: Approx. 142 kg Shape: Cylinder Dia.: Approx. 94 cm Ht.: Approx. 82 cm	Same as above	February 16, 1978 N-I #4	Mission phase out RRL
Engineering Test Satellite-II (ETS-II) "KIKU-2"	Acquistion of launching and tracking/control technologies as well as attitude control technology of a geostationary satellite and check for the functions of onboard equipment.	Weight: Approx. 130 kg Shape: Cylinder Dia.: Approx. 140 cm Ht.: Approx. 90 cm	Type of orbit: Geostationary (130° E longitude)	February 23, 1977 N-I #3	Mission phase out NASDA RRL
Experimental Communications Satellite ECS) "AYAME"	Establishment of launching, tracking/control, and attitude control technologies of a geostationary satellite as well as experiments on millimeter-waves. However, the satellite lost contact during the apogee motor firing.	Weight: Approx. 130 kg Shape: Cylinder Dia.: Approx. 140 cm Ht.: Approx. 95 cm	Type of orbit: Geostationary (145° E longitude)	February 6, 1979 N-I #5	Lost contact RRL
Experimental Communications Satellite (ECS-b) "AYAME-2"	Back up of AYAME, mission of which is the same as above. However, the satellite lost contact during the apogee motor firing.	Weight: Approx. 130 kg Shape: Cylinder Dia.: Approx. 140 cm Ht.: Approx. 95 cm	Same as above	February 22, 1980 N-I #6	Lost contact RRL
Engineering Test Satellite-III (ETS-III)	Development of production and operation technology for satellites requiring high power. Tests on a variety of functions such as three-axis attitude control, deployable solar paddles and on-board equipment.	Weight: Approx. 385 kg Shape: Box type with deployable solar paddles Ht.: Approx. 195 cm Section: 85x85 cm	Type of orbit: Circular Period: Approx. 105 min. Altitude: Approx. 1,000 km Inclination: Approx. 45°	mid-1982 N-I #7	Development phase NASDA ETL*3 NAL*4

*Note: 1. Acqusition of telemetry data continues
2. Radio Research Laboratories, Ministry of Posts & Telecommunications
3. Electrotechnical Laboratory, Agency of Industrial Science & Technology, Ministry of International Trade & Industry
4. National Aerospace Laboratory, Science & Technology Agency

(continue)

(continued)

Satellite	Mission	Weight and Dimension	Orbital Parameters	Launch Date/ Vehicle	Remarks / Main Experimenter/User
Engineering Test Satellite-IV (ETS-IV) "KIKU-3"	Confirmation of launching performance of N-II vehicle, acquisition of data on launching environment as well as technologies for production and management of large-scale satellites, and test of functions of equipments on board the satellite.	Weight: Approx. 640 kg Shape: Cylinder Dia.: Approx. 210 cm Ht.: Approx. 280 cm	Type of orbit: Geostationary transfer Apogee: Approx 36,000 km Perigee: Approx 225 km Inclination: Approx. 28.5° Period: Approx. 10 hours	February, 1981 N-II #1	Mission phase out NASDA NTT NAL ETL
Geostationary Meteorological Satellite-2 (GMS-2) "HIMAWARI-2"	Improvement of meteorological service in Japan, and development of meteorological satellite technology. Almost the same performance as "HIMAWARI".	Weight: Approx. 340 kg Shape; Cylinder Dia.: Approx. 210 cm Ht.: Approx. 440 cm	Type of orbit: Geostationary (140° E longitude)	August 1981 N-II 2	In operation MSC
Communications Satellite-2 (CS-2a)	Development of communication satellite technology in accordance with increasing demands for satellite communications. Its performance is comparable to "SAKURA".	Weight: Approx. 350 kg Shape: Cylinder Dia.: Approx. 220 cm Ht.: Approx. 350 cm	Type of orbit: Geostationary (135° E longitude)	January to February, 1983 N-II	Development phase Telecommunications Satellite Corporation of Japan
Communications Satellite-2 (CS-2b)	On orbit spare of CS-2a, assuming the same mission as above.	Same as above	Type of orbit: Geostationary (135° E longitude)	August to September, 1983 N-II	Development phase Same as above
Maritime Observation Satellite (MOS-1)	Observation of marine phenomena, especially colors and surface temperature of the sea, and establishment of the fundamental technology of earth coservation satellites.	Weight: Approx. 750 kg Shape: Hexagonal prism with deployable solar paddles	Type of orbit: Sun-synchronous Height: Approx. 900 km Inclination: Approx. 99°	FY 1986 N-II (2stage)	Development phase (Multi-user)
Broadcasting Satellite-2 (BS-2a)	Elimination of the poor TV reception areas, and development of technology for broadcasting satellites, having a performance comparable to "YURI".	Weight: Approx. 350 kg Shape: Box-type with deploy able solar paddles	Type of orbit: Geostationary (110° E longitude)	FY 1983 N-II	Development phase Telecommunications Satellite Corporation of Japan
Broadcasting Satellite-2 (BS-2b)	On orbit spare of BS-2a, assuming the same mission above.	Same as above	Type of orbit: Geostationary (110° E longitude)	FY 1985 N-II	Development phase Telecommunications Satellite Corporation of Japan

