# *ALOS Data Users Handbook*

Revision C

March 2008

Earth Observation Research and Application Center

Japan Aerospace Exploration Agency

# INTRODUCTION

Japan's Earth-observing satellite program consists of two series, corresponding to different objectives of observations; namely, one comprises satellites mainly for atmospheric and marine observations, and the other mainly for land observations. The main objective of the Advanced Land Observing Satellite (ALOS) is to contribute to cartography, regional observation, disaster monitoring, and resources surveying, by further advancing land observation technologies applied to the Japanese Earth Resources Satellite-1 (JERS-1), and the Advanced Earth Observing Satellite (ADEOS). ALOS is equipped with three remote-sensing instruments: the Panchromatic Remote-sensing Instrument Stereo Mapping (PRISM) to measure precise land elevation, the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) to observe what covers land surfaces, and the Phased Array type L-band Synthetic Aperture Radar (PALSAR) to enable day-and-night and all-weather land observations. ALOS is thus expected to show a high-resolution capability in land observations.

Various data products obtained through ALOS are expected not only to contribute greatly to the development of science in a wide range of fields, but also to be quite efficiently used in various practical areas, such as natural resources management and disaster monitoring, mitigating damage, and designing local development programs.

Global environmental problems have, besides the climate change problem (and perhaps without regard to climatic change), a relation to problems of resources, the food problem in particular. Production shortages of principal cereals and sharp increases in their prices would firstly put significant pressure on fragile areas and destabilize the global system. Because problems related to resources arising from land and water might destabilize the global system, this is really a pivotal issue of common global significance. To strengthen and overcome the fragility of the production base of food, however, it is important to gather local information with respect to land, water, and vegetation. As is represented by the necessity to preserve biological diversity, preserving eco-systems and protecting gene resources have started to be recognized as globally important issues; and they, too, need locally collected information on a global scale.

In other words, one can no longer say that low-accuracy imagery resolution is good enough for handling global problems. To the contrary, high-accuracy data that is usable at a local level are now increasingly required on a global scale, and it is now becoming technologically feasible to obtain such high-accuracy data.

Meantime, global environmental problems, as symbolized by the Kyoto Protocol, are moving from the phase of merely discussing evaluations of the magnitude of the impact and elucidating the mechanism of occurrence to the phase of discussing countermeasures and consensus-building, and implementing practical strategies. With respect to reducing greenhouse gases emissions, for instance, preservation of forests is considered to be an effective measure to collect and solidify carbon dioxide, in addition to carbon taxes, emission right trading, development of energy conservation technologies, etc. As forest preservation and rehabilitation policies are closely related to localities, and are thus considered to necessarily create direct conflicts of interest with local communities, it is a prerequisite to have harmony with local needs in order to implement environmental policies in a smooth and effective manner. Any global policy that brings with it significant disadvantages to local residents will not be sustainable. Consequently, locally collected data on the area in question is required to realize policies from a global viewpoint. The objectives of stabilizing food production and mitigating disaster risks through preservation and sustainable use of land and water resources, as well as maintenance of biological diversity through preservation of eco-systems, in particular, are rightly the essential issues of concern for local planning and administration, which have long been pursued in individual regions.

To establish a realistic environmental policy, while keeping harmony between the requirements from a global viewpoint and the needs of a locality, it is necessary and important to have detailed local data, which have global coverage and at the same time can reflect local needs.

The data obtained through ALOS are considered to provide an effective solution to satisfy such needs. By demonstrating the entire picture of the ALOS Project and, at the same time, by providing a variety of technological information on satellites and land systems in this paper, we expect to be able to contribute to promoting the further use of ALOS data.

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# ALOS Data Users Handbook

## Tables Of Contents

# ALOS Data Users Handbook

# List of Tables and Figures

[TABLES]

[FIGURES]

# Section 1 INTRODUCTION

## 1.1 Objectives

The purpose of this document is to provide various information needed for users to effectively use data obtained through ALOS. We introduce not only various information related to standard products, but also information related to ALOS itself, as well as other related information about the sensors on the Satellite and the ground systems.

## 1.2 Scope and Structure

This document is composed of the following eight Sections and Appendices.

- Section 1: Objectives, scope and construction of this document.
- Section 2: Outline of ALOS mission.
- Section 3: Introduction to ALOS satellite system, sensors, and data interface specifications.
- Section 4: Introduction to ALOS ground systems.
- Section 5: Introduction to ALOS mission operations and basic operation scenario.
- Section 6: Introduction to ALOS data product definition.
- Section 7: Outline of the ALOS standard data processing algorithm.
- Section 8: Introduction to the ALOS data distribution by JAXA.
- Appendix: Related information including list of abbreviations, reference materials, and points of contact.

Data product definitions and data processing algorithms dealt with in this document are only described in outline. Thus, for further details, refer to related documents in Appendices. The data distribution services described in Section 8 covers the services for individuals such as researchers, general users, and PIs among the data distribution services by JAXA.

# Section 2 ALOS Mission

## 2.1 ALOS Mission

Japan's Earth-observing satellite program consists of two series, corresponding to different objectives of observations; namely, one type comprises satellites mainly for atmospheric and marine observations, and the other type mainly for land observations. The main objective of the Advanced Land Observing Satellite (ALOS) is to contribute to cartography, regional observation, disaster monitoring, and resources surveying, by further advancing land observation technologies applied to the Japanese Earth Resources Satellite Unit 1 (JERS-1), and the Advanced Earth Observing Satellite (ADEOS). ALOS is equipped with three Earth observation sensor instruments: the Panchromatic Remote-sensing Instrument Stereo Mapping (PRISM) to measure precise land elevation, the Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2) to observe what covers land surfaces, and the Phased Array type L-band Synthetic Aperture Radar (PALSAR) to enable day-and-night and all-weather land observations. ALOS is thus expected to show a high-resolution capability in land observations. The ALOS satellite was successfully launched from the Tanegashima Space Center on January 24, 2006 (Japan Standard Time) using an H-IIA launch vehicle.

ALOS aims to achieve the following missions by collecting high-resolution land observation data on a global scale.

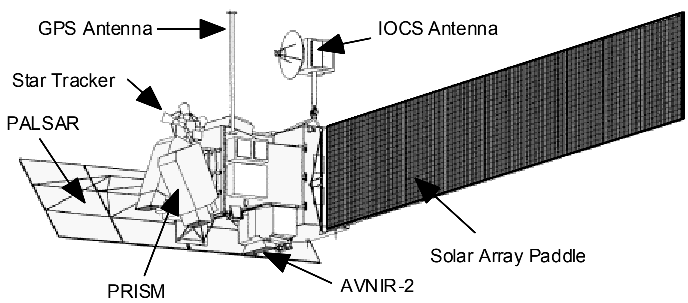



Figure 2.1-1 Overview of ALOS Satellite

- **Production and renewal of topographical maps on a global scale (spatial data infrastructure):**

  ALOS specifically aims to successfully obtain dimensional measurements of land with an accuracy of less than 5 meters in terms of topographical altitude, with an interval of grids of about 10 meters (which is more or less equivalent to a topographical map of 1:25,000). As the measuring technology of land elevation from imagery is relatively well established, the situation is advantageous for observations by satellites. Furthermore, by superimposing topographical altitude data with data from high-resolution photovoltaic-sensors and synthetic aperture radar (SAR), information on vegetation and soil can be provided as a combined unit. With regard to regions where topographical altitude data have been well compiled, it is now possible to make observations focusing on changes on the surface of the Earth. This type of data constitutes the spatial data basis on a global scale.

- **Support for sustainable development in various parts of the world through regional observations:**
  Besides construction of the above spatial data basis, we intend to support preservation and management of as well as sustainable development and use of the environment and resources on a regional level, by providing various information on environmental and resources extracted from satellite images.

- **Monitoring large-scale disasters around the world:**
  Unexpected disasters such as droughts, volcanic eruptions, and floods often fatally damage sustainable and stable regional development. Together with various satellite and disaster monitoring systems already available, we intend to collect and provide data relating to disasters.

- **Surveying of natural resources around the world:**
  In addition to monitoring land and water resources, we intend to support regional development by providing information that is useful for surveying mineral resources.

- **Development of technologies necessary for future Earth observations:**
  ALOS is a quasi-only high-resolution satellite for collecting fundamentally complete information on the entire Earth, and as such, there are many challenging research and development themes to follow in the areas of sensor development technology as well as data-processing technology. As these technologies will have big impacts on next-generation Earth observation technologies, ALOS is also an important technological development project.

## 2.2 ALOS Data Node Concept

The ALOS Data Node Concept is a plan to rapidly use ALOS data on an international basis and to provide services matching with the needs of various parts of the world, by dividing the globe into regions, whereby each region bears responsibility for processing, preserving, and distributing ALOS data by way of a data node to be established at each region.

As the volume of data obtained through ALOS will be as large as 1 Tera Bytes or more a day, or over 20 times the data obtained through conventional satellites, it is difficult for one organization or even for one country alone to deal with such a huge volume. Meantime, because interest in using ALOS data is worldwide, the ALOS Data Node Concept based on international task-sharing was conceived. The representative organizations selected by individual regions, which are called ALOS Data Node Organizations, are responsible for providing appropriate user services to the ALOS data users in their respective areas, and thus they are obliged to establish ALOS Data Nodes equipped with functions for ALOS data-processing, archiving, and distribution. ALOS Data Node Organizations are expected to cooperate with each other to promote the use of ALOS data, and to improve supplies of services to users.

Each Data Node Organization will receive level 0 data from JAXA based on an agreement with JAXA, and create products and distribute them to local users. Under the agreement with JAXA, it can also receive data through its X-band receiving stations (in this project, they are categorized as foreign receiving stations) and use them.

ALOS Data Node Concept is expected to contribute to the following.

- Enhancement of ALOS data processing and archiving capabilities.
- Promotion of scientific use as well as operational use of ALOS data.
- Enlargement of international collaboration in the fields of validation and scientific research activities.
- Improvement of services for potential users of ALOS data.

At present, the following four Data Node Organizations including JAXA will share the entire Earth. In addition, Geo-Informatics and Space Technology Development Agency (GISTDA) of Thailand will join the framework of ALOS Data Node as an Asian Sub-node.

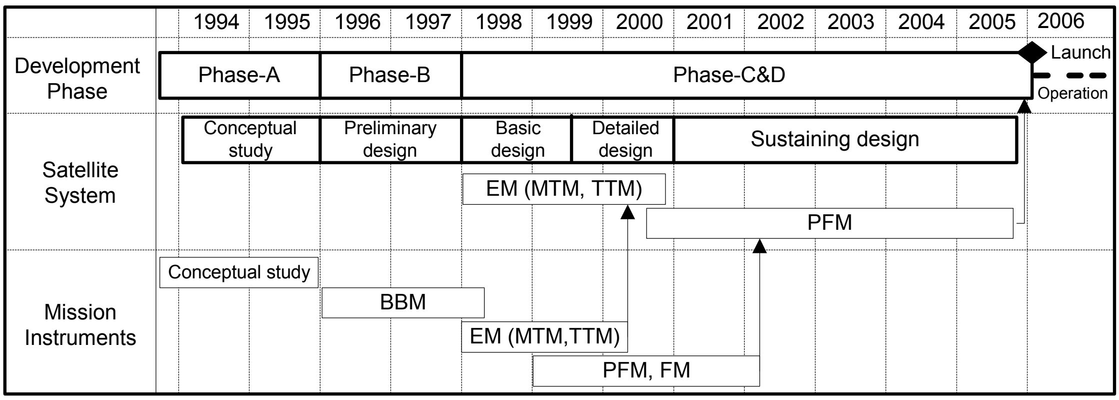
- Data Node responsible for Asia: Japan Aerospace Exploration Agency (JAXA)
- Data Node responsible for Europe and Africa: European Space Agency (ESA)
- Data Node responsible for North/South America: National Oceanic and Atmospheric Administration (NOAA) and Alaska Satellite Facility (ASF)
- Data Node responsible for Oceania: Geoscience Australia (GA)

## 2.3 ALOS Program

JAXA started a feasibility study of the ALOS satellite system as well as BBM development and testing of critical parts of sensor instruments in fiscal year 1994. During the period of fiscal 1996 and 1997, it conducted trial fabrication and testing of the satellite bus itself together with preliminary designing of Earth observing sensors and trial fabrication and testing of Bread Board Model. By fiscal 1998, it confirmed the feasibility of the sensors and the satellite system, and in the same year it moved to the phase of large-scale development. It executed the tasks of maintenance design as well as testing the Proto-Flight Model by launched in January 2006.

While development of the ALOS Satellite has been performed by JAXA, some components of the Phased Array type L-band Synthetic Aperture Rader (PALSAR), one of the sensors to be loaded on ALOS, have been developed under the responsibility of the Ministry of Economy, Trade and Industry (METI) as a collaborative project with JAXA.

Meantime, as for land surface facilities, in addition to those owned by Japanese domestic agencies, including JAXA in particular, and METI (Earth Remote Sensing Data Analysis Center – ERSDAC), Geographical Survey Institute (GSI), Ministry of Agriculture, Forestry and Fisheries (MAFF), Ministry of the Environment (MOE), Japan Coast Guard (JCG), etc., the system to be established by the above Data Node Organizations will be used for achievement of ALOS missions.




BBM: Bread Board Model, EM: Engineering Model, MTM: Mechanical Test Model,
TTM: Thermal Test Model, PFM: Proto Flight Model

Figure 2.3-1 ALOS Development Master Schedule

# Section 3 Outline of ALOS Satellite System

## 3.1 Satellite System

The ALOS satellite system configuration is shown in Figure 3.1-1, and the main characterisctics are shown in Table 3.1-1.

ALOS carries the following three mission instruments for Earth observation.

- Panchromatic Remote-sensing Instrument Stereo Mapping (PRISM)
- Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2)
- Phased Array type L-band Synthetic Aperture Rader (PALSAR)

In addition, the following mission instruments are carried.

- Technical Data Acquisition Equipment (TEDA)
- Deployment Monitor (DM)
- Laser Reflector (LR)
- Mission Data Handling System (MDHS)

Data from observation mission instruments as well as from TEDA are, during normal operation, multiplexed by MDC in MDHS and downlinked to the ground station either directly or through the Data Relay and Tracking Satellite (DRTS) via Ka-band transmission after recording and reproduction with the Mission Data Recorder (MDR). Data are transmitted to the ground stations by X-band, depending on the need.

