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INVITED PAPERS

**ALOS MISSION AND RELATED ACTIVITIES IN JAXA TO SUPPORT  
DISASTER MANAGEMENT AND SUSTAINABLE DEVELOPMENT**

**Submitted by Japan Aerospace Exploration Agency (JAXA) and  
Swedish Space Corporation \*\***

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\*\* Prepared by Mr. Kazuo Ohta, Mr. Masanobu Shimada and Mr. Takeo Tadono, Earth Observation Research Center, Japan Aerospace Exploration Agency (JAXA), Mr. Chu Ishida, Satellite Application Center, JAXA and Mr. Ake Rosenqvist, Swedish Space Corporation .

## ALOS MISSION AND RELATED ACTIVITIES IN JAXA TO SUPPORT DISASTER MANAGEMENT AND SUSTAINABLE DEVELOPMENT

Kazuo Ohta <sup>\*1</sup>, Masanobu Shimada <sup>\*1</sup>, Takeo Tadono <sup>\*1</sup>, Chu Ishida <sup>\*2</sup>,  
Ake Rosenqvist <sup>\*3</sup>

(\*1) Earth Observation Research Center  
Japan Aerospace Exploration Agency (JAXA)  
Harumi Island Triton Sq. Office Tower X, 1-8-10 Harumi, Chuo-ku, Tokyo 104-6023, JAPAN

(\*2) Satellite Application Center  
Japan Aerospace Exploration Agency (JAXA)  
Shin-otemachi bldg. 7F, 1-6-5 Marunouchi, Chiyoda-ku, Tokyo 100-8260, JAPAN

(\*3) Swedish Space Corporation  
P.O. Box 4207, SE-171 04 Solna, Sweden

### 1. Overview of ALOS

The Japan Aerospace Exploration Agency (JAXA) launched the Advanced Land Observing Satellite “Daichi” (ALOS) on 24 January 2006.

Currently, ALOS is in the commissioning phase to check and calibrate the characteristics and qualities of data from the mission instruments. JAXA plans to release the calibrated data after the commissioning phase, from late October 2006.

The mission objectives of ALOS include cartography, regional observation, and disaster monitoring. Geographic information such as elevation, topography, land use and land cover maps are necessary basic information in many fields of practical application and research areas as well as the change detection and evaluation after big disasters.

JAXA became a member of the International Charter “Space and Major Disasters” in February 2005 by using ALOS as a space resource. Even though the JAXA membership is in full function

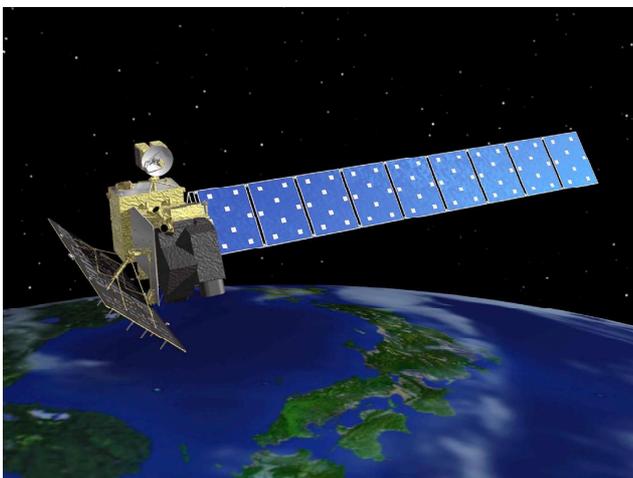
after the commissioning phase of ALOS, JAXA used ALOS to acquire several images after the natural disasters such as landslides in Philippines, the volcanic eruption of Mt. Merapi and the earthquake in Java, Indonesia and floods in Thailand.

ALOS has three mission instruments to achieve the mission objectives, *i.e.*, two optical imagers and an L-band Synthetic Aperture Radar. The optical imagers are the Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM) that consists of 3 telescopes of forward, nadir and backward view with 2.5 m spatial resolution, and the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) that has 10 m spatial resolution in nadir viewing, multi-spectral imaging and cross-track viewing capabilities. The radar is the Phased Array type L-band Synthetic Aperture Radar (PALSAR) that has up to 10 m spatial resolution (2 looks), variable off-nadir angle beaming and full polarimetric capabilities.

