

# ADEOS-II TT&C operation with space network system

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## 1. Introduction

The earth has evolved steadily for extremely long years of 4,000 millions. In recent years, its environment has been undergoing rapid change that has never been happened before such as frequent occurrence of abnormal weather worsening “hole” in the ozone layer, decrease of tropical rain forests, global warming across the world. To clarify their mechanism of dynamic and global activities, the Earth observation by satellite from space will ferret out the approach to the bright future for human life.

Objective of the Advanced Earth Observing Satellite- II (ADEOS-II), as a successor of ADEOS, is to acquire data contributing for international global climate change research, as well as for application such as meteorology and fishery. Among the research areas, ADEOS-II is particularly dedicated to water and energy cycling and carbon cycling.

Scientific goals of ADEOS-II are summarized in three points. To monitor regularly the water and energy cycle as a part of the global climate system, to estimate quantitatively the biomass and fundamental productivity as a part of carbon cycle, which play an important role for global warming, and to observation succeeded from ADEOS. Monitoring of water and energy cycle, among the three above, is the most important one for the ADEOS-II mission.

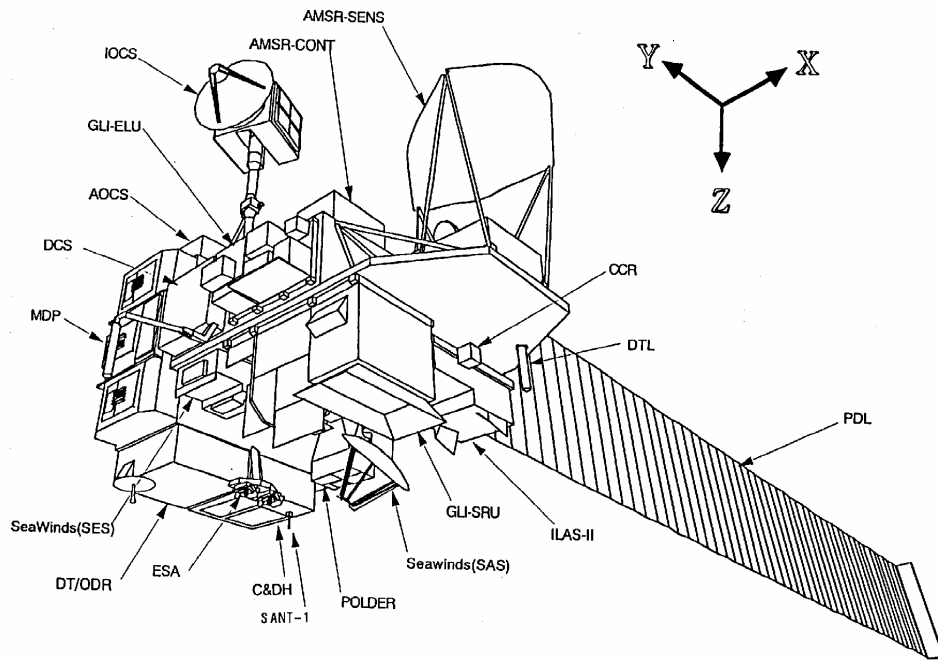
## 2. ADEOS-II Satellite Characteristics

ADEOS-II is the largest satellite Japan has ever developed, having dimensions of 4X4X5m. When the solar array paddle (approx.3X24m) is deployed, it has a span of 11m in the flight direction and 29m in the perpendicular direction (See Figure 1).

The spacecraft consists of a mission module which carries mission instruments and a bus module which carries bus subsystems. Other mission instruments are located on the earth viewing panel. C&DH, MDP, DT, EPS, AOCS and RCS units are located on the bus module. Each unit has an independent thermal control and a minimum of interfaces with other unit, which makes it easier to shorten spacecraft integration and testing period.

ADEOS-II was launched on 14 December, 2002 from Tanegashima Space Center by H-IIA #4. After Initial Critical Phase for four days, ADEOS-II AOCS mode was switched to normal mode. Main events in Critical Phase for about 27 days are ‘DCS antenna deployment’ on 18 December, ‘AMSR run-up’ from 3 January

Figure 1: Overview of ADEOS-II



ADEOS-IIの軌道上外観

3.1-2

to 7 January, and 'GLI detector cool down' on 10 January. In 'AMSR run-up' and 'GLI cool down', the operation of ADEOS-II was supported by foreign stations (KRU, KER: CNES and PER: ESA). After confirming the 'GLI cool down', Critical phase was finished.