The main purpose of Deployment Monitor (DM) is to monitor deployment status of the instruments onboard the satellite including the Deployment System on a real-time basis during the initial onorbit period, and the data are transmitted to the ground stations either directly or after recording and reproduction by S-band or X-band.

The orbit of the Satellite is the Sun-synchronous Sub-recurrent Orbit (SSO) with a 46-day recurrent period. During normal operation, PRISM and AVNIR-2 observe nadir the satellite typically, while PALSAR basically observes with an off-nadir angle of 34.3 degrees. Disaster area monitorings are performed using the pointing function of AVNIR-2 and the changable off-nadir angle function of PALSAR.

Table 3.1-1 ALOS Main Specifications

| Item | | Specification |
|---|---|---|
| Launch | Vehicle | H-IIA |
| | Date | January 24, 2006 |
| | Site | Yoshinobu Launch Site, Tanegashima Space Center |
| Orbit | Type | Sun-Synchronous Subrecurrent |
| | Local Time at DN | 10:30 AM ± 15min. |
| | Altitude | 691.65km (above equator) |
| | Inclination | 98.16 degree |
| | Orbital Period | 98.7 min. |
| | Revolutions per day | 14+27/46rev./day |
| | Recurrent Period | 46 days |
| | Longitude Repeatability | +/-2.5km (above equator) |
| Mission Instruments | Earth Observation | Panchromatic Remote-sensing Instrument for Stereo Mapping (PRISM)<br>Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2)<br>Phased Array type L-band Synthetic Aperture Radar (PALSAR) |
| | Other | Technical Data Acquisition Equipment (TEDA) |
| Mission Data Handling System | Data Compression | PRISM：1/4.5, 1/9 (Non-Reversible compression)<br>AVNIR-2：3/4 (Reversible compression) |
| | Multiplex Method | CCSDS Multiplex |
| | Data Recording and Reproducing | High Speed Solid State Recorder (HSSR) 1 set<br>-Recording capacity: over 96GB<br>-Recording speed: 360/240/120Mbps (selectable)<br>-Reproducing speed: 240/120Mbps (selectable) |
| | | Low Speed Solid State Recorder (LSSR) 1 set<br>-Recording capacity: 1GB (0.5GB x 2 partitions)<br>-Recording speed: 40kbps<br>-Reproducing speed: 16Mbps |
| IOCS System | Ka band | Transmission: 26.1GHz<br>Receiving: 23.540GHz<br>Transmission rate (symbol rate / data rate):<br>For DRTS 277.52Msps / 240Mbps |
| | S band | Transmission: 2220.00MHz<br>Receiving: 2044.25MHz |
| Direct Transmission | X band | Frequency: 8105MHz<br>Transmission rate (symbol rate / data rate):<br>138.76Msps / 120Mbps |
| | USB | Transmission: 2220.00MHz<br>Receiving: 2044.25MHz |

ALOS

- Mission Instruments
  - Panchromatic Remote-Sensing Instrument for Stereo Mapping (PRISM)
  - Advanced Visible and Near Infrared Radiometer type 2 (AVNIR-2)
  - Phased Array type L-band Synthetic Aperture Radar (PALSAR)

    (Earth Observation Mission Instruments)
  - Technical Data Acquisition Equipment (TEDA)
  - Deployment Monitor (DM)
  - Laser Reflector (LR)
  - Mission Data Handling System (MDHS)

    (Other Mission Instruments)
    - MDHS Digital Assembly
      - Data Compression (DC)
      - Mission Data Coding (MDC)
      - Mission Data Recorder (MDR)
    - Data Relay Satellite Communication (DRC)
    - Direct Transmission (DT)
- Bus Instruments
  - Telemetry Tracking and Command System (TT&C)
  - Electrical Power Subsystem (EPS)
  - Solar Array Paddle (PDL)
  - Attitude and Orbit Control Subsystem (AOCS)
  - Structure Subsystem (STR)
  - Thermal Control Subsystem (TCS)
  - Reaction Control Subsystem (RCS)
  - Integration Hardware (INT)

Figure 3.1-1 ALOS System Configuration

## 3.2 Overview of Mission Instruments

### 3.2.1 Earth Observing Mission

Overview of three mission instruments for Earth Observing Mission onboard ALOS are given below. As for the ALOS satellite operations including the three sensors, please refer to Section 5.

#### 3.2.1.1 PRISM

PRISM is a panchromatic radiometer operating in the visible near infrared region, and has three telescopes for forward, nadir and backward view. The forward and the backward telescopes are installed for stereo images so as to realize a base-to-height ratio of 1.0 against satellite flight direction. An observation concept of PRISM is shown in Figure 3.2-1.

PRISM has an Earth rotation correction function to correct distortion of observation views by the three telescopes due to the Earth's rotation and obtains images by selecting automatically the best image extraction position.

Each telescope of PRISM has over 70km of field of view; observation width will be 35km in the normal observation mode (Observation Mode 1) with the three telescopes. The FOV can be pointed electrically ±1.5 degree (approx. 17.5km). The nadir telescope can output data with a 70km swath width. For this mode, 35km swath width data of the backward telescope can be output simultaneously.

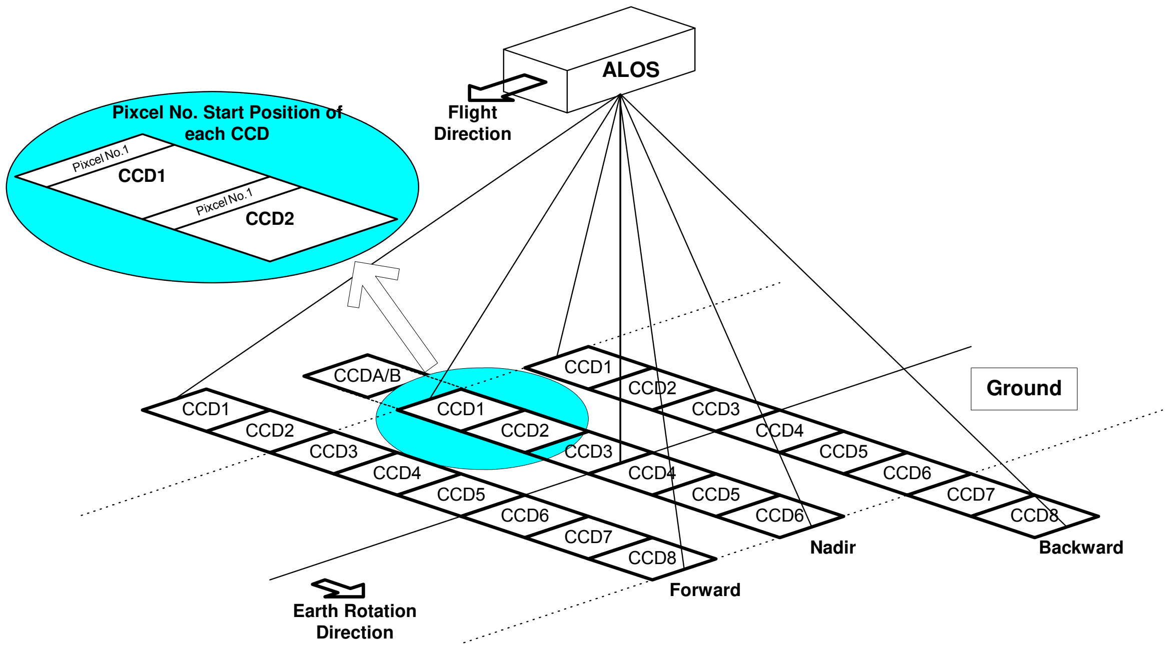



Figure 3.2-1 PRISM Observation Concept

Function of PRISM is described as follows:

(1) PRISM has three telescopes for forward, nadir and backward views, where the observation range is panchromatic band in the visible near infrared region, and acquires each observation data.

(2) Each telescope of PRISM has over 70km of field of view: observation width will be 35km in the normal observation mode for the three telescopes. The nadir telescope can output data with a 70km swath width. When 70km observation mode of the nadir is selected, only the observation data of the backward radiometer can be acquired simultaneously.

(3) When 35km observation mode is selected, the FOV can be pointed electrically ± 1.5 degrees. (Approximately 17.5 km, cross-track direction)

(4) In the nadir radiometer, resolution of horizontal direction is approximately 2.5 meters. With respect to the forward and backward views, observation is carried out with the equivalent angle resolution to the nadir view.

(5) PRISM has an Earth rotation correction function to correct the distortion of observation views due to the Earth's rotation, even if satellite does not carry out the yaw steering to correct it.

(6) PRISM obtains images by selecting automatically the best image extraction position according to the satellite position information provided from the satellite system.

(7) PRISM exchanges telemetry signals for monitoring the PRISM condition and command signals for giving the instructions of each part's operation with ALOS, and carries out the operation control.

(8) PRISM has an experimental function for obtaining the data for future sensor development.

(9) PRISM has an electrical calibration function in order to calibrate electrical system installed after a detector.

PRISM instrument configuration is given by Table 3.2-1 and the block diagram is by Figure 3.2-2.

Table 3.2-1 PRISM Instrument Configuration

| System | Unit | Component | Major Module |
|---|---|---|---|
| PRISM System | Nadir View Scanning Radiometer Unit (PRI-N-SRU) | Optics | Optics |
| | | Detector | Detector module |
| | | | Drive Electronics |
| | | | Pre-amp Electronics |
| | | Analog Signal Processor | Post-amp Electronics |
| | | | A/D Converter |
| | | | Controller / Time Generator |
| | | | Structure (STR) |
| | | Power Supply* | |
| | | Thermal INT | |
| | | Radiometer Structure | |
| | | Integration | Wire Harness |
| | Forward View Scanning Radiometer Unit (PRI-F-SRU) | Optics | Optics |
| | | Detector | Detector module |
| | | | Drive Electronics |
| | | | Pre-amp Electronics |
| | | Analog Signal Processor | Post-amp Electronics |
| | | | A/D Converter |
| | | | Controller / Time Generator |
| | | | Structure (STR) |
| | | Power Supply* | |
| | | Thermal INT | |
| | | Radiometer Structure | |
| | | Integration | Wire Harness |
| | Backward View Scanning Radiometer Unit (PRI-B-SRU) | Optics | Optics |
| | | Detector | Detector module |
| | | | Drive Electronics |
| | | | Pre-amp Electronics |
| | | Analog Signal Processor | Post-amp Electronics |
| | | | A/D Converter |
| | | | Controller / Time Generator |
| | | | Structure (STR) |
| | | Power Supply* | |
| | | Thermal INT | |
| | | Radiometer Structure | |
| | | Integration | Wire Harness |
| | Thermal Control Unit (PRI-HCE) | Thermal Control* | Thermal control circuit |
| | | Thermal INT | |
| | Electrical Unit (PRI-ELU) | Asymmetric Cache Buffer/Editor* | Digital Signal Processor |
| | | | Controller |
| | | | Power Supply |
| | | Thermal INT | |
| | | STR | |
| | | Integration | Wire Harness |
| | Integration (PRI-INT) | | Wire Harness |

*Redundancy construction

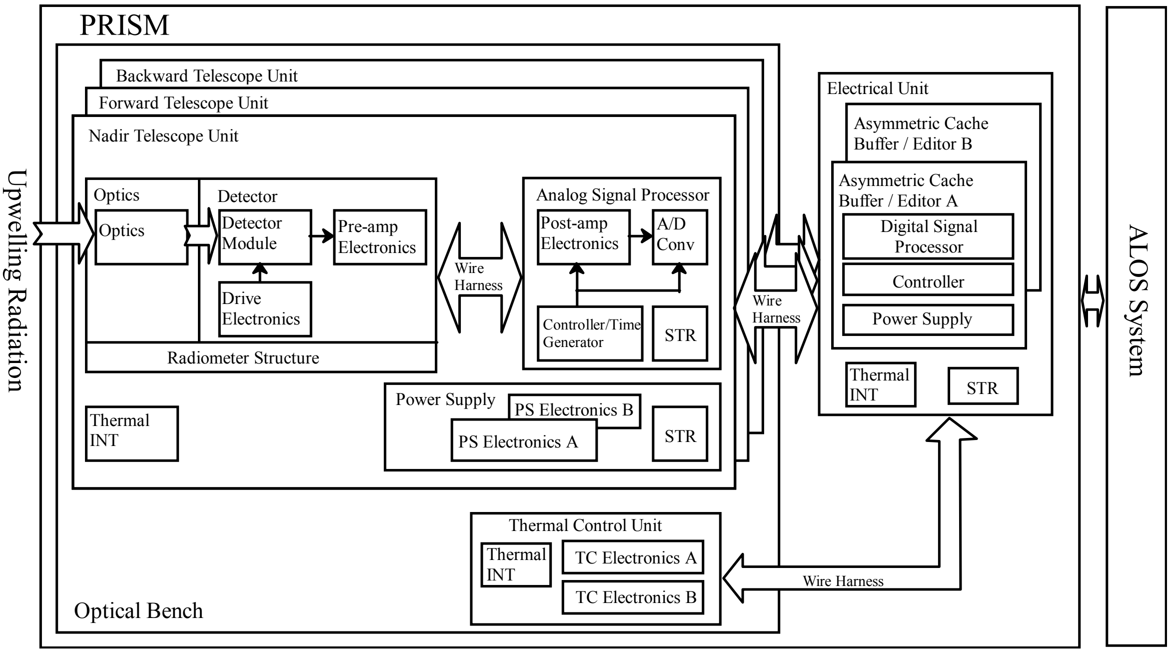



Figure 3.2-2 PRISM Block Diagram

Main characteristics of PRISM are shown in Table 3.2-2 and the main operation modes are given by Table 3.2-3.