ALOS is a follow-on mission of the Japanese Earth

Resources Satellite-1 (JERS-1) and the Advanced Earth Observing Satellite (ADEOS) to upgrade satellite-based land observing technology. Figure 1 shows an artistic image of ALOS on orbit. The satellite mass is approximately four tons, and the design life is from three to five years. ALOS will be in a Sun-synchronous orbit with, approximately, the inclination angle of 98 degrees, the altitude of 692 km at the equator, and the repeat cycle of 46 days. The distance between the adjoining orbits at the equator is approximately 60 km, and the unit for the swath width of each mission instrument is considered 70 km with adequate overlaps. In case of big disasters, ALOS attempts to capture images of the disaster area by any of its instruments within a few days by adequately using pointing capabilities of the instruments.

Considering the very high speed data produced from each instrument, ALOS is designed to use a 240 Mbps inter-satellite link, by JAXA's Data Relay Test Satellite (DRTS), for its major data downlink. ALOS also have a X-band direct downlink capability to the local ground stations, however, this downlink data rate is only 120 Mbps due to the limitation of current available frequency resource for this satellite. The direct downlink is planned for AVNIR-2 and for the ScanSAR mode of PALSAR.



**Fig.1 Artistic image of ALOS on orbit ©JAXA**

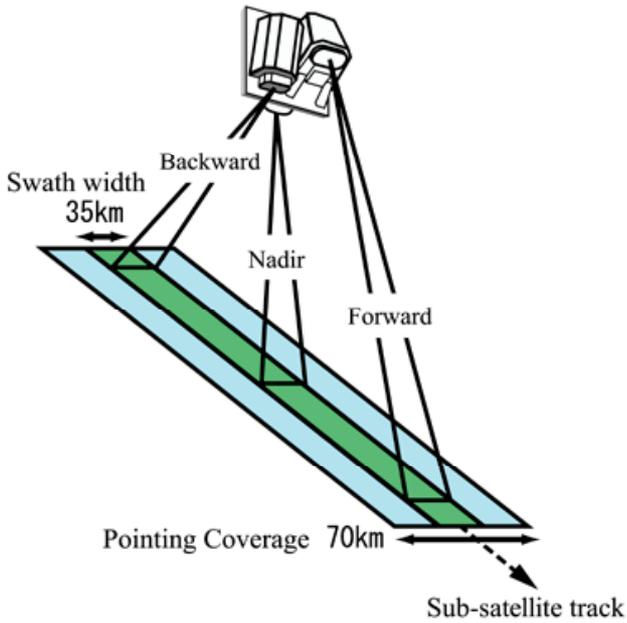
## 2. Characteristics of mission instruments

### 2.1 PRISM

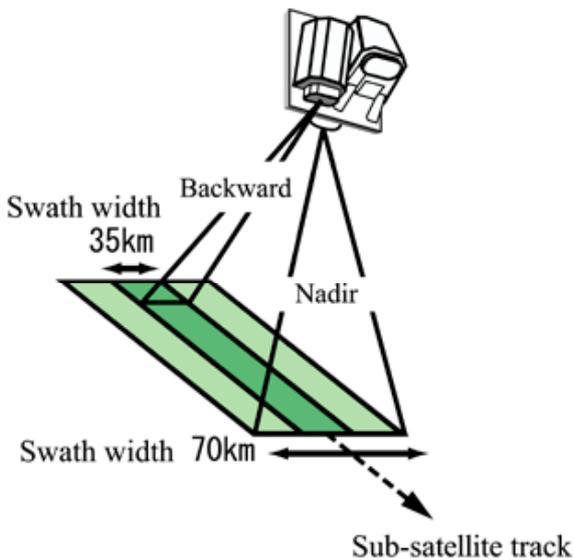
PRISM will be used to generate a digital surface model (DSM) with high spatial resolution. PRISM consists of three independent optical systems for a forward, nadir and backward view which mutual viewing alignment is fixed to achieve the stable elevation extraction accuracy of 5 m for an accurate DSM in order to correspond to the 1:25,000-scale topographic maps. PRISM basically acquires three images of the same point on the ground in the same orbit with a 2.5-meter spatial resolution.

Figures 2 and 3 illustrate the PRISM observation geometries, and Table 1 summarizes the primary characteristics of the PRISM. The nadir-looking radiometer can provide along-track coverage of 70 km wide, and the forward- and backward-looking radiometers provide each coverage of 35 km wide. This means that the global coverage of PRISM by the triplet (forward, nadir and backward viewing) mode takes 92 days.

