A SAR System on the ALOS

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ABSTRACT:

The Advanced Land Observing Satellite (ALOS) is a Japanese high resolution earth observation satellite and will be used for cartography, environmental and hazard monitoring. National Space Development Agency of Japan (NASDA) has recently investigated users' requirements and conducted a feasibility study on the ALOS. As a result, mission requirements were clarified, and then proposed specifications for sensors and a satellite system were defined. The ALOS has both optical and microwave imaging sensors to achieve these requirements. Especially, the L-band synthetic aperture radar (SAR), which is a follow-on sensor of the JERS-1/SAR, has capabilities of look-angle change and the ScanSAR mode.The ALOS is scheduled to be launched in 2002 by Japanese H-II rocket. This paper introduces an outline of mission concepts, a satellite system configuration, and the SAR characteristics of the ALOS.

1. INTRODUCTION

There are many kinds of remote sensing satellites in orbit and in planning stage. Some satellites, such as the NOAA's and the ADEOS-II (Nakajima *et al.*, 1994) are dedicated to global observation by using wide-swath sensor and relatively short orbit repeat cycle. On the other hand, high resolution satellites, such as the Landsat, the SPOT and the JERS-1 are providing useful data for regional observation.

NASDA surveyed future needs on regional observation and clarified the user's requirements. NASDA also conducted a feasibility study on sensors and a satellite system and defined proposed specifications. As the result, the Advanced Land Observing Satellite (ALOS), which is focusing on regional observations, was decided. And a high resolution optical sensor (AVNIR-2: Advanced Visible and Near-infrared Radiometer type-2) as well as a synthetic aperture radar (PALSAR: Phased Array type L-band Synthetic Aperture Radar, formerly called 'VSAR') were chosen as the mission instruments of the ALOS. The Japanese government has just authorized the phase B budget of the ALOS. The ALOS project is going to the preliminary design and the BBM phase. The ALOS is currently scheduled to be launched in 2002 by Japanese H-II rocket.

This paper introduces mission concepts and general characteristics of the ALOS satellite. In the latter part of this paper, we will concentrate on the detailed characteristics of the PALSAR system.

2. MISSION CONCEPT

The main mission of the ALOS are cartography, environmental and hazard monitoring by using both optical and microwave high resolution sensors. Maps are very important information for managing a country's resources: e.g., cultivated area, forest, and so on. In Japan, 1/25,000 maps cover whole Japanese territory, and are being revised about every five years by the Japanese Geographical Survey Institute. However, "paper" maps larger than 1/31,680 scale cover only 31% of the whole world. Especially, in developing countries, more than 90% are unmapped in this scale. Also, in recent years, Geographical Information System (GIS) has been developed eagerly in many countries, however, enough "digital" geographical data has not been collected yet. The "digital" data of wide area could be efficiently collected by remote sensing, particularly, from space. The GIS is very efficient way to manage the countries' resources, because of its capability and flexibility, that making/revising precise maps on GIS using remotely sensing data, are helpful to the "sustainable development". These maps are also useful to environmental monitoring. According to our recent investigation, to make/revise 1/25,000 scale maps needs 2.5 m horizontal resolution for determination of land conditions, and 5 m vertical accuracy for drawing elevation contours. Also, multispectral bands of 10 m horizontal resolution as well as L-band SAR data are required for classification of land cover, such as vegetation, forests, urban area, and so on (Osawa *et al.*, 1995).

In early 1995, Hanshin area in the west part of Japan suffered severe damage from a tremendous earthquake. Dislocations of land and soil liquefaction, which were caused by the earthquake, were observed by the SAR interferometry and the high-resolution optical sensors. The usefulness of such kind of satellites for hazard monitoring was confirmed (Sudo *et al.*,1995). The users' requirements for hazard monitoring are "as prompt as possible" and "as precise as possible". According to our study, to choose adequate orbit and employ cross-track pointing mechanisms of the sensors let a polar orbiting satellite to observe damaged area within 48 hours.

3. ALOS SATELLITE SYSTEM

In order to accommodate high performance sensors, the ALOS satellite system should have several outstanding capabilities. First one is precise determination of position and attitude, and second one is mass data handling capability. The ALOS equips a star-tracker for accurate attitude determination and carrier phase tracking Global Positioning System (GPS) receivers for precise position determination. The position and attitude accuracies of the ALOS will be set to achieve the requirements from the geometric accuracies and the derived height accuracies of the sensor data.

To handle huge data generated by the AVNIR-2 and the PALSAR, the ALOS has mass data memories on board. The memories should have 706 Gbits storage capacity and 240 Mbps data handling capability. The candidates for these mass memories are optical data recorders and solid state memory recorders. The ALOS also equips a high data rate transmission capability through the Data Relay Technology Satellites (DRTS) scheduled to be launched before the ALOS's launch. They allow us to get ALOS data in real time for hazard monitoring. Table 1 shows the ALOS satellite system characteristics, and figure 1 gives its in-orbit configuration.