Table 3.2-2 PRISM Main Characteristics

| Item | Forward | Nadir | Backward | Note |
|---|---|---|---|---|
| Observation Band | 0.52 to 0.77 µm | | | |
| IFOV | 3.61 µrad | | | |
| FOV | 5.8 deg. | – | | 70 km swath |
| | 2.9 deg. | 2.63 deg. | | 35 km swath |
| Scan Cycle | 0.37ms | | | |
| Pointing Angle | ± 1.5 deg. | ± 1.36 deg. | | For triplet observation |
| MTF | > 0.2 | | | Including MTF degradation along track by spacecraft flight |
| S/N | > 70 | | | |
| Gain Setting | 4 steps | | | |
| AD Bit | 8 | | | |
| Data Rate | < 960 Mbps (320 Mbps/telescope) | | | Before compression |
| Angle from nadir | ± 23.8 deg. (for forward and backward) | | | Along track |

Table 3.2-3 PRISM Operation Modes

| Mode | | Content | Remarks |
|---|---|---|---|
| Observation | 1 | Nadir / Forward / Backward views simultaneous observation | Nominal mode (35km swath of each view) |
| | 2 | Nadir 70km + Backward 35km simultaneous observation | |
| | 3 | Nadir 70km observation | |
| Calibration | 1 | Electrical Calibration Mode (Get Electronics calibration data after the detector) | Condition is the same as Observation Mode 1 |
| | 2 | Blackbody Calibration Mode (Measure offset level of image signal when zero input signal) | ditto |

### 3.2.1.2 AVNIR-2

AVNIR-2 obtains highresolution image data in four bands of visible and near infrared. AVNIR-2 has a cross track pointing function in the range ±44 degrees (positive for left of satellite flight direction). An observation concept of AVNIR-2 is shown in Figure 3.2-3.

AVNIR-2 consists of three units: scanning radiometer unit (SRU) for optical system, electorical unit (ELU) for electrical interface with the ALOS spacecraft, and harness (HNS) connecting SRU and ELU electrically.

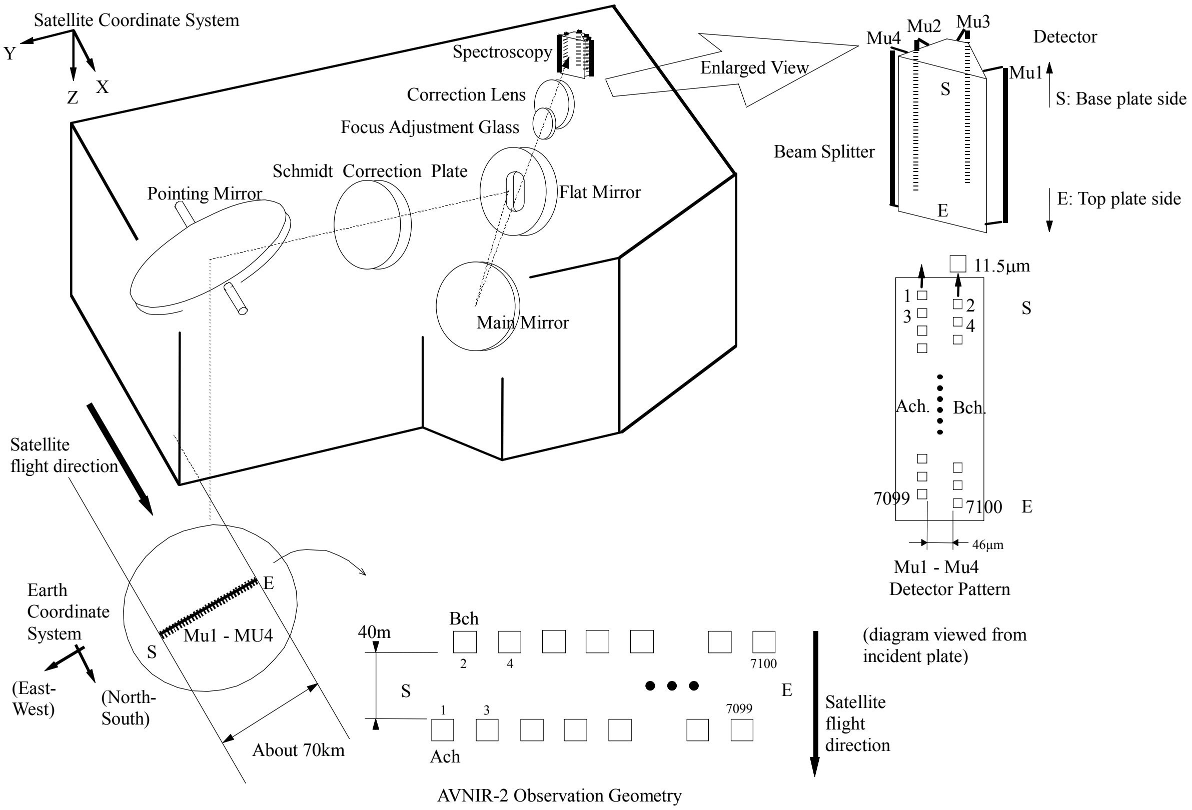



Figure 3.2-3 AVNIR-2 Observation Concept

Function of AVNIR-2 is described as follows:

(1) AVNIR-2 obtains high-resolution image data from observation in four bands of visible and near infrared. Instantaneous field of view angle is 14.28 μrad (converted distance on the ground surface: approximately 10 meters), and field of view angle is approximately 5.8 degrees (converted distance on the ground surface: approximately 70 kilometers).

(2) A cross track pointing function in the range ±44 degrees (positive for left of satellite flight direction).

(3) Optical calibration function which calibrates all systems of AVNIR-2 including the optical system using internal lamp, and electrical calibration function for calibrating the electrical system installed after detector.

(4) In order to enhance S/N, detector has a stagger alignment that increases the area ratio of pixel, and electronic scanning method which has linear array detector is being adopted. And AVNIR-2 obtains two-dimensional image of land and coastal area by scanning of two directions; in the cross track direction, the scanning of CCD itself, and in the along track direction, the scanning by using the motion of satellite body.

(5) A gain switching function in the Analog Signal Processor which meets the difference between high and low latitudes and difference of the ground surface's luminance of each season, and an electronic shutter function which can control signal storage time are installed. Both functions can control their operations independently for each band.

(6) AVNIR-2 exchanges (sends and receives) the following signals with ALOS, and carries out the operation control. 1) Telemetry signal for monitoring the AVNIR-2 condition. 2) Command signal for giving the instructions of each part's operation.

(7) AVNIR-2 carries out thermal control independently aside from ALOS system. With respect to the instruments related to observation and calibration, the characteristic of these instruments is maintained by narrowing the thermal control range. For other instruments, they have a function for keeping the range of storage temperature or operation temperature.

AVNIR-2 instrument configuration is given by Table 3.2-4 and the block diagram is by Figure 3.2-4.

Table 3.2-4 AVNIR-2 Instruments Configuration

| System | Unit | Component | Major Module / Electronics |
|---|---|---|---|
| AVNIR-2 System | Scanning Radiometer Unit (SRU) | Pointing Mechanism Assembly (PMA) | Pointing Mirror Module<br>Pointing Mechanism Module |
| | | Optics (OPT) | Condenser Module<br>Spectroscopy Module<br>Focus Adjustment Module<br>Telescope Module |
| | | Detector (DET) | Detector Module<br>Pre-amp Module |
| | | Analog Signal Processor (ASP) | Post-amp<br>Gain Switcher Electronics<br>A/D Conv. Electronics |
| | | Optical Cal. Assembly (OCA) | Lamp Cal. Module A<br>Lamp Cal. Module B |
| | | Structure (STR-S) P/N: S/N: | |
| | | Integration (INT-S) | |
| | Electronic Unit (ELU) | Drive Control Assembly (DCA) | Controller<br>DC/DC DCA |
| | | Digital Signal Processor (DSP) | Cal. Electronics<br>Multiplex Module<br>TLM/CMD Process Module<br>Timing Signal Switcher<br>DC/DC DSP |
| | | TLM/CMD Processor (TLM/CMD) | TLM/CMD Processor<br>DC/DC TLM/CMD |
| | | Digital Signal Processor (DSP) | Cal. Electronics<br>Multiplex Module<br>TLM/CMD Process Module<br>Timing Signal Switcher<br>DC/DC DSP |
| | | Power Supply (PWR) | Power Interface Unit<br>Thermal Controller<br>DC/DC THC<br>DC/DC SRU<br>DC/DC LMP |
| | | Structure (STR-S) | |
| | | Integration (INT-S) | |
| | Harness (HNS) | | |

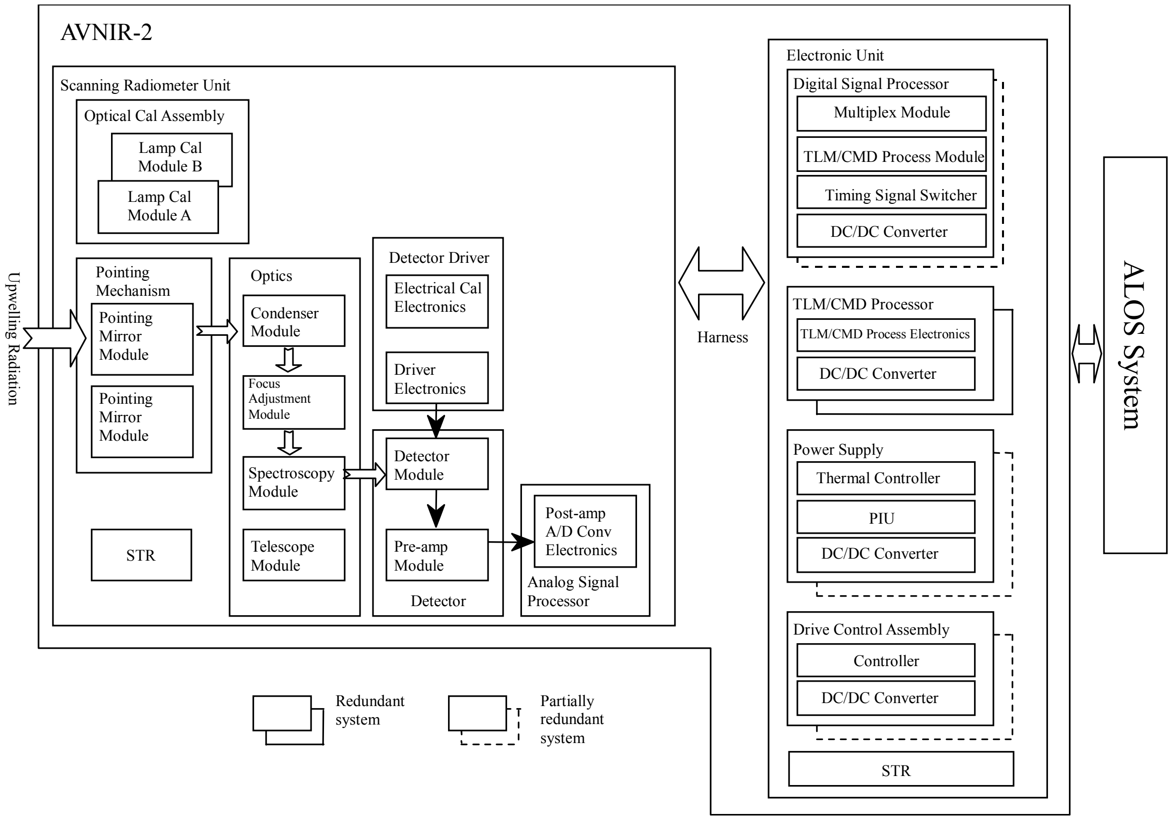



Figure 3.2-4 AVNIR-2 Block Diagram

Main characteristics of AVNIR-2 is shown in Table 3.2-5 and the main operation modes are given by Table 3.2-6.

Table 3.2-5 AVNIR-2 Main Characteristics

| Item | Specification | Remarks |
|---|---|---|
| Observation wavelength | ch 1: 0.42 – 0.50 µm<br>ch 2: 0.52 – 0.60 µm<br>ch 3: 0.61 – 0.69 µm<br>ch 4: 0.76 – 0.89 µm | |
| Spatial resolution (IFOV) | 10m (Approx. 14.28 µrad) | |
| Spatial frequency transmission characteristics | ch 1-3: 0.25, ch 4: 0.20 | |
| Observation width | > 70 km (Approx. 5.8 degree) | |
| Number of detectors | 7100 / band | |
| Scan cycle | 1.48 millisecond | |
| MTF | Band 1 – 3 : > 0.25<br>Band 4 : > 0.20<br>(At the Nyquist frequency) | |
| Gain | 4 steps | |
| S/N | > 200 | Settable per band |
| Registration accuracy between bands | Setting accuracy within ± 8 µm<br>Variation element within ± 4 µm<br>(on the orbit) | |
| Pointing angle | ± 44 degree | |
| Pointing setting step angle | 0.01875 degree/pulse | At light axis |
| Pointing angle setting accuracy | Within 0.05 degree | |
| Pointing angle reading accuracy | Within 0.05 degree | |
| Encoder unit | 0.044 degree (light axis) | |
| AD bit | 8 bit / pixel | |
| Data rate | 160 Mbps (40 Mbps/band) | Before compression |

Table 3.2-6 AVNIR-2 Operation Modes

| Mode | | Content | Remarks |
|---|---|---|---|
| Observation | | Observation | |
| Standby | | Set and keep a condition to transit into observation mode or calibration modes | |
| Calibration | 1 | Calibration using internal lamp A | |
| | 2 | Calibration using internal lamp B | |
| | 3 | Calibration using both internal lamps A and B | Option |

### 3.2.1.3 PALSAR

PALSAR is an L band Synthetic Aperture Radar which can change off-nadir angle in the range from 9.7 to 50.8 degrees. Spatial resolution at off-nadir 34.3 degrees is 10m for the high resolution mode. PALSAR also has a wide area observation mode called ScanSAR. An observation concept of PALSAR is shown in Figure 3.2-5.

