December 8, 2006

The 2nd ALOS Research Announcement

Calibration and Validation, Utilization Research, and Scientific Research

Proposals Due: February 15, 2007

Earth Observation Research Center
Japan Aerospace Exploration Agency

CONTENT

1. INTRODUCTION

The second Research Announcement (RA) of the Japan Aerospace Exploration Agency (JAXA) is soliciting research proposals for scientific and practical research. The first RA was issued in 1999 for researchers all over the world. After the successful launch of the Advanced Land Observing Satellite (ALOS, “Daichi”) on 24 January 2006, and the completion of its commissioning phase, JAXA decided to issue this second RA specifically for researchers in Asia and Russia. This change is based on the successful construction of the ALOS Data Node (ADN) (see Appendix E), the worldwide data-distribution strategy, newly developed for the ALOS project.
This research will support the ALOS Research Plan to be carried out by members of the ALOS research team exploiting PRISM, AVNIR-2 and PALSAR sensor data. Membership in this team will be conferred on successful respondents to this RA. Proposals are solicited for conducting research in the following three categories:

- Calibration and Validation of ALOS data products and sensors
- Utilization research
- Scientific research

ALOS follows the Japanese Earth Resources Satellite-1 (JERS-1) and the Advanced Earth Observing Satellite (ADEOS) and will utilize advanced land observation technology. ALOS will be used for cartography, regional observation, disaster observation, and resources surveying.
ALOS mission objectives are to:

(1) develop digital surface models (DSMs), or digital elevation models (DEMs), and related geographic data products for Japan and other countries including those in the Asian-Pacific region (Map Making),
(2) perform regional observation for "sustainable development" (harmonization between Earth environment and development) (Regional Observation),
(3) conduct disaster monitoring around the world (Disaster Monitoring),
(4) survey natural resources (Resources Survey), and
(5) develop sensor and satellite technology for future Earth-observing satellites (Technology Development).

JAXA began distributing the calibrated standard data on 24 October 2006. The expected operational lifetime of ALOS is five years from initial launch.

The Principal Investigators (PIs) can cover the full range of ALOS science and applications, including (1) land use and land cover research, (2) topography and geology, (3) terrestrial (vegetation) ecosystem, agriculture and forestry research, (4) climate system, hydrological processes and water resources related research, (5) oceanography and coastal zone related research, (6) disaster and earthquakes, (7) resource exploration, (8) development of spatial data infrastructure, (9) basic studies on scattering and interferometric characteristics, (10) basic studies for accurate observation with high-resolution optical sensors, and (11) Polar research.

Applicants may submit their proposals any time before 15 February 2007. Proposals will be peer reviewed by the end of April 2007. Once applicants have been accepted, they will be integrated into the ALOS research team.
Participation as an ALOS Principal Investigator (PI) is open to researchers in the Asian and Russian region, shown in Fig. 1, with the exception of the Democratic People’s Republic of Korea, from all categories of organizations: educational institutions, research institutes, private enterprises and government institutions and any other organizations.
Funds for PIs are not available under this RA.
The advantages of a PI are:

- access to relevant ALOS data (limited amount) at no cost.

APPENDIX A provides technical and programmatic information concerning the ALOS system, data products, characteristics of each sensor, and general operation concept.
APPENDIX B provides objectives of the research activities covered by this RA.
APPENDIX C provides information on ALOS sample products.
APPENDIX D contains the basic guidance needed for preparing proposals in response to this RA.
APPENDIX E provides information on ALOS Data Node.
APPENDIX F contains a draft of the research agreement between JAXA and accepted applicants.

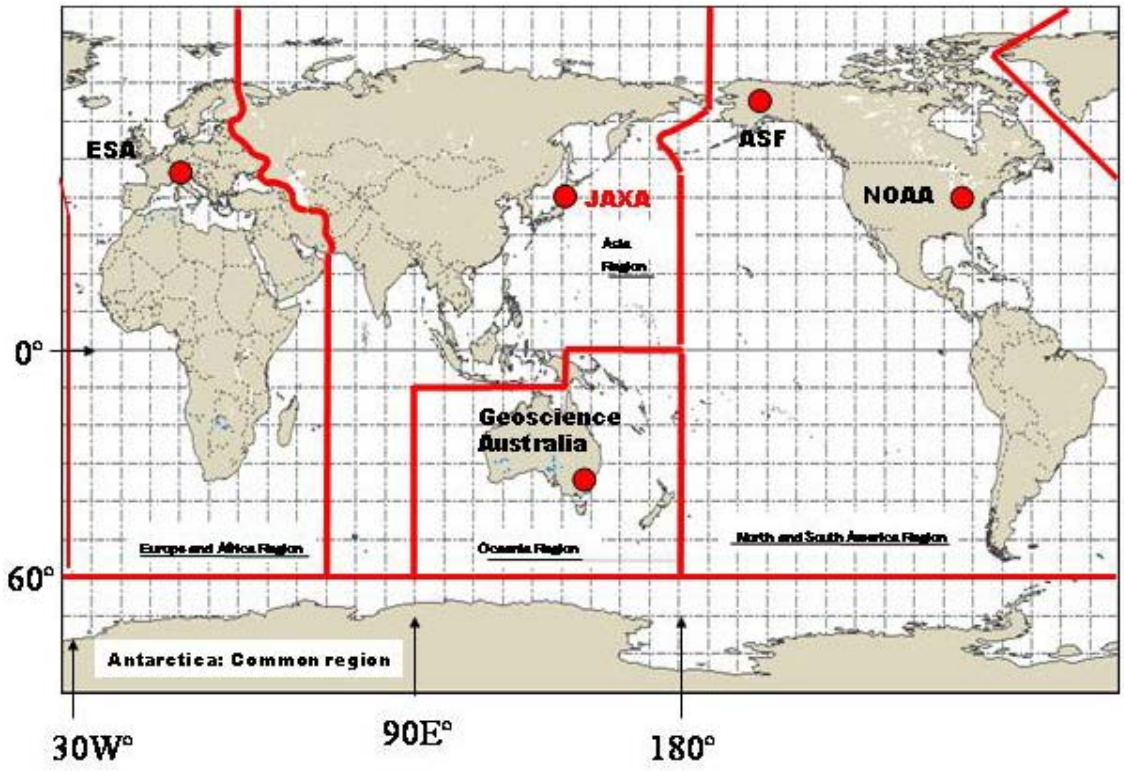

Fig. 1. ALOS Data Nodes zone definitions

2. SUMMARY OF MISSION INSTRUMENTS

ALOS has three remote sensing instruments: the Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM) for generating Digital Surface Models (DSMs), the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) for multispectral land coverage observation, and the Phased Array type L-band Synthetic Aperture Radar (PALSAR) for 24-hours all weather land observation. These sensors are expected to contribute to high-resolution land observation. (A detailed description of each payload is given in APPENDIX A-2.)

2.1 Panchromatic Remote-Sensing Instrument for Stereo Mapping

The Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM) is a panchromatic radiometer with 2.5meter spatial resolution. It has three telescopes for forward, nadir and backward views enabling us to generate DSMs with accuracy sufficient for 1/25,000 scale maps.

2.2 Advanced Visible and Near Infrared Radiometer type 2

The Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) mainly observes land and coastal zones and can provide land cover and land use information maps for monitoring regional environments. The instrument also has a cross-track pointing function for disaster monitoring.

2.3 Phased Array type L-band Synthetic Aperture Radar

The Phased Array type L-band Synthetic Aperture Radar (PALSAR) is an active microwave sensor that enables all-weather, 24 hour land observation. It has improved performance over the Synthetic Aperture Radar (SAR) on the Japanese Earth Resources Satellite-1 (JERS-1). The sensor has a steerable beam in elevation and the ScanSAR mode, which allows us to obtain a wider swath than conventional SARs. PALSAR was jointly developed by JAXA and the Japan Resources Observation System Organization (JAROS).

3. RESEARCH GOALS AND OBJECTIVES

The various products derived from ALOS data are expected to contribute significantly to the advancement of science. The research results in this RA will be utilized effectively for various applications such as Earth environment monitoring, natural resource exploration, disaster monitoring, and regional development planning. This RA specifically solicits research that uses ALOS data alone or in conjunction with other datasets in three categories, (1) Calibration and Validation, (2) Utilization Research, and (3) Scientific Research.

3.1 Calibration and Validation of ALOS data products and sensors

The three imaging sensors onboard ALOS are designed for superior performance in various aspects of high-resolution Earth observation.

These sensors must be calibrated and validated for us to achieve

- realistic performance in measuring an image's radiance (radar back scattering) and locations and
- the potential of retrieving geophysical parameters (digital elevation model, geo-location, forest distribution, ice-monitoring, interferometry, disaster monitoring) for Earth environmental monitoring.

In this RA, we have set two research goals related to the above. We would like to solicit your research proposals for achieving these goals.

(1) Calibrate Individual Sensors

This category seeks to clarify the sensor's input and output relationship (including determining calibration coefficients) as well as the sensor characterization with or without ground truth data. The target sensors are PRISM, AVNIR-2, and PALSAR.
More detailed research items are given below.

PRISM

- Sensor performance evaluation (including image quality evaluation)
- Geometric calibration
- Radiometric calibration (including stripe removal and determining calibration coefficients)

AVNIR-2

- Sensor performance evaluation (including image quality evaluation)
- Geometric calibration
- Radiometric calibration (including stripe removal and determining calibration coefficients)

PALSAR

- Sensor performance evaluation (including image quality evaluation)
- Geometric calibration
- Radiometric calibration (including antenna pattern determination and polarimetry)

(2) Develop and Validate Algorithms for Extracting Physical Parameters

It is important to develop algorithms that extract geophysical parameters from the calibrated images and truth data. It is also important to validate the estimated geophysical parameters using the above algorithms.
The many geophysical parameters that might be derived from ALOS data are listed in APPENDIX B. JAXA defined 1) DEM/DSM and 2) orthophoto images are the geographical products to be produced preferentially, however, proposals on developing and validating the other geophysical parameters are also welcome.

3.2 Utilization Research

The objectives of the earlier Japanese Earth Observation Satellites emphasized the scientific element. However, except for a limited category of data that is already being used operationally, this satellite data has not been used operationally due to many technical and operational issues. Therefore, in the preparatory operational phase of Earth observation data, utilization technology must be urgently established, and operational use in social systems is expected. A significant effort will thus be made to enhance opportunities fully employing data processing technology cultivated by JERS-1 and ADEOS as well as for promoting new developments.
The integration of ALOS data with numerical prediction models of sea ice, sea state, and disasters as well as monitoring and managing agricultural products, forestry, and fishery will directly lead to national benefits. Providing ALOS data for international utilization will also lead to the discovery of potential users and the enhancement of the market. Moreover, a wide range of provided data and user-oriented or value-added services will be able to satisfy a variety of market needs from personal to commercial applications.
Examples of utilization research are given below.