The radiometers are placed on both sides of the optical bench, which has precise temperature control to stabilize thermal distortion. Forward and backward radiometers are inclined  $\pm 23.8$  degrees from the nadir to realize a base-to-height ratio of 1 (one). Each radiometer will use electrical pointing (within  $\pm 1.2$  degrees cross-track) in order to compensate the Earth rotation effect and obtain a set of images of the same area observed by the three radiometers. Thus, three fully overlapped stereo images (triplet) 35 km wide are obtained without mechanical scanning or yaw steering of the satellite. The acquired data are compressed by lossy compression with a Joint Photographic Experts Group (JPEG) extension in the PRISM instrument, and transmitted through the DRTS to the JAXA ground station.



**Fig. 2. Observation geometry of the triplet mode**



**Fig. 3. Observation geometry of nadir and backward modes**

**Table 1. PRISM characteristics.**

Number of bands	1 (Panchromatic)
Wavelength	0.52 - 0.77 micrometers
Number of optics	3 (Nadir, Forward, and Backward)
Base to height ratio	1.0 (between Forward and Backward)
Spatial resolution	2.5 m (Nadir)
Swath width	70 km (Nadir or Nadir + Backward) 35 km (Triplet mode)
Signal to noise ratio	> 70
MTF	> 0.2
Number of detectors	28,000 (70km swath), 14,000 (35km)
Pointing angle	-1.2 to +1.2 deg. (Triplet mode)
Bit length	8 bits/pixel
Data rate (raw)	960 Mbps (Triplet mode)
Data compression	Lossy, JPEG extension (onboard)
Data downlink rate	240 Mbps (1/4.5 compression) 120 Mbps (1/9 compression)

## 2.2 AVNIR-2

AVNIR-2 is a visible and near-infrared radiometer for observing land and coastal zones, and suitable for producing land cover and land-use classification maps for monitoring regional environment. AVNIR-2 is a successor to the previous AVNIR sensor onboard the Advanced Earth Observing Satellite (ADEOS), which operated from 1996 to 1997.

Table 2 summarizes the characteristics of the AVNIR-2. Its primary improvement from AVNIR is its spatial resolution. AVNIR-2 provides 10-meter spatial resolution, improved by 6 meters, at nadir with the same multi-spectral bands as AVNIR. AVNIR had the 16-m resolution at nadir. Another improvement is the cross-track pointing capability for prompt observation of disaster areas and the same observation areas as PALSAR. The pointing angle

of AVNIR-2 is +/- 44 degrees across track, corresponding to a +/- 750 km coverage on the ground.

**Table 2. AVNIR-2 characteristics.**

Number of bands	4
Wavelength (micrometers)	Band 1 : 0.42-0.50 Band 2 : 0.52 - 0.60 Band 3 : 0.61 - 0.69 Band 4 : 0.76 - 0.89
Spatial resolution	10 m (at Nadir)
Swath width	70 km (at Nadir)
Signal to noise ratio	> 200
MTF	Band 1-3 : > 0.25 Band 4 : > 0.2
Number of detectors	7,000 / Band
Pointing angle	-44 to +44 deg.
Bit length	8 bits/pixel
Data downlink rate	120 Mbps

### 2.3 PALSAR

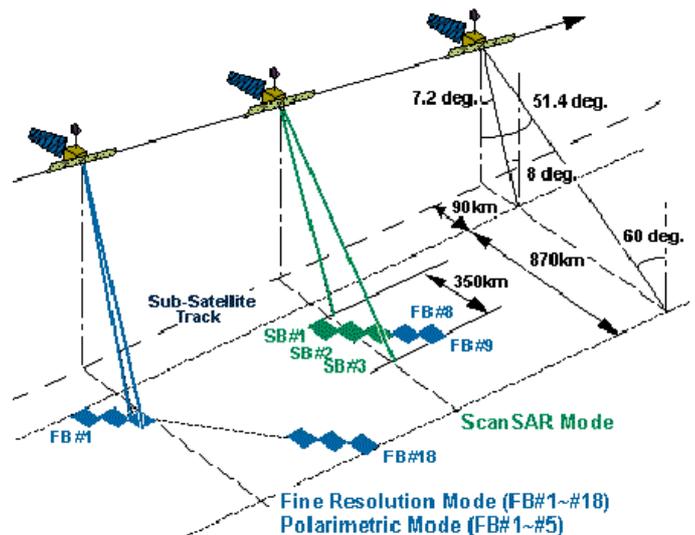
PALSAR is an active microwave sensor using the L-band frequency for cloud-free and day-and-night land observations, and has an improved performance over the Japanese Earth Resources Satellite-1 (JERS-1) SAR.

