July 20, 2012

The 4th ALOS Research Announcement for ALOS-2

Calibration and Validation,
Utilization Research and Scientific Research

Proposals Due: October 31, 2012

Earth Observation Research Center
Japan Aerospace Exploration Agency

CONTENT

1. INTRODUCTION

This Japan Aerospace Exploration Agency (JAXA) 4th ALOS Research Announcement (RA) solicits the research proposals for science and utilization research using the Advanced Land Observing Satellite-2 (ALOS-2), which carries the L-band Synthetic Aperture Radar, PALSAR-2 and will be launched in 2013. Proposals are solicited for the following three categories:

- Calibration and Validation of ALOS-2 data products and sensors
- Utilization research
- Scientific research

ALOS-2 will utilize high resolution based advanced land observation technologies. ALOS-2 will be used for disaster monitoring, environmental monitoring for sustainable Earth in forestry, cryospheric, and sea ice, natural resources (agriculture, ocean monitoring, and resources), technology development for the future Earth remote sensing (satellite and sensor).

ALOS-2 mission objectives are to:

(1) Disaster Monitoring (including the solid earth research)
(2) Environmental monitoring for sustainable Earth in Forestry, Cryospheric, and sea Ice
(3) Natural Resources (Agriculture, Ocean monitoring, and resources)
(4) Technology Development for the Future Earth Remote sensing (satellite and sensor)

The target operational lifetime of ALOS-2 is seven years after the launch. JAXA will start distribution of the calibrated standard products from seven months after the launch.

The Principal Investigators (PIs) can cover the full range of ALOS-2 science and applications, including (1) Calibration and Validation, (2) land use and land cover research, (3) topography and geology, (4) terrestrial (vegetation) ecosystem, agriculture and forestry research, (5) climate system, hydrological processes and water resources related research, (6) oceanography and coastal zone related research, (7) disaster and earthquakes, (8) resource exploration, (9) development of spatial data infrastructure, (10) basic studies on scattering and interferometric characteristics, (11) Polar research, and (12) Ionospheric researches.

Applicants may submit any time before 31 October 2012. Proposals will be peer reviewed by the end of Jan 2013. Applicants submitting accepted, applicants will be integrated into the ALOS research team.

Participation as an ALOS PI is open to global researchers 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-2, ALOS, and JERS-1 data (limited amount) at no cost.

APPENDIX A provides technical and programmatic information concerning the ALOS-2 system, data products, characteristics of PALSAR-2, and general operation concept.
APPENDIX B provides objectives of the research activities covered by this RA.
APPENDIX C contains the basic guidance needed for preparing proposals in response to this RA.
APPENDIX D contains research agreement between JAXA and the Research Organization for accepted applicants.

2. Summary of Mission Instrument

ALOS-2 has one remote sensing instrument, the Phased Array type L-band Synthetic Aperture Radar-2 (PALSAR-2) for 24-hours all weather land observation. This sensor is expected for high-resolution global land observation. A detailed description of payload is given in APPENDIX A-2.

2.1 Phased Array type L-band Synthetic Aperture Radar– 2 (PALSAR-2)

The PALSAR-2 is the successor of PALSAR on ALOS with enhanced performances and the functions. The sensor achieves 1m-resolution by the spotlight mode with two-dimensional steerable beams, and wide observation swath of 350 km or 490km by ScanSAR with steering beams in elevation, and multiple polarimetric high qualities Strip mode imaging. PALSAR-2 is solely developed by JAXA.

3. Research Goals and Objectives

The various products derived from ALOS-2 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-2 sensor and data products

PALSAR-2 is designed for superior performance in various aspects of high-resolution Earth observation, and it 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, etc.) 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) Calibration

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 sensor is PALSAR-2.
More detailed research items are given below.

- 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-2 data are listed in APPENDIX B. JAXA defined 1) DEM/DSM and 2) ortho images as 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 earlier Japanese Earth Observation Satellite emphasized the scientific element. Except for a limited category of data that is already being used operationally, the satellite data has not been used operationally owing to many technical and operational issues. However, 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 ALOS as well as for promoting new developments.

The integration of ALOS-2 data with numerical prediction models of sea ice, sea state, and disasters as well as monitoring and managing agricultural products, and forestry, and fishery will directly lead to national benefits. Providing the ALOS-2 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 seas 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, etc.)
- Natural disasters (forest fires, flooding, landslide, earthquakes, etc.)
- Pollution monitoring (oil spill, red tide, etc.)
- Geology and natural resources exploration
- Applications related to SAR interferometry (digital elevation models, crustal movements, vegetation distribution, etc.)
- Development of the Geographic Information System (GIS) database at national land
- Educational use

Proposals should indicate research and development activities requiring operational use of ALOS-2 data products, whether derived from ALOS-2 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-2 will contribute to promoting 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-4 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 satellites data (such as from JERS-1 or ALOS). 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
- Microwave scattering, SAR interferometry, and the Polarimetric SAR researches

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 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 conditions;

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

Other detailed conditions, such as the number of the data scenes, shall be determined through review by JAXA. Applicants must realize that data for PIs will be limited by satellite operations, processing facility capabilities and so on. Refer to APPENDIX A-2 for the non-observable areas of PALSAR-2.

JAXA shall not be liable for data loss, deterioration in data quality, or delay of data supply resulting from problems of ALOS-2 or ground facilities, or for not providing ALOS-2 data due to matters beyond JAXA's control.

4.2 Data Distribution before ALOS-2 launch

The PIs can use the JAXA archived data observed by ALOS and JERS-1.

- Standard Data Products

The PIs will be provided the following data after the conclusion of the research agreements.

- JERS-1 SAR/OPS, ALOS (PRISM, AVNIR-2, and PALSAR) Level 1

4.3 Data Distribution after ALOS-2 launch

The PIs can obtain ALOS-2 data that will be planned in the ALOS standard operation plan, which is decided, based primarily on the ALOS Operation Concept and Observation Strategy (APPENDIX A-4). Applicants are highly recommended to consider their own research proposals based on the Observation Strategy, and consider the observation constraints of each sensor.

- Standard Data Products

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

- PALSAR-2 Level 1.1, Level 1.5, and 2.1

5. Funding

JAXA will not provide funds to PIs.

6. Qualifications of Applicants

We welcome all the global researchers from educational institutions, research institutes, private enterprises, government institutions, and any other organizations, domestic or foreign, to submit research proposals for peaceful and non-commercial purposes.

7. Benefits and Responsibilities of PIs

7.1 Benefits

PIs can request satellite data listed in section 4 at no cost, in the condition of the acceptance by JAXA after the selection of PIs. After the launch of ALOS-2, PI may submit observation request of ALOS-2 (Form 2b).

7.2 Responsibilities

7.2.1 Interim Report

The PIs will be required to submit interim reports on the status of their researches in the format given by JAXA. They are highly encouraged to participate in PI meetings held by JAXA, and present the progress and accomplishments of their researches. In particular, PIs must submit an interim report to JAXA by end of March 2015 for interim evaluation. The successful PIs in the interim evaluation can continue their researches.

