# APPENDIX 4

# OVERVIEW OF
# THE ADVANCED LAND OBSERVING SATELLITE-2
# (ALOS-2) MISSION

## 1. Introduction

The Advanced Land Observing Satellite-2 (ALOS-2) is succeeding 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 its orbit is at noon in order to complement other SAR satellites which are in dawn-dusk orbits.

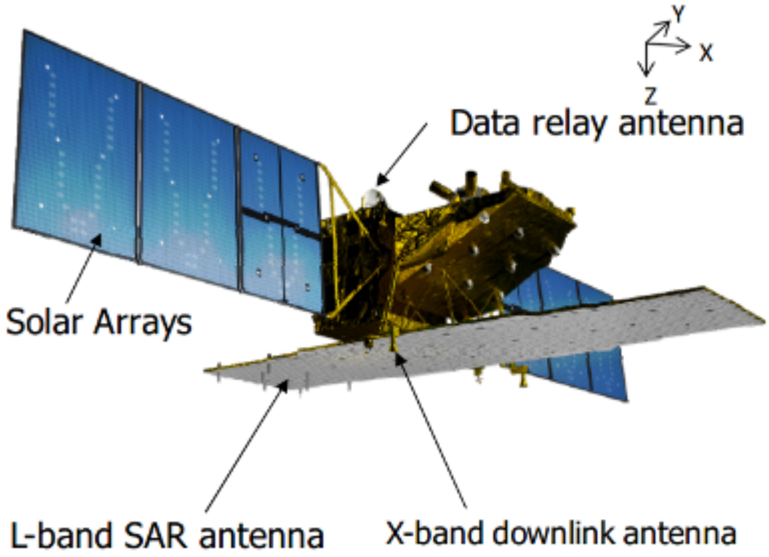


Fig. 1 ALOS-2 in-orbit configuration.

Table 1 ALOS-2 specification.

| | |
|---|---|
| Observation mode | Stripmap: 3 to 10 m resolution, 50 to 70 km swath<br>ScanSAR: 100 m/60 m resolution, 350 km/490 km swath<br>Spotlight: 1×3m resolution, 25 km swath |
| Orbit | Sun-synchronous sub-recurrent orbit<br>Altitude: 628 km<br>Local sun time: 12:00 +/- 15 min<br>Revisit: 14 days<br>Orbit control: < +/-500 m |
| Launch | May 24, 2014 (JST), H-IIA launch vehicle |
| Design lifetime | 5 years (target: 7 years) |
| Satellite mass | Approx. 2 tons |
| Downlink | X-band: 800 Mbps (16QAM), 400/200 Mbps (QPSK)<br>Ka-band: 278 Mbps (QPSK) |