- Land use and land cover change monitoring
- Forecasting of sea-state conditions and sea ice for off-shore applications
- Ship traffic monitoring and fishery management in coastal waters
- Agriculture and forestry management

(planting status, agricultural productivity estimation, vegetation changes)
- Natural disasters (forest fires, flooding, landslide, earthquakes)
- Pollution monitoring (oil spill, red tide)
- Geology and natural resources exploration
- Applications related to SAR interferometry
  (digital elevation models, crustal movements, vegetation distribution),
- Development of the Geographic Information System (GIS) database of national land
- Educational use

Some utilization research will require providing of data products satisfying user requirements in near real-time. In this case, applicants must specify their requirements and clarify the propriety. Proposals should indicate research and development activities requiring operational use of ALOS data products, whether derived from ALOS data alone or from ALOS data integrated with that of other satellites. Such proposals should also include the definition of new products and algorithms required for the application development.
In addition, applicants should define objectives, methods, and implementation plans of the projects as precisely as possible, and their plan should indicate the means, the feasibility of realization, and the anticipated economic effects gained by achieving the objectives.
See APPENDIX B for details on utilization research.

3.3 Scientific Research

The data products obtained by ALOS will contribute to promoting of science. It will be essential to address many environmental issues (such as vegetation change, biomass burning, water resource management, resource assessment, disaster and earthquake mitigation, and cryosphere monitoring) in a broad range of Earth science disciplines. Our current knowledge of the complex interactions between the various components of the Earth system is not yet sufficient to predict environmental changes with the accuracy required for effective strategic development.
Proposals in response to this RA may address one or several Earth Science domains including both basic scientific research (e.g. land surface properties, measurement principles, and algorithm development for derivation of geophysical parameters) and studies of Earth Science processes. The targets have various time and spatial scales from local to regional and global. It may be possible to compare these analyses with analyses for other satellite data (such as from JERS-1 or ADEOS). Examples of major objectives are presented below.

- Land use and land cover change
- Topography and geology
- Terrestrial ecosystem, agriculture and forestry
- Climate system, hydrological processes, and water resource related research
- Oceanography and coastal zone related research
- Process studies for microwave scattering and SAR interferometry
- Basic studies for measuring accuracy by optical sensors with fine spatial resolution
- Polar research to correspond with the International Polar Year (IPY)

More detailed information is given in APPENDIX B. In addition, proposals should include the definition of objectives, scope and approach as well as an implementation plan for the research. The implementation plan should also indicate time horizons and means necessary for the achievement of the prospected results.

4. DATA DISTRIBUTION

4.1 Data Policy

For this RA, the data will be provided free of charge to PIs who agree to the following.

1) JAXA (JAXA and METI for PALSAR data) possesses all intellectual property rights of the provided data and products.
2) Provided data shall be utilized only for peaceful and non-commercial purposes.
3) Provided data shall be utilized only for conducting RA activities that comply with the research proposal.
4) Provided data shall not be transferred to any unauthorized third party or person without JAXA's prior written consent, with the exception of authorized Co-Investigators (CIs).

Other detailed conditions, such as the number of data scenes, shall be determined through review by JAXA.

Applicants must realize that data for PIs will be limited by satellite operations, the position of the Data Relay and Tracking Satellites (DRTS) and other eventualities. Refer to APPENDIX A-2 for the non-observable areas of each sensor.

JAXA shall not be liable for data loss, deterioration in data quality, or delay of data supply resulting from problems of ALOS or ground facilities, or for not providing ALOS data due to bad weather or matters beyond JAXA's control.

4.2 Data Distribution

The selected PIs shall utilize the archived JAXA data acquired from observation by ALOS, other satellites, and airborne SAR. The ALOS data for use in the ALOS standard operation plan, is primarily based on the ALOS Operation Concept and Observation Strategy (APPENDIX A-4). JAXA will not accept observation requests from the selected PIs. It is highly recommended that applicants consider their own research proposals based on the Observation Strategy, as well as the observation constraints of each sensor.

(1) Standard Data Products

The PIs will be provided the following data after the conclusion of their research agreements. Further detailed information is presented in Table 5 of APPENDIX A-3.

- PRISM Level 1A, Level 1B1 and Level 1B2
- AVNIR-2 Level 1A, Level 1B1 and Level 1B2
- PALSAR Level 1.0, Level 1.1 and Level 1.5

(2) Higher-Level Data Products of EORC

JAXA plans to produce the following higher-level data products beginning in March 2007. The data products from JAXA's selected area may be provided to PIs as sample datasets. Other products may also be provided for some requests. However, PIs should not base their research plans on the expectation of such products, and should be responsible for utilizing such products.

- PRISM DSM, Orthophoto Image
- AVNIR-2 Orthophoto Image
- PALSAR DEM, Orthophoto Image

(3) Satellite data belonging to JAXA

Satellite data here means sensor data from MOS, JERS, ADEOS, TRMM, ADEOS-II, ERS*, SPOT*, RADARSAT*, LANDSAT* and IRS*.

(4) Airborne L-band SAR (Pi-SAR) data

JAXA has operated its own airborne L-band SAR on test sites in Japan since 1998. PIs may utilize the archived data, however the database is available only in Japanese, at the following web site:

http://www.eorc.jaxa.jp/ALOS/Pi-SAR/index.html

5. FUNDING

JAXA will not provide funds to PIs.

6. QUALIFICATIONS OF APPLICANTS

We welcome all researchers in the Asian and Russian regions shown in Fig. 1 above (with the exception of the Democratic People's Republic of Korea) from educational institutions, research institutes, private enterprises, government institutions, and any other organizations, domestic or foreign, to submit research proposals for peaceful, non-commercial purposes.

7. BENEFITS AND RESPONSIBILITIES OF PIS

7.1 Benefits

Upon acceptance by JAXA, PIs may request satellite data and airborne SAR data listed in section 4 at no cost.

7.2 Responsibilities

7.2.1 Interim Report

The PIs will be required to submit interim reports on the status of their research in the format given by JAXA. They are highly encouraged to participate in PI meetings held jointly by JAXA and ADN organizations, and present the progress and accomplishments of their research. In particular, PIs must submit an interim report to JAXA by the end of January 2008, for interim evaluation during February-March 2008. PIs who pass the interim evaluation may continue their research.

7.2.2 Final Report

All PIs must submit their final reports to JAXA in English in accordance with the instructions in the agreement. They must present their results or part of their results at a meeting, symposium or workshop conducted by JAXA.

8. PROPOSAL SUBMISSION

8.1 General Conditions

Because quite a number of proposals are expected to be submitted from many countries, we might not accept proposals that do not adhere strictly to the format. The following are required in all proposals.

- **Applicants must register their profiles through the ALOS Home Page (http://www.eorc.jaxa.jp/ALOS/ra/schedule.htm) by February 15, 2007. JAXA will use these profiles only for RA purposes.**
- The proposal must be written in the format defined by JAXA and provided on the ALOS Home Page. (Please refer to this section and APPENDIX D.)
- It is highly recommended that applicants send their proposals and complete sets of all attachments, such as reprints of papers, in PDF format, to the email address of the ALOS Research Announcement Office (aproject@jaxa.jp) by February 15, 2007. The acceptable maximum file size by email is 10MB. If email transmission is not possible, applicants must send **six copies** of the proposal, including a complete set of attachments, such as reprints of papers, to the ALOS Research Announcement Office by postal mail.

They must be received by JAXA no later than February 15, 2007.

- All proposals should be type-written in either English or Japanese, with a font size smaller than 12 points.
- Each page must have a page number in the middle of the foot of the page and the name of the applicant in the upper right corner.

Proposals are not returned.

8.2 Language

Applicants must submit their proposals to JAXA in either English or Japanese. However, **applicants in Japan** are required to submit the **"information of applicants"** in the proposal cover sheet (APPENDIX D form 1a) **in both English and Japanese.**

8.3 Length

Unless otherwise specified in this RA, proposals should be as brief as possible, concentrating on substantive material. Proposals should not exceed 20 pages.
For further details, see APPENDIX D.

8.4 Proposal Contents

Please refer to APPENDIX D.

8.5 Where to Send Proposal (by postal mail)

Please send all necessary application papers for the second RA by postal mail to the following address. **These must be received no later than February 15, 2007.**

ALOS Research Announcement Office (Kazuo Ohta, Project Coordinator)
Earth Observation Research Center (EORC)
Japan Aerospace Exploration Agency (JAXA)
2-1-1, Sengen, Tsukuba, Ibaraki 305-8505, Japan
Tel: +81-29-868-2475 Fax: +81-29-868-2961
Email: aproject@jaxa.jp

9. SELECTION OF PROPOSALS

9.1 Evaluation and Selection Procedures

Proposals will be reviewed and evaluated by experts on the Research Evaluation Committee assigned by JAXA based on the evaluation criteria shown in 9.2. Final decisions on acceptance of proposals will be made by JAXA (the ALOS Research Board), taking into account the overall balance of different proposals and their resource requirements as well as the evaluation result. PIs will be notified of proposal acceptance by the end of April 2007 (current plan).

9.2 Evaluation criteria

1) Overall social, scientific, or technical merit of the proposal or unique and innovative methods, approaches, or concepts demonstrated by the proposal.
2) Applicant's capabilities, related experience, facilities, techniques, or unique combinations of these that are integral factors for achieving the proposal objectives.
3) Relevance to the objectives of the ALOS Research Plan.
4) Technical possibility within the research period.

9.3 Follow-on Action

After applicants are notified of selection as a PI, they are required to observe the terms and conditions of the projects including, but not limited to, data distribution and publications of

results. APPENDIX F is the draft of the agreement prepared for this RA. We request that the chosen PIs conclude their research agreements to comply with this draft agreement. JAXA will later send the actual agreement form to the chosen PIs, who should follow the procedures therein.

10. CANCELLATION AND POSTPONEMENT OF RA

JAXA reserves the right to cancel this RA upon notice delivered by JAXA. JAXA assumes no liability for canceling the RA, for postponing the RA schedule, or for anyone's failure to receive actual notice of cancellation.

11. RESEARCH ORGANIZATIONS

The following research organizations are being established to evaluate and select the proposals at the Earth Observation Research Center (EORC) of JAXA.

A new ALOS Research Board, chaired by an ALOS program scientist, will be established. The existing ALOS Research Group, led by the ALOS Science Project Manager, will support the ALOS Research Board, and the selected PIs will participate in the activities of the ALOS Research Group.

The ALOS Research Board in EORC will review the evaluation results provided by the Research Evaluation Committee, and make recommendations to EORC for final selections. The Research Evaluation Committee, whose members are selected by the ALOS Research Board, evaluates research proposals based on predetermined criteria, and will be organized outside JAXA to ensure fair evaluation of proposals.

Dr. Yasuoka, JAXA Technical Counselor at EORC, supervises all of the activities.

12. SCHEDULE

The schedule of this RA is shown in 12.1.

12.1 ALOS Second Research Announcement (this RA)

Document release	December 8, 2006
Deadline for registration and submission of proposals	February 15, 2007
Notification of PI selection	April 30, 2007 (subject to change)
Contract (agreement procedure)	May 2007
PI meeting and Symposia (annual)	October 2007 (subject to change)
Deadline for interim report	January 31, 2008
Interim evaluation	February-March 2008*

* JAXA will conduct one interim evaluation of results from PIs selected in both the first and second RAs. The agreement for each PI selected in this second RA will extend from its signing date until the end of March 2008. The successful PIs after the interim evaluation may continue their research until the end of July 2009.