Table 3 summarizes the characteristics of PALSAR,

**Table 3. PALSAR characteristics.**

Mode	Fine Resolution		ScanSAR	Polarimetry
Center frequency	1270 MHz (L-band)			
Chirp bandwidth	28 MHz	14 MHz	14 or 28 MHz	14 MHz
Polarization	HH or VV	HH+HV or VH+VV	HH or VV	HH+HV+VH+VV
Incidence angle	8-60 deg.	8-60 deg.	18-43 deg.	8-30 deg.
Range resolution	7-44 m	14-88 m	100 m (multi-look)	24-89 m
Swath width	40-70 km	40-70 km	250-350 km	20-65 km
Bit length	5 bits	5 bits	5 bits	3 or 5 bits
Data downlink rate	240 Mbps	240 Mbps	120 or 240 Mbps	240 Mbps
NE sigma zero	< -23 dB (70 km swath)		< -25 dB	< -29 dB
S/A	> 16 dB (70 km swath)		> 21 dB	> 19 dB

and Fig. 4 illustrates the observation geometry. PALSAR has three observing modes, fine resolution with single or dual polarization, ScanSAR, and full polarimetry. The fine resolution mode is a conventional one; the ScanSAR mode can observe 250 to 350 km wide (depends on the number of scans) of SAR images at the expense of spatial resolution.



**Fig. 4. PALSAR observation geometry for each mode**

### 3. Data products

**Table 4. Product summaries.**

Sensor	PRISM	AVNIR-2	PALSAR
Standard Products	1A: Uncorrected image, scene unit (Raw data) 1B1: Radiometrically corrected image 1B2: Geometrically corrected image		1.0: Uncorrected image, scene unit (Raw data) 1.1: Single-look complex data on slant range (SLC) 1.5: Multi-look processed image (Amplitude)
High-level Products	DSM Ortho-rectified image	Ortho-rectified image	DSM by interferometry Ortho-rectified image
Research Products	- Scene frame DSM - Pan-sharpened image with AVNIR-2	- Land use, land cover - Albedo map - Vegetation map <i>etc.</i>	- Forest and biomass maps - Surface deformation - Sea-ice, soil moisture, snow parameters <i>etc.</i>

Table 4 summarizes the ALOS data products processed by JAXA. This defines three different product types; standard, high-level and research products. The standard product consists of Levels 1A, 1B1 and 1B2 for optical sensors and Levels 1.0, 1.1 and 1.5 for PALSAR, processed at the Earth Observation Center (EOC) of JAXA. The format descriptions of the standard products are published *via* internet:

<http://www.eorc.jaxa.jp/ALOS/doc/format.htm>

The high-level and research products will be generated in the Earth Observation Research Center (EORC) of JAXA. The high-level products are DSMs generated from PRISM stereo pair image and the PALSAR interferometry technique, and ortho-rectified images of each sensor. JAXA/EORC plans to produce the research products with some geophysical parameters, *i.e.*, forest and biomass related parameters, surface deformation detection, sea-ice distribution, soil moisture distribution, and snow related parameters, primary using the PALSAR data. Land-use, land-cover classification, and surface albedo will be estimated by AVNIR-2. These products will demonstrate the capabilities for applications as well as contribute to

scientific activities.

### 4. Data distribution

Considering that the total data produced by the ALOS sensors on a daily basis (approx. 700 G byte) will be beyond the capabilities of any single agency to attempt to manage, but that there exists world-wide interest in the use of ALOS data, JAXA has established the concept of the ALOS Data Nodes with local archives, as a mechanism for sharing the processing and distribution load.

Each ALOS Data Node (ADN) is managed by a partner organization or consortium, by agreement with JAXA, and undertake to participate in certain tasks relating to the reception and near real time processing (in some cases), off-line processing, promotion, distribution, and archiving of ALOS data in support of the data users within their region, as well as of research study of ALOS data. Each Node is associated with a geographical zone, which defines the physical location of the ALOS users that the Node has mandate to support as an ADN partner. These zones are approximately defined in Fig. 5. The Geo-Informatics and Space Technology Development Agency (GISTDA) of Thailand will

additionally serve as a sub-Node within Asia.

Each Node has a capability of producing the same quality of the Standard Products as JAXA Products. The higher level products may be defined by the individual Nodes.