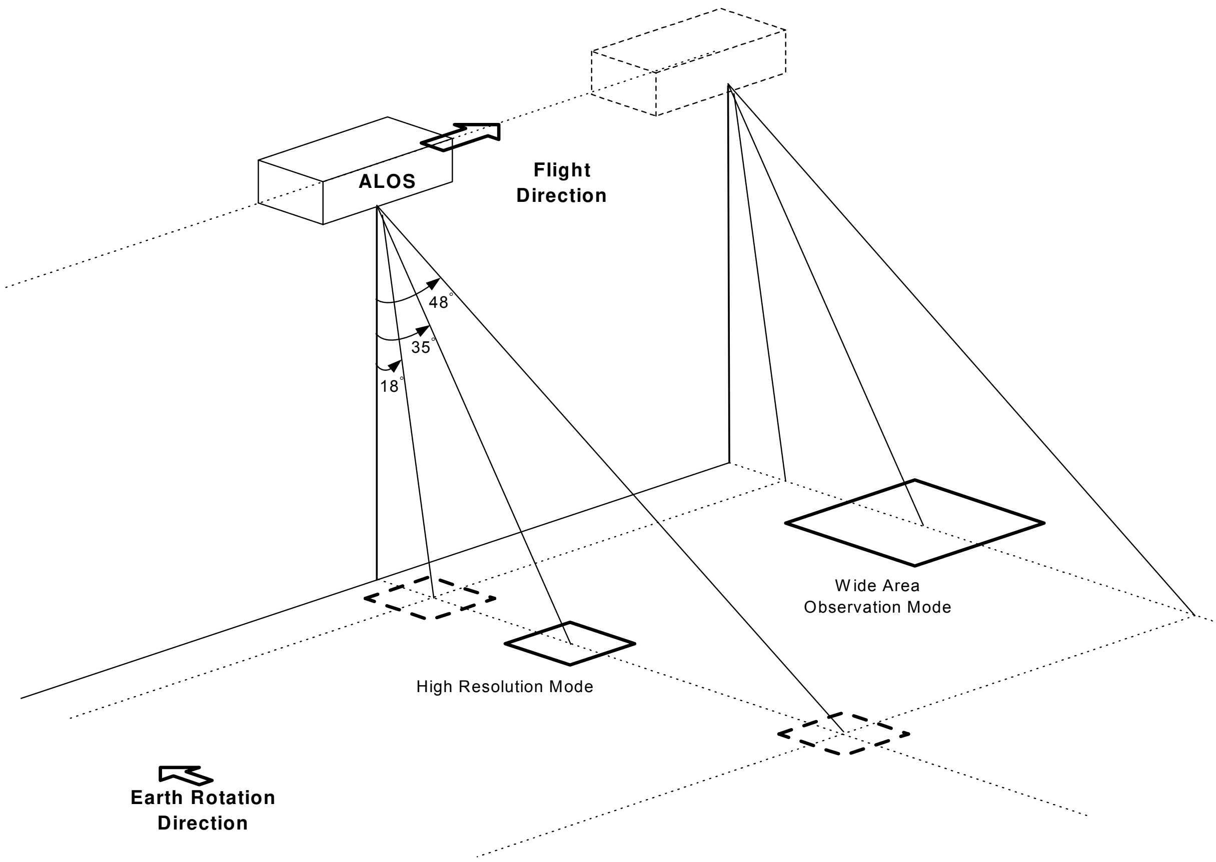



Figure 3.2-5 PALSAR Observation Concept

Instrument configuration of PALSAR and main characteristics of PALSAR are shown in Tables 3.2-7 and 3.2-8 respectively.

Table 3.2-7 PALSAR Instrument Configuration

<table>
<tr><th>System</th><th>Unit</th><th colspan="3">Component</th><th>Q’ty</th></tr>
<tr><td rowspan="25">PALSAR System</td><td rowspan="13">Antenna Unit (ANT)</td><td rowspan="3">Antenna Structure System (ASTS)</td><td colspan="2">Antenna panel (APNL)</td><td>4</td></tr>
<tr><td colspan="2">Deployment structure (DPM)</td><td>1</td></tr>
<tr><td colspan="2">Storage and opening structure (HDM)</td><td>1</td></tr>
<tr><td rowspan="6">Transmission/Reception Module (TRS)</td><td colspan="2">Transmission/reception module (TR)</td><td>80</td></tr>
<tr><td colspan="2">Transmission/reception power source (PTR)</td><td>8</td></tr>
<tr><td rowspan="3">RF Divider (DIV)</td><td>3 dividers (DIV-3)</td><td>12</td></tr>
<tr><td>4 dividers (DIV-4)</td><td>3</td></tr>
<tr><td>8 dividers (DIV-5)</td><td>24</td></tr>
<tr><td colspan="2">Control divider (CNT)</td><td>4</td></tr>
<tr><td colspan="3">Heater control circuit in antenna unit (AHCE)</td><td>4</td></tr>
<tr><td colspan="3">Thermal control system in antenna unit (ATCS)</td><td>1</td></tr>
<tr><td colspan="3">Instrumentation system in antenna unit (AHNS)</td><td>1</td></tr>
<tr><td colspan="3">Antenna for REV (REV)</td><td>12</td></tr>
<tr><td rowspan="11">Electric Circuit Unit (ELU)</td><td rowspan="3">Transmission/Reception (TRX)</td><td colspan="2">Signal generating unit (SG)*</td><td>1</td></tr>
<tr><td colspan="2">Transmission unit (TX)*</td><td>1</td></tr>
<tr><td colspan="2">Reception unit (RX)*</td><td>1</td></tr>
<tr><td rowspan="2">Signal Processing (SP)</td><td colspan="2">System control unit</td><td>2</td></tr>
<tr><td colspan="2">Data processing unit</td><td>2</td></tr>
<tr><td colspan="3">Power Divider (PWD)</td><td>1</td></tr>
<tr><td colspan="3">Antenna deployment driving circuit (ADE)</td><td>1</td></tr>
<tr><td colspan="3">Heater control circuit in electric circuit (EHCE)</td><td>1</td></tr>
<tr><td colspan="3">Thermal control system in electric circuit (ETCS)</td><td>1</td></tr>
<tr><td colspan="3">Instrumentation system in electric circuit (EHNS)</td><td>1</td></tr>
<tr><td colspan="3">Electric circuit structure (ELS)</td><td>1</td></tr>
<tr><td colspan="4">Instrumentation connecting various units (AEHN)</td><td>1</td></tr>
</table>

* Redundancy construction

Table 3.2-8 PALSAR Main Characteristics

| **Observation Mode** | | **Fine Resolution** | | **Direct Downlink** | **ScanSAR** | **Polarimetric** | **Remarks** |
|---|---|---|---|---|---|---|---|
| Frequency | | L band | | | | | Center Frequency:<br>1270MHz |
| Polarization | | HH or VV | HH+HV or VV+VH | HH or VV | HH or VV | HH+HV+<br>VV+VH | |
| Incidence Angle | | 8 – 60 deg. | 8 – 60 deg. | 8 – 60 deg. | 18 – 36 deg. (3 scans)<br>18 – 40 deg. (4 scans)<br>18 – 43 deg. (5 scans) | 8 – 30 deg. | Off-nadir Angle:<br>9.7 – 50.8 deg. |
| Resolution | Range | 10 m* | 20 m* | 20 m* | 100 m* | 30 m* | Number of looks of the ScanSAR mode is more than 8 by both range and azimuth. |
| | Azimuth | 10 m<br>(2 looks)<br>20 m<br>(4 looks) | 10 m (2 looks)<br>20 m (4 looks) | 10 m (2 looks)<br>20 m (4 looks) | 100 m | 10 m (2 looks)<br>20 m (4 looks) | |
| Swath Width | | 70 km* | 70 km* | 70 km* | 250 km (3 scans)<br>300 km (4 scans)<br>350 km (5 scans) | 30 km* | |
| AD Bit | | 5 bits | | 5 bits | 5 bits | 5 bits | |
| Data Rate | | 240 Mbps | | 120 Mbps | 120 / 240 Mbps | 240 Mbps | |
| Radiometric Accuracy | | Relative accuracy within 1 scene: <1dB<br>Relative accuracy within 1 orbit: < 1.5 dB | | | | | |
| EIRP | Swath Width 70km | < -23 dB* | | | < -25 dB* | < -29 dB* | Under study about transmission pulse width |
| | Swath Width 60km | < -25 dB (target)* | | | | | |
| S/A | Swath Width 70km | > 16 dB* | | | > 21 dB* | > 19 dB* | Applied for respectively range and azimuth directions |
| | Swath Width 60km | > 21 dB (target)* | | | | | |

*) Meets under the following off-nadir angle. For other angles, it is necessary to keep specifications as similar as possible.
- Fine Resolution Mode : Off-nadir angle 34.3 deg.
- Direct Downlink Mode : Off-nadir angle 34.3 deg.
- ScanSAR Mode : 4th scan (off-nadir 34.1 deg.)
- Polarimetric Mode : Off-nadir angle 21.5 deg.

Note) Above descriptions are specifications over the equator.

The main characteristics and operation modes of PALSAR are shown in Tables 3.2-9 and 3.2-10 respectively.

Table 3.2-9 PALSAR Calibration Mode

| Mode | Content | Remarks |
|---|---|---|
| Noise Measure 1 | Measure the noise level when one transmission-receiving module is on with termination of module LNA input. | Periodically performed |
| Noise Measure 2 | Measure the noise level when all transmission-receiving modules are on with termination of module LNA input. | |
| Noise Measure 3 | Measure the noise level when the only transmission module is off without termination of module LNA input. | Performed for each observation |
| Transmitter Power Monitor | Monitor transmission power of each TR module | |
| Transmitter Wave Pattern Monitor | Loop back RF signal at the calibration module of the receiving assembly; replica of transmission wave pattern is obtained. | |
| Receiving REV | Receive RF transmitted from the REV antenna, and calibrate antenna pattern using a tone signal. | Option |
| Transmission REV | Receive RF transmitted from the observation antenna by the REV antenna, and calibrate antenna pattern using a tone signal. | |
| Total Characteristics of Receiving System | Receive calibration signal transmitted from the REV antenna, and measure total characteristics of the receiving system using a tone signal. | |
| Total Characteristics of Transmission System | Receive RF transmitted from the observation antenna by the REV antenna, and measure total characteristics of the transmission system using a tone signal. | |
| I/O Characteristics when Receiving | Input calibration signal directly to receiving signal at the receiving assembly not though the antenna assembly using a tone signal. | |
| ATT Characteristics of Receiving System | Input calibration signal directly to receiving signal at the receiving assembly not though the antenna assembly using a tone signal. | |
| Frequency Characteristic Measure of Receiving System | Receive and measure calibration signal transmitted from the REV antenna with variable frequencies of tone signals. | |

Table 3.2-10 PALSAR Observation Mode

| **Mode** | **Content** |
|---|---|
| High Resolution | High resolution observation by single polarization or simultaneous receiving of two polarizations |
| ScanSAR | Wide area observation by ScanSAR (single polarization)<br>The same data rate as that of the high resolution mode or half this rate. |
| Direct Downlink | Observation with half the rate of that of the high resolution mode (single polarization) |
| Polarimetric | Observation with four polarizations simultaneously |

Note: Each observation mode is broken down into more parts depending on polarization and off-nadir angle, etc.

### 3.2.2 Other Mission Instruments

#### 3.2.2.1 Deployment Monitor（DM）

DM monitors unfolding behaviors of the solar paddle, the DRC antenna, and the PALSAR antenna, and also monitors disturbance of the spacecraft during deployments. DM is a CCD camera system consisting of six cameras to carry out real-time monitoring by compressed images or detailed monitoring by stored data on each deployment during the critical phase. The real-time data are transmitted via HKDR of the TT&C system. The stored data are recorded onto MDR of the MDHS system and then transmitted as mission data after establishment of communication links.

Table 3.2-11 DM Operation Modes

| Modes | Number of Operating Camera |
|---|---|
| All-off | 0 |
| Standby | 0 |
| Solar Paddle Deployment | 3 (Max) |
| DRC Antenna Deployment | 3 (Max) |
| PALSAR Antenna Deployment | 3 (Max) |
| S/C Attitude Disturbance Monitor | 3 (Max) |

#### 3.2.2.2 TEDA

TEDA is a sensor to measure space environment and consists of the following two sensors:

- Light Particle Telescope (LPT) to monitor energy and flux of electron, proton, and alpha particle;
- Heavy Ion Telescope (HIT) to monitor spatial distribution and transition of heavy ions.

Data from TEDA are multiplexed as low rate mission data at MDHS, recorded onto LSSR, and then reproduced to ground. TEDA normally operates 24 hours per day.

#### 3.2.2.3 LR (Laser Reflector)

LR is an instrument for ranging of the satellite to reflect lasers transmitted from ground forward incident direction with the corner cubic reflector. There is no data interface with any other onboard equipment.

LR is loaded on earth directional side of ALOS to receive laser signals transmitted from ground. Precise location of satellite is determined by measuring the time that the laser signals come back to laser ranging station on the ground after reflected by LR. LR can reflect signals to the same direction that those come from because LR has structure of complexes of three mirrors combined with 90 degrees.

Figure 3.2-6 Overview of Laser Reflector

### 3.2.3 Mission Data Handling System (MDHS)

The function of MDHS is as follows:

- Data Compression
- Data Multiplex and Coding
- Data Recording and Reproduction
- Data Relay Satellite Communication
- Direct Transmission

MDHS consists of the following subsystems for each function:

- Data Compression (DC)
- Mission Data Coding (MDC)
- Mission Data Recorder (MDR)
- Data Relay Satellite Communication (DRC)
- Direct Transmission (DT)

The main function of each subsystem is shown below:

### 3.2.3.1 Data Compression (DC)

Data Compression (DC) functions to compress mission data of PRISM and AVNIR-2. PRISM data is compressed by an irreversible compression with a compression rate of 1/4.5 or 1/9 as shown in Table 3.2-12.

Table 3.2-12 Data Compression of PRISM Data

| Instrument | Data rate before compression | Compression rate | Data rate after compression | Reversibility |
|---|---|---|---|---|
| PRISM | 960Mbps (320Mbps x 3 systems) | 1/4.5 | 240Mbps (80Mbps x 3 systems) | Irreversible |
| | | 1/9 | 120Mbps (40Mbps x 3 systems) | Irreversible |

AVNIR-2 data is compressed by a reversible compression with a compression rate of 3/4 as shown in Table 3.2-13.

Table 3.2-13 Data Compression of AVNIR-2 Data

| Instrument | Data rate before compression | Compression rate | Data rate after compression | Reversibility |
|---|---|---|---|---|
| AVNIR-2 | 160Mbps (40Mbps x 4 bands) | 3/4 | 120Mbps (30Mbps x 4 systems) | Reversible |

### 3.2.3.2 Mission Data Coding (MDC)

MDC functions to multiplex mission data and other telemetry data. The Earth observation mission instrument data processed at MDC are shown in Table 3.2-14.