13. RESEARCH ANNOUNCEMENT OFFICE

ALOS Research Announcement Office (Kazuo Ohta, Project Coordinator)

Earth Observation Research Center (EORC)
Japan Aerospace Exploration Agency (JAXA)
2-1-1, Sengen, Tsukuba, Ibaraki 305-8505, Japan
Tel: +81-29-868-2475 Fax: +81-29-868-2961
Email: aproject@jaxa.jp

APPENDIX A ALOS SYSTEM DESCRIPTION
APPENDIX A-1 ALOS CHARACTERISTICS

The Advanced Land Observing Satellite (ALOS) is a Japanese solution to high-resolution Earth observation. It is equipped with three mission instruments: Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM), Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2), and Phased Array type L-band Synthetic Aperture Radar (PALSAR). In order to fully utilize the data obtained by these sensors, ALOS was designed with a mass data handling capability and precision position and attitude determination capabilities that will be essential to high-resolution remote-sensing satellites in the next decade.

Table 1. ALOS Characteristics.

Item	Characteristics	Remarks
Launch Date	24 January 2006	
Launch Vehicle	H-IIA	
Launch Site	Tanegashima Space Center, Japan	
Spacecraft Mass	Approx. 4 tons	
Generated Power	Approx. 7kW	End of Life
Altitude	691.65km	At Equator
Inclination	98.16 °	
Repeat Cycle	46 days	Sun-Synchronous Semi-Recurrent
Sub-cycle	2 days	
Design Life	3-5 years	
Attitude determination accuracy	2.0×10^{-4} ° (off-line)	
Position determination accuracy	1m (off-line)	
Data Rate (Down link)	240Mbps via DRTS, 120Mbps (direct transmission)	
Onboard Data recorder	Solid-state data recorder (90Gbytes)	

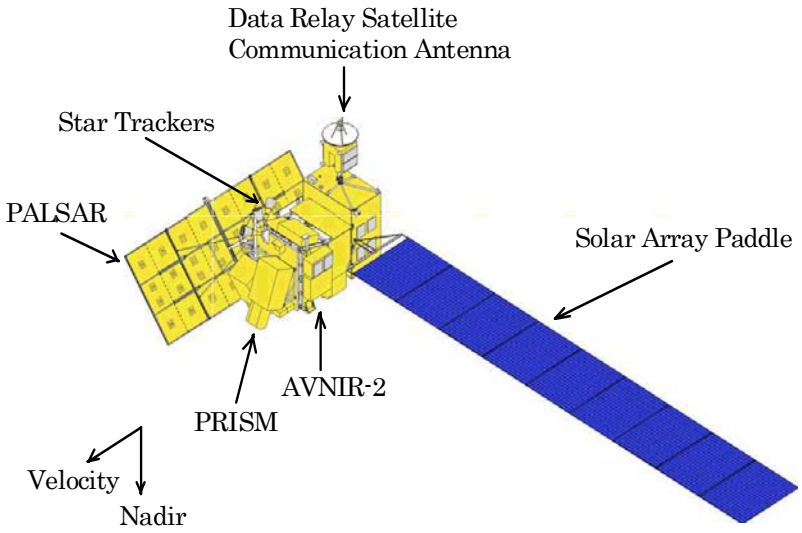

Fig.1. ALOS in-orbit configuration

APPENDIX A-2: CHARACTERISTICS OF EACH SENSOR

1. Panchromatic Remote-Sensing Instrument for Stereo Mapping

The Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM) is a major instrument of ALOS. It has three independent catoptric systems for nadir, forward and backward looking to achieve along-track stereoscopy. Each telescope consists of three mirrors and several CCD detectors for push-broom scanning. The nadir-looking telescope provides 70km width coverage; forward and backward telescopes each provide 35km width coverage.

As depicted in Fig.2, the telescopes are installed on both sides of its optical bench with precise temperature control. Forward and backward telescopes are inclined ±24 degrees from nadir to realize a base-to-height ratio of 1. PRISM's wide field of view (FOV) provides fully overlapped three-stereo (triplet) images (35km width) without mechanical scanning or yaw steering of the satellite. Without this wide FOV, forward, nadir, and aft-looking images would not overlap each other due to the Earth's rotation.

PRISM's 2.5meter resolution data will be used for extracting a highly accurate digital surface model (DSM). PRISM Characteristics are shown in Table 2.

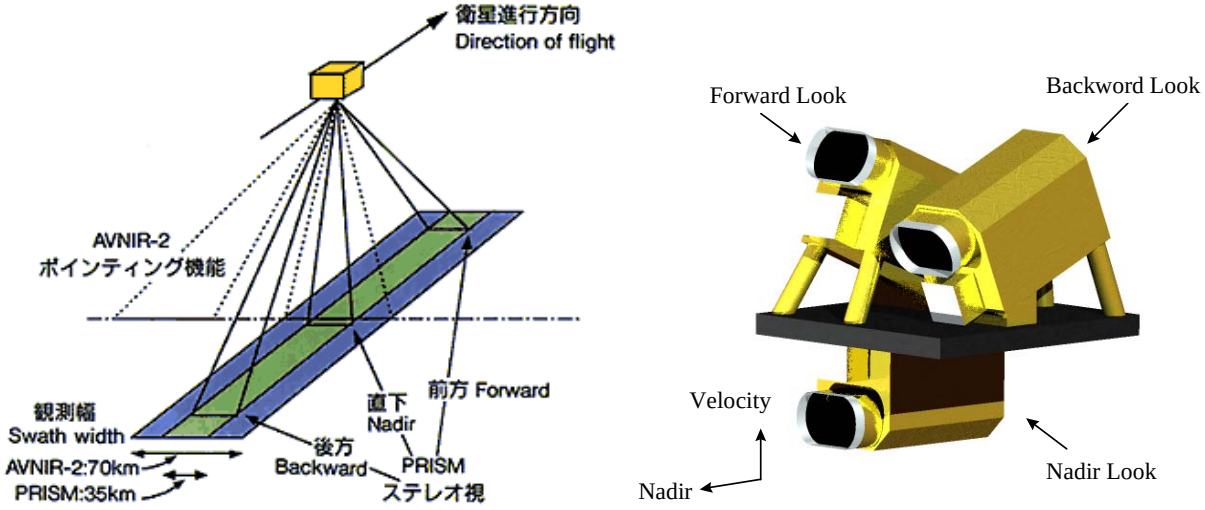

Fig. 2. PRISM Overview

Table 2. PRISM Characteristics .

Item	Characteristics	Remarks
Number of Telescopes	3	
Wavelength	0.52 - 0.77μm	
Base to Height Ratio	1.0	between fore and aft looking
IFOV	2.5m	
Swath Width	70km / 35km	Nadir / fore and aft
S/N	≥70	
MTF	≥ 0.2	
Number of Detectors	28,000 / band (Swath Width 70km) 14,000 / band (Swath Width 35km)	
Number of Bands	1	Panchromatic
ADC	7 bits	
Pointing	-1.2 ° to 1.2 °	

NOTE: PRISM cannot observe areas beyond latitudes 82 degrees south and north.

2. Advanced Visible and Near Infrared Radiometer type 2

The Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) is a successor to AVNIR onboard the Advanced Earth Observing Satellite (ADEOS) launched in August 1996. AVNIR-2's main improvement over AVNIR's is its instantaneous field-of-view (IFOV). AVNIR-2 provides 10-meter resolution images compared with the 16 m resolution of AVNIR in the multispectral region. The higher resolution was realized by improving the CCD detectors (AVNIR: 5,000 pixels per CCD, AVNIR-2: 7,000 pixels per CCD) and their electronics. Another improvement is the pointing angle. The pointing angle of AVNIR-2 is +-44 degrees for prompt observation of disaster areas.

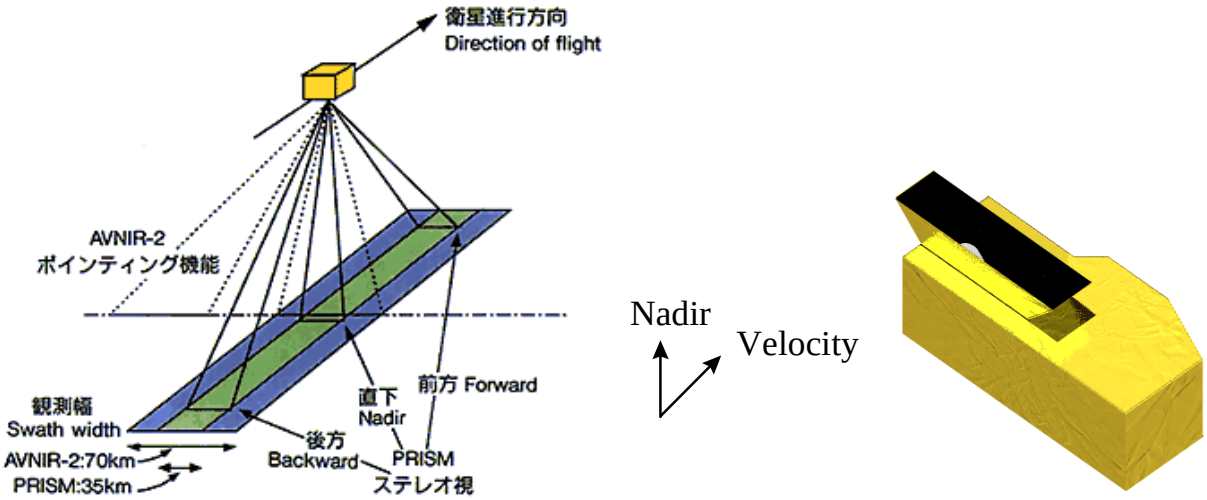

Fig. 3. AVNIR-2 Overview

Table 3. AVNIR-2 Characteristics

Item	Characteristics	Remarks
Number of Bands	4	
Wavelength	Band 1 0.42 - 0.50 µm	
	Band 2 0.52 - 0.60 µm	
	Band 3 0.61 - 0.69 µm	
	Band 4 0.76 - 0.89 µm	
IFOV	10 m	
Swath Width	70 km	
S/N	≥ 200	
MTF	Band 1 - 3: ≥ 0.25	
	Band 4: ≥ 0.20	
Number of Detectors	7000 / band	
ADC	8bits	
Pointing	-44 ° to 44 °	

NOTE: AVNIR-2 cannot observe areas beyond latitudes 85 degrees south and north.

3. Phased Array type L-band Synthetic Aperture Radar

The Phased Array type L-band Synthetic Aperture Radar (PALSAR) is Japan's second space borne SAR using L-band frequency. The high-resolution mode is a conventional one. PALSAR will have another attractive observation mode, the ScanSAR mode. This mode will allow us to acquire a 250 to 350km width (depending upon the number of scans) of SAR images at the expense of spatial resolution. This is three to five times wider than conventional SAR images and is considered to be useful for sea-ice extent and rain-forest monitoring. PALSAR was jointly developed by JAXA and the Japan Resources Observation System Organization (JAROS).