Satellite	Mission	Weight and Dimension	Orbital Parameters	Launch Date/Vehicle	Remarks / Main Experimenter/User
Geodetic Satellite-1 (GS-1)	Establishment of a new geodetic network of Japan, regulation of the domestic triangulation net, improvement of the marine geoditic net, as well as development of technology for geodetic satellites.	Weight: Approx. 200 kg Shape: Inflatable ballon-type with about 1,000 of laster reflectors on its surface (Dia.: Approx. 10m)	Type of orbit: Circular Height: Approx. 1,500 km Inclination: Approx. 50°	FY 1985 (TBD) ETV-II	Definition phase NASDA GSI*
Earth Resources Satellite-1 (ERS-1)	Establishment of active-type observation technology and performance of earth resources observation as well as monitoring of land-use, agricalture, forestry, environment, and observation for prevention of hazards and serveilance of coastal area.	Under consideration		FY 1989 H-I (2 stage)	Research & study phase (Multi-user)

*Note: Geographical Survey Institute, Ministry of Construction

Table 2. Parameters of HIMAWARI-2 (GMS-2)

Observation Sensors		
° Visible and Infrared Spin Scan Radiometer		
Wave length (μm)	0.5 ~ 0.75 (Visible)	10.5 ~ 12.5 (Infrared)
Ground resolution (km)	1.25	5
Number of scan lines	10,000	2,500
Time for one scence (min)	25	25
Detector	Photomultiplexer	HgCdTe Semi-conductor

° Space Environment Monitor			
Objects :	protons	electrons	α particles
Sensitive level : (Mev)	0.8 ~ 100	> 2	8 ~ 370

Power System Spin array :	270 W (after 5 years)
Attitude Control Spin Stabilization :	(100 ± 1 rpm)
Weight (kg)	296 (excluding AKM expended 44 kg/ beginning on geostationary orbit)
Design life (year)	5
Fuel storage (year)	3

Table 3. Parameters of CS-2

Communication System		
Frequency band	K band	C band
Up-link (MHz)	27500 ~ 29250	5925 ~ 6425
Down-link (MHz)	17700 ~ 19450	3700 ~ 4200
Number of active transponders	6	2
Band Width (MHz)	130	180
Transmission Power (dBm)	34	34.5
Noise figure (dB)	12	6.2
Antenna gain (dB)	> 33	> 25
Antenna radiation area	Japanese mainland	all over Japan
Power System		
Solar array power (w)	409 (after 5 years)	
Attitude Control		
Spin stabilization	(approx. 90 rpm)	
Antenna pointing accuracy (deg.)	< 0.3	
Weight (kg)	350 (beginning on geostationary orbit)	
Design life (years)	5	