7.2.2 Final Report

All PIs must submit their final reports to JAXA in English in accordance with 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

We might not accept proposals, which do not adhere strictly to the format. The following are required in all proposals.

- **Applicants must register their submission intention at first from the ALOS Home Page** (***http://www.eorc.jaxa.jp/ALOS/en/ra/ra4_guide.htm***).
- The proposal must be written in the template format provided on the ALOS Home Page. (Please refer to this section and APPENDIX C.) Form 1, 2, and 3 are mandatory.
- Applicants are to send their proposals in PDF format with reprints of papers (PDF) by using e-mail or the file transfer service to the ALOS-2 Research Announcement Office (aproject@jaxa.jp) by due date. The upper limit of the acceptable bytes per E-mail is 10 MB.
- All proposals should be typewritten 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 bottom and the name of the applicant in the upper right corner.

Proposals are not returned.

8.2 Language

Applicants must basically 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 (Form 1, APPENDIX C) **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 C.

8.4 Proposal Contents

Please refer to APPENDIX C.

8.5 Where to Send Proposal (by a postal mail)

Please send all the necessary application papers for this RA by postal mail to the following address **by October 31, 2012** (accepted date by JAXA).

ALOS-2 Research Announcement Office
Earth Observation Research Center (EORC)
Japan Aerospace Exploration Agency (JAXA)
2-1-1, Sengen, Tsukuba, Ibaraki 305-8505, Japan
Tel: +81-50-3362-7303 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-2 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 January 2013 (as a 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, which are integral factors for achieving the proposal objectives.
3) Relevance to the objectives of the ALOS-2 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 comply with the terms and conditions of the projects including, but not limited to, data distribution and publications of results. APPENDIX F is the agreement prepared for this RA, and selected PIs are requested to conclude research agreements and are required to comply with this agreement. Upon receipt of application form applicants, JAXA will send confirmation sheet to conclude an actual agreement to the selected PIs later.

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. Schedule

Document release	July 20, 2012
Deadline for registration and submission of proposals	October 31, 2012
Notification of PI selection	January 30, 2013 (planned)
Contract (agreement procedure)	February 1-March 31, 2013
PI meeting and Symposia (planned once per year)	September 2013 (planned) ~
Deadline for Interim report	March 31, 2015
Interim evaluation	TBD*

* Research duration is normally 3 years and could be extended to 5 years at maximum, where JAXA plans to conduct the interim evaluation of results from PIs for possibility evaluation for up two years' extension.

12. Research Announcement Office

Masanobu Shimada, Ph.D.
c/o ALOS-2 Research Announcement Office
Earth Observation Research Center (EORC)
Japan Aerospace Exploration Agency (JAXA)
2-1-1, Sengen, Tsukuba, Ibaraki 305-8505, Japan
Tel: +81-50-3362-7303 Fax: +81-29-868-2961
Email: aproject@jaxa.jp

APPENDIX A ALOS System Description

APPENDIX A-1 Characteristics

The Advanced Land Observing Satellite-2 (ALOS-2) will succeed to the radar mission of ALOS which had contributed to cartography, regional observation, disaster monitoring, and resources surveys.

ALOS-2 is equipped with a SAR antenna just under its body and with two solar array paddles at both sides, as shown in Figure 1. The observation data is transmitted directly to a ground station via X-band or through inter-satellite communication via Ka-band. The transmission speed is 800 Mbps maximum for X-band and 278 Mbps for Ka-band, respectively. Table 1 shows system specifications of ALOS-2. The local sun time of it orbit is at noon in order to complement other SAR satellites which are in dawn-dusk orbits.

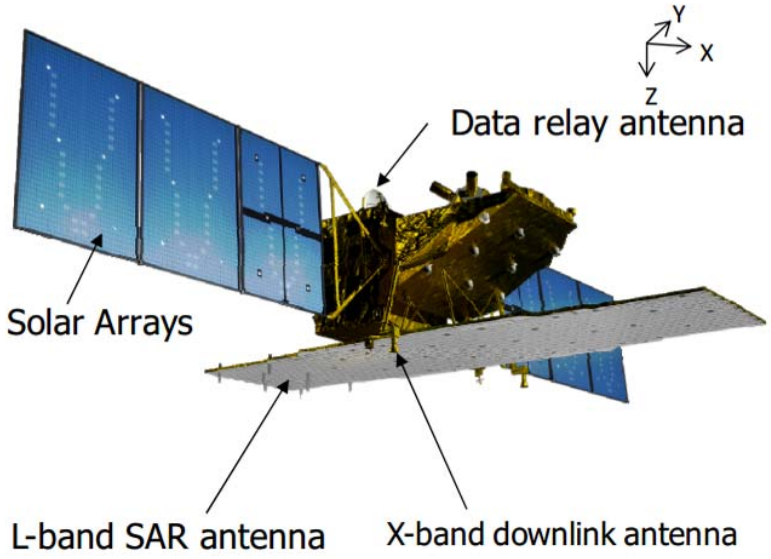


Fig. 1 ALOS-2 in-orbit configuration

Table 1 ALOS-2 specification

Observation mode	Stripmap: 3 to 10m res., 50 to 70 km swath ScanSAR: 100m/60m res., 350km/490km swath Spotlight: 1×3m res., 25km swath
Orbit	Sun-synchronous sub-recurrent orbit Altitude: 628km Local sun time : 12:00 +/- 15min Revisit: 14days Orbit control: < +/-500m
Life time	5 years (target: 7 years)
Satellite mass	Approx. 2t
Launch	JFY2013, H-IIA launch vehicle
Downlink	X-band: 800Mbps(16QAM), 400/200Mbps(QPSK) Ka-band: 278Mbps (QPSK)

APPENDIX A-2 PALSAR-2 Characteristic

ALOS-2 carries the state-of-the-art L-band Synthetic Aperture Radar (SAR) called PALSAR-2. PALSAR-2 has a Spotlight mode (1×3m resolution in Az×Rg), a Stripmap mode (3 to 10 m resolution) and a ScanSAR mode. The Spotlight mode and a high resolution mode will allow providing users with more detailed data than ALOS/PALSAR. The ScanSAR mode will allow us to acquire a 350 to 490 km width (depends on number of scans) of SAR images at the expense of spatial resolution. The observation frequency of ALOS-2 will also be improved by greatly expanding the observable areas (2,320km). Right-and-left looking function by satellite maneuvering and electric beam steering using active phased array antenna establish the incidence angles from 8 to 70 degrees on both side of the satellite.