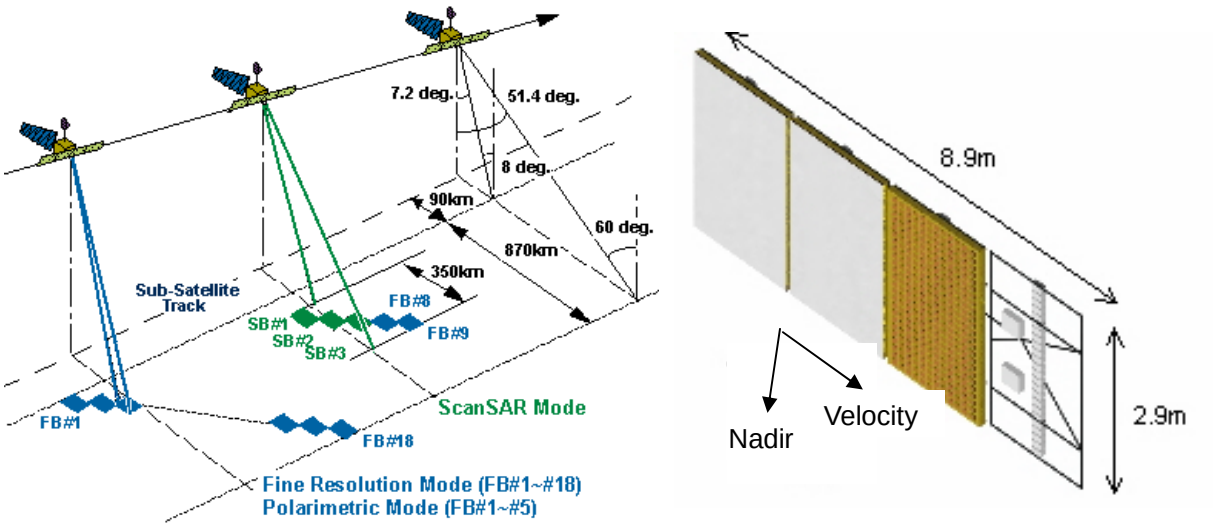

Fig. 4. PALSAR Overview

Table 4. PALSAR Characteristics

Item	Characteristic		
Mode	High resolution	ScanSAR	Polarimetric (Experimental)*
Center Frequency	1,270MHz	1,270MHz	1,270MHz
Bandwidth	28 / 14MHz	28 / 14MHz	28 / 14MHz
Polarization	HH or VV / HH+HV or VV+VH	HH or VV	HH+HV+VH+VV
Resolution**	10m (2 look) / 20m (4 look)	100m (multi look)	30m
Swath Width**	70km	250 - 350km	30km
Incidence Angle	8 - 60 °	18 - 43 °	8 - 30 °
NEσ^0 (tentative)**	≤ -23 dB (Swath Width 70km) ≤ -25 dB (Swath Width 60km)	≤ -25dB	≤ -29dB
S/A (tentative)** ***	≥ 16 dB (Swath Width 70km) ≥ 21 dB (Swath Width 60km)	≥ 21dB	≥ 19dB
AD bit	3 / 5	5	3 / 5
Data Rate	240M	240M	240M
Antenna Size (tentative)	AZ: 8.9m × EL: 2.9m (Electrical)		

NOTE: PALSAR cannot observe areas beyond latitudes 81 degrees south and north.

* Due to power consumption, the operation time will be limited.

** High resolution mode Off-nadir is 34.3deg.
ScanSAR mode 4th scan (Off-nadir is 34.1deg.)
Polarimetric mode Off-nadir is 21.5deg.

*** S/A level may deteriorate due to engineering changes in PALSAR.

4. Mass Data Handling

In order to handle the enormous volume of data generated by PRISM and AVNIR-2, ALOS has data compression (DC) capability. Each telescope of PRISM generates 320Mbps raw data, so 960Mbps data is transferred to DC (Fig. 5). The data is compressed to 240Mbps using a JPEG-like technique consisting of the discrete cosine transform (DCT) and Huffman encoding. Although the technique is lossy compression, the accuracy of extracting DEM from the lossy compressed data is almost the same as extracting it from uncompressed data.

AVNIR-2 generates 160Mbps of raw data that is compressed using Differential Pulse Code Modulation (DPCM), a lossless data compression technique based on that of AVNIR.

Compressed data of PRISM and AVNIR-2, and uncompressed PALSAR data are then transferred to the Mission Data Coding (MDC) system where an error correction code (Reed-Solomon (255,223) interleave depth 5) is added. The Bit Error Rate requirement of ALOS mission data is 1×10^{-16}.

The Mission Data Recorder (MDR) is a mass data storage device. It will hold 720Gbits, enough for 50-minute data recording at 240Mbps. The recorder will be a Solid State Data Recorder (SSR) using 64Mbit DRAM with Flip-Chip bonding.

Real-time or recorded data will then be transferred to the Data Relay Technology Satellite (DRTS), which is a Japanese geostationary data relay satellite, via the DRC subsystem. DRTS is located at 90E above the equator. DRTS has 240Mbps handling capability and is currently used by ALOS and will be used by the Japanese Experiment Module (JEM, “Kibo”), attached to the International Space Station.

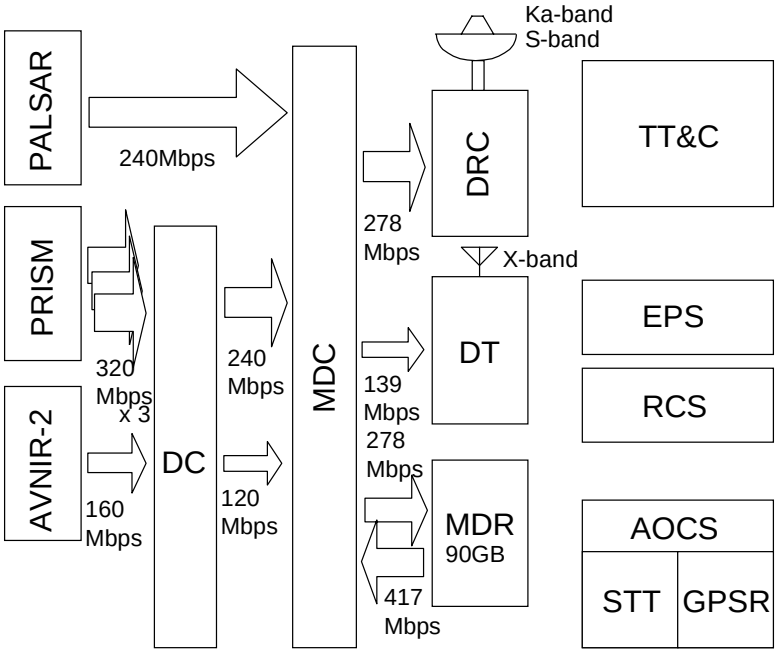

Fig. 5. ALOS Block Diagram with Data Flow.

5. Position and Attitude Determination

For geometric correction, we need precise position and attitude knowledge of satellites. ALOS has high precision star-trackers and an inertial reference unit for precision attitude determination, and a dual-frequency GPS receiver for precision position determination. In addition to onboard attitude and position determinations, off-line precision attitude and position determinations are provided to improve precision. The goal is to determine the position of each PRISM pixel on the ground to within 2.5m.

APPENDIX A-3: DATA PRODUCTS

1. Definition of ALOS Data Products

Three categories of data products are defined - Raw or Level 0 data, level 1 products and higher level products.

1.1 Raw data or Level 0 data

Raw data is the demodulated bit stream and is temporarily archived in JAXA. Level 0 data is frame-synchronized, de-packetized decoding data. This level 0 data is permanently archived in JAXA and is for distribution to ALOS data node organizations.

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1.2 Level 1

Level 1 is radiometrically and geometrically corrected data and is a standard JAXA product for ALOS users, though only a relatively small percentage of Level 0 data is processed to Level 1 product.

1.3 Higher-level data product

Products above level 2 are higher-level data products. Higher-level data products are made more sophisticated by, for example, processing with digital elevation models. These products will be provided by JAXA's EORC from March 2007.

2. Standard Data Products

Table 5. Standard data products of each sensor

Common

Level	Definition	Note
Raw	Demodulated bit stream	Packetized Temporarily archived
0	Frame synchronization and PN decoding of CADUs and R-S Error Detection and Correction of VCDUs Extracted mission telemetry, orbit and attitude data are stored on separate files.	Compressed (except for PALSAR) Permanently archived Level for distribution to Data Node

PRISM

Level	Definition	Note
1A	Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied). Individual files for forward, nadir, and backward looking data.	
1B1	Radiometrically calibrated data at Sensor input	
1B2	Geometrically corrected data Options G: Systematically Geo-coded (No option: Geo-referenced)	Map projection Resampling Pixel spacing

AVNIR-2

Level	Definition	Note
1A	Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied).	
1B1	Radiometrically calibrated data at Sensor input	
1B2	Geometrically corrected data Options G: Systematically Geo-coded (No option: Geo-referenced) D: Correction with coarse DEM	Map projection Resampling Pixel spacing

PALSAR

Level	Definition	Note
1.0	Reconstructed, unprocessed signal data appended with radiometric and geometric correction coefficients (appended but not applied). In Polarimetric mode, polarimetric data is separated.	
1.1	Range and azimuth compressed complex data on slant range. Full resolution	Beam modes: Full resolution mode, Low data rate mode, Polarimetric mode SLC: Single Look Complex Used for interferometry
1.5	Multi-look processed image projected to map coordinates. Option G: Systematically Geo-coded (No option: Geo-referenced)	Map projection Resampling Pixel spacing

APPENDIX A-4 ALOS OPERATION CONCEPT AND OBSERVATION STRATEGY

1. Priority of Sensor Observation Mode

1.1 PRISM Observation Mode

The priorities of observation over land areas (including coastal zones) and polar regions in the day light zone are as follows.

1.1.1 Observation in three-line mode with 35km swath width

(1) Global land area

1.1.2 Nadir viewing mode with 70km swath width

(1) On demand

1.2 AVNIR-2 Observation Mode

The priorities of observation over land areas (including coastal zones) and polar regions in the day light zone are as follows.

1.2.1 Nadir viewing mode with 70km swath width

(1) Global land area

1.2.2 Pointing mode along cross-track direction

(1) Post disaster observation

(2) Simultaneous observation with PALSAR for specified areas

(3) On demand

1.3 PALSAR Observation Mode

The priorities of observation over land areas (including coastal zones) and polar regions are as the follows.

1.3.1 High resolution mode with off-nadir angle 34.3 degrees, HH and HH/HV polarizations, in night zone

(1) Global land area

1.3.2 Other modes (ScanSAR, Polarimetry, other off-nadir angles)

(1) Specified areas

(2) Post disaster observation

(3) On demand

Specified areas will be determined based on the requirements of the appropriate organizations. “On demand” observations will only be available when there are no conflicting observations having higher priority.

2. ALOS Observation Strategy

The ALOS mission features an observation strategy for pre-launch, systematic, and global-observation plans for all three instruments. The current observation strategy is on the following web page:

http://www.eorc.jaxa.jp/ALOS/obs/overview.htm

This observation strategy will be updated every six months based on the actual results of observation and other considerations.