Table 1. ALOS Satellite System characteristics

Launch	2002
Launch vehicle	H-IIA
Spacecraft mass	about 3,850 kg
Generated power	about 7 kW
Orbit	sun-synchronous near recursive
-altitude	720 +/- 60 km
-inclination	98 degree
-repeat cycle	45-52 days
-local time at descending node	10h 30m am
Mission instruments	AVNIR-2, PALSAR, DCS

4. PALSAR CHARACTERISTICS

The PALSAR is the Japanese second spaceborne SAR using L-band frequency and will have a cross-track pointing capability from 18 to 55 degrees of incidence angle. Table 2 summarizes the PALSAR characteristics as well as the JERS-1/SAR's.

4.1 Observation Modes

The PALSAR basically has three modes in its observation, such as fine resolution, ScanSAR , and low data rate modes. The fine resolution mode, a strip SAR, is a conventional mode and mainly used for detailed regional observations and repeat-pass interferometry. The goal of this mode is to achieve 10 meters of spatial resolution both in range and azimuth directions, 70 km of swath width, -25 dB of noise equivalent backscattering coefficient (NEσ^0), and 25 dB of Signal-to-Ambiguity (S/A) ratio at a look-angle of 35 degrees. Its signal to noise ratio was determined from the average backscattering coefficient of natural targets and the accuracy of elevation determination by using SAR interferometry. The PALSAR's S/A level is about 10 dB higher than that of JERS-1/SAR's, and will improve data quality especially in the coastal region. A five bits quantization excludes a Sensitivity Time Control (STC) of the receiver and phase errors at the changing points of the receiver gain.

The PALSAR will have another attractive observation mode which is the ScanSAR mode. This mode will allow us to get about more than 250 km width of SAR images by sacrificing spatial resolution, which is about three times wider than conventional SAR (e.g. JERS-1/SAR) images and is considered to be useful for sea ice extent and rainforest monitoring. When we use an optimized orbit, by using pointing and ScanSAR capabilities, we can get the data from the same target area in less than five days.

The observed data in the low data rate mode can be transmitted directly to the ground stations by using X-band frequency. Because of narrow band width in the X-band down-link frequency, the maximum data rate in this band is limited to 120 Mbps. By sacrificing spatial resolution in range direction, dynamic range, and swath width of the fine resolution mode, we can transmit the observation data either in 120 Mbps or 60 Mbps. Even in the 60 Mbps data, the data quality may be almost as same as the JERS-1/SAR's.

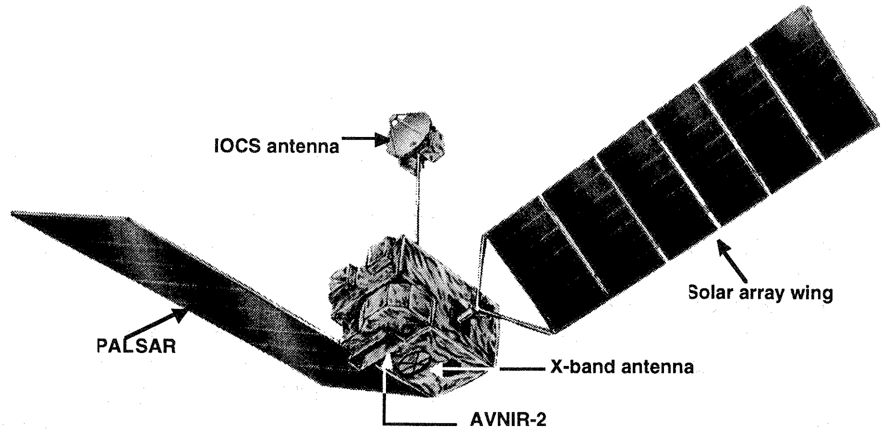

Figure 1. ALOS spacecraft in-orbit configuration

Table 2. PALSAR basic characteristics

Observation mode		Fine resolution	ScanSAR	Low data rate		Note	Comparison JERS-1/SAR
				1	2		
Frequency		L-band				Center freq. -T.B.D.	L-band centered at1275MHz
Polarization		HH or VV				Selectable by commands	HH
Incidence angle		20-55deg.	18-36deg.(3 scans) 18-40deg.(4 scans) 18-43deg.(5 scans)	20-55deg.	20-55deg.	Look angle range 18-48 deg.	37-42deg. (fixed) Look angle:35 deg.
Spatial resolution	Range	10m*	100*m	10m*	20m*	* at look-angle of 35 deg.	18m
	Azimuth	10m(2looks) 20m(4looks)	100m	10m(2looks) 20m(4looks)	10m(2looks) 20m(4looks)		18m (3 looks)
Swath		70km*	250km(3 scans) 300km(4 scans) 350km(5 scans)	50km*	50km*	* at look-angle of 35 deg.	75km
Bit length		5bits I + 5bits Q		3bits I + 3bits Q			3bits I + 3bits Q
Data rate		240Mbps	120Mbps	120Mbps	60Mbps		60 Mbps
Radiometric accuracy		1dB					
Noise equivalent backscattering coefficient		-25dB*				* at look-angle of 35 deg.	-20.5dB
S/A		25dB*				* at look-angle of 35 deg.	14 dB
Mass		440kg					228kg
Power consumption		1100W					500W