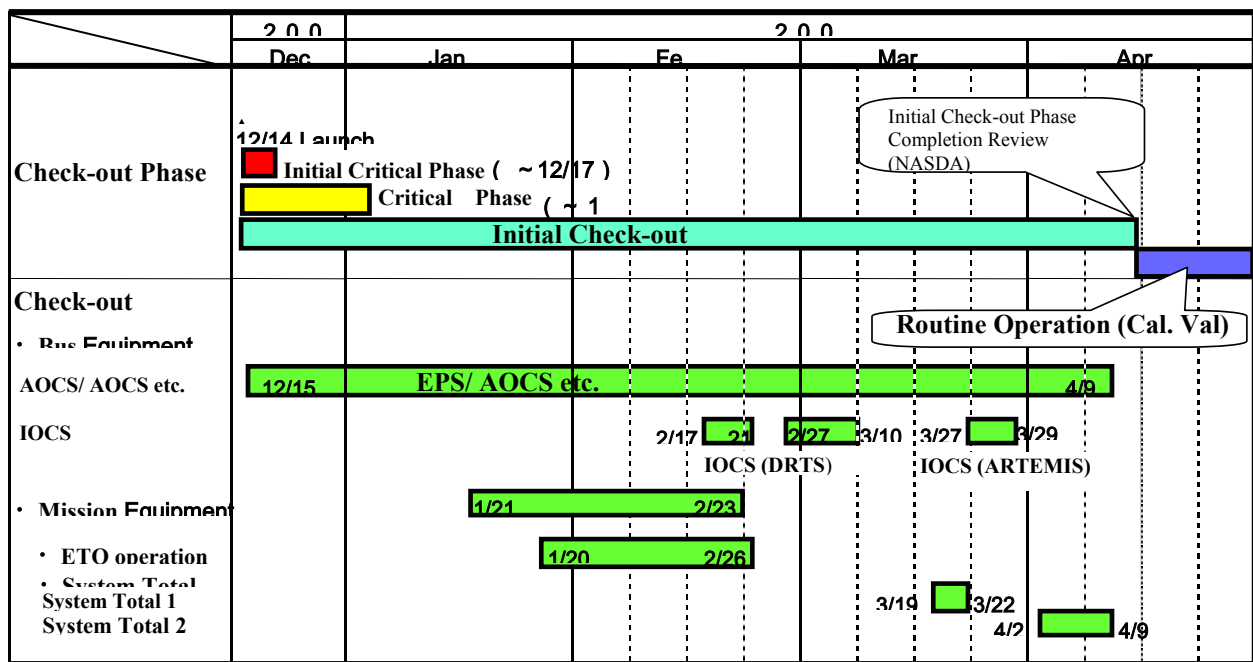
After then, Initial Checkout phase started that the functional tests in orbit of each bus instrument and mission instrument. Initial Checkout phase had been continued for three months. It consists of each instrument functional test and System Total Test. System Total Test which was the total test of ADEOS-II was carried out. And more, some of the mission instruments started its observation to acquire mission data just after its checking out (Early Turn On: ETO). System Total Test which included ADEOS-II satellite and ground segments test was done with Data Relay Test Satellite, DRTS (KODAMA) and TT&C operation and acquisition of mission data were carried out via DRTS. After Initial Checkout phase, ADEOS-II was shifted to Routine Operational phase on 14 April, 2003.