Table 3.2-14 Mission Data Processed at MDC

| Instrument | Data |
|---|---|
| PRISM<br>Compressed Data | 1/4.5 compressed :240Mbps (80Mbps x 3 systems)<br>1/9 compressed :120Mbps (40Mbps x 3 systems) |
| AVNIR-2<br>Compressed Data | 3/4 compressed :120Mbps |
| PALSAR | 240Mbps<br>120Mbps |

In addition, the following data are input to MDC as well, and are processed by the VCA service of the CCSDS:

- DM Non-compressed Data
- STT Raw Data

The following low rate mission data are multiplexed by the multiplex service.

- PRISM Mission Telemetry
- PALSAR Mission Telemetry
- TEDA Data
- AOCS Attitude Data
- AOCS STT Data
- AOCS GPSR Data
- TT&C System Telemetry

The low rate mission data are always recorded at the Low Speed Solid State Recorder (LSSR) for 24 hours, and reproduced during a visible area.

The data are output after Reed-Solomon encoding as an error correction encoding. VMD functions to select an output system from DRC, DT and MDR, and set the routing.

### 3.2.3.3 Mission Data Recorder (MDR)

MDR functions to record and reproduce the data multiplexed at MDC. There are two types of recorder in MDR: HSSR for recording high rate mission data and LSSR for recording low rate mission data over 24 hours. The main characteristics of HSSR and LSSR are shown in Tables 3.2-15 and 3.2-16 respectively.

Table 3.2-15 HSSR Main Characteristics

| Item | Characteristics |
|---|---|
| Type of Recorder | Solid state recorder |
| Recording Capacity | 96Gbyte (EOL, after RS encoding)<br>(Information only: 82Gbyte) |
| Recording Rate | 360/240/120Mbps (selectable)<br>(240Mbps is the fastest for one channel) |
| Reproducing Rate | 240/120Mbps (selectable) |
| Number of Channels | Recording 2CH, Reproducing 1CH |
| Simultaneous Recording and Reproducing Function | Simultaneous recording and reproducing is operational up to a total of 360Mbps<br>(It can be recorded and reproduced at different rates) |
| 2CH Simultaneous Recording Function | 240Mbps = 120Mbps x 2CH<br>360Mbps = 120Mbps + 240Mbps |

Table 3.2-16 LSSR Main Characteristics

| Item | Characteristics |
|---|---|
| Recorder Type | Solid State Data Recorder |
| Recording Capacity | Partition 1 0.5Gbit (BOL)<br>Partition 2 0.5Gbit (BOL) |
| Recording Rate | Slower than 40Kbps (Nominal) |
| Reproducing Rate | 15Mbps (fastest) |
| Number of Channels | Recording 1CH, Reproducing 1CH |

### 3.2.3.4 Data Relay Satellite Communication (DRC)

Data Relay Satellite Communication (DRC) establishes a communication link with a data relay satellite. The target satellite is DRTS. Mission data are transmitted via Ka-band at following data rates:

- For DRTS: 277.52 Msps / 240 Mbps (symbol rate / information rate)

DRC also has a function to transmit and receive telemetry and commands of the TT&C system via S-band.

### 3.2.3.5 Direct Transmission (DT)

Direct Transmission (DT) carries out a direct transmission to ground stations with one band of X-band at the following data rate:

- 138.76 Msps / 120 Mbps (symbol rate / information rate)

## 3.3 Overview of Spacecraft Bus Instruments

### 3.3.1 Telemetry, Tracking and Command (TT&C)

Telemetry, tracking and command subsystem (TT&C) is an instrument to receive command signals from ground station directly or via DRTS, and to distribute to each subsystem after demodulating and decoding the signals. TT&C also transmits telemetry data of each subsystem directly or via DRTS to the ground station after taking, editing, recording and modulating the data. TT&C has a function to relay ranging signals as well as light load mode function and autonomous/automatic function.

For the first time as Earth observation satellites developed by JAXA, A CCSDS protocol is used for TT&C, and standard of MIL-1553B is adopted for databus.

### 3.3.2 Electrical Power Subsystem (EPS)

The important jobs of ALOS's EPS are to accept the electrical power as much as 7,000W generated by Solar Array Paddle (PDL) at the dayside orbit, to provide that electrical power to ALOS's components, and to charge Batteries (BAT) for use at the nightside orbit.

Other jobs of EPS are electrical power suppliment for deployment of PDL, PALSAR and DRC antenna after ALOS - H-IIA separation, electrical and thermal maintenance of BAT, and electrical protection of ALOS's components against excess current generated on PDL.

EPS consists of the following components:

- Power Control Unit (PCU)
- Battery Charge Control Unit (BCCU)
- Battery (BAT)
- Ordnance Controller (ODC)
- Reconditioning Load (RCL)
- Shunt Dissipater (SHNT)

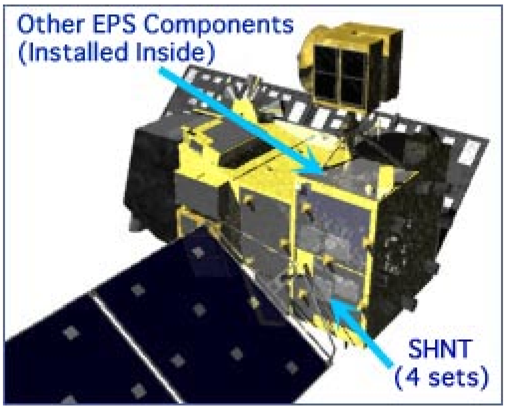



Figure 3.3-1 Onboard EPS Location

Four sets of Shunt Dissipater (SHNT) are the silver pizza boxes in front on the photo, which convert the excessive electrical power from PDL to heat and dissipate it into the space. They are placed outside the satellite body on the PDL side open to the space. Other EPS components are installed inside.

ALOS has five sets of NiCd type battery (BAT). BAT is manufactured, tested and then being kept in a refrigerator to avoid specific deterioration. They are installed at the satellite just before the launch operation.

NiCd type battery comes not to be able to provide enough current more than a certain level, if discharging and charging repeatedly at that same level (Memory effect). Reconditioning Load (RCL) is used to force batteries discharge more than normal level to avoid this memory effect.

Power Control Unit (PCU) manages the efficient charge and discharge procedure between PDL and BAT, and provides stable voltage of electric current to all ALOS's components. It sends control signals of shunt dissipation to SHNT and control signals of charging current to Battery Charge Control Unit (BCCU), by checking PDL's power generation and BAT voltage.

Battery Charge Control Unit (BCCU) is equipped with each BAT one by one. It actually charges BAT at the dayside orbit and discharge at the nightside orbit, according to the control of PCU. It also protects BAT by stopping charge at high temperature (33 °C) and by heating up BAT in low temperature (2 °C).

ALOS's PDL, PALSAR antenna and DRC antenna are folded down at the top seat of rocket in launching. They have to be deployed for working after ALOS's separation from the rocket in the space. Ordnance Controller (ODC) sends the electric current, at this time, from BAT to explosive materials to free them from holding bolts.

### 3.3.3 Solar Array Paddle (PDL)

The Solar Array Paddle (PDL) generates the electrical power for satellite from Sunlight on the orbit.

Five minutes after Satellite-Rocket separation, ALOS fires eight separation nuts and stowed solar paddle begins to deploy by the power of spring. ALOS rotates and tracks its solar paddle to the Sun after stabilization of satellite attitude.

ALOS's solar paddle is designed to generate over 7,000W at EOL (End of Life), this is the largest power supply paddle JAXA has ever developed.

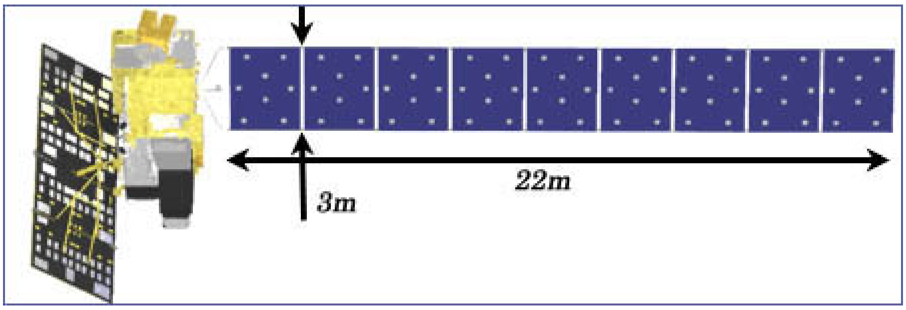



Figure 3.3-2 ALOS Solar Paddle

The Single paddle composed with nine solar panels is the significant point of ALOS's appearance. The performance of solar generators change for the worse when shadow falls on the surface. However ALOS's orbit, called "Sun Synchronous", has a characteristic of fixed sun angle to the orbit plane, ALOS will see the Sun only left side from its flight direction and the solar paddle is installed only the left side.

ALOS’s Solar Array Panels (PAD) adopts "Light-Rigid Panel". Aluminum honeycomb are sandwiched by carbon-fiber reinforced plastics (CFRP), and solar cells are stuck on the one side of this sandwiched panel. High radiation efficiency adiabators are stuck on the back side of solar panel, and temperatures of panels are controlled within appropriate range.

ALOS controls its attitude to keep its sensors direct to the earth, and the location of the Sun changes as the ALOS rotates on the orbit. To keep maximum efficiency of the paddle, ALOS must rotate the paddle to face it right angle to the Sunlight. The Paddle Drive Mechanism (PDM) is the component installed at the root of the paddle, and PDM has the function of rotating the paddle and transporting the power from the paddle to ALOS's power supply systems.

### 3.3.4 Attitude and Orbit Control Subsystem (AOCS)

ALOS's Attitude and Orbit Control Subsystem (AOCS) has function to acquire information of satellite attitude and location by using Earth Sensor (ESA), Inertia Reference Unit (IRU), Star Tracker (STT), and GPS Receiver (GPSR), and also has function to keep satellite correct attitude and orbit by driving Reaction Control Subsystem (RCS) gas jet, Reaction Wheel (RW) and Magnetic Torquer (MTQ).

To make world map of 1/25,000 scale derived from PRISM's 2.5 meters resolution image, spacecraft's attitude must be kept and determined precisely as we have never developed. The specifications of AOCS are as follows:

- Pointing Stability (Maximum of satellite’s stagger)
  - Four ten-thousandths of degrees per 5 seconds or less (4.0e-4deg/5sec)
- Pointing Determination Accuracy (error of satellite’s direction)
  - Four ten-thousandths of degrees (4.0e-4deg) at onboard processer
  - Two ten-thousandths of degrees (2.0e-4deg) at off-line processing on the ground
- Location Determination Accuracy (error of orbit satellite): 1m

ALOS Star Tracker (STT) can determine satellite attitude with high accuracy of 0.0002deg comparing observed location and magnification of stars with its own star catalog. The large three hoods are installed to shield star detector from direct or reflected Sun light. STT mormally operates by using STT-1 facing forward and STT-3 facing backward. However in the case of interference of the Moon etc, STT will change its operation mode using STT-2 located at center to avoid malfunction for attitude detecting. Surface of the hoods are covered with Multi Layer Insulation (MLI) to keep STT's function normally controlling its thermal condition in the severe environment of direct Sunlight and darkness of night.

There are two frequencies (L1 and L2) of GPS signals we can receive from GPS satellites. General GPS receivers only receive L1 signal, but ALOS has dual frequency GPS receivers that can receive both L1 and L2 signals. And those receivers can measure a phase of carrier wave of those signals. It is necessary to correct an error of inflected radio wave in ionosphere (about 10m error occurs) to meet a high location accuracy requirement of less than 1m, and the requirement can be achived by the dual-frequency phase measuring GPS receivers. That’s why the GPS receiver is adopted by ALOS.

### 3.3.5 Satellite Structure (STR)

With high resolution observing sensors, ALOS's performance of observation will be changed for the worse by thermal distortion of the structure of spacecraft. To avoid this thermal distortion, the main truss structure of ALOS was made from carbon fiver reinforced plastics (CFRP) and aluminum joints connect those truss. Thermal expansion of aluminum joints are designed to be cancelled by CFRP truss, and each CFRP truss in the bus structure are covered by silver thermal insulators to minimize those distortion. In addition, PRISM's whole systems are covered by black polyimide insulators to keep and control its thermal range within 0.5 degree in orbit. In launch condition, maximum acceleration is three times as much as the land surface, so the satellite must be designed to endure those heavy loads.

### 3.3.6 Thermal Control Subsystem (TCS)

ALOS control its thermal condition by two ways to keep its component within proper thermal range. The one is passive control installing proper insulators or radiators on the surface of the satellite to control its thermal condition by their optical properties. The other is active control switching heaters, moving louvers and so on according to the satellite's thermal condition.

Sheets covering the satellite, silver, gold and black, are thermal blankets and almost all satellites use those blankets to keep their thermal condition. Some thermal elements like heaters and heat pipes are integrated inside this model. TTM thermal vacuum test was conducted to confirm their function and satellite's design for thermal control.

To trash the waste heat out, radiators are used to radiate the heat to deep space. Thermal insulators (Multi Layer Insulation: MLI) are used to protect direct solar radiation or inappropriate heat loss from inside the satellite.

ALOS is designed to control some thermal-sensitive components and sensors actively using heaters, heat pipes, and some thermal elements.

Some heaters are switched by thermostats, and others are controlled by the Heater Control Electronics (HCE) by temperature data measured by thermometers. PRISM, the most thermal-sensitive sensor on ALOS, is designed to be controlled within the range of 0.5 °C at any satellite thermal conditions.

### 3.3.7 Reaction Control Subsystem (RCS)

ALOS's reaction control subsystem (RCS) has thrusters (gas jet modules) as the actuators for controlling the satellite's attitude and orbit after ALOS - H-IIA separation. Two types of thrusters are assembled on ALOS's RCS according to its role.

1[N] (about 100g) thrusters are used for attitude control. There are two sets of 1[N] thrusters (16 thrusters total) and another one set is on standby in the case of emergency. For orbit control, four 4[N] (about 400g) thrusters are used. They are organized for two pairs and ALOS can control its orbit another pair of 4[N] or 1[N] thrusters in the case of emergency.