APPENDIX B: ALOS RESEARCH PLAN

1. Goals of ALOS Research Plan

To achieve the ALOS mission, it is essential not only to distribute data products to users, but also to promote scientific and utilization research for ALOS data in broad categories ranging from the environmental and resource sciences to computer science. This Plan suggests research categories that are strongly related to acquisition and application of ALOS data and that will be promoted by association and efforts of PIs in this RA and EORC.

2. Calibration and Validation of Each Sensor and Related Basic Studies

Calibration and Validation of PRISM, AVNIR-2 and PALSAR on processing Level 1 data from Level 0 data are most important and necessary to improve the accuracy of high resolution DEM and biomass distribution data. Moreover, related basic studies required for Calibration and Validation of these sensors are essential for the development of the next generation of sensors that will have higher performance.

3. General Goals

The general goals determine which categories to select, how to contribute to each category, and what kinds of data products and algorithms are required. The categories mentioned below are classified based on the categories of undergoing core projects of the International Geosphere-Biosphere Program (IGBP).

3.1 Land Use and Land Cover Research

This research reveals land use and land cover changes, and contributes to clarifying the mechanism of such changes and the development of change models. It is important to develop the following products and algorithms for these purposes.

3.1.1 **High-resolution Digital Elevation Model:** Topographical conditions strongly influence land use determination and its change process as well as environmental impacts such as soil erosion and runoff changes. In these research categories, a Digital Elevation Model (DEM), or Digital Surface Model (DSM), which corresponds to a 1: 5,000 to 1:100,000 scale topographical map is useful. Algorithms for stereo matching and interferometric measurement need to be developed.

3.1.2 **Orthophoto image (PRISM, AVNIR-2, PALSAR images) and land use and land cover data:** These can reveal the sprawl of urban areas and villages, changes of agricultural land and agricultural practices, and deforestation. Radar images may also be able to detect tillage variations (variation of tillage surface roughness) and changes of cropping patterns.

3.2 Topography and Geology

This research contributes to measuring changes in terrain and watercourses due to soil erosion and slope failure as well as to classifying and analyzing terrain features with elevation data. It is thus essential that the following data products and algorithms be developed.

3.2.1 **High-resolution DEM:** High-resolution DEM can be used for terrain classification and analysis as well as watercourse analysis.

3.2.2 **Orthophoto image (particularly PALSAR image):** An orthophoto image can be used for the extraction and classification of terrain features among other uses.

3.2.3 **Elevation change due to soil erosion and sedimentation:** Interferometric measurement is expected to provide a method for measuring time-series changes of land elevation. An area where a topographic condition changes remarkably due to soil erosion and sedimentation, such as the Yellow River basin, is selected as the objective area.

3.3 Terrestrial (Vegetation) Ecosystem, Agriculture and Forestry Research

This research contributes to clarifying vegetation dynamics with emphasis on the carbon cycle, monitoring agricultural production, estimating productivity of pastures based on the vegetation dynamics, and investigating biomass changes caused by human activities. For this purpose, the following data products and algorithms need to be developed using AVNIR-2 data or other satellite data.

3.3.1 **Forest distribution monitoring:** Methods for measuring global forestry distribution are expected to be advanced using PALSAR or AVNIR-2.

3.3.2 **Vegetation biomass distribution measurement:** Vegetation biomass is a key parameter that describes vegetation dynamics. A method of measuring vegetation biomass focusing on forests with simultaneous observations by PRISM and AVNIR-2 is expected to be developed.

3.3.3 **Application to forest management:** A method of monitoring deforestation and afforestation and estimating forest growth should also be developed concurrently with the development of a biomass measurement method.

3.3.4 **Monitoring the productivity of pastures and crop land:** The development of a method for determining the crop planting area, estimating productivity of pastures and crop land in a specific area, based on intensive observation by both PALSAR and AVNIR-2, is expected. In addition, a method of monitoring the changes of agricultural production and productivity of pastures caused by drought should also be developed.

3.3.5 **Monitoring vegetation change due to human activities such as biomass burning:** A method for measuring and monitoring the variation of biomass density and vegetation structure due to biomass burning in specific areas, with intensive observations using PALSAR together with AVNIR-2, needs to be developed.

3.3.6 **Desertification Monitoring:** This aims at monitoring the decline of land productivity and soil degradation due to excessive cultivation and pasturage and improper irrigation. Methods of indirectly monitoring desertification need to be developed by observing vegetative deterioration using PALSAR and AVNIR-2 as well as directly monitoring salt accumulation on the soil surface using AVNIR-2.

3.4 Climatic System, Hydrological Processes, and Water Resources Related Research

3.4.1 **Surface process:** In research on surface processes, it will be useful to develop methods to understand vegetation distribution, measure soil moisture, and to prepare soil moisture datasets.

(1) Vegetation monitoring: Development of algorithms for measuring key parameters for water vapor estimation such as biomass density or Leaf Area Index (LAI) is expected. Development of methods for integrating other satellite data is also important.

(2) Estimating soil moisture distribution: Development of algorithms for measuring soil moisture with PALSAR needs to be facilitated. Development methods for integrating other satellite data with PALSAR data may also be essential.

(3) **Run-off analysis:** ALOS data will contribute to run-off analysis under various conditions related to climate and land even in areas where there is insufficient available data.

- **High-resolution DEM:** A high-resolution DEM, having much higher resolution than the existing 1km DEM, has the potential of making the run-off analysis more accurate and reliable.
- **Datasets of land use / land cover and their changes:** These datasets will help analyze water valance and run-off variation due to land use and land cover changes. Using additional satellite data will make this research more successful.

3.4.2 **Water pollution analysis:** This research aims at estimating the quantity of water pollutant load and analyzing flow-down conditions by providing more accurate topographical data, and land use and land cover datasets.

(1) **High-resolution DEM:** A high-resolution DEM will enable more accurate analysis of the flow-down of the water pollutant load due to soil erosion and estimation of the amount.

(2) **Datasets of land use / land cover and their change:** These datasets facilitate analyzing the quantity of the water pollutant load by land use and land cover changes. Combined with hydrological analysis, these datasets reveal the condition of the pollution effluent. Using additional satellite data will make this research more successful.

3.4.3 **Snow and ice related analysis:** Accurately analyzing snow and ice in the following categories using high resolution sensor data from ALOS will contribute to understanding changes of climate and water resources (hydrological cycles), the International Polar Year (IPY) related researches and others.

(1) **Estimating states and changes of snow cover and snow-water equivalent:** Analysis using the observation data from PALSAR and AVNIR-2 will help to accurately predict and understand the seasonal or annual change of snow cover and snow-water equivalent.

(2) **Measuring and analyzing variations of ice sheets and glaciers:** Analysis of Interferometric measurements by PALSAR and observation by AVNIR-2 will contribute to understanding the ice sheet mass balance and mountain glacier variation in the South Pole, Greenland, and other areas.

(3) **Sea ice monitoring:** Analyzing the observation data from PALSAR and AVNIR-2 will contribute to determining the extent and seasonal or annual variation of ice sheets in the Polar Regions and coastal zones. Furthermore, using ScanSAR data from PALSAR will contribute to the methodological development of extensive sea ice monitoring, and using polarimetric data of PALSAR will improve the accuracy of sea ice classification.

3.5 Oceanography and Coastal Zone Related Research

3.5.1 **Coastal zone related research:** Providing information on wave, sea surface wind, water current, sea ice, topographical change and sand drift in coastal areas can support economic activities in coastal areas such as sea traffic, pollution control and fisheries. For this purpose, it is necessary to develop and prepare the following algorithms and products.

(1) **Oil spill datasets of coastal zones:** Techniques for extracting the polluted areas from PALSAR images is expected to be developed. It is necessary to analyze sea surface wind and the spectrum of ocean waves around the area to accurately extract polluted areas. At the same time, datasets that analyze these factors must be developed.

(2) **High-resolution DEM of coastal zones:** High-resolution DEM of coastal zones combined with water depth data will contribute to analyzing transformation of sea wave and coastal topography and impacts of sea level rise.

(3) **Datasets of sea surface wind and wave height in coastal zones:** It is possible to prepare datasets for coastal sea-surface winds and waves using PALSAR data. A method that predicts coastal current by utilizing a numeric simulation model along with these datasets should also be developed. These are useful for giving a boundary condition for the analysis of coastal transformation and sand drift.

(4) **Datasets of sea ice:** Methods for monitoring coastal sea ice and for providing data accurately using PALSAR and AVNIR-2 need to be developed. Coastal ice datasets are useful for the various coastal activities of human beings.

3.5.2 **Ocean dynamics:** Utilization of PALSAR or development methods using PALSAR together with other satellite data will contribute to studies on air-sea interaction, sea waves, and the dynamics of various ocean phenomena in coastal zones and the open seas.

(1) **Coastal topography-air-sea interaction:** Strong or weak wind zones are generated locally in a coastal sea because of coastal topography. Though such changes of sea-surface are essentially important to coastal waves and water currents, little research has been conducted in these areas. High-spatial resolution information collected by PALSAR on ocean waves and sea surface winds is expected to greatly contribute to studying the coastal topography-air-sea interaction and probing its mechanism.

(2) **Wave-current interaction and various phenomena in the ocean:** Studies on the interactions between ocean waves and currents using data acquired in the ScanSAR mode of PALSAR need to be promoted. Based on these studies, large-scale ocean currents (like the Black Current), cold/warm water masses, coastal water currents, and internal waves can be visualized from ScanSAR images. This will help us to understand ocean dynamics.

3.6 Disasters and Earthquakes

3.6.1 **Diastrophism:** Methods for monitoring land surface deformations due to diastrophism employing interferometric observation by PALSAR need to be developed.

3.6.2 **Volcano monitoring:** A method for monitoring the deformation of mountains caused by volcanic activities should be developed.

3.6.3 **Slope failure:** It is necessary to develop a method for the risk analysis of slope failure using high-resolution DEMs generated by PRISM and PALSAR. Datasets of land use and land cover in slope areas will contribute to estimating surface erosion and water infiltration as well as forecasting the damage due to slope failure.

3.6.4 **Analysis and simulation of flooding and inundation:** By applying high-resolution DEMs, we can conduct run-off (flooding) analysis and inundation in areas where we previously lacked sufficient data. This will contribute to advancing methods for analyzing and investigating these phenomena. At the same time, land cover and land use data will improve the reliability of these analyses as well as damage forecasting and refuge planning.

3.6.5 **Tidal wave analysis:** It is expected that tidal wave tracing analysis with high-resolution DEMs can be conducted in areas where we previously lacked sufficient data. This will contribute to advancing the methods of analyzing and investigating these phenomena. Furthermore, land cover and land use data together with high-resolution DEMs will improve the reliability of these analyses as well as damage forecasting and refuge planning.

3.6.6 **Disaster monitoring techniques:** Disaster monitoring techniques reveal damage due to drought, flood, fire, slope failure, tidal wave and earthquake disaster. Furthermore, these techniques can be applied to quick and accurate damage assessment (for example, the effect on agricultural production).

3.7 Resource Exploration

Resource exploration research techniques for mineral resources need to be developed. Analysis methods integrating PRISM, AVNIR-2, and PALSAR images with DEMs will be examined.