Table1: ADEOS-II Main Characteristics

Dimension	Main body (X-axis ×Y-axis ×Z-axis)	Approx. 5×4×4m
	Solar Array Paddle	Approx. 3×24m
Weight	Total weight	Approx. 3680kg
	Mission Instruments mass	Approx. 1300kg
Life Span	Designed Life Span	3 years
	Propellant	For 5 years
Orbit	Category	Sun-synchronous sub-recurrent orbit
	Altitude	802.9km
	Inclination	98.62deg.
	Period	101minutes
	Recurrent Period	4 days
Launch	Local Sun Time	AM 10:30±15
	Launch Vehicle	H-IIA Rocket
Launch Site	Launch Site	Tanegashima Space Center
	Mission Instrument	Advanced Microwave Scanning Radiometer
Mission Instrument	Global Imager	
	SeaWinds	
	POLDER	
	Improved Limb Atmospheric Spectrometer II	
	Technical Data Acquisition Equipment	
The Others	Data Collection System: DCS	
Communications & Data Handling Subsystem	Frequency	S-Band (Command/ Telemetry) Ka-Band (Mission Data)
	Bit Rate	Command: 500bps Telemetry:4096bps
	Tracking Method	Auto & Program Tracking
	Data Processing	Data Bus System
	Data Recorder	HK Data Recorder×1
Direct Communication Subsystem	Frequency	S-Band (Command/ Telemetry) X-Band (Mission Data)
Mission Data Processing Subsystem	Function	Transmitting Data Selection Transmitting Route Selection Mission Data Recording/ Reproduction
	Data Recorder	MDR×3(simultaneous operations) ODR×1
Electrical Power Subsystem	Regulation Method	33.5~52V Floating Bus
	Battery	NiCd Battery 50AH×4
Paddle Subsystem	Type	Flexible Paddle
	Power Generation	500W(EOL)
Attitude Orbit	Control System	Zero-Momentum/ 3axis max.

Control Subsystem	Attitude Error	±0.3 degree per axis max.
	Attitude	±0.065 deg per axis max. (target)
	Attitude Stability	±0.008 deg/ sec per axis max.
Reaction Control Subsystem	Thruster	20N thruster ×4 1N thruster×16
Direct Transmission for Local Users	Data Rate	23.4375 kbps
Thermal Control	Type	Independent Thermal Control

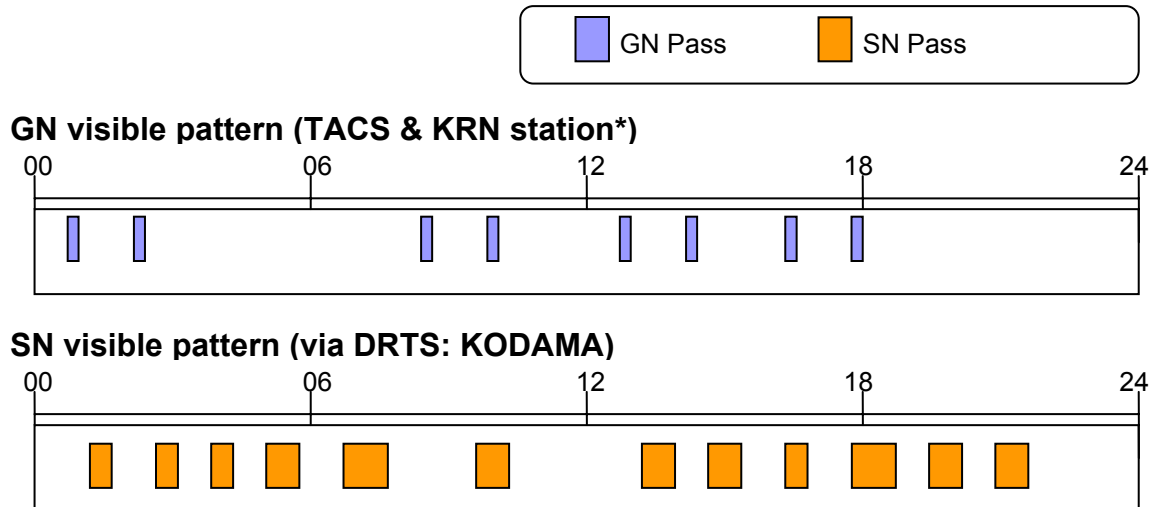
Table2: ADEOS-II Main Initial Checkout phase schedule



### 3. ADEOS-II TT&C Operation

One of the most characteristic operations of ADEOS-II is global-scale observation. In order to accomplish this mission, ADEOS-II has various communications ways. One of them is to use the space network system (SN). SN is a system that consists of ground stations, data relay satellite and SN user spacecraft like ADEOS-II. The main data relay satellite for ADEOS-II is Data Relay Test Satellite (DRTS: KODAMA), which was launched in September 2002. By launching ADEOS-II, JAXA has been established all elements which compose SN with JAXA's own technology.

ADEOS-II has the Inter-Orbital Communications Subsystem (IOCS) in order to communicate with Data Relay Satellite. With IOCS, ADEOS-II can communicate to ground station via Data Relay Satellite with S-



\* TACS is JAXA's ground stations in Japan. KRN station is also JAXA's one in Kiruna, Sweden.