Table 4. Parameters of BS-2

Communication System	
Frequency	
Up-link (GHz)	14.219 and 14.296
Down-link (GHz)	11.919 and 11.996
Band Width (MHz)	27 (each channel)
Transmission Power (W)	100 (each channel)
Noise figure (dB)	< 7.5
Transmission antenna gain	Japan mainland (dB) > 37 All over Japan (dB) > 28
Power System	
Solar array power (W)	825 (after 5 years at summer solstice)
Attitude Control	
Three-axis stabilization ;	zero-momentum
Antenna pointing accuracy (deg)	< 0.1
Weight (kg)	350 (beginning on geostationary orbit)
Design life (year)	5
Fuel storage (year)	> 4

Table 5. Parameters of MOS-1

Observation sensors	
° MESSR	
Object :	multispectral image data of the earth
Wave length (μm) :	0.51 ~ 0.59 0.61 ~ 0.69 0.72 ~ 0.80 0.80 ~ 1.1
Swath width (km) :	100 (each side of nadir)
Ground resolution (km) :	0.05
° VTIR	
Object :	temperature of the sea surface
Wave length (μm)	0.5 ~ 0.7 6 ~ 7 10.5 ~ 11.5 11.5 ~ 12.5
Swath width (km) :	approx. 500
Ground resolution (km) :	0.9 (visible) 2.7 (infrared)
° MSR	
Object :	atmosphere water vaper
Frequency (GHz) :	23.8 and 31.4
Swath width (km) :	approx. 300
Ground resolution (km):	40 and 30
Power System	
Solar paddle	>540 W (after 2 years)
Attitude Control	
Three axis stabilization	(pitch-biased-momentum wheels)
Weight (kg)	750
Orbit	
Sun synchronous	
altitude (km) :	909
inclination (deg) :	99°
Time of passing descending node (hour) :	10 (a.m.)
Design life (year)	2

Table 6. Parameters of ETS-III

Attitude Control	
Three axis stabilization :	digital attitude control electronics 3 reaction wheels
Attitude sensors :	Earth sensor , Rate gyros (X2) Inertial Reference Units (x3)
Accuracy :	0.5° pitch & roll 0.7° Yaw (on altitude 1,000km)
12 thrusters :	N
Power System	
Solar paddle power (W) :	>300 (beginning : a right solar illumination) > 260 (after one year)
Batteries Ni-Cd type :	8 AH X 3
Experimental devices	
° Vidiconcamera :	3 CdSe vidicon tubes
spectral band	0.48 ~ 0.88 μm
number of scan lines	480
° Ion engine	
propellant : electron	bombardment mercury ion
thrust :	0.18 gram weight
specific impulse :	2,200 sec.
° Active thermal control system heat pipe, thermal louver, heater	
° Magnetic attitude control system	
Weight (kg)	385 (beginning)
Design life (year)	1
Orbit	
Circular	
Attitude :	Approx. 1,000 km
Inclination :	Approx. 45°