Although each Node is the focal point for the support of the ALOS users within its own zone, regional distributor(s) appointed by each Node will serve as the commercial data distributor and service agent for the users of commercial purposes within the relevant zone. JAXA appointed the Remote Sensing Technology Center of Japan (RESTEC) as the Primary Distributor (PD), which will serve as the organizer of all the regional distributors appointed by Nodes and also serve as the regional distributor in Asian region except Thailand. In Thailand, GISTDA will also serve as the regional distributor. JAXA plans to distribute the Standard Products only to the non-commercial users that have official

agreements with JAXA, and the other users, even though for a non-commercial use, has to purchase them from RESTEC or regional distributors. Currently, regional distributors in other Node regions have not yet been appointed, but will be in function by the time of ALOS data release, which is planned in late October 2006.

There is one exception only for the PALSAR data distribution. As JAXA and the Ministry of Economy, Trade and Industry (METI) jointly developed PALSAR instrument, METI has an equal right to distribute the PALSAR data. The Earth Remote Sensing Data Analysis Center (ERSDAC), under METI agreement, will also distribute the PALSAR data, and ERSDAC is outside of this ADN concept. The PALSAR data products processed by the ERSDAC are similar to the JAXA Standard Products, however, they may be slightly different because of the differences in processing algorithms and formats applied.

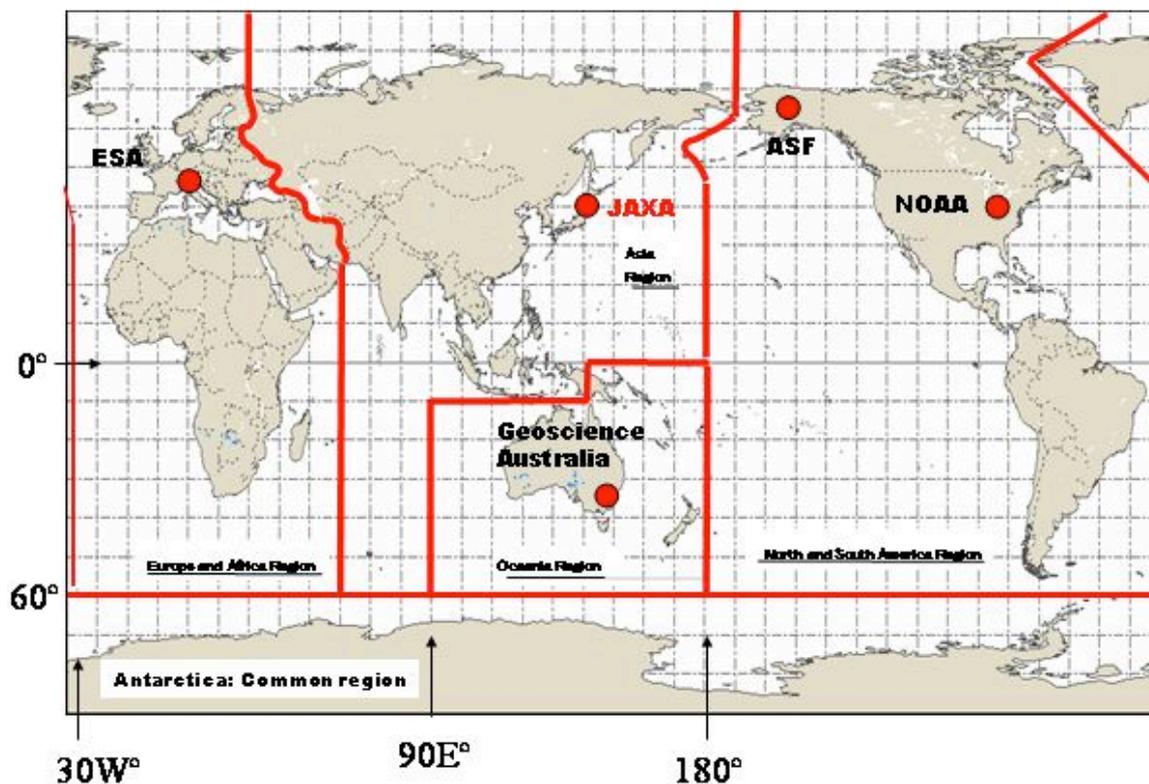


Fig. 5 ALOS Data Nodes zone definitions

## **5. ALOS User Interface Gateway (AUIG) and other on-line services**

The ALOS User Interface Gateway (AUIG) is the web based on-line service that provides to the general users the search and browsing service for the acquired images, ALOS flight path information, the observation plan up to a week ahead, and a special page for reporting near real-time image delivery after the emergency observations in case of big disasters. The AUIG also provides special functions to the authorized users with JAXA agreements. The URL of this AUIG is the following:

<https://auig.eoc.jaxa.jp/>

This JAXA system is under evaluation and limited functions are served currently. It will be fully on service on the date of ALOS data release.