ALOS's RCS uses hydrazine as the fuel. In vacuum, fuel and oxidizer are needed for combustion. But hydrazine combust with catalyzer dissocciating and generating hot gas without oxidizer. Hydrazine is widely used for satellite's fuel because of simplicity of thrusters and components.

ALOS has three tanks and total capacity of them is over 180kg. This capacity is enough for five years operation of ALOS's attitude and orbit control.

## 3.4 Mission Instrument Observation Data

### 3.4.1 PRISM Data Format

PRISM has six CCDs for the nadir telescope, and eight CCDs both for the forward and for the backward respectively, with each CCD consisting of 5,000 pixels arrayed in the cross track direction. In the normal observation mode with 35km width, 14,592-pixel image data are output from each telescope from the preset extraction position incorporating correction of effects from the pointing angle and earth rotation, and 29184-pixel data are output for the nadir 70km observation mode as well. The output data are divided into three systems of 4,864 pixels (6 systems for the nadir 70km mode), and each data set is irreversibly compressed at the DC subsystem. The compressed data are assigned a VCID for each system and packetized, and then transmitted to ground. Figure 3.4-1 shows the observation data interface of PRISM.

Where, the data interfaces for Calibration Mode 1 and Calibration Mode 2 are the same as that of Observation Mode 1.

AUX data [status, high frequency angle sensor data (ADS data), imaging start time (line counter and GPS time)] and start position of extraction are attached with the image data. However, as for the 1st line data after PRISM DATA ENA (data output start) command sending, it cannot be defined because the residual data in the memory is output as in both image data and AUX data. Extraction start position immediately changes after command transmission for extraction start pixel position addressing (PRISM electronic pointing position addressing). Since image data deals with 16 lines as 1 block, it changes after a 1-block (16 lines) end.

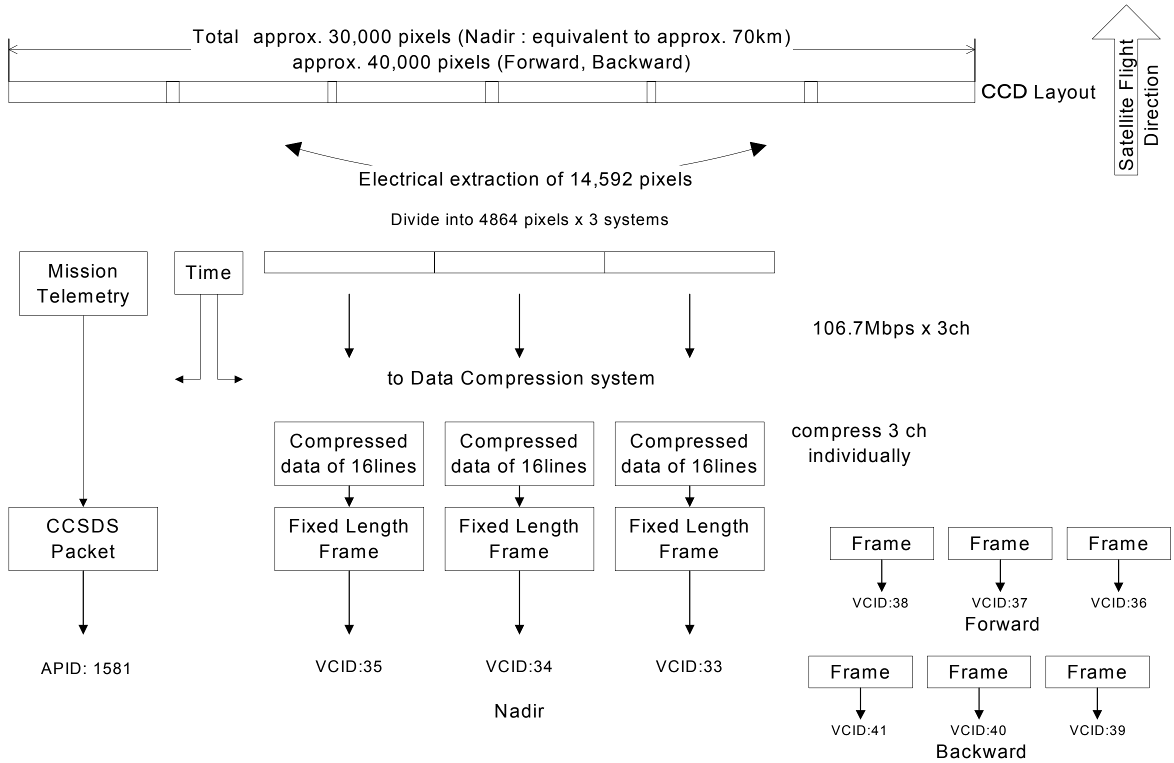



Figure 3.4-1 PRISM Data Interface (Nominal Observation Mode)

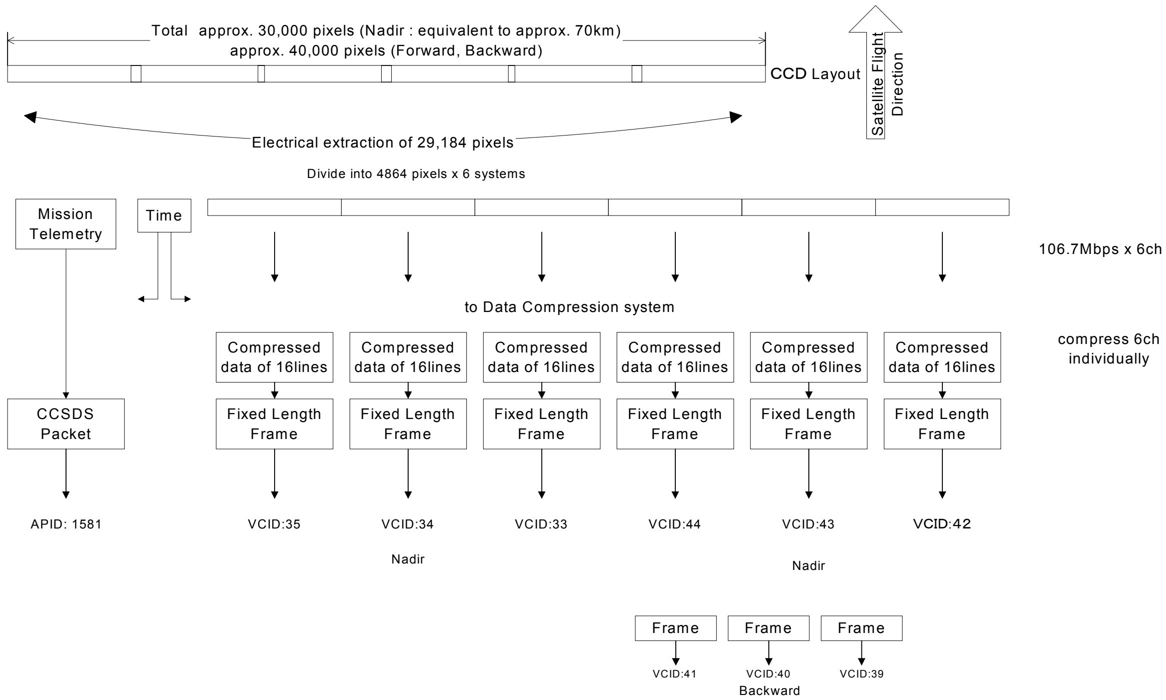



Figure 3.4-2 PRISM Data Interface (Nadir 70km Observation Mode)

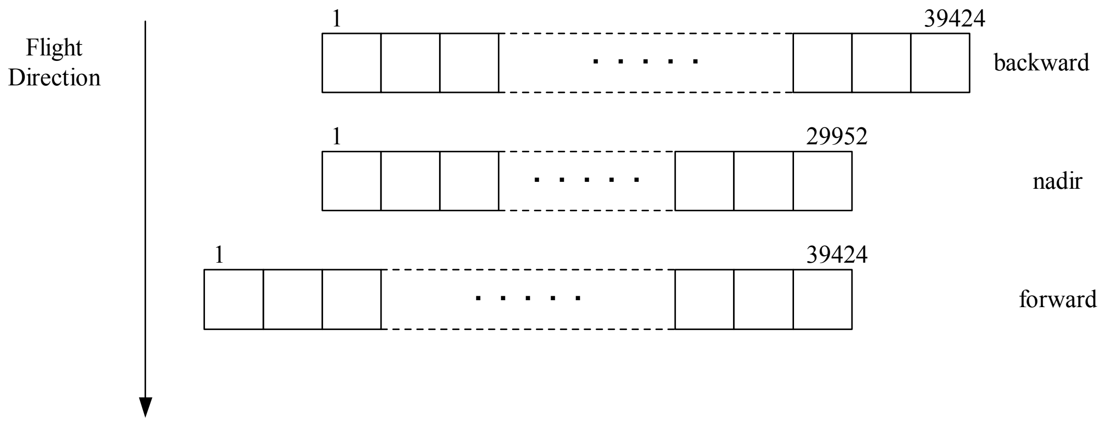



Figure 3.4-3 PRISM Pixel Footprint

In nominal observation of PRISM, 14,592 pixels are extracted from the range of extraction shown in the Tables 3.4-1 and 3.4-2, and divided by three systems with 4,864 pixels, and compressed at each system, and then downlinked after adding a VCID for each system. Therefore it is necessary for the ground processing to connect data of three virtual channels of each radiometer. Nadir view radiometer and forward/backward view radiometer consist of six CCDs and eight CCDs respectively, and have overlapped pixels in both ends. The overlapped pixel areas are shown in the Tables 3.4-1 and 3.4-2.

Table 3.4-1 Extraction Area of Nadir Telescope [*3], [*4]

| CCD No. | Extraction Area | | Overlapped Pixel Area (nominal) [*2] (Absolute pixel no.) | |
|---|---|---|---|---|
| | Pixel no. [*1] | Absolute pixel no. [*1] | | |
| 1 | 1 to 4,992 | 1 to 4,992 | 4,961 to 4,992 | — |
| 2 | 1 to 4,992 | 4,993 to 9,984 | 4,993 to 5,024 | 9,953 to 9,984 |
| 3 | 1 to 4,992 | 9,985 to 14,976 | 14,945 to 14,976 | 9,985 to 10,016 |
| 4 | 1 to 4,992 | 14,977 to 19,968 | 14,977 to 15,008 | 19,937 to 19,968 |
| 5 | 1 to 4,992 | 19,969 to 24,960 | 24,929 to 24,960 | 19,969 to 20,000 |
| 6 | 1 to 4,992 | 24,961 to 29,952 | 24,961 to 24,992 | — |

[*1]: Numbering only for the valid pixels of the CCDs
[*2]: Number of electrical overlapped pixels is 32 (nominal) for each overlapped area of each CCD
[*3]: Electrical extraction pixels (14,592) include the overlapped pixels within the extraction area.
[*4]: Use the absolute pixel number for specifying a start pixel of extraction by the electrical pointing command.

Table 3.4-2 Extraction Area for Forward and Backward Telescopes [*3], [*4]

| CCD No. | Extraction Area | | Overlapped Pixel Area (nominal) [*2] (Absolute pixel no.) | |
|---|---|---|---|---|
| | Pixel no. of each CCD [*1] | Absolute pixel no. [*1] | | |
| 1 | 1 to 4,928 | 1 to 4,928 | 4,897 to 4,928 | — |
| 2 | 1 to 4,928 | 4,929 to 9,856 | 4,929 to 4,960 | 9,825 to 9,856 |
| 3 | 1 to 4,928 | 9,857 to 14,784 | 14,753 to 14,784 | 9,857 to 9,888 |
| 4 | 1 to 4,928 | 14,785 to 19,712 | 14,785 to 14,816 | 19,681 to 19,712 |
| 5 | 1 to 4,928 | 19,713 to 24,640 | 24,609 to 24,640 | 19,713 to 19,744 |
| 6 | 1 to 4,928 | 24,641 to 29,568 | 24,641 to 24,672 | 29,537 to 29568 |
| 7 | 1 to 4,928 | 29,569 to 34,496 | 34,465 to 34,496 | 29,569 to 29,600 |
| 8 | 1 to 4,928 | 34,497 to 39,424 | 34,497 to 34,528 | — |

[*1]: Numbering only for the valid pixels of the CCDs
[*2]: Number of electrical overlapped pixels is 32 (nominal) for each overlapped area of each CCD
[*3]: Electrical extraction pixels (14,592) include the overlapped pixels within the extraction area.
[*4]: Use the absolute pixel number for specifying a start pixel of extraction by the electrical pointing command. Nos. 1 to 1,270 of CCD1 and nos. 3,691 to 4,928 (absolute pixel nos. 38,187 to 39,424) of CCD8 are out of the guaranteed range on its optical function, and therefore these pixels cannot be extracted.

The PRISM data format is shown in Figure 3.4-4. The 4,864-pixel data consist of odd numbered pixels and even numbered pixels. The odd numbered pixels and the even numbered pixels are arrayed on the same line when they are projected to ground. In addition, the AUX data shown in Table 3.4-3 are attached. The AUX data are separated from the image data at the DC subsystem and only the image data of 4,864 pixels are compressed. The AUX data are attached again to the compressed image data as Application Data Segment and then transmitted to ground. The AUX data format is illustrated in Figure 3.4-5.

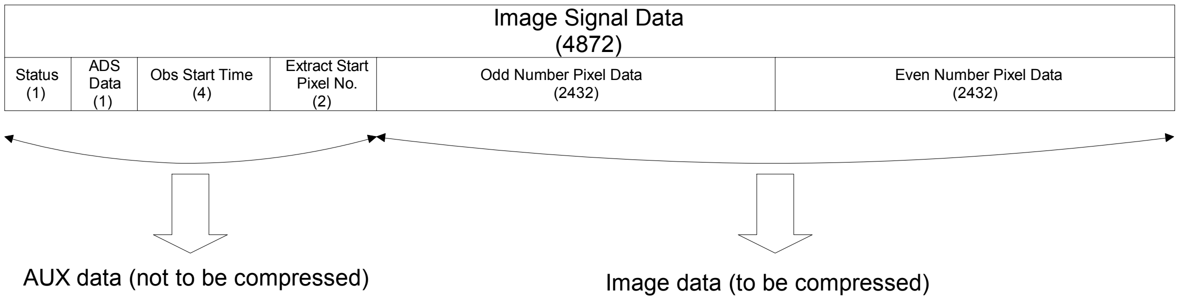



Figure 3.4-4 Data Format of PRISM (Before Compression)

Table 3.4-3 AUX Data

| Items | Number of bytes |
|---|---|
| Status | 1 |
| High Frequency Angle Sensor Data (ADS data) | 1 |
| Observation Start Time (line counter + GPS time) | 4 |
| Extraction Start Pixel Number | 2 |

## (1) Status

8-bit status signal to indicate the operation status of each telescope.