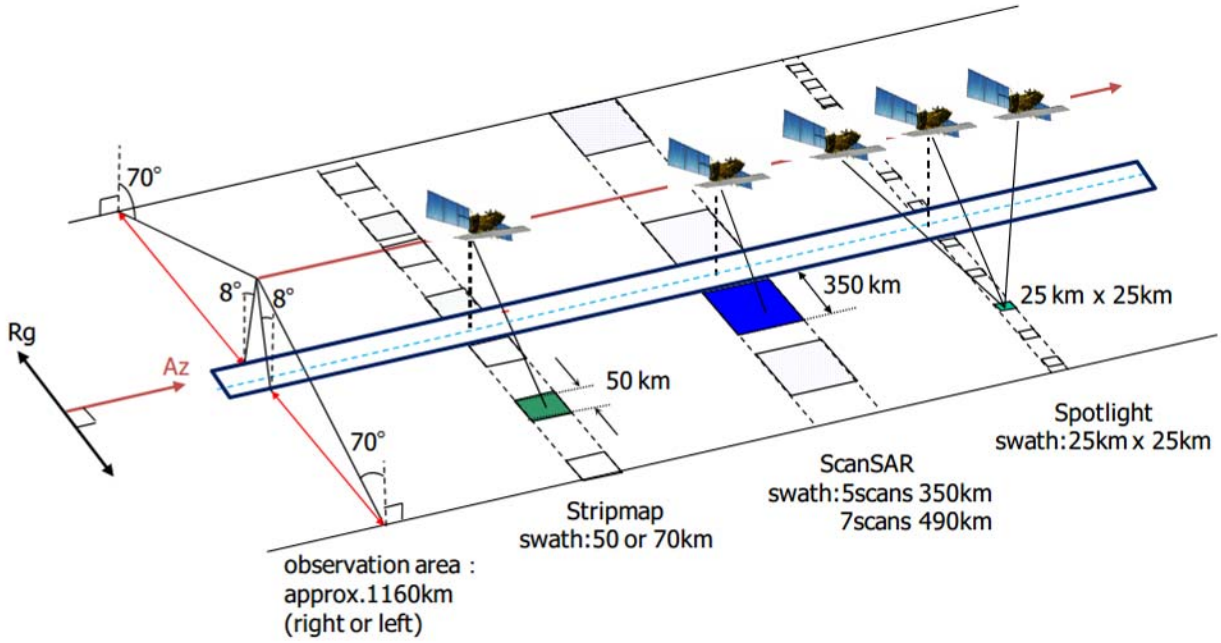


Fig. 2 PALSAR-2 observation modes

Table 2 PALSAR-2 specification

Observation mode		Spotlight	Stripmap			ScanSAR
			Ultra-Fine	High-Sensitive	Fine	
Incidence angle		8 to 70degrees				
Band width		84MHz	84MHz	42MHz	28MHz	14MHz/28MHz*
Ground resolution		3m x 1m (Rg x Az)	3m	6m	10m	100m(60m)
Swath		25km	50km	50km	70km	350km(490km)
Polarization		Single	Single/Dual	Single/Dual/ Full/Compact	Single/Dual/ Full/Compact	Single/Dual
NESZ		-24dB	-24dB	-28dB	-26dB	-26dB/-23dB
S/A	Rg	25dB	25dB	23dB	25dB	25dB(20dB)
	Az	20dB	25dB	20dB	23dB	20dB

The parameters specified at 37degrees incidence angle above the equator.
* 28MHz bandwidth in ScanSAR mode is used for only 350km swath

PALSAR-2 is composed of two subsystems; Antenna subsystem (ANT) and Electric Unit (ELU). ANT is an active phased array antenna, which steers a beam both in elevation and azimuth direction (plus-minus 30 degrees in elevation and plus-minus 3.5 degrees in azimuth). Figure 3 shows the antenna configuration of PALSAR-2. The size of ANT is 10 m in azimuth and 3 m in elevation, and is composed of five electrical panels, which have 180 Transmit-Receive-Modules (TRMs) in total. The Spotlight mode and Ultra-Fine mode use the three of five panels to satisfy resolution requirement and the other modes use all panels. The transmitted power is 3950 W and 6120 W respectively.

Figure 4 shows the system diagram of PALSAR-2. Key components of the Electric Unit (ELU) are Exciter (EX), Transmitter (TX), Receiver (RX), Digital Processor (DP), and System controller (SC). As for RF signal, EX generates pulses, selects two chirp signals (up or down and phase modulation) with a selected center frequency either 1257.5, 1236.5 or 1278.5 MHz in order to avoid interference to Radio Navigation Satellite Services which use L-band, and stretches the signal to a selected bandwidth either 84 MHz, 42 MHz, 28 MHz or 14 MHz. Received radar echo signals are compressed by BAQ or DS-BAQ algorithm. Compression mode is selected from 4 bit, 2 bit, or no compression.

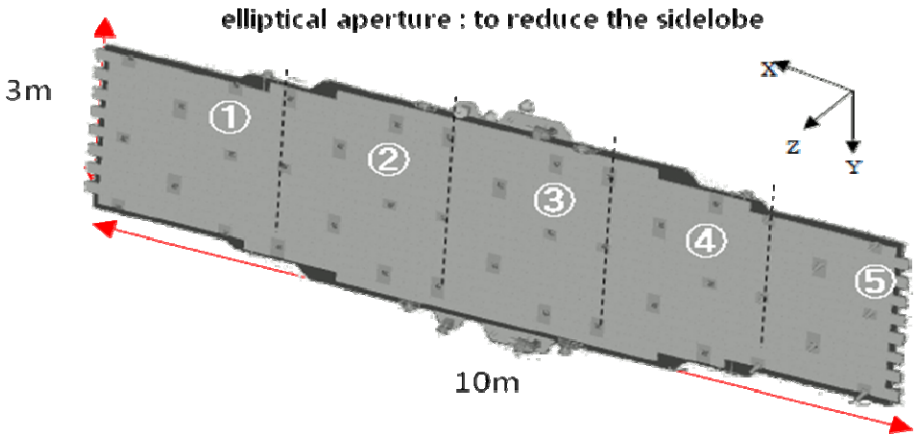
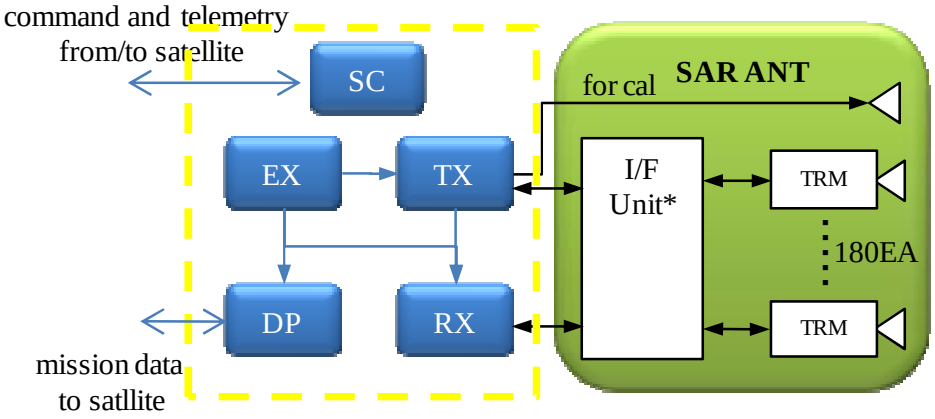


Fig. 3 PALSAR-2 antenna configuration



*: Dual receive antenna system is seleceted at I/F Unit

Fig. 4 PALSAR-2 system diagram

APPENDIX A-3 Data Products

1. Definition of ALOS-2 Data Products

Two categories of data products are defined - level 1 products and higher level products.