3.8 Development of Spatial Data Infrastructure

3.8.1 **Techniques for developing spatial data infrastructure:** Automatic recognition and three-dimensional measurement of terrain features need to be developed to efficiently generate high-resolution DEMs and spatial data on artificial structures, which are the basis of various scientific research and practical uses. For three-dimensional measurement, orientation methods and stereo matching methods for PRISM images need to be developed. Furthermore, an algorithm for interferometric measurement needs to be developed for PALSAR. In addition, a method integrating images (from PRISM, AVNIR-2 and PALSAR) with DEM needs to be developed for automatic recognition and three-dimensional measurement of terrain features such as roads, large structures and urban areas.

3.8.2 **Management and retrieval techniques for very large databases:** Using ALOS data as a test case, techniques for very large spatial databases are expected to be developed. Examples include data storage and management techniques, and an efficient retrieval method based on a map or coordinates.

3.9 Basic Studies on Scattering and Interferometric Characteristics

In order to expand the application fields of PALSAR data, including improvements of interferometric analysis, polarimetric analysis, and terrain correction methods, the following study will be performed.

3.9.1 Decomposition method for polarimetric SAR data

Decomposition methods for PALSAR polarimetric data should be studied and developed. This methodology will be applied to land cover classification using scattering characteristics of the targets.

3.9.2 Polarimetric and interferometric data analysis

Interferometric analysis is applied to the polarimetric data acquired from PALSAR repeat-pass observation. An applied field example is tree height estimation in forested areas.

3.10 Basic studies for accurate observation with high resolution optical sensors

Research on the following topics needs to be conducted to develop the next-generation high-resolution optical sensors.

(1) The accuracy of satellite position and attitude determination, including the rate of the variation of the attitude that will affect the pointing accuracy and resolution of the optical sensors, needs to be analyzed and evaluated.

(2) Impacts of the shock during launch, temporal degradation, and temperature changes inside the instruments on optical alignment (including the optical benches and the structures with optical alignment), photoelectric transfer characteristics, and sensor resolution need to be analyzed and evaluated.

(3) It is necessary to develop a code to analyze the effect of multi-scattering of the atmosphere, especially regarding aerosols, whose spatial conditions fluctuate largely with time, and to estimate the surface albedo with high speed and high accuracy.

(4) A suitable filter for the modulation transfer function (MTF) correction needs to be developed to restore observation data degraded by the MTF of each sensor or atmospheric influences.

4. Strategic Goals

We define the development of specific data products and algorithms for promoting other scientific researches as "strategic goals." These are selected considering their relevance to the ALOS mission and the goals of this plan, and resource limitations.

4.1 Data products

4.1.1 **Global High-resolution DEM and Orthophoto image (PRISM, AVNIR-2, and PALSAR):** These data products form the basis of many fields of research and practical applications. They are provided only by ALOS at the moment. However, resources required to generate these data are so large that the accuracy and resolution may change according to the objective area. Global coverage will be pursued by coordinating with other data node organizations.

4.1.2 **Global Biomass density dataset (PALSAR and AVNIR-2):** Biomass is not only one of the most important parameters for estimating the carbon cycle, but also provides a basis for forestry management. However, it is difficult to measure on the ground and there is no data covering a large area. Since only ALOS is equipped with L-band, which favors biomass observation, it is expected that biomass density data will be generated using PALSAR images along with AVNIR-2 images and high resolution DEMs. These activities will allow us to conduct time series analysis with Global Forest Mapping (GFM) datasets from JERS-1 SAR data.

4.1.3 **Land surface deformation dataset (Earthquake-prone areas only):** The distribution of deformed land surfaces can be extracted by interferometric measurement. Monitoring diastrophism is essential in the Pacific Rim area, including Japan, which is always threatened by earthquakes. Land surface deformation data will be collected by periodic satellite observation and continuous ground observation

4.2 Algorithms

4.2.1 **Automated generation of high-resolution DEM and orthophoto image:** A large computing capability is usually required to generate high-resolution DEMs and orthophoto images, and the quality of these products is affected strongly by the performance of the algorithms used. Algorithms for automated generation of high-resolution DEMs and orthophoto (including an algorithm to estimate satellite position and altitude) need to be developed.

4.2.2 **Accuracy improvement of the biomass measurement method:** The development of algorithms using DEMs and AVNIR-2 images together with other satellite images for measuring global biomass distribution with higher accuracy is requested.

4.3 Calibration and Validation for each Sensor and Related Basic Studies

Calibration and validation of each sensor is necessary for improving the quality of the data products such as high-resolution DEMs and biomass density data. In addition, basic studies on calibration and validation for improving the accuracy of each sensor should also be pursued as strategic goals.

4.3.1 Calibration and validation for optical Sensors

To generate high-quality products from optical sensors, AVNIR-2 and PRISM, the basic study for very accurately evaluating radiance characteristics, geometric characteristics, spatial resolution, system noises, and other factors is considered to be one of the strategic objectives.

(1) Accuracy improvement of radiance and brightness calibration

The radiance and brightness of optical sensors will be calibrated by using pre-flight test data, internal calibration source data, and external calibration data after launch. The main output of this study is to estimate absolute calibration coefficients. In particular, an important challenge will be the improvement of stability characteristics with ground-based experiments with calibration after launch and development of the radiative transfer model with high accuracy.

(2) Accuracy improvement of DSM

Algorithms for automatically evaluating and correcting registration and pointing accuracy, and for automatically producing high-resolution DSMs using stereo matching images will be developed.

(3) Atmospheric correction

Algorithms should be improved to estimate the surface albedo on a heterogeneous surface using optical sensor data, taking into account the effect of multi-scattering in the atmosphere, especially spatial and temporal changes of aerosols.

4.3.2 Calibration and validation for PALSAR system

A basic study for achieving high radiometric accuracy of the PALSAR system is considered to be one of the strategic objectives.

(1) Accurate estimation of normalized radar cross section

The relation between the digital number and the normalized backscattering coefficient for PALSAR standard products will be determined by using the pre-flight test data, internal calibration source data, and external calibration data. The main outputs of this study are the estimated in-orbit antenna elevation patterns and the absolute calibration coefficients.

(2) Accuracy improvement of interferometric SAR data

In order to derive accurate digital elevation models as well as crustal movements, a study on achieving an accurate phase difference will be done by using repeat-pass interferometric datasets acquired by the PALSAR system.

(3) Accuracy improvement of polarimetric SAR data

PALSAR's polarimetric observation mode is currently an experimental mode. However, this observation mode will be the main operation mode in future SAR systems. In order to prepare for the practical use of fully polarimetric data, polarimetric calibration with the data acquired from PALSAR polarimetric observation mode should be studied. The methodology to derive phase correction, cross talk, and gain imbalance will be developed and investigated.

APPENDIX C: ALOS SAMPLE PRODUCTS

The following web page contains samples of the standard products of each sensor processed at the Earth Observation Center (EOC) at JAXA. Data is provided to help you confirm the data format, using real data from each sensor. Please remember that the data have not been calibrated or validated.

http://www.eorc.jaxa.jp/ALOS/doc/sproduct.htm

APPENDIX D: PROPOSAL CONTENTS AND APPLICATION FORMS

1. Proposal Coversheet

1.1 Information of Applicant (Form 1a)

- Identifying information of principal applicant: Legal name, official title, department, organization, address, country, phone number, facsimile number, and email address
- Co-applicant information: Name, organization, and email of each co-applicant
- Biographical Information, experience and papers in related fields of principal applicant
- Signature of principal applicant

1.2 Information of Proposal Contents (Form 1b)

- Research Category (Calibration and Validation, Utilization Research, or Scientific Research)
- Research Title : A brief and valid project title
- Main Sensor (PRISM, AVNIR-2, PALSAR, or none)
- Supplemental Sensor (PRISM, AVNIR-2, PALSAR, or none)
- Data Requirement (Required, not Required, the minimum and maximum number of required scenes)
- Abstract: (200 - 300 words) Objective, significance in the research field, method, result, and schedule

2. Detailed Description of Proposal (Up to five pages)

The main body of the proposal should be a detailed statement of the work to be undertaken and should include objectives and expected significance in relation to knowledge of the art in the field and to related work in progress elsewhere. The statement should outline the plan of work, including the broad design of experiments to be undertaken and a description of experimental methods and procedures. The project should be described in terms of the following items.

- Table of contents
- Objective
- Significance in the research field
- Methodology
- Algorithm to be used
- Anticipated results
- Type of truth data and its acquisition plan (Area, Product level, Volume, Term, Season)
- Product Utilization Plan (Product level, Volume, Term, Season)

3. Work Plan (Research Schedule) (Form 2)

Provide the research schedule in Form 2. Include descriptions of the major activities of the research and associated schedules. This schedule should be planned between May 2007 and the end of July 2009.

4. Details of Data Requirements

4.1 JAXA-Owned Satellite Datasets (Form 3a)

To request the following satellite datasets, complete Form 3a.
JAXA has the authority to provide datasets received from:

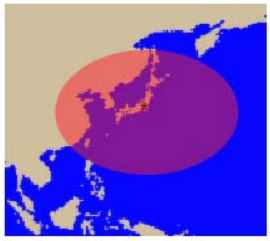
- Marine Observation Satellite (MOS) (global)
- Japanese Earth Resources Satellite (JERS) (global)
- Advanced Earth Observing Satellite (ADEOS) (global)
- Tropical Rainfall Measuring Mission (TRMM) (global)
- European Remote-sensing Satellite (ERS) (only around Japan) *
- LANDSAT (only around Japan) *

- SPOT (only around Japan) *
- RADARSAT (only around Japan) *
- Indian Remote Sensing Satellite (IRS) (only around Japan) *

* Data from foreign satellites are limited to the area received at the ground station in Japan, as portrayed in the following figure. The red area indicates the visible circle considering the skyline at the ground station. JAXA can receive data inside this circle that shows minimum and maximum latitude and longitude. If the antenna angle is changed, the circle may be extended somewhat.

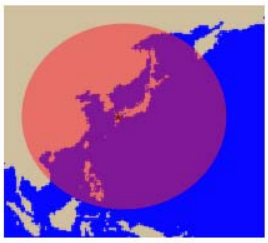
ERS

Latitude N 13 - N 54
Longitude E112 - E166



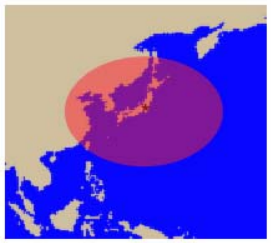
IRS

Latitude N 5 - N 61
Longitude E 97 - E163



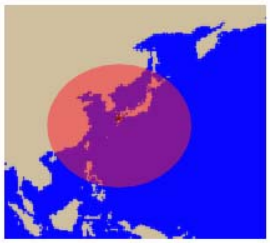
SPOT

Latitude N 12 - N 55
Longitude E106 - E172



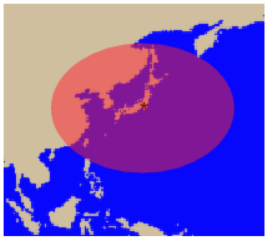
RADARSAT

Latitude N 12 - N 53
Longitude E107 - E150



LANDSAT

Latitude N 15 - N 52
Longitude E114 - E164



You cannot order the data, but can search for the browse data via the internet if you access the following address. JAXA recommends that you search for the data of the requested area in advance.