Status: 1 byte

| b7-b6 | b5-b3 | b2 | b1 –b0 |
|---|---|---|---|
| Gain | Electrical Cal Level | Ele Cal | Mode |

Figure 3.4-5 AUX Data Format for Status

a) Gain: 2 bits to indicate gain selection status

"00": GAIN 1

"01": GAIN 2

"10": GAIN 3

"11": GAIN 4

b) Electrical Calibration Level: 3 bits to indicate status of electrical calibration level

"000": AUTO "100": EC_3

"001": EC_0 "101": EC_4

"010": EC_1 "110": Invalid

"011": EC_2 "111": Invalid

c) Electrical Calibration: 1 bit to indicate status of electrical calibration

"0": E-CAL

"1": NO E-CAL

d) Mode: 2 bits to indicate status of mode selection

1) Forward View

"00": 35km Obs

"01": Invalid

"10": Invalid

"11": Invalid

2) Nadir View

"00": 35km Obs

"10": 70km Obs

"11": Invalid

3) Backward View

"00": 35km Obs

"01": Invalid

"10": Invalid

"11": Invalid

(Note) When a gain change is set up for each telescope, the gain specified in the Gain of AUX data coincides with the gain of the observation data corresponding to the AUX data. Moreover, since command execution synchronizes with the sensor scanning, there is no influence on the image in the middle of scanning.

### (2) High Frequency Angle Sensor Data

The 10-bit data are stored in ch1 and ch2 of the three channels of each telescope as shown in Figure 3.4-6. It sub-commutates X, Y, Z component data every three lines with the 2-bit ID indicating the component. The high frequency angle sensor data attached to each telescope are identical in value.

High Frequency Angle Sensor Data (ADS data): 1 byte

| | b7 | b6 | b5 | b4 | b3 | b2 | b1 | b0 |
|---|---|---|---|---|---|---|---|---|
| ch1 | ID | | D9 | D8 | D7 | D6 | D5 | D4 |
| ch2 | ID | | D3 | D2 | D1 | D0 | X | X |
| ch3 | ID | | X | X | X | X | X | X |

ID 00:unvalid
01:X
10:Y
11:Z

D9 - D0: Data
Nth line : X
N+1st line : Y
N+2nd line : Z
N+3rd line : unvalid
N+4th line : X (hearinafter repeted)

Figure 3.4-6 AUX Data Format for High Frequency Angle Sensor Data

### (3) Observation Start Time

Observation Start Time: 4 bytes

| b31-b29 | b28-b16 | B15-b0 |
|---|---|---|
| Line Count. | GPS Sec-low-order 13bits | Internal Count.(LSB=16μsec) |

Figure 3.4-7 AUX Data Format for Observation Start Time

a) Line Counter

Value of a 3-bit counter is incremented at each line. An image line counter which repeats 0-7 continuously for all image data. The counter can be used for check for loss of an image line.

b) GPS Second – Low-order 13 bits

Low-order 13 bits of GPS seconds of GPS Time distributed as PCD data.

c) Internal Counter

High-order 16 bits of a 20-bit counter to count 1MPPS supplied from DMS. 1LSB indicates 16μsec. It is reset at the 1PPS of a GPS even second sent from DMS.

(Note 1) The internal counter is the counter inside PRISM, and its 1 bit stands for 16 μs. The counter is reset every second. The counter ranges 0 to 0.999984 seconds (F423 h x 16 μs), but it may be displayed as 1.0 second by the 1-bit display error. (An error is not produced even when displayed as 1.0 second. Because GPS second is not also updated until the internal counter value is reset.)
(Note 2) An observation start time is calculated as follows:

Observation start time = GPS second + Internal counter value x 16 μs

The observation start times attached to the three telescope channels are coincident. In addition, the same value of the observation start time is stored for different telescopes when they are used to observe simultaneously. In the nadir 70km observation mode, an identical observation start time is attached for the simultaneous observation data of 3ch data of the first half and 3ch data of the second half.

d) Time Determination

PRI-ELU takes in the auxiliary data (PCD) and 1PPS reference time (PCD) once a second, and these data are distributed each second from ALOS/DMS by U-SDB I/F. The 1PPS reference time is the time of each even second when the 1PPS reference signal is handled as an epoch.

PRI-ELU adds imaging time data to the observation signal using the 1PPS reference time, 1PPS reference signal and 1MPPS reference signal as follows (see Figure 3.4-8):

In SRU, the electric charge accumulated at each element of the CCD is transmitted to the transmission register of the CCD as a trigger of LineSync from ELU. The completion of electric charge transmission ($\Phi_{TG}$ falling of CCD) is defined as the actual observation time "tn" of each line.

After the completion of the electric charge, data are forwarded from ASP to ELU and stored in the buffer during the period by the next LineSync.

ELU takes time data and ADS data in the internal buffer as a trigger of LineSync. The time is defined as Tn.

ELU takes the starting points of the 1PPS reference time (every even second) $T_{GPS}$ (total 40 bits) acquired by U-SDB I/F at the timing of the 1PPS reference signal.

Since the resolution of the 1PPS reference time is 1 second, in order to obtain the resolution which can discriminate the PRISM imaging cycle (0.370 millisecond), it drives a 19-bit self-running counter inside PRI-ELU using the 1MPPS reference signal, and generates the time of 1LSB = 2 microseconds.

The self-running counter is reset at the timing of each 1PPS reference signal and counts up again.

PRI-ELU inputs the count value of the self-running counter until adding an imaging time data to an observation signal and the 1PPS reference time ($T_{GPS}$) into AUX data as time data ($T_n$). $T_n$ is given as follows:

It is a total of 29 bits of the high-order 16 bits (16 µsec resolution; 0 to approx. 1 sec) of the 19-bit self-running counter (1LSB = 2µsec) and the low-order 13 bits (1 second resolution; 0 to 8,191sec) of GPS seconds (24 bits) of $T_{GPS}$.

The relation between real imaging time ($t_n$) and ($T_n$) is as follows:

$$t_n = T_n + \Delta T_{delay} + \delta T_{3\sigma p-p}$$

$$\Delta T_{delay} = \Delta T_{DET/ASP} - \Delta T_{ELU} \ : Fixed\ bias$$

$$\delta T_{3\sigma p-p} \ : Indefinite\ error$$

The elements of the fixed bias are given in Table 3.4-4 and the elements of indefinite error are given in Table 3.4-5.

Table 3.4-4 Fixed Bias of PRISM Imaging Time Data

| | | |
|---|---|---|
| Fixed Bias ($\Delta T_{delay}$) | 1.714 (μsec) | (a) - (b) |
| (a) Processing delay at DET/ASP | 2.214 (μsec) | Completion of transmission from Sync |
| (b) Processing delay at ELU | 0.500 (μsec) | Taking of time data from Sync |

Table 3.4-5 Indefinite Error of PRISM Imaging Time Data

| | |
|---|---|
| Indefinite Error $\delta T_{3\sigma o\text{-}p}$ | 16.5 (μsec)<br>(3σp-p) |

The high-order time information (GPS week 16 bits + GPS second high-order 11 bits) is not included in the time data attached to the observation signal. The information can be extracted from PCD data in the PRISM mission telemetry which is multiplexed to the observation signal at ALOS/MDHS, and transmitted to the ground.

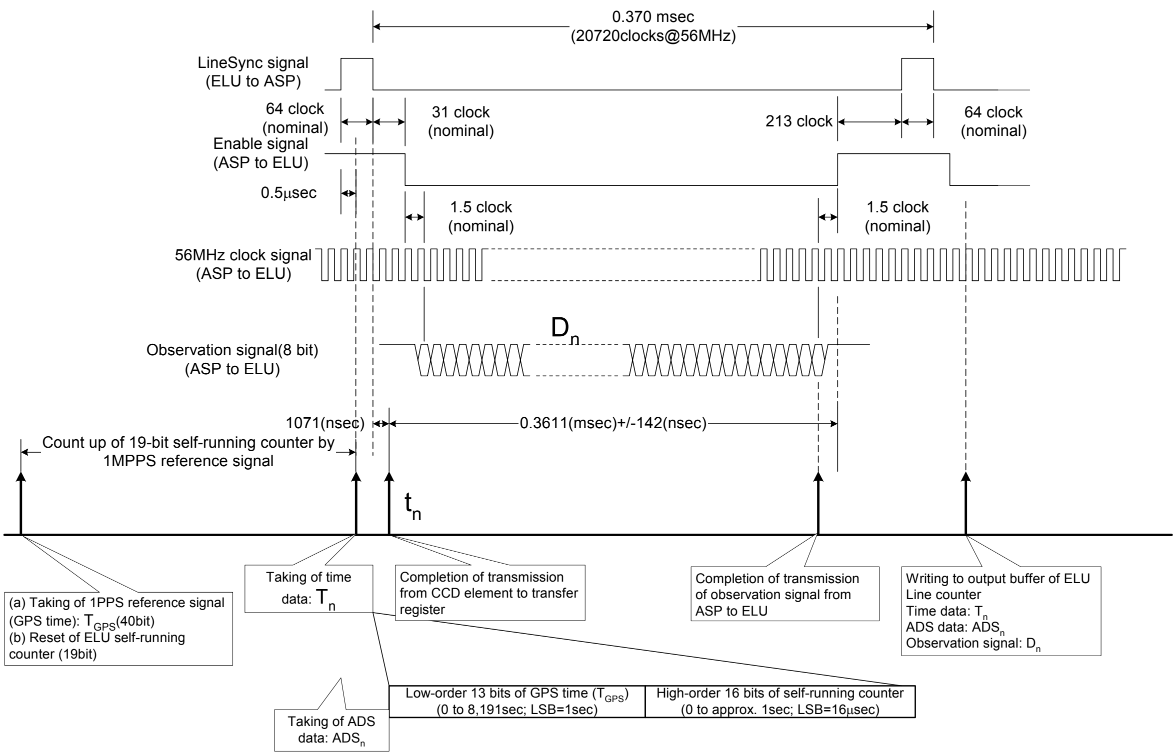



Figure 3.4-8 Addition Sequence of Imaging Time

PRI-ELU takes all PCD that consists of the 1PPS reference time and auxiliary data each second, and outputs all of them as mission telemetry each second. To confirm line loss of imaging in ground processing, a 3-bit line counter is added to the image data along with the imaging time.

The relation between imaging time data and real imaging is as follows:

The imaging time added to the image data is the time with the fixed bias of processing in ASP and ACF to the completion time of electric charge transmission of CCD. At this time, the imaging by the CCD is shown in Figure 3.4-9.

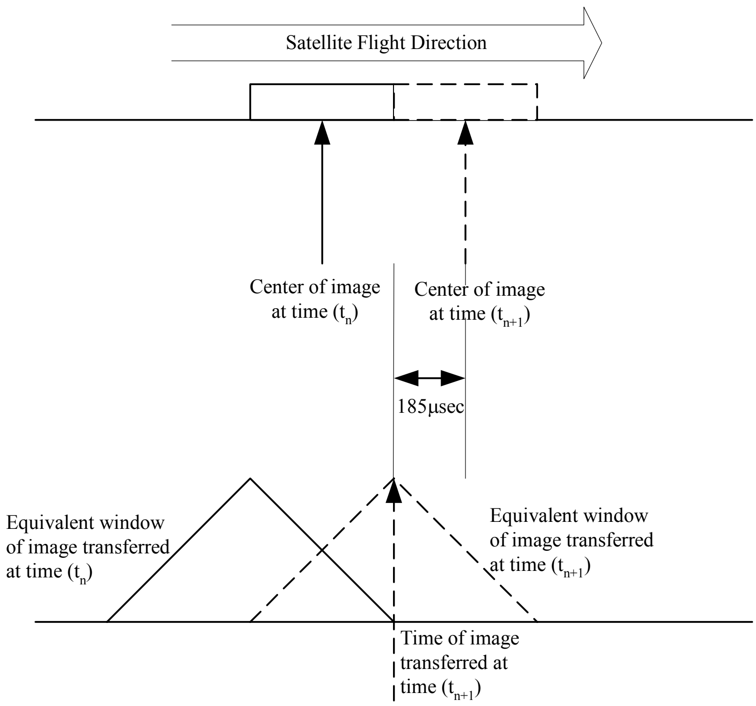



Figure 3.4-9 Relation between Imaging Time and Imaged Time

The center of the image data transferred at the imaging time ($t_{n+1}$) is located in a position which is shifted 0.5 pixels from the position at which the pixel points at $t_{n+1}$, as shown in Figure 3.4-9. Therefore, it is necessary to consider the 0.5 pixels as the offset of the imaged time (t) to the imaging time.

$$t = t_{n+1} - 185\mu sec = T_{n+1} + \underbrace{[\Delta T_{DELAY} - 185\mu sec]}_{\text{This part is the offset of the imaged time.}}$$

Therefore, the imaged time (t) will have the offsets shown in Table 3.4-6 against the time ($T_{n+1}$) added to image data.