1.1 Level 1

Level 1 is radiometrically and geometrically calibrated data and is a standard JAXA product for ALOS-2 users.

1.2 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 started providing by JAXA's EORC from one year after ALOS-2 launch.

2. Standard Data Products

Table 3 PALSAR Standard data products

Level	Definition	Note
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
2.1	Ortho-rectified and slope corrected products	Map projection Resampling Pixel spacing

APPENDIX A-4 ALOS-2 Operation Concept and Observation Strategy

1. General of the observation plan

ALOS-2 will be operated based on the basic observation plan-2 (BOS-2) that will be optimized as the background mission while the emergency observation will be the highly prioritized operation for the disaster mitigations. The BOS-2 will be open to the public through ALOS-2 web when it will be ready.

The BOS-2 will be designed to achieve the Earth observation using the several modes of the PALSAR-2, i.e., high resolution strip mode (84MHz-singe polarization), Dual polarization mode (42 MHz-Dual Polarization), Quad-mode (42MHz-Full polarization), Dual Strip (28 MHz), and ScanSAR (14 MHz-Dual-350Km /490Km swath) for observing the solid earth (deformation study), biosheric study (forest monitoring, carbon estimation) and Cryospheric study (sea-ice, polar monitoring), and map generation.

APPENDIX B ALOS Research Plan

1. Goals of ALOS Research Plan

To achieve the ALOS-2 mission, it is essential not only to distribute data products to users, but also to promote scientific and utilization research for ALOS-2 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 PALSAR-2 and Related Basic Studies

Calibration and Validation of PALSAR-2 on processing Level 1 data are most important and necessary to improve the accuracy of deformation and biomass distribution data. Moreover, related basic studies required for Calibration and Validation of these sensors are essential for development coming generation sensors which have high 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: 25,000 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 and land use and land cover data: These can reveal sprawl of urban areas and villages, changes of agricultural land and agricultural practices, deforestation, etc. Radar images may also be able to detect tillage variations (variation of tillage surface roughness) and changes of cropping pattern.

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 Ortho image (PALSAR-2 image): An ortho image can be used for extraction and classification of terrain features and so on.

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 which 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 PALSAR-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-2.

3.3.2 Vegetation biomass distribution measurement: Vegetation biomass is a key parameter which describes vegetation dynamics. A method of measuring vegetation biomass with focus on forests with observations by PALSAR-2 is expected to be developed.

3.3.3 Application to forest management: A method of monitoring deforestation and a forestation 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: Developing 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-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-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 -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, to 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 is expected. Development of methods for integrating other satellite data is also important.

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

- **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.
- **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-2 will contribute to understanding changes of climate and water resources (hydrological cycles), and so on.

- **Estimating states and changes of snow cover and snow-water equivalent:** Analysis using the observation data from PALSAR-2 can help accurately predict and understand the seasonal or annual change of snow cover and snow-water equivalent.
- **Measuring and analyzing variations of ice sheets and glaciers:** Analysis of Interferometric measurements by PALSAR-2 will contribute to understanding the ice sheet mass balance and mountain glacier variation in the South Pole, Greenland, and so on.
- **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 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-2 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 which 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-2 data. A method which predicts coastal current by utilizing a numeric simulation model along with these datasets should be also developed. These are useful for giving of a boundary condition for analysis of coastal transformation and sand drift.

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

3.5.2 Ocean dynamics: Utilization of PALSAR-2 or development methods using PALSAR-2 together with other satellite data will contribute to studies on air-sea interaction, sea waves, and 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-2 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-2 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 interferometoric observation by PALSAR-2 are needed to be developed.

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

3.6.3 Slope failure: It is necessary to develop a method for risk analysis of slope failure using high-resolution DEMs generated by PALSAR-2. 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 of 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 haven't had enough data. This will contribute to advancing methods for analyzing and investigating those 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 haven't had enough 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 technique: Disaster monitoring techniques reveal damage due to drought, flood, fire, slope failure, 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 resource need to be developed. Analysis methods integrating PALSAR-2 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, algorithms for interferometric measurement need to be developed for PALSAR-2. In addition, a method integrating images 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 database: Using ALOS data as a test case, techniques for very large spatial database are expected to be developed. Examples include data storage and management techniques, 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-2 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-2 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 which 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 multiscattering 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.

3.11 Basic studies for Ionospheric researches

ALOS/PALSAR research notified that the L-band SAR is very sensitive to the ionospheric behavior and the characteristics. Based on this, ionoshereic researches are highly solicited in this RA.

4. Strategic Goals

We define development of specific data products and algorithms for promoting the other scientific researches as "strategic goals." These are selected considering the relevance to the ALOS-2 mission and the goals of this plan, resource limitations, etc.

4.1 Data products

4.1.1 Global Orthophoto image (PALSAR-2): This data products form the basis of many fields of research and practical applications. They are provided by only ALOS-2 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-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-2 is equipped with L-band, which favors biomass observation, it is expected that biomass density data will be generated using PALSAR-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 biomass measurement method: Development of algorithms using DEMs and AVNIR-2 images together with other satellite images for measuring global biomass distribution with higher accuracy is solicited.

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 PALSAR-2 system

A basic study for achieving high radiometric accuracy of the PALSAR-2 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-2 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-2 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-2 polarimetric observation mode should be studied. The methodology to derive phase correction, cross talk, and gain imbalance will be developed and investigated.

APPENDIX C Proposal Contents and Application Forms

1. Proposal Coversheet

1.1 Information of Applicant (Form 1)

- Identifying information of principal applicant: Legal name, official title, department, organization, address, country, phone number, facsimile number, and E-mail address
- Co-applicant information: Name, organization, and E-mail 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

- Research Category (Calibration and Validation, Utilization Research, or Scientific Research)
- Research Title: A brief and valid project title
- Main Sensor (PALSAR-2, or none)
- Supplemental Sensor (PALSAR-2, 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 20 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
- Kind of truth data and its acquisition plan (Area, Product level, Volume, Term, Season, etc.)
- Product Utilization Plan (Product level, Volume, Term, Season, etc.)
- Work plan
- Data processing and analysis equipment

3. Details of Data Requirements

3.1 JAXA-Owned Satellite Datasets (Form 2a)

To request the following satellite datasets, complete Form 2a. JAXA has the authority to provide datasets received from:

- Japanese Earth Resources Satellite (JERS) (global)
  ISS *https://www.eoc.jaxa.jp/iss/jsp/index.html*
- Advanced Land Observing Satellite (ALOS) (global)
  ALOS User Interface Gateway (AUIG) *https://auig.eoc.jaxa.jp/*

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

3.2 ALOS-2 Data Request (Form 2b)

To request the following satellite datasets, complete Form 2b.

- Advanced Land Observing Satellite-2 (ALOS-2) (global)

4. Application Form for Research Agreement for the Advanced Land Observing Satellite-2 (Form 3)

RO and PI need to comply with the terms and conditions of the Research Agreement for this RA. Application form for this RA needs to be signed by personal at RO duly authorized to sign the research agreement. The Agreement shall become effective as of the date of the issuance of the Confirmation Sheet prescribed by JAXA in response to an application by the Research Organization.