## 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.

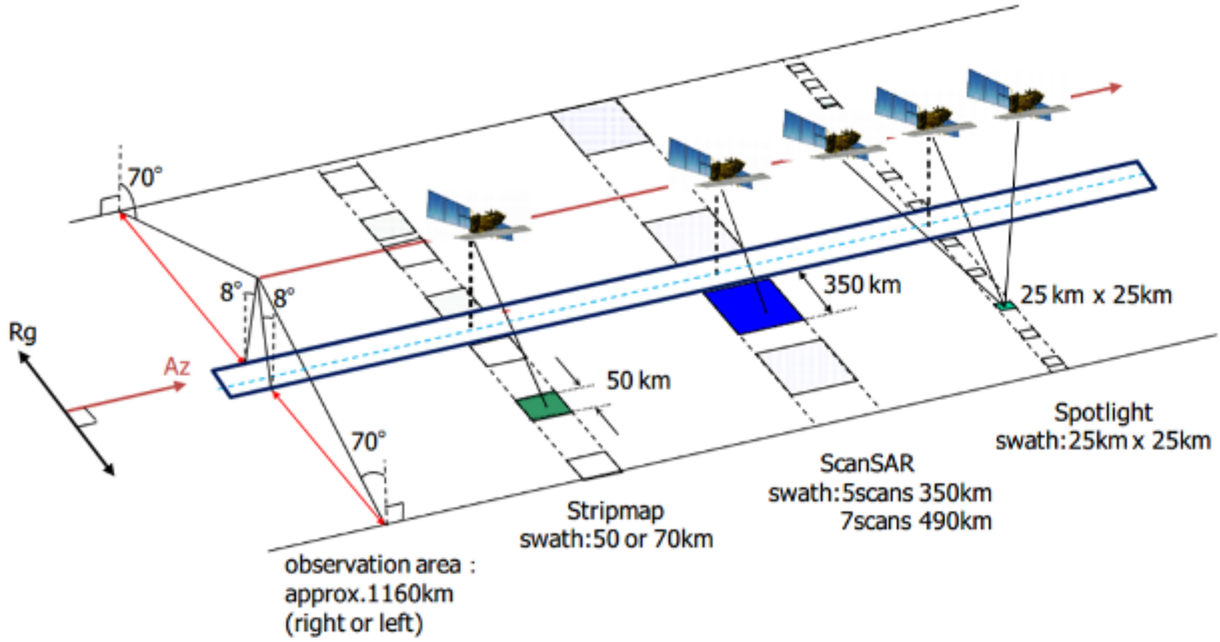

Fig. 2 PALSAR-2 observation modes.

Table 2 PALSAR-2 specification.

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

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

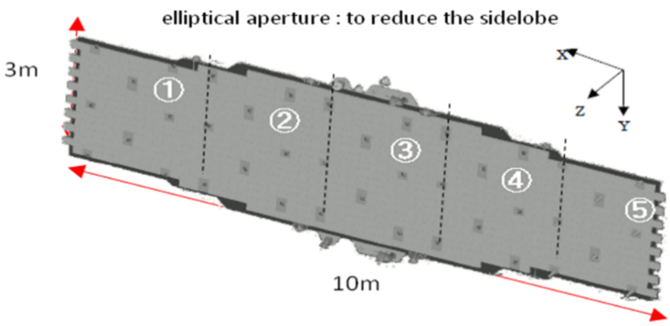


Fig. 3 PALSAR-2 antenna configuration.

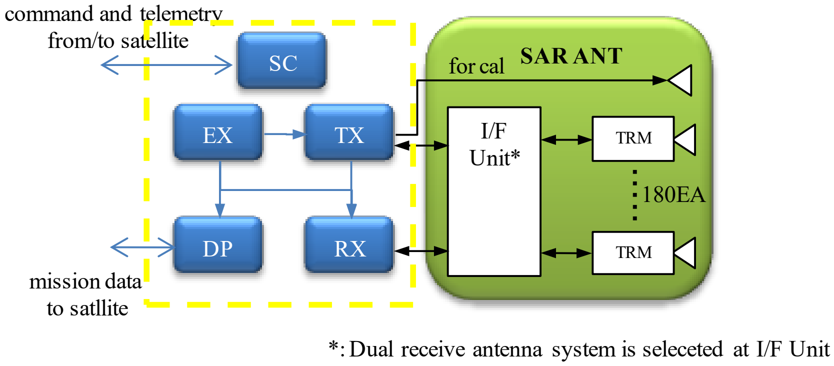


Fig. 4 PALSAR-2 system diagram.

## 3. ALOS-2 Data Products

### 3.1 Definition of ALOS-2 Data Products

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

### 3.1.1 Level 1

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

### 3.1.2 Higher-level data product

Products above level 2 are higher-level data products. Higher-level data products are made more sophisticated by processing with digital elevation models. This is provided by JAXA's EORC as soon as ready.

### 3.2 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<br>SLC: Single Look Complex used for interferometry |
| **1.5** | Multi-look processed image projected to map coordinates.<br>Option<br>G: Systematically Geo-coded (No option: Geo-referenced) | Map projection<br>Resampling<br>Pixel spacing |
| **2.1** | Ortho-rectified and slope corrected products | Map projection<br>Resampling<br>Pixel spacing |

## 4. ALOS-2 Operation Concept and Observation Strategy

ALOS-2 is operated based on the Basic Observation Scenario-3 (BOS-3) that is optimized as the background mission while the emergency observation is the highly prioterized operation for the disaster mitigations. The BOS-3 is open to the public through ALOS-2 i.e. https://www.eorc.jaxa.jp/ALOS/en/alos-2/obs/pal2_obs_guide_e.htm

The BOS-3 is designed to achieve the Earth observation using the several modes of the PALSAR-2, i.e. high resolution strip mode (84 MHz-singe polarization), Dual polarization mode (42 MHz-Dual Polarization), Quad-mode (42 MHz-Full polarization), Dual Strip (28 MHz), and ScanSAR (14 MHz-Dual-350 Km /490 Km swath) for observing the solid earth (deformation study), biosperic study (forest monitoring, carbon estimation) and Cryospheric study (sea-ice, polarer monitoring), and map generation.