For the general users to order and purchase ALOS image products in the Asian region, RESTEC will provide an on-line system named "CROSS" for this purpose. The URL of this RESTEC system is the following:

<https://cross.restec.or.jp>

The similar systems will be established by the relevant Node / regional distributor for the users in each Node region. The details will be announced by the time of the data release by RESTEC and relevant Nodes.

## **6. JAXA activities to support disaster management**

JAXA supports two major activities related to the disaster management.

The first one is the International Charter "Space and Major Disasters".

JAXA became a member of this International Charter in February 2005 by using ALOS as a space

resource. This Charter, the Charter on cooperation to achieve the coordinated use of space facilities in the event of natural or technological disasters, aims at providing space data acquisition and delivery in a unified manner to those affected by natural or man-made disasters through Authorized Users by the Charter. After the commissioning phase of ALOS, JAXA will fully conduct the activities to support this Charter. Even under such a preliminary condition, JAXA has conducted several data acquisitions from ALOS such as landslides in Philippines, the volcanic eruption of Mt. Merapi and the earthquake in Java, Indonesia, and reported to the Charter secretariat office.

Except for these Charter activities, ALOS acquired images after the floods in Thailand and Indonesia, and for the volcanic activity monitoring in Japan.

The second activity is the Sentinel-Asia Project. This project is our agency's broader and more regional approach toward the application of space technologies to support the disaster management than the Charter and the ALOS mission.

This project has been discussed since November 2004 in the Asia-Pacific Regional Space Agency Forum (APRSAF), which was established in 1993 to enhance the development of space programs in the Asia-Pacific region and promote regional cooperation in the field of space technology and its applications, and was approved as the pilot project in the 12<sup>th</sup> APRSAF meeting in October 2005 in Kitakyushu, Japan.

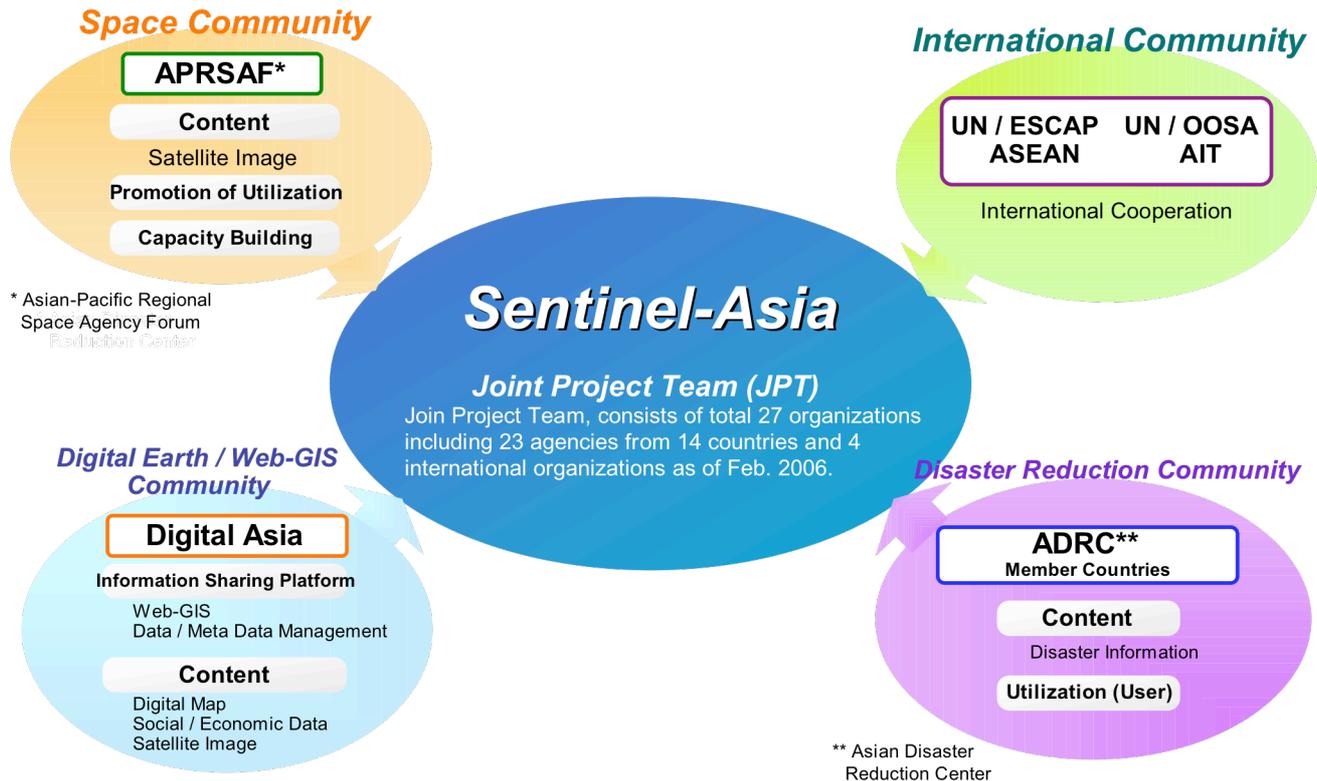
The objective of this Sentinel-Asia Project is to contribute to the disaster management in Asia-Pacific region by using space technologies and GIS based information technologies. The framework of this project is shown in the Fig. 6. To organize and promote this project, the Joint Project Team (JPT) was established consisting 27 organizations including 23 agencies from 14 countries and 4 international organizations.