5. Personnel A short biographical sketch of the principal applicant, a list of Personnel 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 you have institutional support from your organization for implementing your proposal.

Form 1

Proposal No.
(Leave blank for JAXA use)

＜Cover Sheet＞
Researcher Profile

Principal Investigator, PI:

Name: _____

Title: _____

Department: _____

Organization: _____

Address: _____

Nationality: _____ E-mail address: _____

Tel: _____ Fax: _____

Co-Investigator, CI:

Name	organization	E-mail address

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

Signature of principal applicant: _____ Date: _____

<Cover Sheet>

Information of Proposal Contents

1. Research Category (check one)* [√]

Calibration and Validation: [ ] Sensor calibration [ ] Validation of geophysical parameters

Utilization and Scientific Researches: [ ] Disaster and earthquake [ ] Land-use and land-cover research

[ ] Vegetation, forestry and wetland [ ] Agriculture [ ] Geography [ ] Geology

[ ] Hydrology [ ] Snow and ice [ ] Polar research [ ] Oceanography and coastal zone

[ ] Resources related research [ ] Climate and whether [ ] Polarimetry and interferometry

[ ] Education [ ] Others

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

2. Main Sensor (check one or more)

[ ] PALSAR-2 [ ] None

3. Supplemental Sensor (check one or more)

[ ] PALSAR [ ] AVNIR-2 [ ] PRISM [ ] JERS-1/SAR [ ] JERS-1/OPS [ ] None

4. Research Title:

5. Abstract of Proposal: (within 600words)

6. Research Schedule

Form 2a
Request form for JAXA archived data

Satellite/ sensor	Region of interest (Path-Row/lat-lon)	season	Process level	No. of scenes

* Detailed data ordering and provision procedure will be informed by JAXA.

Form 2b
Data order form for ALOS-2/PALSAR-2

Satellite/ sensor	Region of interest (Path-Row/lat-lon)	season	Process level	No. of scenes
ALOS-2 PALSAR-2				
ALOS-2 PALSAR-2				
ALOS-2 PALSAR-2				
ALOS-2 PALSAR-2				
ALOS-2 PALSAR-2				
ALOS-2 PALSAR-2				

* Detailed data ordering and provision procedure will be informed by JAXA.

Form 3

Proposal No.
(Leave blank for JAXA use)

Kazuo Tachi
Director
Program Management and Integration Department
Space Applications Mission Directorate
Japan Aerospace Exploration Agency (JAXA)
2-1-1 Sengen, Tsukuba-shi, Ibaraki 305-8505, JAPAN

Application Form
For
Research Agreement
For
the Advanced Land Observing Satellite-2
between
the Japan Aerospace Exploration Agency and
the Research Organization (for the fourth RA)

Dear Mr. Tachi:

We have read and agree to comply with all the terms and conditions of the "Research Agreement for the Advanced Land Observing Satellite-2 between the Japan Aerospace Exploration Agency and the Research Organization (for the fourth RA)" and apply for conclusion of the Agreement.

Principal Investigator:

Name: _____

Title: _____

Department: _____

Organization: _____

Address: _____

Country: _____ E-mail: _____

Telephone: _____ Facsimile: _____

PI Number: _____(Leave blank for JAXA use)

Research Title:

_____

RO Contact Point for Contract Matters (Please fill in if there is a contact point other than PI):

Name: _____

Department: _____

Organization: _____

Address: _____

Country: _____ E-mail: _____

Telephone: _____ Facsimile: _____

Co-Investigators: Attachment

*Signature of Authorized Personnel at RO
Name and Title of Authorized Personnel
Name of Research Organization

*Signature of the person el duly authorized to conclude the research agreement on behalf of the RO

PI No. _____
(Leave blank for JAXA use)

List of Co-Investigators

Co-Investigators

Name	Organization	E-mail

APPENDIX D

RESEARCH AGREEMENT
FOR THE
ADVANCED LAND OBSERVING SATELLITE-2
BETWEEN THE
JAPAN AEROSPACE EXPLORATION AGENCY (JAXA)
AND
THE RESEARCH ORGANIZATION
(FOR THE FOURTH RESEARCH ANNOUNCEMENT)

JAPAN AEROSPACE EXPLORATION AGENCY

This agreement ("Agreement") is entered into between the Japan Aerospace Exploration Agency, established under the provisions 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 ("JAXA") and a research organization ("Research Organization") that submitted an application form for the below described research activities to JAXA, hereinafter collectively referred to as "the Parties."

WITNESSETH

WHEREAS, JAXA issued the Research Announcement ("RA") to engage in collaborative research using the Advanced Land Observing Satellite-2 (ALOS-2), which carries the L-band Synthetic Aperture Radar 2 (PALSAR-2). Proposals are solicited for three categories, Calibration and Validation of ALOS-2 data products and sensors, Utilization research, and Scientific research, and the Research Organization applied pursuant to such RA;

WHEREAS, JAXA accepted the Research Organization's proposal that was submitted in response to the RA, delivered the confirmation sheet to the Research Organization and JAXA further desires to utilize such proposal in JAXA's project; and

WHEREAS, JAXA desires to engage in the above research activities in collaboration with the Research Organization.

NOW, THEREFORE, in consideration of the mutual agreements hereinafter set forth, and for other good and reasonable consideration, the receipt and adequacy of which are hereby acknowledged, the Parties hereby agree as follows:

Article 1. Definitions

1. The following capitalized terms shall have the following meanings:

(1) "Research Results" means the technical results and scientific knowledge derived from the implementation of the Research Projects pursuant to this Agreement, including all inventions, ideas, designs, literary works, algorithms, and technological developments, such as programs, that can execute the algorithm(s).

(2) "Intellectual Property Rights" generated in the course of implementation of the Agreement means the following:

(i) Industrial Property Rights (as defined below);

(ii) Potential Industrial Property Rights (as defined below); and

(iii) Program/Data Copyrights (as defined below).

"Industrial Property Rights" means all domestic and foreign patents, utility models, and industrial designs.

"Potential Industrial Property Rights" means all domestic and foreign application rights for patents, utility models, or industrial designs.

"Program/Data Copyrights" means all domestic and foreign copyrights related to computer programs, software and databases.

(3) "Earth Observation Satellite Data" means data sets obtained from satellites which are retained by JAXA at the time of execution of this Agreement and are provided to RO. The available data sets (including names of satellites, sensors, and observation periods that can be offered) are listed in Attachment 1 of this Agreement.

2. In this Agreement, "Invention, etc." means inventions in terms of items subject to patent rights, utility models in terms of items subject to utility model rights, creations in terms of items subject to copyrights such as design rights and programs, and ideas in terms of items subject to algorithms and know-how.