# APPENDIX 5

# OVERVIEW OF
# THE ADVANCED LAND OBSERVING SATELLITE-4
# (ALOS-4) MISSION

## 1. Introduction

The Advanced Land Observing Satellite-4 (ALOS-4) will observe the Earth's surface using its onboard the Phased Array type L-band Synthetic Aperture Radar-3 (PALSAR-3). The data will be utilized for monitoring disaster, forest, sea ice, infrastructure, and many other applications with the advantages of Synthetic Aperture Radar (SAR) such as all-weather and day-and-night observation capability. With further improved observation performance compared to the predecessor PALSAR-2 aboard ALOS-2, the satellite aims at achieving both high resolution and a broader observation swath.

ALOS-4 is equipped with a SAR antenna at the lower part of its body and with two solar array paddles at both sides, as shown in Figure 1. The observation data is transmitted to a ground station via. Ka-band data downlink with maximum rate of 3.6 Gbps. ALOS-4 will operate in the same orbit plane as ALOS-2. Table 1 shows system specifications of ALOS-4.

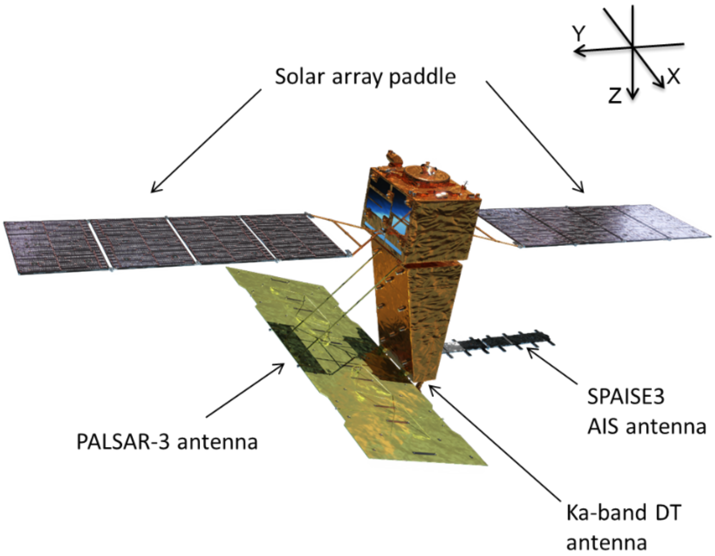


Fig. 1 ALOS-4 in-orbit configuration.

Table 1 ALOS-4 current specifications (under designed).

| | |
|---|---|
| Mission Instruments | ・ PALSAR-3 (Phased Array-type L-band Synthetic Aperture Radar-3)<br>・ SPAISE3 (SPace based AIS Experiment 3) |
| Orbit | ・ Sun-synchronous sub-recurrent orbit<br>・ Altitude: 628 km<br>・ Inclination angle: 97.9 degree<br>・ Local sun time at descending: 12:00 ± 15 min.<br>・ Revisit time: 14 days (15-3/14 rev/day)<br>(Same orbit as ALOS-2) |
| Launch | June 30, 2024 by H-3 Flight 3 as planned |
| Mission lifetime | 7 years |
| Satellite mass | Approx. 3 tons |
| Data downlink | 3.6 Gbps/1.8 Gbps (Ka-band) |

## 2. PALSAR-3 Specification

ALOS-4 carries the state-of-the-art L-band SAR called PALSAR-3. For the continuity of ALOS-2 data, PALSAR-3 will inherit the major function and performance (NESZ, S/A, etc.) of PALSAR-2 aboard ALOS-2. The observation swath width of PALSAR-3 will be expanded from PALSAR-2 without spoiling the spatial resolution by using the digital beam-forming (DBF) technique.

Fig. 2 and Table 2 show geometries and specifications of PALSAR-3, respectively. Spotlight and Stripmap modes will provide high resolution data. ScanSAR mode will observe wider area with 700 km swath width at the expense of spatial resolution. The observation repetition frequency of ALOS-4 will also be improved owing to the expanded swath width.