- MOS, JERS, ADEOS, TRMM, ERS, SPOT***, LANDSAT**/*** data search
  https://www.eoc.jaxa.jp/iss/en/index.html
- RADARSAT**, IRS** data search
  https://cross.restec.or.jp/

** RADARSAT, IRS, LANDSAT (#2 - #5) data archived through March 31, 2001.
*** SPOT, LANDSAT (#7) data archived through March 31, 2002.

4.2 JAXA-Owned Airborne L-band SAR (Pi-SAR) Datasets (Form 3b)

To request data from JAXA's airborne L-band SAR (Pi-SAR), complete Form 3b. Detailed information of this Pi-SAR data is available on the following web page, and only in Japanese, because all the available data sets were originally acquired in Japan.

http://www.eorc.jaxa.jp/ALOS/Pi-SAR/index.html

5. Personnel

A short biographical sketch of the principal applicant, a list of principal publications, and any exceptional qualifications should be included. Provide similar biographical information on the co-applicants as well.

6. Data processing and analysis equipment

Please describe available facilities and major items of equipment especially adapted or suited to the proposed research project, and any additional major equipment that will be purchased by applicants. Please state whether or not you have institutional support from your organization for implementing your proposal.

Form 1a

Proposal No.
(Leave Blank for JAXA Use)

Proposal Cover Sheet
For
ALOS Second Research Announcement

Information of Applicant

Principal Applicant:

Name: _____

Official title: _____

Department: _____

Organization: _____

_____

Address: _____

Country: _____ Email: _____

Telephone: _____ Facsimile: _____

Co-applicants:

Name	Organization	Email
_____	_____	_____
_____	_____	_____
_____	_____	_____
_____	_____	_____

Biographical Information, Experience, Papers in Related Fields of Principal Applicant:

Signature of principal applicant: _____

Form 1b

Proposal No.
(Leave Blank for JAXA Use)

Information of Proposal Contents

1. Research Category (check one)* [√]

[ ] Calibration and Validation [ ] Utilization Research [ ] Scientific Research

→[ ] Calibrate Individual Sensors

[ ] Develop and Validate Algorithms for Extracting Physical Parameters

* Our priority for the proposal selection will not be judged from your selected category.

2. Main Sensor (check one or more)

[ ] PRISM [ ] AVNIR-2 [ ] PALSAR [ ] none

3. Supplemental Sensor (check one or more)

[ ] PRISM [ ] AVNIR-2 [ ] PALSAR [ ] none

4. Data Requirements

[ ] Required [ ] not Required

→ Satellite Data (Enter the maximum and minimum number of required scenes)

	MOS	JERS	ADEOS	TRMM	ADEOS-II	ERS	SPOT	LANDSAT	RADARSAT	IRS	ALOS
Minimum											
Maximum											

→ ALOS Simulation Data (check one or more.)

[ ] For the Optical Sensors [ ] For the SAR

5. Research Title:

_____

6. Abstract of Proposal:

_____

_____

_____

_____

_____

Form 2

Proposal No.
(Leave Blank for JAXA Use)

Work Plan (Research Schedule)

Research Title: _____ Name of Principal Investigator: _____

Abstract of RA Activities:

Year	2006			2007						2008						2009		
Month	10	12	2	4	6	8	10	12	2	4	6	8	10	12	2	4	6	7
Milestones									*Interim Evaluation									
Activities																		

Form 3a

Proposal No.
(Leave Blank for NASDA Use)

Details of Data Requirements

Research Title: _____ Name of Principal Applicant: _____

JAXA-Owned Satellite Data (MOS, JERS, ADEOS, TRMM, ADEOS-II, ERS, SPOT, LANDSAT, RADARSAT, IRS)

Satellite	Sensor	Location (Path/Row or Lat/Lon)	Observation Period	Number of Scenes		Level of Processing
				Minimum	Maximum	

NOTE: The form in which the data is supplied, either on-line transmission or media transfer, will depend on the data volume.

Form 3b

Proposal No.
(Leave Blank for JAXA Use)

Details of Data Requirements

Research Title: _____ Name of Principal Applicant: _____

JAXA-Owned Pi-SAR Data

Scene ID	Location	Observation Date

APPENDIX E ALOS DATA NODE

ALOS Data Node (ADN): Concept

All data produced by the ALOS sensors on a daily basis (approximately 700Gbyte) will be well beyond the management capabilities of any single agency. As there is still a world-wide interest in the use of ALOS data, JAXA has established the concept of ALOS Data Nodes with local archives. These should aid in processing and distribution.

By agreement with JAXA, each ALOS Data Node (ADN) is managed by a partner organization or consortium, Each partner participates in certain tasks. These include reception and near-real-time processing, off-line processing, promotion, distribution, archiving of ALOS data to support data users within their region, and research study of ALOS data. Each Node is associated with a geographical zone defining the physical location of the ALOS users, which the Node supports by mandate as an ADN partner. These zones are approximated in Fig. 1. GISTDA of Thailand will serve as an additional sub-Node in Asia (*).

(*) The group of countries determined to be in the sub-Node zone are the Kingdom of Thailand, Union of Myanmar, Lao People's Democratic Republic, Socialist Republic of Vietnam, Kingdom of Cambodia, Malaysia, Republic of Indonesia, Republic of Singapore, Brunei Darussalam, and the Republic of the Philippines

Each Node produces the same quality of Standard Products as those of JAXA. The higher level products may be defined by the individual Nodes.

Although each Node is the focal point for support of ALOS users within its own zone, the regional distributor(s) appointed by each Node will serve as commercial data distributor(s) and service agent(s) for commercial users within the relevant zone(s). JAXA appointed the Remote Sensing Technology Center (RESTEC) as the Primary Distributor (PD), which serves as both the regional distributor in Asia and Russia, and the coordinating agency among all of the regional distributors. RESTEC will also serve as the Regional Distributor (RD) of the Oceania Node by coordinating with Geoscience Australia, the Oceania Node organization, and JAXA. Each of the other Nodes will soon announce their Regional Distributors.

There is only one exception for PALSAR data distribution. Because JAXA and the Ministry of Economy, Trade and Industry (METI) developed the PALSAR instrument jointly, METI has an equal right to distribute the PALSAR data. The Earth Remote Sensing Data Analysis Center (ERSDAC), with METI agreement, will also distribute the PALSAR data, although ERSDAC is outside of this ADN concept. The PALSAR data products processed by ERSDAC resemble the JAXA Standard Products, but may differ slightly because of the variations in processing algorithms and application formats.

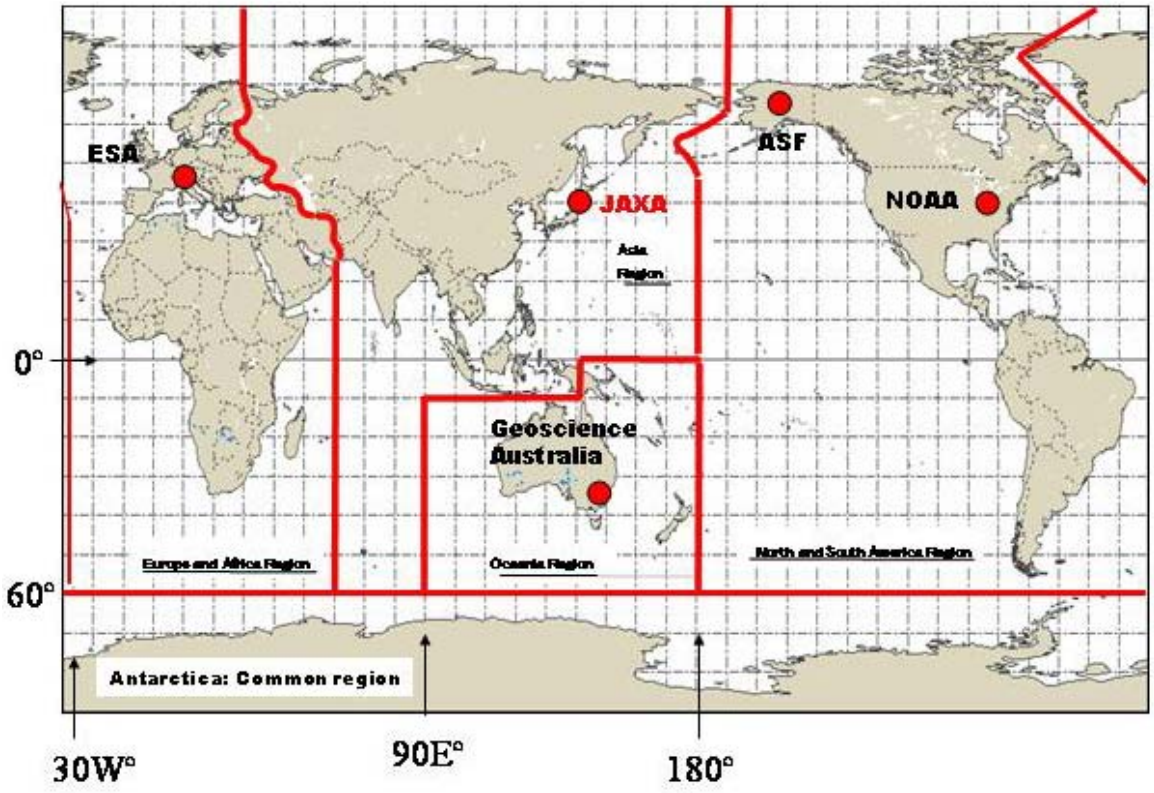


Fig. 1. Zone definitions for ALOS Data Nodes

ALOS Data Node organizations

Asia: Japan Aerospace Exploration Agency (JAXA)

Asia Sub-Node: Geo-Informatics and Space Technology Development Agency (GISTDA)

Oceania: Geoscience Australia

North and South America: National Oceanic & Atmospheric Administration (NOAA) and Alaska Satellite Facility (ASF) of the University of Alaska Fairbanks

Europe and Africa: European Space Agency (ESA)

APPENDIX F DRAFT RESEARCH AGREEMENT

RESEARCH AGREEMENT
FOR THE
ADVANCED LAND OBSERVING SATELLITE
BETWEEN
JAPAN AEROSPACE EXPLORATION AGENCY (JAXA)
AND
RESEARCH ORGANIZATIONS

For the Second RA

December 1, 2006
JAPAN AEROSPACE EXPLORATION AGENCY

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This agreement is made between the Japan Aerospace Exploration Agency, established under the provision of the Law concerning the Japan Aerospace Exploration Agency on October 1, 2003, represented by its President and having its principal office at 7-44-1 Higashimachi, Jindaiji, Choufu-shi, Tokyo, Japan (hereinafter referred to as "JAXA") and the Research Organization that submitted the application form for this agreement to JAXA (hereinafter referred to as the "Research Organization").