This project and beyond will be implemented by the stepwise approach:

- Step1: Utilization of earth observation satellite data for disaster management and construction of disaster information sharing platform, which is called “Sentinel-Asia Project” (2006-2007)

- Step2: Utilization of satellite communications system besides earth observation satellites (2008-2009)
- Step3: Establishment of comprehensive disaster management support system (2010- )

*Best-efforts, voluntary initiative by participating organizations*



**Fig. 6 Framework of the Sentinel-Asia Project**

The activities of this project includes the followings:

- Emergency observations from satellites, currently ALOS, in case of major disasters through the Asian Disaster Reduction Center (ADRC) from its member countries and space organizations.
- Wildfire monitoring by using Terra/MODIS data.
- Information sharing platform named “Digital Asia”, based on Web-GIS server, development in order to integrate the acquired data in this project and related information to disaster management overlaid on GIS.

- Capacity building for the utilization of satellite image for disaster management.

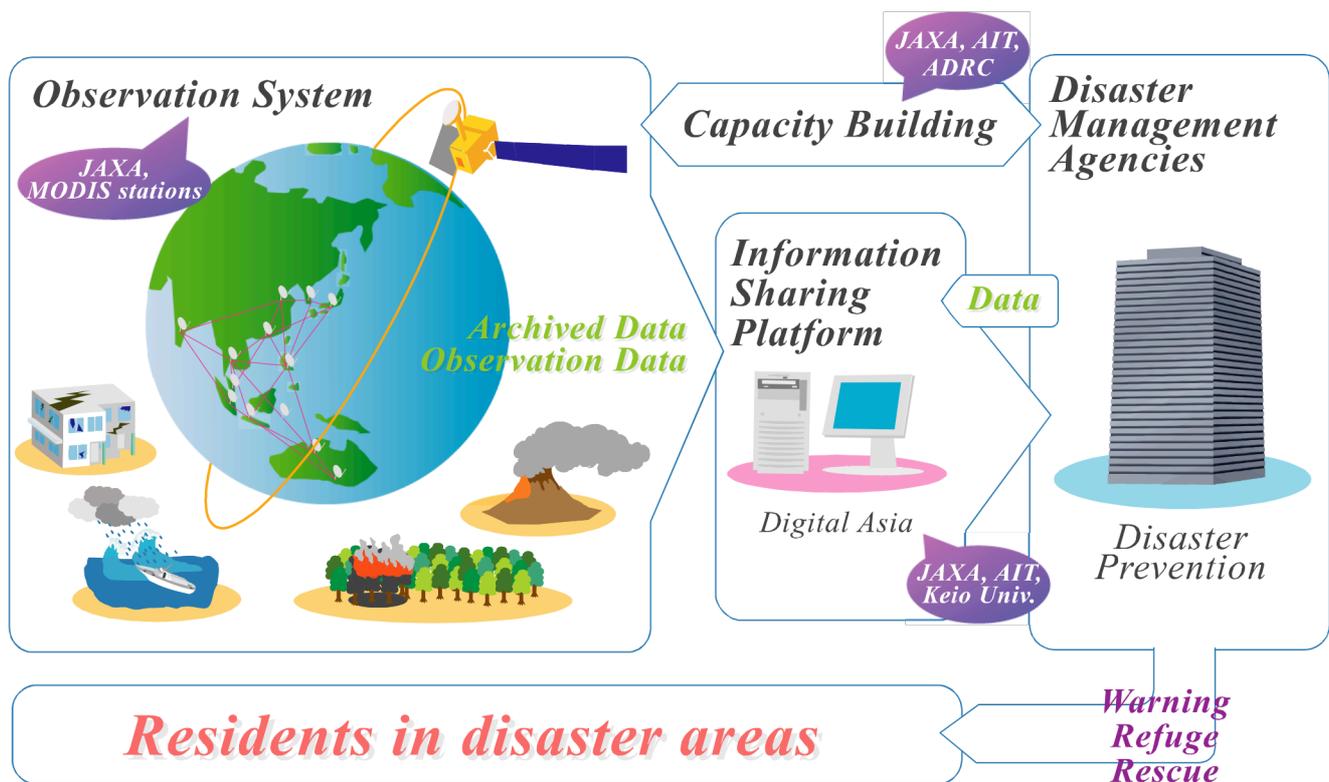
The overall project activity flow is shown in Fig. 7. This project will start in October 2006 after the commissioning phase of ALOS satellite.