Figure 2: ADEOS-II Visible pattern  
Upper is GN pattern, Bottom is SN one

Band and Ka-Band. S-Band is used for TT&C operation. Ka-Band is used for transmission of mission data to ground station. Though it was already described that the main Data Relay Satellite for ADEOS-II is DRTS, ADEOS-II also communicated with the Advanced Relay TEchnology MISsion (ARTEMIS) which was launched by ESA in 2001 in Initial Checkout phase. When ADEOS-II communicated with ARTEMIS, ADEOS-II telemetry data was transmitted to REDU station which is ARTEMIS feeder link station. Then ADEOS-II telemetry data was sent to Tsukuba Space Center (TACC) and monitored. On the other hand, command data was sent from TACC to ADEOS-II via REDU station and ARTEMIS.

The most agreeable reason why ADEOS-II utilize SN is that SN operation time for each pass is much longer than GN one. This means ADEOS-II can get global data and high resolution data. It is beneficial to utilize SN not only to get global data but also to operate TT&C. Figure2 shows the difference of GN visible pattern from SN one. Because the altitude of ADEOS-II is about 800km and its orbit is polar one, the operational time is about 10-15 minutes for a pass. It is TACS and KRN station that ADEOS-II communicates to ground station directly. TACS is JAXA's ground station, Katsuura, Masuda and Okinawa in Japan. KRN station also means JAXA's one in Kiruna, Sweden. Obviously, ADEOS-II can communicate with SN much longer than GN. ADEOS-II is able to communicate over almost all a day. In case of longer operational time, it is about 50 minutes. This long time pass is useful to send a large amount of commands. Some instruments need program data or data table for its operation. One of these instruments is OnBoard Computer (OBC). ADEOS-II has OnBoard Computer (OBC) in it. OBC has various functions. One of them is OBC automatic/ autonomous functions. The automatic function is to send commands to each instrument from OBC automatically on orbit according to data tables which was

registered beforehand. The

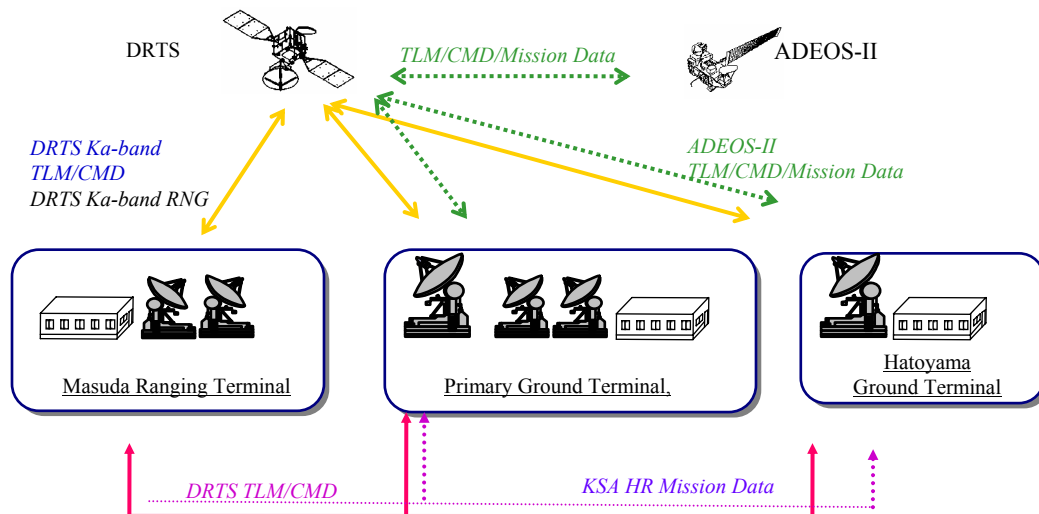


Figure 3: Overall Construction of the Space Network System

autonomous function is to check the specified telemetries and find abnormalities and dissociate them from the other. ADEOS-II needs to send a large amount of commands for OBC operation. And longer operational time and more passes can make operation planning easier. Furthermore, it makes monitoring time longer. If something abnormal occurs to ADEOS-II, it can be found earlier and it will be dealt with suitably. Thus, to utilize SN brings a lot of advantages.