Recognizing that the Advanced Land Observing Satellite (hereinafter referred to as "ALOS") was launched by JAXA from Japan on January, 2006 to contribute to the global and regional land observation in cooperation with the Ministry of Economy, Trade and Industry (hereinafter referred to as "METI") for peaceful purposes,

Recognizing that JAXA shall provide the Panchromatic Remote-sensing Instrument for Stereo Mapping (hereinafter referred to as "PRISM") and the Advanced Visible and Near Infrared Radiometer type 2 (hereinafter referred to as "AVNIR-2") for flight on the ALOS spacecraft,

Recognizing that JAXA and METI shall jointly develop the Phased Array type L-band Synthetic Aperture Radar (PALSAR), which will also fly on the ALOS spacecraft,

Recognizing that JAXA issued the Second Opportunity of Research Announcement (hereinafter referred to as "RA") in December 2006, for PRISM, AVNIR-2 and PALSAR on the ALOS spacecraft, and the Principal Investigator (hereinafter referred to as "PI"), who belongs to the Research Organization, submitted a proposal in response to the RA,

And recognizing that JAXA has selected, based on the proposal, PIs for three categories (1) Calibration, and Validation of ALOS data products and each sensor, (2) Utilization research, and (3) Science research;

The parties hereto agree as follows:

1. Definitions

As used in this agreement, the following terms shall have the meanings indicated.

"ALOS" consists of the spacecraft plus all the instruments onboard the spacecraft, whether provided by JAXA or by any other agency.

"ALOS data" mean all primary data originating from ALOS, including a processed product that retains the original pixel structure and can be converted back to the original data.

A "PI" is the person who has been selected to perform their RA activities and who belongs to the Research Organization, and whose name is shown on the "Work Plan";

The "Co-Investigator" (CI) is the person who supports the PI in performing the research defined in this agreement with approval by the Research Organization and notification to JAXA.

"Research" is defined in the RA and further detail is described in the "Work Plan."

The "Interim Evaluation" evaluates the research results and the progress reports by JAXA. JAXA schedules the Interim Evaluation in early 2008, in which the PIs, whose results are satisfactory, will be re-selected and expected to continue their RA activities as described in article 3.

"Research Results" means the results derived from the implementation of this RA.

"Progress Reports" means the reports that describe the status of the RA activities.

"Commercial use" of ALOS data involves for-profit activities and all uses other than its application for scholarly or scientific investigations.

2. Purpose and Scope

The purpose of this agreement is to establish the terms and conditions under which the Research Organization shall conduct the RA activities. The Research is described in the Work Plan.

3. Period of Performance

This agreement shall come into force upon issuance of a confirmation sheet prescribed by JAXA and shall continue in effect until March 31, 2008, unless terminated as described in article 25.

This agreement shall be automatically renewed until July 31, 2009, if JAXA sends a notice that the Interim Evaluation shows the Research Results and Progress Reports made by the Research Organization are satisfactory.

In spite of the previous paragraph, articles 6 i), 8, 9, 10, 11, 12, 18, 19, 20, 26, 27 and 28 shall remain in

force after the expiration of this agreement.

4. Affiliation

If the PI's affiliation changes, the Research Organization shall coordinate with JAXA the proposed change in advance, such as changing the PI (keeping the Research Organization) or changing the Research Organization (keeping the same PI).

JAXA shall not bear any of the cost incurred by this change.

5. Responsibilities of JAXA

JAXA shall make its best efforts to perform the following tasks.

a) Accept data processing requests by the PI and deliver the ALOS data to the PI. It may not be possible t

b) Supply the necessary information to PIs in order to conduct RA activities including the simulation data and satellite operation data.

c) Evaluate the Research Results and Progress Report for the Interim Evaluation and send the results to the PI.

d) Hold workshops and meetings to evaluate the research results and the progress reports and exchange information among PIs and JAXA.

6. Responsibilities of the Research Organization

The Research Organization shall make its best efforts to perform the following tasks.

a) Conduct the RA activities.

b) When selecting or adding CIs, consult JAXA for authorization with the list of the CIs and their responsibilities and work, conduct the RA activities, supervise the CI's research activities, and be responsible for all their research activities in accordance with the terms and conditions of this agreement.

c) Submit the Research Results and the Progress Report to JAXA before the date of Interim Evaluation. JAXA will notify PIs about the detailed schedule.

d) Deliver the Research Results as a final report by the end of the performance period as described in article 3.

e) Communicate the progress of the RA activities to JAXA, upon JAXA's request.

f) Participate in workshops and meetings and report the Research Results and Progress Reports of its RA activities.

g) Inform JAXA promptly of any anomaly or delay of schedule encountered in implementing the research activities.

h) Use all the ALOS data provided by JAXA only for the purpose of this agreement and refrain from copying the ALOS data itself except for back up; refrain from distributing the data to any third party, except authorized CIs, without JAXA's prior written consent.

7. Amount of ALOS Data Available

A PI can request up to 50 (TBD) ALOS data scenes per research theme within a Japanese fiscal year, from April 1 to March 31. If a PI requests fewer than 50 (TBD) ALOS data scenes per research theme within a Japanese fiscal year, the remaining number of scenes can be carried over to the next Japanese fiscal year.

8. Transfer of Technical Data

Except as otherwise provided in this article, each party under this agreement shall transfer all technical data considered to be necessary to fulfill the receiving party's responsibilities under this agreement, to the extent feasible. The parties will undertake to handle expeditiously any request for technical data presented by the other party for the purpose of this agreement. Neither party shall have any right to require the other party to transfer any data, the transfer of which would violate the laws or regulations of the country having jurisdiction of such transfer.

The furnishing party shall mark with a notice or otherwise clearly indicate the technical data that are to be protected for proprietary rights purposes or export control purposes. Such a notice shall indicate any specific conditions regarding how such technical data may be disclosed or used by the receiving party including, for export control (a) that such technical data shall be used or disclosed only for the purpose of fulfilling the receiving party's responsibilities under this agreement, and, for proprietary rights (b) that such technical data shall not be disclosed, duplicated or used by persons or entities other than the receiving party, or for any other purpose, without the prior consent of the furnishing party.

Each party shall observe any clearly indicated limitation on the handling of transferred technical data.

9. Intellectual property rights

JAXA retains the intellectual property rights of all ALOS data. As an exception, METI is the joint owner of PALSAR data. Research Organizations shall appropriately indicate this in all publications.

10. Usage of Research Results

Both parties shall retain irrevocable, royalty-free, and non-exclusive rights, including but not limited to, using, editing, reproducing, modifying, improving, or distributing any provided research results for its own purposes excluding commercial purposes.

If the Research Organization alters or improves any provided research results, the Research Organization shall provide a written notice to JAXA describing the alterations or improvements.

JAXA can exercise the rights mentioned in the first paragraph above without prior consent of the Research Organization by any means, including digital medium or network, after the Research Organization has provided JAXA with the research results.

The research results, progress report, the modified research results and so on obtained under this agreement shall be utilized for peaceful purposes.

11. Commercial Use

Commercial use of the research results obtained through this agreement is beyond the scope of this agreement. In such cases, the two parties shall agree as otherwise to define the necessary conditions.

12. Publication of Results

The results obtained through the performance of these RA activities by the Research Organization will be made available to the general public in a timely manner.

The publishing parties shall add a statement to the publication that indicates, as appropriate, that the research results have been obtained through the cooperation between the research organization and JAXA (JAXA/METI for PALSAR, if necessary) in JAXA's ALOS RA.

The parties will coordinate with each other in advance concerning publications that relate to the other's performance under this agreement.

The publishing party shall, as between the parties hereto, have all rights in such publication as are protected by copyright law.

The Research Organization shall provide JAXA with three (3) copies of such publications. The Research Organization shall grant JAXA an irrevocable, royalty-free, non-transferable and non-exclusive right to use, edit, copy, or distribute the provided publications, unless an academic society responsible for its publication requires the Research Organization to transfer its copyright to it.

Neither party shall, without the consent of the other party, publish information disclosing an invention prior to filing a patent application on that invention.

13. Guarantees
JAXA shall not guarantee the quality of the Earth observation data or its timely distribution.

JAXA reserves the right to curtail or suspend ALOS data supply to the Research Organization in the event of that such activities are found to conflict with Japan's national interest, or where the spacecraft and/or JAXA ground equipment limitations require such action, or in exceptional circumstances including, but not limited to, limitations on the life of ALOS.

14. Language
All communications between the Research Organization and JAXA under this agreement shall be in English.

15. Force Majeure
Neither party is liable for failure, delay or suspension to perform its part of this agreement when such failure is due to the reason including, but not limited to, fire, war, inevitable accident, act/policy of government, legal restrictions beyond the control of the party.

16. Taxes and Customs
If any customs fees and/or taxes of any kind are levied on the transactions necessary for the implementation of this agreement, after seeking to develop the necessary free customs clearance and waiver of applicable duties and taxes, such customs fees and/or taxes shall be borne by the party of the country levying the fees and/or taxes.

17. Funding
There will be no exchange of funds under this agreement. Each party shall bear the necessary costs to fulfill its own responsibilities under this agreement.

18. Limitations on Liabilities
JAXA and the Research Organization agree to waive any claim against the other with respect to any injury or death of its employees or the employees of its related entities, with respect to damage of any kind, or any loss of its own property or property of its related entities arising out of activities under this agreement (hereinafter referred to as "Damages"), except such Damages that arise through willful misconduct and except intellectual property rights.

19. Invention and Patent
Except as set forth in paragraph 2 of this article, nothing in this agreement shall be construed as granting or implying any right to, or interest in, patents owned or inventions that are independently developed by the parties or their contractors or subcontractors.

If an invention is jointly made by any combination of the parties during the implementation of this agreement, patent protection shall be requested jointly by the parties involved on the basis of equal rights, unless otherwise agreed by the parties involved, taking into consideration their contribution to the invention.

20. Confidentiality
The Research Organization shall not disclose any information except public domain information and the publications produced in accordance with article 12 obtained through the performance under this agreement without the prior written consent of JAXA and shall take reasonable steps to maintain such information in confidence.

21. Government Approvals
Each party shall obtain such permits, licenses, and other government authorizations as are required for it to perform its responsibilities under this agreement, and shall comply with all respective laws and regulations.

22. Suspension
When the Research Organization fails to meet the purposes of this agreement or to comply with the terms of this agreement, JAXA may suspend execution of this agreement, in whole or in part, pending corrective action by the Research Organization or a decision by JAXA to revoke this agreement.

23. Termination
In the event that either party wishes to terminate this agreement, it shall notify the other in writing, in which case this agreement will terminate thirty days after receipt of such notification.

Upon the decision of termination, the Research Organization shall promptly deliver to JAXA all work in progress, and all work that is completed and otherwise ready for delivery.

24. Amendment

JAXA may amend this agreement without prior notice to the Research Organization.

25. Entire Agreement

The foregoing constitutes the entire agreement between the parties with respect to the subject matter thereof and supersedes and cancels all prior representations, negotiations, commitments, undertakings, communications (whether oral or written), acceptances, understandings, and agreements between the parties with respect to or in connection with any of the matters to which such agreement applies.

26. Dispute Resolution

The parties agree to make their best efforts to solve amicably any dispute, controversy, or difference arising out of, in connection with, or resulting from this agreement.

27. Arbitration

All disputes that cannot be amicably settled by the method defined in the previous paragraph hereof will be settled by arbitration in Tokyo in accordance with the Commercial Arbitration Rules of the Japan Commercial Arbitration Association.

28. Governing Law

This agreement shall be governed and interpreted under the laws of Japan.