3. In this Agreement, "utilization" of the intellectual property rights and Research Results means act defined in Article 2, Paragraph 3 of the Patent Act, act defined in Article 2, Paragraph 3 of the Utility Model Act, act defined in Article 2, Paragraph 3 of the Design Act, enforcement of rights defined in Articles 21 and 27 of the Copyright Act (including utilization of secondary work created by JAXA or the Research Organization), and use of algorithms and know-how.

4. In this Agreement, "Principal Investigator" ("PI") means the Research Organization employee who submitted the proposal in response to the RA and was selected to be responsible for the Research Projects. "Co-Investigator" ("CI") means a person who supports the PI in performing the Research Projects and are in the “List of Co-Investigators” of the Application form for Research Agreement.

Article 2. Responsibilities

1. JAXA shall make reasonable efforts to perform the following tasks related to the Research Projects:
   a) Provide the Earth Observation Satellite Data required for performing the Collaborative Research to the Research Organization free of charge;
   b) Provide information satellite required for performing the Collaborative Research to the Research Organization such as Satellite Operation data
   c) Hold research presentation meetings (Research Presentation Meeting) to check progress of the research and other necessary meetings;
   d) Carry out an Evaluation based on the report made in the Research Presentation Meeting stipulated in the previous Paragraph, or a interim report.
2. For the purpose of ensuring the Research Organization's performance of the above obligations, the Research Organization shall perform certain actions including, but not limited to:
   a) Conduct and complete the Research Projects in accordance with the Proposal and Collaborative Research Plan.
   b) Participate in the Research Presentation Meeting hosted by JAXA in response to the request from JAXA;
   c) Report on the Research Results and progress of research in the Research Presentation Meeting stipulated in the previous Paragraph
   d) , Deliver an interim report to JAXA by March 31, 2015, and Furthermore, upon completion of the research period, the Research Organization shall report all the Research Results obtained throughout the entire period of the Collaborative Research in the Final Report and submit it to JAXA.; and
   e) Alternatively may substitute the submission of a thesis published during the Research Period for the submission of the report of Research Results.

Article 3. Finalization of the Contract

The Agreement shall become effective as of the date of the issuance of the Confirmation Sheet prescribed by JAXA in response to an application by the Research Organization. The period of the Agreement shall be the period described in the Confirmation Sheet issued by JAXA.

Article 4. Researchers

1. The Research Organization shall ensure that the Collaborative Researchers (PI and CIs),listed in the application form to participate in the Collaborative Research.
2. JAXA shall allow those who are listed in the Confirmation Sheet to participate in the Research Projects.
3. The Research Organization shall ensure that all the Collaborative Researchers engaging in the Research Projects act in accordance with the terms and conditions of the Agreement.
4. In the event that the Research Organization intends to newly select or add CIs, the Research Organization shall first notify JAXA in written form in advance and obtain the consent of JAXA for such personnel. The Research Organization shall take necessary measures to cause such CI to follow the Collaborative Research Agreement.
5. In the event that the PI dies, retires from the Research Organization, takes a leave of absence from work, or comes to be no longer engaged in the Research Projects, the Research Organization shall immediately notify JAXA as such and JAXA and RO may at its sole discretion terminate this Agreement; provided however, that the Research Organization may designates a researcher who belongs to the Research Organization as the PI's successor by sending notification to JAXA. JAXA will send notification to the Research Organization to decline such PI’s successor with a rational reason within 30 days upon receipt of notification by

the Research Organization, and in such case, this Agreement will terminate.

Article 5. Research Funding

Each party shall bear the necessary costs of fulfilling its own responsibilities under this Agreement.

Article 6. Ownership of the Rights to the Acquired Equipment

Equipment acquired by each party in the course of the Research Projects shall be owned by the party who purchased such equipment.

.

Article 7. Providing and Rights of Earth Observation Satellite Data by JAXA

1. JAXA will provide the Research Organization with the Earth Observation Satellite Data for the Research Projects free of charge via internet in accordance with Article 2, Paragraph 1, a) subject to the following conditions:
   a) JAXA will provide to the Research Organization standard data for JERS, ALOS and ALOS-2 standard data. The Research Organization agrees and accepts that JAXA may not provide all the Earth Observation Satellite Data which the Research Organization may request due to JAXA's facility capabilities and resource limitations. Note that the each Earth Observation Satellite Data required by the Research Organization and to be provided to the Research Organization, shall be limited to fifty scenes every fiscal year.
   b) Research Organizations shall not request JAXA of new observation request for JERS and ALOS data. Provision of ALOS-2 data is based on Basic Observation Scenario.
   c) JAXA does not guarantee a specific quality or the timely provision of the Earth Observation Satellite Data and does not take responsibility for the quality or any delay of provision of such data; and
   d) JAXA reserves the right to curtail or suspend Earth Observation Satellite Data supply to the Research Organization due to faults or difficulties relating to the satellite, limitations on their operations, or any other reasons, and JAXA shall be exempt from any responsibility for such curtailing or suspension.
   e) Research Organization shall bear the costs of media and shipment if Research Organization requests to provide the Earth Observation Satellite Data via media.
2. With respect to the Earth Observation Satellite Data provided by JAXA, the Research Organization shall:
   a) Not duplicate the Earth Observation Satellite Data except for the purpose of backup. However, this excludes duplication for distributing to authorized researchers engaged in the Research Project (PI and CIs) which are necessary for the Collaborative Research Project.
   b) Not provide or disclose the Earth Observation Satellite Data except to the PI and CIs;
   c) Only use the Earth Observation Satellite Data for the singular purpose of advancing the efforts of the Research Projects; and
   d) Return or otherwise appropriately manage the Earth Observation Satellite Data upon completion of this Agreement, according to the directives of JAXA.
3. Any rights regarding the Earth Observation Satellite Data provided by JAXA shall conform to the following:
   a) JAXA retains the intellectual property rights of all the Earth Observation Satellite Data, except for ALOS PALSAR data of which METI is the joint owner.
   b) If value-added products(modified products with high-level processing which are irreversible to standard data. High-level data processing includes data analysis or combining multiple-satellite data, image processing based on external information, and physical quantity conversion.)are solely developed by Research Organization out of Earth Observation Satellite Data, in the course of executing the Research Projects, Research Organization retains the intellectual property rights of such value-added products.
   c) If Research Organization and JAXA jointly modify the Earth Observation Satellite Data which is provided by JAXA and develop any value-added products, Research Organization and JAXA will discuss the allocation of rights to the value-added products in consideration to degree of contribution or other factors to be considered;
   d) Except for cases under paragraph b) and paragraph c), all Intellectual Property Rights of the

data or product developed by modifying the Earth Observation Satellite Data shall be owned by JAXA and;

e) In case Research Organization uses the modified Earth Observation Satellite Data for commercial purposes, Research Organization shall notify JAXA and comply with a license condition to be set by JAXA.

Article 8. Disclosure of Technical Data

1. For the purpose of performing the Research Projects, JAXA or the Research Organization may provide the other party with the Technical Data such as satellite operation data, in-situ data, or program, free of charge, and provide advice if necessary.
2. JAXA or the Research Organization shall use the provided Technical Data solely for the purpose of conducting the Research Projects. JAXA or the Research Organization shall not disclose the provided Technical Data to any third party.
3. JAXA or the Research Organization shall return or otherwise appropriately keep the Technical Data in accordance with the instructions of JAXA upon the termination of this Agreement.