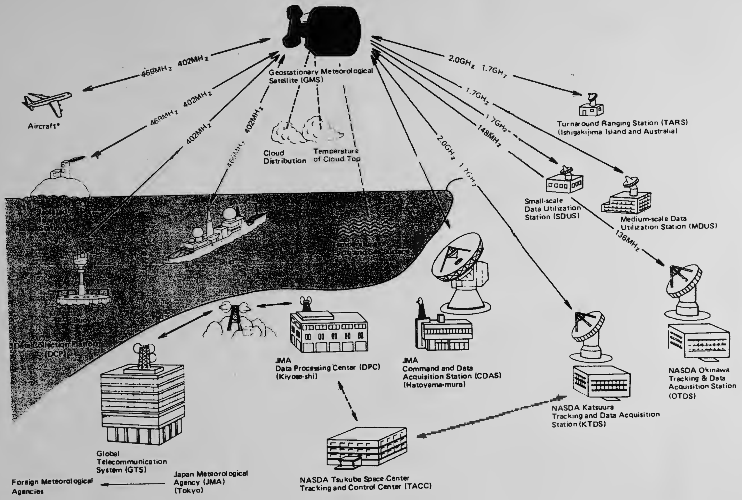
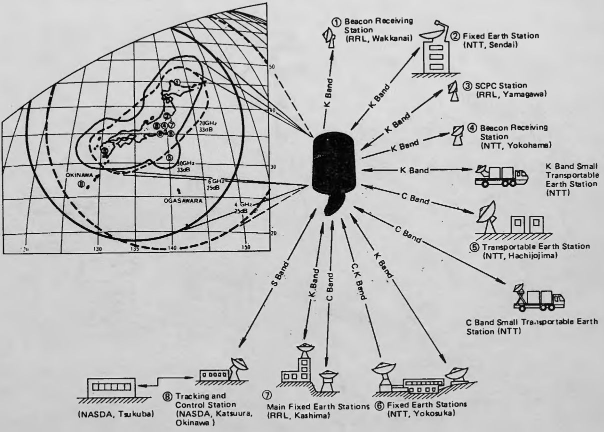


Fig. 1 HIMAWARI - 2



① Beacon Receiving Station (RRL, Wakkanai)
② Fixed Earth Station (NTT, Sendai)
③ SCPC Station (RRL, Yamagawa)
④ Beacon Receiving Station (NTT, Yokohama)
K Band Small Transportable Earth Station (NTT)
⑤ Transportable Earth Station (NTT, Hachijojima)
C Band Small Transportable Earth Station (NTT)
⑥ Fixed Earth Stations (NTT, Yokosuka)
⑦ Main Fixed Earth Stations (RRL, Kashima)
⑧ Tracking and Control Station (NASDA, Katsuura, Okinawa)
(NASDA, Tsukuba)
K Band
C Band
S Band
C,K Band
20GHz 33dB
30GHz 33dB
6 GHz 25dB
4 GHz 25dB
OKINAWA
OGASAWARA

Fig. 2 CS-2

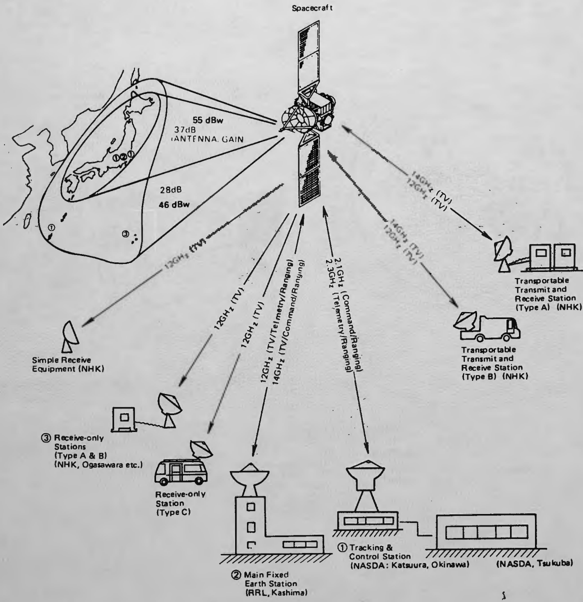

Spacecraft
55 dBw
37dB
ANTENNA GAIN
28dB
46 dBw
12GHz (TV)
12GHz (TV)
12GHz (TV)
12GHz (TV/Telemetry/Ranging)
14GHz (TV/Command/Ranging)
2.1GHz (Command/Ranging)
2.3GHz (Telemetry/Ranging)
14GHz (TV)
12GHz (TV)
14GHz (TV)
12GHz (TV)
Transportable Transmit and Receive Station (Type A) (NHK)
Transportable Transmit and Receive Station (Type B) (NHK)
Simple Receive Equipment (NHK)
③ Receive-only Stations (Type A & B) (NHK, Ogasawara etc.)
Receive-only Station (Type C)
② Main Fixed Earth Station (RRL, Kashima)
① Tracking & Control Station (NASDA: Katsuura, Okinawa)
(NASDA, Tsukuba)