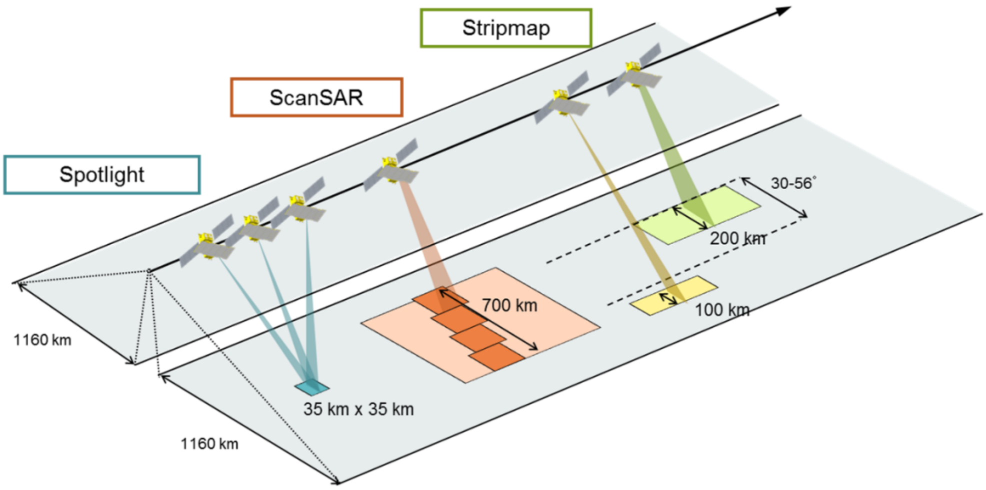


Fig. 2 Geometry of PALSAR-3 observation modes.

Table 2 PALSAR-3 observation modes and specifications.

| Observation mode | Spotlight | Stripmap 3m | | Stripmap 6m | | Stripmap 10m | | ScanSAR |
|---|---|---|---|---|---|---|---|---|
| SAR mode | Sliding-spotlight | Stripmap | | | | | | ScanSAR |
| Center frequency (MHz) | 1257.5 | 1257.5 | | 1236.5 or 1257.5 or 1278.5 | | | | |
| Bandwidth (MHz) | 84 | 84 | | 42 | | 28 | | 28 |
| Resolution (m) | 3 x 1 (Rg x Az) | 3 | | 6 | | 10 | | 25 (1 look) |
| Swath width (km) | 35 x 35 (Rg x Az) | 200 | 100 | 200 | 100 | 200 | 100 | 700 (4 scan) |
| Polarization (HV basis) | 1, 2 | 1, 2 | 1, 2, 4 | 1, 2 | 1, 2, 4 | 1, 2 | 1, 2, 4 | 1, 2 |
| Incidence angle range (degree) | 8-70 | 30-56 | 8-70 | 30-56 | 8-70 | 29-56 | 8-70 | 8-70 |
| Split-band option (for ionospheric correction) | N/A | N/A | N/A | N/A | N/A | 28+10 MHz | N/A | N/A |

*Items in red color represent improvements or modifications from PALSAR-2

## 3. Standard Product

PALSAR-3 Standard Data Products (Level 1) are radiometrically and geometrically calibrated data and will be provided for ALOS-4 users. Table 3 shows the definitions of the Standard Data Products. In addition, higher-level data products including global mosaic and disaster map are planned to be released.

Table 3 PALSAR-3 standard data procucts.

| Level | Definition |
|---|---|
| 1.1 | Range and azimuth compressed single-look complex (SLC) data on slant range |
| 1.5 | Geo-coded or geo-referenced amplitude image projected to map coordinate |
| 2.1 | Ortho-rectified amplitude image projected to map coordinate |

## 4. ALOS-4 Operation Concept and Observation Strategy

To achieve these mission objectives of ALOS-4, it is necessary to establish a common observation scenario to make effective use of the limited observation resources, and to conduct systematic observations in time and space. In ALOS-4, the "Basic Observation Scenario (BOS)" is defined as a common observation scenario as in ALOS and ALOS-2, and observations are performed based on this scenario. For emergency observations required to grasp the disaster situation, or for observations required by individual users, individual observation requests are drafted separately from the BOS and observations are performed according to the priority level defined with the BOS.

Since ALOS-4 is expected to be operated simultaneously with ALOS-2, the observation plan will be appropriately discussed and updated so that it will be integrated and consistent between ALOS-2 and 4.

More detail of the ALOS-4 BOS is presented on the public through EORC ALOS seriese website i.e.,

https://www.eorc.jaxa.jp/ALOS/en/alos-4/a4_observation_e.htm