Article 9. Usage of Research Results

1. All Research Results obtained through the course of the Collaborative Research ("Jointly-Owned Research Results") may be used for non-commercial and peaceful purposes by the Parties (or by a third party including for JAXA or the Research Organization) without prior consent of the other party.
2. With regard to copyrights in the Interim and Final Reports submitted by the Research Organization to JAXA, JAXA may freely use, edit, copy, and distribute such reports. In this case, the Collaborative Researchers shall waive any related moral rights to the copyrights in the Interim and Final Reports.

Article 10. Ownership of Research Results

1. Both Parties shall solely own the rights of the Research Results only if JAXA or the Research Organization solely generates such Research Results in the course of Research Projects.
2. The Parties shall jointly own the rights to the Research Results obtained through the course of the Collaborative Research and the ownership of such results shall be determined upon mutual agreement between the Parties, taking into consideration the degrees of contribution by JAXA and the Research Organization.

Article 11. Application of Intellectual Property Rights

1. JAXA or the Research Organization shall give the other party prompt written notice of Intellectual Property Rights generated in the course of the Collaborative Research, such as Inventions, Utility Models, and Creations, and discuss the ownership of such generated Intellectual Property Rights, as well as whether it is necessary to submit an application for registration of such Intellectual Property Rights.
2. JAXA and/or the Research Organization shall take any necessary procedures for any Industrial Property Rights owned by and/or held by each Collaborative Researcher (including inventions, etc., jointly generated by such Joint Researcher and JAXA or the Research Organization) to be transferred by such Joint Researcher to JAXA or the Research Organization.
3. If JAXA or the Research Organization solely generates Potential Intellectual Property Rights in the course of the Research Projects ("Solely-Owned Intellectual Property Rights"), the party may take steps to apply for the registration of the resulting Intellectual Property Rights as solely-owned ones, provided that it shall obtain prior confirmation of the other party. In this case, expenses for application and rights preservation shall be borne by the party solely holding the Intellectual Property Rights.
4. In the event that the Parties jointly generate an invention, etc., and submit an application for Intellectual Property Rights to such invention, the Parties shall enter into a separate joint ownership agreement ("Joint Ownership Agreement") and jointly perform submission of the application and other procedures according to the Joint Ownership Agreement. In this case,

expenses for application and rights preservation shall be borne by both JAXA and the Research Organization in accordance with the degree of ownership.

Article 12. Application of Intellectual Property Rights Overseas

1. Regulations of the previous Article shall apply to the case of application and rights preservation of the Intellectual Property Rights in foreign countries.
2. In the event of an application of the Intellectual Property Rights jointly owned by the Parties pursuant to Paragraph 4 of the previous Article, the Parties shall discuss whether it is necessary to submit an application for registration of such Intellectual Property Rights.

Article 13. Utilization of Intellectual Property Rights

In case either of the Parties utilizes the Intellectual Property Rights obtained in the course of Research Projects, such party shall obtain the consent of the other party in advance and pay a utilization fee as set forth in the separate utilization agreement, except for the case stipulated in Article 9.

Article 14. License of Utilization of Intellectual Property Rights to Third Party

1. The Parties may grant to any third party a license to use the Intellectual Property Rights obtained in the course of Research Projects, provided, however that the relevant party shall obtain the written prior consent of the other party, and determine the licensing terms after discussion with the other party, except for the case stipulated in Article 9.
2. In the case of granting a license to use the Intellectual Property Rights to a third party as in the previous Paragraph, the relevant party shall collect the usage fee from such third party as set forth in the separate usage agreement. The usage fee to be collected from the third party shall be distributed between the Parties pro rata in proportion to their respective interests in those rights.

Article 15. Transfer of Interests to Jointly-Owned Intellectual Property Rights

1. The Parties may transfer their respective interests to the Jointly-Owned Intellectual Property Rights generated in the course of the Collaborative Research only to their respective designees after discussion between the Parties. Such transfer may be carried out pursuant to a separate transfer agreement. In this event, the Parties shall cause its designee to succeed to all of its rights and obligations with respect to those Intellectual Property Rights.
2. If JAXA or the Research Organization disclaims its interests in the Jointly-Owned Intellectual Property Rights, the relevant party shall give the other party prior notice thereof and transfer its interests to the other party, only if the other party wishes to acquire it.

Article 16. Improved Invention

If JAXA or the Research Organization alters or improves the Jointly-Owned Intellectual Property within one (1) year from the application for registration of the original Jointly-Owned Intellectual Property Rights, the party shall provide a written notice without delay to the other party describing the alterations or improvements. Ownership and other issues of the Intellectual Property Rights concerning the altered or improved invention shall be determined through discussion between the Parties.

Article 17. Designation of Know-How

1. After mutual agreement by the Parties, JAXA and the Research Organization shall promptly designate as know-how the Research Results which are appropriately to be treated as know-how ("Know-How").
2. For designation of Know-How, a period during which the Research Results are designated to be Know-How shall be specified.
3. After designating the Know-How, such Know-How shall be kept in confidence in principle, for five (5) years commencing on the day immediately following the date of the completion of this Agreement; provided, however, that JAXA and the Research Organization may extend or

shorten that period upon mutual agreement.

Article 18. Utilization of Facilities

1. The Parties may use facilities and equipment ("Facilities") of the other party free of charge with the prior consent of the other party if it is necessary for implementation of the Research Projects.
2. The Parties shall follow the rules and regulations of the other party in case of using the Facilities of the other party.

Article 19. Installation of Equipment

1. The Parties may, if necessary for implementation of the Research Projects, install necessary equipment and other materials into the facility of the other party with the prior consent of the other party. In this case, the party which installs such equipment shall follow the rules and regulations of the other party.
2. In the event that JAXA or the Research Organization uses the materials, etc., installed by the other party (Installed Material), such party shall obtain the prior consent of the other party and shall not use the Installed Material for other purposes than the Research Projects.
3. In the event that JAXA or the Research Organization loses or damages the Installed Material, such party should immediately notify the other party of such fact irrespective of the reason.

Article 20. Delivery, Storage, and Returning of Lent Equipment

1. The Parties may lend machinery or other materials to the other party if it is required for implementation of the Research Projects.
2. Upon delivery of the machinery or other materials ("Lent Equipment") lent in accordance with the previous Paragraph, the owner of the Lent Equipment ("Lessor") shall submit to the other party a Note of Delivery and the other party shall submit to the Lessor a receipt.
3. The Parties shall confirm the items, amount, etc. of the Lent Equipment upon delivery of the Lent Equipment and if there is a shortage in the amount or any defect (including ones whose quality and/or specification does not meet the requirements), JAXA or the Research Organization shall notify such fact to the Lessor and receive an instruction from the Lessor.
4. JAXA and the Research Organization shall manage and use the Lent Equipment with the care of a good manager and should not use the Lent Equipment for purposes other than the Research Projects.
5. JAXA and the Research Organization shall keep a record of usage and management of the Lent Equipment to record the delivery, usage, and returning of the Lent Equipment for the purpose of clarifying the condition of the Lent Equipment.
6. In the case of loss or damage to the Lent Equipment, JAXA and the Research Organization shall immediately notify the fact to the Lessor without delay.
7. The receiving party shall notify the Lessor if any of the Lent Equipment becomes unnecessary due to reasons such as completion, change, or termination of whole or part of the Research Projects and shall take procedures to return the Lent Equipment according to the instructions of the Lessor.