Fig. 3 BS-2

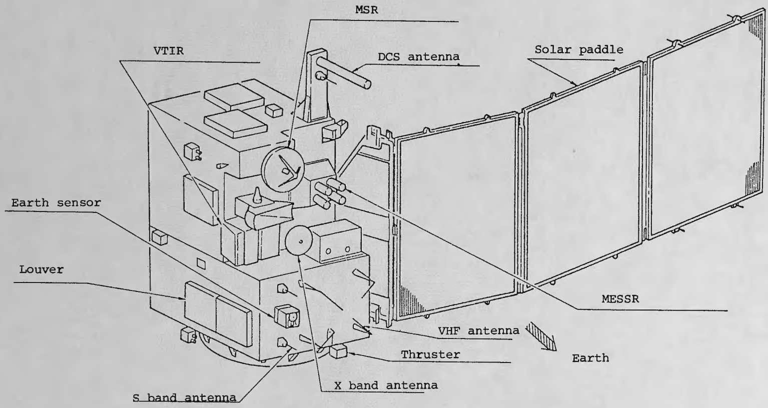


Fig. 4 Configuration of MOS-1

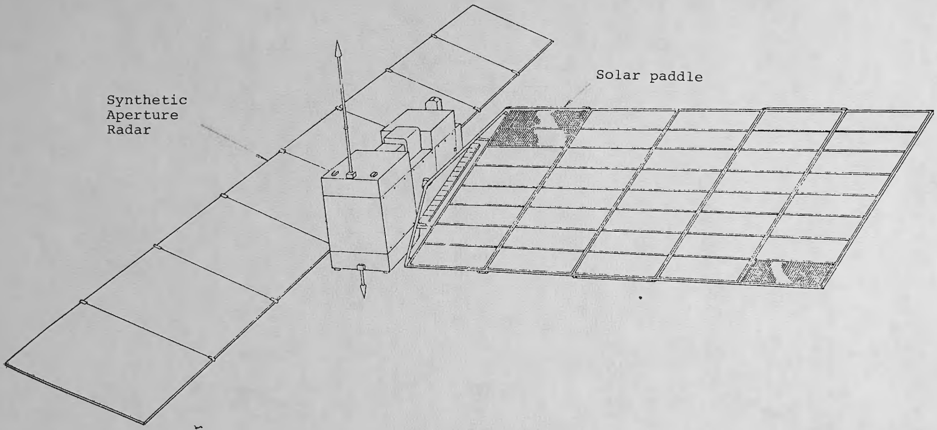


Fig.5 ERS-1 concept

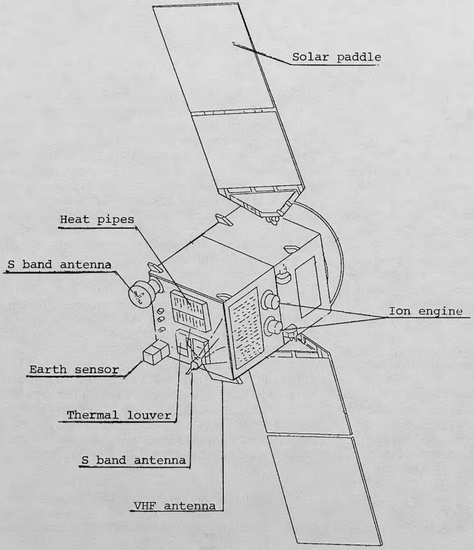


Fig. 6 Configuration of ETS-III