4.2 PALSAR Hardware Configuration

An elevation beam steering, which is used for look angle change in the fine resolution mode or the ScanSAR mode, is achieved by employing the active phased array technique to the PALSAR. In order to implement an active phased-array antenna, light weight T/R modules are necessary and being developed. The antenna elevation angle is mechanically set to 48 degrees of off-nadir angle and can be steered more than 30 degrees to the nadir by controlling five bits phase-shifter in each T/R module.

In order to achieve 10 meters' range resolution in the processed data, a bandwidth of 30 MHz is required in transmitting chirp signal. For the ScanSAR and the low data rate modes, the chirp bandwidth should be reduced to around 15 MHz. A digital chirp generator which generates variable bandwidth (15-30 MHz) will be used for producing high quality data.

The antenna size will be about 9.0 m long by 3.5 m wide and its mass is about 250 kg. In order to support it firmly, a truss will be attached to the antenna back structure. Several truss structures including deployment mechanisms, such as truss shape, actuator redundancy, and deployment procedure, are under detailed trade off and will be determined soon.

Figure 2 indicates a functional block diagram of the PALSAR system. The PALSAR system will be jointly developed by NASDA and Japan Resources Observation System organization (JAROS). NASDA is responsible for PALSAR integration and the development of the antenna unit including radiation panels, while JAROS is responsible for the development of an electronics unit as well as T/R modules on the antenna unit.

5. CONCLUSIONS

The PALSAR system is the second spaceborne SAR developed in Japan. It is scheduled to be launched in 2002 and will continue to provide L-band image data after JERS-1/SAR. During its operational period, the PALSAR system is expected to contribute greatly to many areas by using L-band frequency and its observation flexibility.

The NASDA conducted the fabrications and tests for sensor's critical components, such as a T/R module, a digital chirp generator, and a antenna truss deployment structure in 1995. During the BBM phase in 1996-1997, the accuracy of beam pointing will be confirmed by a 1/1 scale model.

References

Nakajima, M., 1994. The Development of AMSR and GLI for ADEOS-II, IAF-94-B.3.083.

Osawa, Y., K. Toda, H. Wakabayashi, T. Hamazaki, and H. Takamatsu, 1995. Advanced Land Observing Satellite (ALOS) Mission Objectives and Payloads, Proceedings of the MOMS symposium, Koeln, Germany.

Sudo, N., 1995. Multi Stage Remote Sensing on Great Hanshin Earthquake Disaster Survey, Proc. of 17th Japanese Conference on Remote Sensing, pp. 115 - 116.

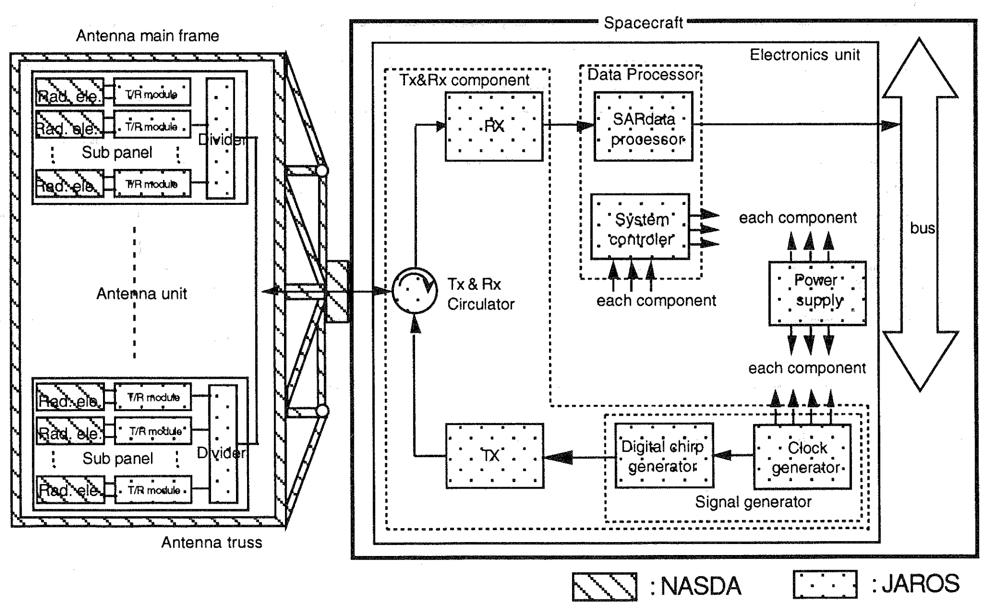

Figure 2. VSAR functional block diagram