### 7. Kyoto & Carbon Initiative

The ALOS Kyoto & Carbon (K&C) Initiative [3] is a project based on the conviction that Synthetic Aperture Radar has the potential to play a significant role in supporting certain environmental conventions,

carbon cycle science and natural conservation with information that cannot be obtained in a feasible manner by any other means. Relevance in this context is the L-band SAR sensitivity to vegetation structure and below-canopy inundation, together with the microwave cloud-penetrating capacity to ensure global observations. Building on the experiences and project structure developed for the JERS-1 SAR Global Forest Mapping project [4, 5], the K&C Initiative is organized as an international

collaborative effort. The Initiative is led by JAXA EORC, which is responsible for the overall management, implementation of the ALOS systematic acquisition strategy, as well as processing and distribution of all ALOS data, while product development is undertaken jointly by EORC and an international K&C Science Team, which involves universities and research organizations from 14 countries.



**Fig.7 The overall flow of the Sentinel-Asia Project**

The main objectives of this K&C Initiative are to support information needs by the followings:

- The terrestrial carbon cycle science community (CO<sub>2</sub> & CH<sub>4</sub> sources and sinks),
- Multinational environmental conventions and declarations such as: the UNFCCC Kyoto Protocol (Forest and Land Cover Change), the Ramsar Wetlands Convention and the Convention on Biological Diversity (wetland characteristics and disturbances), and the UN Millennium Declaration & the UN Convention to Combat Desertification (water

- supply and desertification),
- Environmental conservation.

Using ALOS PALSAR as the principal data source, the Initiative is organized on four themes – Forestry, Wetlands, Desert & Water, and SAR Mosaic Products. During the first three years after the ALOS launch – i.e. 2006-2008, the Science Team and JAXA EORC are undertaking development and subsequent generation of verified, regional-scale prototype products, including, forest and

deforestation maps in four continents, flood duration maps in major river basins, subsurface desert geomorphology maps in Africa, and 50 meter resolution PALSAR mosaics of all land areas on the Earth. More information about the K&C Initiative Science Team and products can be obtained at:  
[www.eorc.jaxa.jp/ALOS/kyoto/kyoto\\_index.htm](http://www.eorc.jaxa.jp/ALOS/kyoto/kyoto_index.htm)

## 8. Summary

ALOS was successfully launched on 24 January 2006, and the checkout of the satellite and ground systems and the data calibration efforts has been favorably proceeding in the commissioning phase.

The calibrated ALOS data will be released in late October 2006, and the JAXA activities to support disaster management and other scientific activities will fully start on this time.

In this paper, ALOS mission and the characteristics of its instruments, ALOS data distribution concept and related data services, and JAXA activities to support for disaster management and sustainable development are briefly introduced.

The unique capability of ALOS will greatly support global mapping for topography, forestry, Land Use and Land Cover, sea ice and coastal monitoring as well as support for disaster management such as big earthquakes, landslides, volcanic eruptions, floods and tsunamis.

JAXA will actively support the global and regional disaster management activities such as the International Charter "Space and Major Disasters" and the Sentinel-Asia project, initially by using ALOS, and also support the activities for sustainable development by promoting such a project as the Kyoto & Carbon Initiative.

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