Article 21. Confidentiality

1. In this Agreement, "Confidential Information" means any information that corresponds to any of the following:
   (1) Any information that includes documents classified "Confidential", any material object such as a sample, or any information, either material or immaterial, which JAXA and the Research Organization agreed to handle as Confidential Information by a written agreement, obtained in the course of these Research Projects; and
   (2) Any information disclosed or distributed to the other party as Confidential Information in the form of a document, a drawing, a photograph, a specimen, a sample, a magnetic tape, a floppy disk, or the like for the purpose of the Research Projects.
2. The Parties shall appropriately keep the Confidential Information secret, and shall not disclose or divulge any Confidential Information to any party other than those who engage in the Research Projects; provided, however, that any information which corresponds to any of the

following is not included in the Confidential Information.

a) Information that is already known to the public when disclosed by the disclosing party;
b) Information that becomes known to the public after the disclosure by the disclosing party without intentional misconduct or negligence of the receiving party;
c) Information that the receiving party already had before the disclosure by the disclosing party;
d) Information that the receiving party acquires from a duly authorized third party not subject to confidentiality obligations;
e) Information that the receiving party independently develops without utilizing information obtained from the disclosing party;
f) Information with prior written consent of the disclosing party for disclosure or publication; or
g) Information that is required to be disclosed by applicable laws, judgment or order of a competent court. In this case, the receiving party shall promptly notify the disclosing party of the necessity of disclosure.

3. The confidentiality obligation under this Article shall remain effective for a period of five (5) years after the termination of the Agreement. However this period of maintaining confidentiality may be extended or shortened by mutual agreement between JAXA and the Research Organization.

Article 22. Publication of Research Results

1. The Parties may disclose or publish the Research Results obtained in the course of the Research Projects ("Publication of Research Results") provided that such publishing party follows the confidentiality obligations stipulated in Article 22.
2. In the case of the previous Paragraph, before publishing, JAXA or the Research Organization ("the publishing party") shall provide the other party with a written document regarding the description of the Research Results to be published and request the written consent of the other party. The other party will not unreasonably withhold consent from the publishing party's request for such publication.
3. The other party, upon receiving the notice, will request correction of the content of the publication in written form if it is judged that such content includes a portion which may lead to the loss of the future interest of the other party and the publishing party shall consult with the other party about such portion. The publishing party may not publish the portion which the other party has notified as having the possibility of resulting in the loss of the future interest of the other party without the consent of the other party.
4. The Research Organization shall state in the publication that such Research Results have been obtained pursuant to this Agreement and identify the owner of the rights to the Earth Observation Satellite Data used in such publication.
5. The period during which the notification pursuant to Paragraph 2 is required shall be one (1) year from the day following the day of termination of the Agreement. However this period may be extended or shortened by mutual agreement between JAXA and the Research Organization.
6. JAXA and the Research Organization shall provide the other party with a copy of the publication immediately after the disclosure or publishing of such publication. Each party is entitled to an irrevocable and royalty-free right to use the provided publications, unless the copyright of such publication is owned or held by an academic society.

Article 23. Security

In the course of the Collaborative Research, the Parties shall take necessary procedures for maintaining order in the areas managed by each party, ensuring appropriate and smooth operation of the research, and ensuring the protection (security) of important assets and information.

Article 24. Termination

1. The Parties may terminate the Agreement in any case that corresponds to any one of the following. In such a case, the Parties agree to waive any claim against the other.
   (1) Upon the consent of both JAXA and the Research Organization;
   (2) When the other party commits a dishonest and/or inequitable act; provided that the breaching party fails to offer any effective and satisfactory remedial measures within seven

(7) days after receiving demands for corrective action from the harmed party;
(3) When the other party breaches the Agreement; provided that the breaching party fails to offer any effective and satisfactory remedial measures within seven (7) days after receiving demands for corrective action from the harmed party;
(4)When JAXA determines that it cannot continue the Research Projects with the Research Organization as a result of the Evaluation stipulated in Article 2, Paragraph 1, d).
(5)When the Research Organization loses a person who is engaged in the Research Projects due to the reasons described in Paragraph 5 of Article 4, such as transfer of the PI; and
(6)When it becomes not feasible for the Research Organization to continue implementation of the Research Projects.
(7)Due to an unavoidable occurrence such as a natural disaster.

2. Upon the termination of the Agreement, the Research Organization shall promptly deliver to JAXA all work including, but not limited to, all works in progress and all work that is completed and otherwise ready for delivery.
3. The Parties shall waive any claim against the other if the Agreement is terminated pursuant to Paragraph 1, Item 7 of this Article.

Article 25. Effective Term

1. The effective term of the Agreement shall be from April 1 2013 to March 31 2016.
2. Termination of this Agreement shall not affect a Party's continuing obligation under Paragraph 2 and 3 of Article 7 (Providing and Rights of Earth Observation Satellite Data by JAXA), Paragraph 3 of Article 8 (Exchange of Technical Information), and Article 9 (Usage of Research Results) through Article 15 (Transfer of interests to Jointly-Owned Intellectual Property Rights) during the effective period of rights set forth in each Article and Paragraph while Article 16 (Improved Invention), Article 17 (Designation of Know-How), Article 21 (Confidentiality) and Article 22 (Publication of Research Results) shall be effective during the period set forth in each Article.

Article 26 Modification

1. JAXA may modify the content of the Agreement. In such case, JAXA shall notify the changes by posting such changes on the website of JAXA and subsequently shall follow the changed Agreement.
2. The Research Organization may terminate the Agreement, if the Research Organization has justifiable grounds, by notifying JAXA of such intent in writing within thirty (30) days from the date of posting of the change on the website of JAXA.

Article 27 Governing Law

The Agreement shall be governed and interpreted under the laws of Japan.

Article 28 Language

All communications between JAXA and the Research Organization under this Agreement shall be either in Japanese or English.

Article 29 Consultation

In the event that any doubt arises with regard to provisions that are not included in the Agreement, it shall be resolved upon mutual agreement between JAXA and the Research Organization as necessary.

Attachment 1 "Earth Observation Satellite Data"

Name of Satellite or Sensor	Observation Period (YY/MM/DD)	Observable Area
JERS (Japanese Earth Observation Satellite) SAR, OPS	1992/09/01～1998/10/11	Global
ALOS (Advanced Land Observation Satellite) PALSAR, PRISM, AVNIR-2	2006/05/16～2011/04/22	Global
ALOS-2 (Advanced Land Observation Satellite-2) PALSAR-2		Global