#### 4. Lesson and Learned

SN system is such a large-scale network system which consists of user satellites, Data Relay Satellite and ground station. So, when a failure is occurred to a part of SN system, it influences other systems. For example, it is heavy rain. When it rains hard, it makes the link between DRTS and ground station disconnect. This is so-called 'Rain attenuation'. In Japan, it is rainy season from June to July, and a shower falls in the evening in summer. And typhoons attack Japan in summer and autumn. SN instruments added new function, TPC (Transmit Power Control), as a counter measure of rain attenuation and control the transmitting power. The addition of this function has been effective for rain attenuation. When it is forecasted that it will rains hard because of rainy season or approach of typhoon, ADEOS-II cancelled SN plan and re-planned GN operation in order to avoid risk. These heavy rain stops SN service. ADEOS-II needs to change operation mode from SN to GN. DRTS also changes operation mode from K-TT&C to USB. But GN resource has a limit. ADEOS-II and DRTS have to adjust other satellites. In this case, the most difficult consideration is to keep passes. ADEOS-II has to keep 6 passes a day at least in order to acquire the ranging data during only GN operation with no SN pass. On the other hands, 8 passes a day during only SN. Because ADEOS-II is Earth observation satellite, mission users need high

resolution orbit data to analysis mission data. The 4 way ranging data, which starts from ground station and via DRTS, ADEOS-II and go back to ground station via DRTS. 4 way ranging data had been calibrated and validated in early routine operation phase. So if ADEOS-II could not keep minimum SN passes to get ranging data, ADEOS-II has to get new passes to acquire ranging data by GN. This is why when SN service stops by the middle of a day, ADEOS-II has to require own minimum passes for ranging in order to keep own operation. It was very difficult to require them because GN instruments were already reserved by other satellite operation. SN user satellites need GN resource when SN has troubles. Just because SN user satellites increase, it does not lead GN resource being reduced.

In routine operation phase, the main data relay satellite for ADEOS-II is only DRTS. DRTS has been located in the east 90 longitudes. It is one of the Communications Satellite (CS) and its mission is to communicate with LEO satellites. Of course DRTS needs HouseKeeping operation for mission. So if anything goes wrong with DRTS, SN service has to stop. Then it is necessary for ADEOS-II to change its TT&C and mission operation plans. If ADEOS-II needs GN resource, it is necessary to adjust other satellites.

Now, it is only ADEOS-II that SN supports. But in near future, Advanced Land Observing Satellite (ALOS) and Japan Experiment Module (JEM) will be launched. The more SN user satellites increase, the harder to keep passes that are needed by each satellite. Considering this, the policy of GN pass assign when SN service stops should be made.

ADEOS-II TT&C operation with SN system has brought wisdom. At first, JAXA was planning to launch two data relay satellites (DRTS-W and DRTS-E) on a geostationary orbit. But the plan was changed to one data relay satellite, only DRTS. When the service of DRTS stopped, ADEOS-II was forced to stop SN operation. If there is another data relay satellite as a back-up, SN user can utilize much more SN system. ADEOS-II usually uses OBC automatic function to communicate to ground station via DRTS. So, OBC automatic operation plan has been considered SN link timing. If SN service stops for days, it is necessary to make operation plan and send to ADEOS-II again. This means that sudden SN service stop brings not only failure of mission data acquisition but also re-planning. And the work management is important when SN service stops. When SN service stops, user satellite has to make emergency plan and nominal operation plan.

## 5. Conclusion

ADEOS-II was launched on 14 December, 2002 and had Initial Checkout phase for four months. After then, ADEOS-II was in routine operational phase. In Initial Checkout phase, instruments were powered on and checked out each performance. At the end of Initial Checkout phase, ADEOS-II carried out System Total Test over the all system. In the test of communication with data relay satellite, ADEOS-II could communicate not only DRTS, but also ARTEMIS. By launching ADEOS-II, JAXA attained to establish all SN composition elements by itself.

The most meaningful thing to utilize SN system is to communicate with ground station longer and more than GN.

SN is a large network system which consists of ground segments, DRTS and user spacecrafts. SN is a main network system for ADEOS-II. But when SN system suddenly stops its service, ADEOS-II has to do re-planning operation in order to keep the TT&C and mission data acquisition. But GN resources have been reserved by other satellites. This is a complexity for SN user satellite. The more SN user satellite increase, the harder it is for SN user satellite to plan. So SN user needs to manage risks.

ADEOS-II has been given a lot of benefits by utilizing SN. Because ADEOS-II is the first satellite to utilize SN, ADEOS-II could use SN as it wanted to do. But ADEOS-II was suffered some problems because ADEOS-II is the first satellite for SN. These experiences will be helpful for next SN user spacecraft, especially ALOS and JEM.