Table 3.4-6 Offset of Imaged Time

| | | |
|---|---|---|
| Offset of imaged time | -183.286 (μsec) | (a) + (b) |
| (a) PRISM Processing Delay | 1.714 (μsec) | |
| (b) Offset based on imaging principle | -185 (μsec) | |

## (4) Extraction Start Pixel Position Data

Extraction Start Pixel Position: 2byte

| b15-b12 | b11-b0 |
|---|---|
| CCD number | Image Buffer Address of each CCD<br>000’H to 99F’H(LSB = 1Word) |

Figure 3.4-10 AUX Data Format at Extraction Start Pixel Position

The CCD no. and the start pixel position data level status are given by the extraction start pixel position data of the forward and backward views (see Table 3.4-7) and that of the nadir view (see Table 3.4-8).

a) Forward/Backward Views

Table 3.4-7 Extraction Start Pixel Position Data of Forward and Backward Views

| **CCD** | **Data added in AUX Data** | | **HK Telemetry Output Data** |
|---|---|---|---|
| | **CCD No.** | **Image Buffer Address of each CCD [Word]** | **Absolute Pixel Position [Byte]** |
| 1 | 0’H | 000’H to 99F’H | 1 to 4928 |
| 2 | 1’H | 000’H to 99F’H | 4929 to 9856 |
| 3 | 2’H | 000’H to 99F’H | 9857 to 14784 |
| 4 | 3’H | 000’H to 99F’H | 14785 to 19712 |
| 5 | 4’H | 000’H to 99F’H | 19713 to 24640 |
| 6 | 5’H | 000’H to 99F’H | 24641 to 29568 |
| 7 | 6’H | 000’H to 99F’H | 29569 to 34496 |
| 8 | 7’H | 000’H to 99F’H | 34497 to 39424 |

Example: When the data added in the AUX data is [3758’H], the HK telemetry output data are calculated as [14784 + 3760 + 1] based on [CCD4] and [758’H], to become [18545].

b) Nadir View

Table 3.4-8 Extraction Start Pixel Position Data of Nadir View

| CCD | Data added in AUX Data | | HK Telemetry Output Data |
|---|---|---|---|
| | CCD No. | Image Buffer Address of each CCD [Word] | Absolute Pixel Position [Byte] |
| 1 | 0’H | 000’H to 9BF’H | 1 to 4992 |
| 2 | 1’H | 000’H to 9BF’H | 4993 to 9984 |
| 3 | 2’H | 000’H to 9BF’H | 9985 to 14976 |
| 4 | 3’H | 000’H to 9BF’H | 14977 to 19968 |
| 5 | 4’H | 000’H to 9BF’H | 19969 to 24960 |
| 6 | 5’H | 000’H to 9BF’H | 24961 to 29952 |

Example: When the data added in the AUX data is [2020’H], the HK telemetry output data are calculated as [9984 + 64 + 1] based on [CCD3] and [020’H], to become [10049].

The relationship between pixel position and image buffer address is as follows:

Pixel position = Image buffer address x 2 + 1

When acquiring stereoscopic data using the three PRISM telescopes, it is necessary to correct the effect of the Earth’s rotation in order to fit the swath width of the forward, nadir, and backward views. PRISM has two types of correction method for Earth rotation: the PRISM Earth rotation correction function and a method that uses the yaw steering of the satellite. These two functions are used complementarily.

In Observation Mode 1, one of the following operations is selected so that there is an overlap between the observation areas of the forward, the nadir, and the backward views.

- When yaw steering is carried out: Earth rotation correction function OFF
- When yaw steering is not carried out: Earth rotation correction function ON

The relationship between pixel position and image buffer address is as follows:

Observation Mode 2 (Nadir 70km + Backward 35km simultaneously) uses the same methods for Earth rotation correction as Mode 1. Depending on the pointing angle of the backward view, it may not be necessary to use the Earth rotation correction function because the swath width of the nadir view has more margin than that of the backward view.

Observation Mode 3 (Nadir 70km) observes only the nadir. Regardless of whether the yaw steering is used, both the ON and OFF Earth rotation correction functions can be selected. This also applies to the Calibration Mode.

### 3.4.2 AVNIR-2 Data Format

AVNIR-2 has a detector that consists of a CCD of 7,100 pixels for each band. The odd numbered pixels and the even numbered pixels from each CCD are output into separate systems as shown in Figure 3.4-11. The odd numbered pixels and the even numbered pixels are arrayed 5 pixels apart in the direction of the satellite flight as shown in Figure 3.4-12.

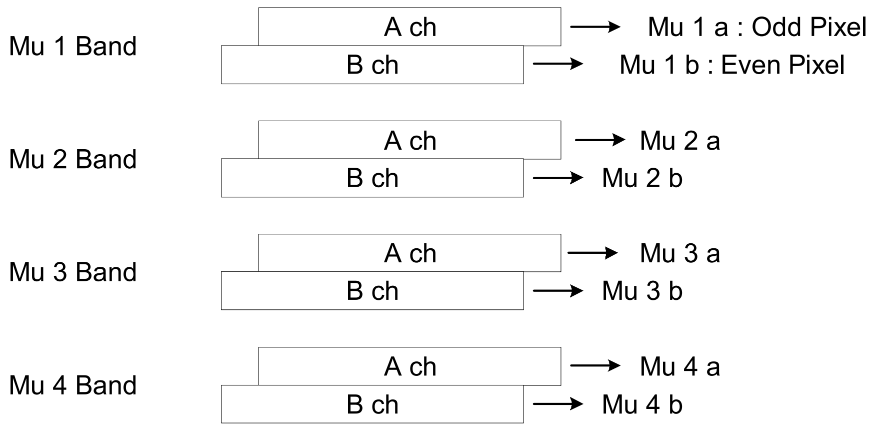



Figure 3.4-11 CCD Output of AVNIR-2

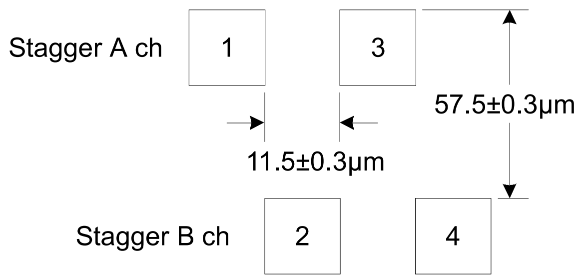



Figure 3.4-12 Layout of the Odd Numbered Pixels and the Even Numbered Pixels of AVNIR-2

The pixel layout of AVNIR-2 is illustrated in Figure 3.4-13. The scan lines of the odd numbered pixels and the even numbered pixels are arrayed 5 pixels apart at the nadir. When pointing is carried out, it is a maximum 7 pixels apart as illustrated in Figure 3.4-14.

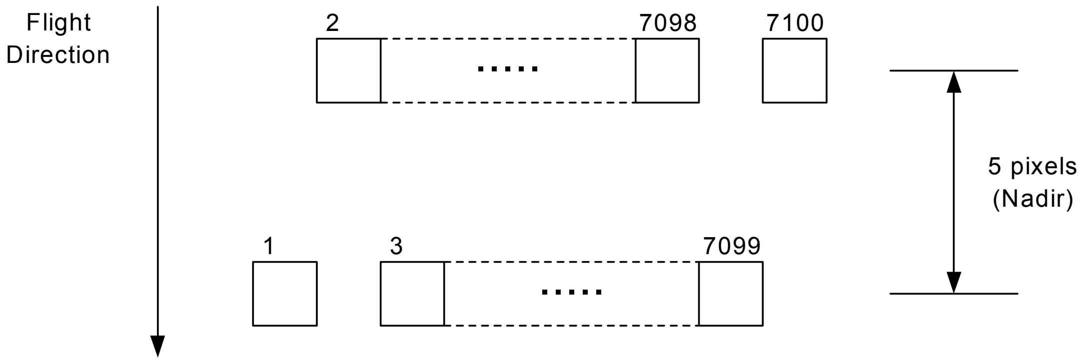
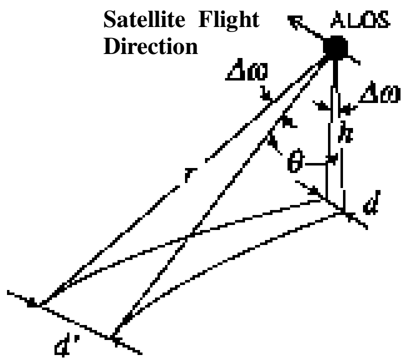



Figure 3.4-13 AVNIR-2 Pixel Layout




$\Delta\omega$ : Deference between sight vectors (rad)
$\theta$ : Pointing angle
$h$ : Altitude of satellite
$r$ : Distance between satellite and ground at $\theta$ of pointing angle
$d,d'$ : Deference between view vectors projected to ground

$d' = r \times \Delta\omega = r \times d / h$

Example of Values

| $\theta$ | $d'$ |
|---|---|
| 0 – 23.3 deg. | 5 pixels |
| 23.3 – 37.3 deg. | 6 pixels |
| 37.3 – 44.0 deg. | 7 pixels |

Figure 3.4-14 Pixel Spacing between Odd Pixels and Even Pixels during Pointing

AVNIR-2 consists of four data bands, and all the bands observe the same point nominally. Each data band (with setting error of ±8μm) is compressed by reversible compression, and then a different VCID is attached to each band and downlinked. The ground data processing needs to compose and process four virtual channels of data. The pixel layout varies depending on the pointing angle. The resolution of each pixel varies as well.

The observation data interface of AVNIR-2 is shown in Figure 3.4-15. Output from the CCD of each band is multiplexed at two systems for the odd numbered pixels and the even numbered pixels, and transferred to the Data Compression (DC) subsystem. Auxiliary data are also sent to the DC as the data necessary for image processing. At the DC, image data of the odd pixels and the even pixels are edited to each band data and compressed reversibly. The data format of the compressed AVNIR-2 data is illustrated in Figure 3.4-16. A VCID is assigned to each band of the compressed AVNIR-2 data, and transmitted to ground after packetizing with auxiliary data. The contents of the image auxiliary data are shown in Table 3.4-9 and the format is shown in

Figure 3.4-17.

The data interfaces of the Calibration Modes 1 to 3 are the same as that of the Observation Mode.

Note: In some bands of Mu1-Mu4, even with gain or exposure coefficient changes, there is no influence (such as stripe noise) on the image of the other bands not undergoing such change. Moreover, since the command execution and sensor scan are synchronized, there is no influence on the image in the middle of scanning.

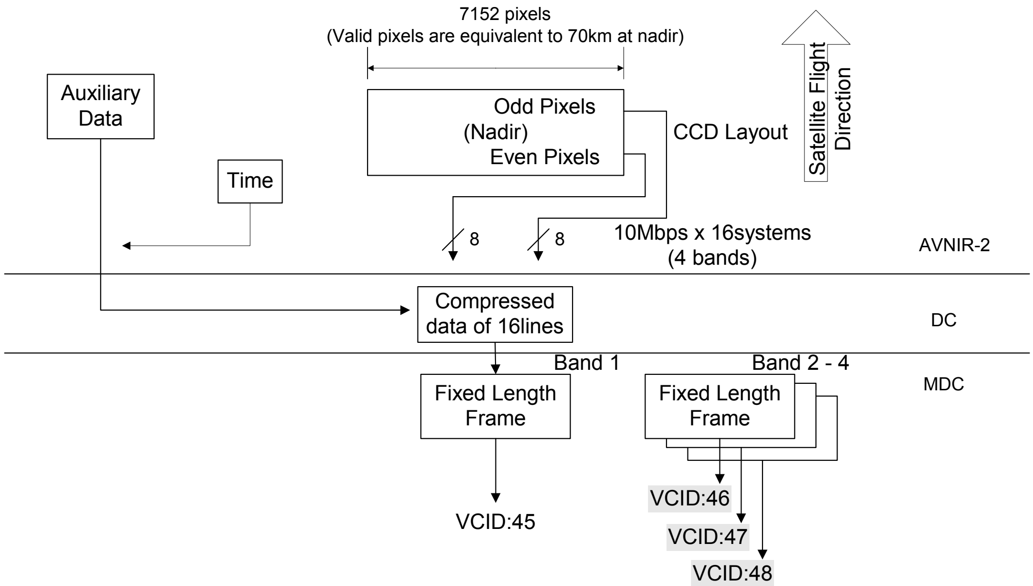



Figure 3.4-15 AVNIR-2 Data Interface

| Odd Pixel Data (3576) | | | | | | | Even Pixel Data (3576) | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dummy (4) | Optical Black (4) | Optical White (4) | Valid Pixels (3550) | Optical White (4) | Dummy (2) | Electrical Cal (8) | Dummy (4) | Optical Black (4) | Optical White (4) | Valid Pixels (3550) | Optical White (4) | Dummy (2) | Electrical Cal (8) |

Figure 3.4-16 AVNIR-2 Data Format (before compression)

Table 3.4-9 Auxiliary Data

| Items | Number of bytes |
|---|---|
| Time Data | 5 |
| Line Counter | 2 |
| Data for Quick Look | 5 |

The image auxiliary data of AVNIR-2 is transferred from AVNIR-2 to MDHS separately from the image data.

The data are attached to each data band as an Application Data Segment at the MDHS system (IDCP). Therefore the auxiliary data for each band have identical values.

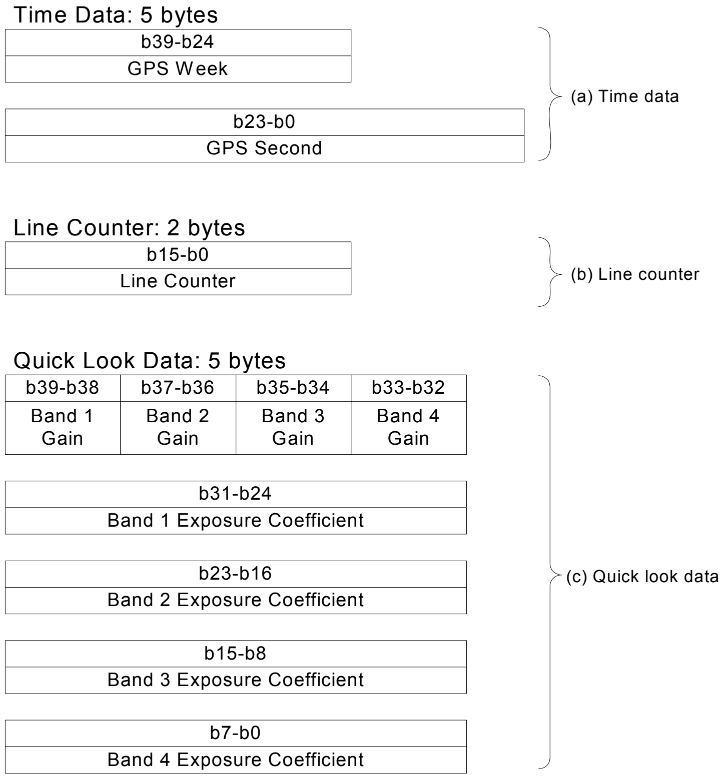



Figure 3.4-17 Auxiliary Data Format of AVNIR-2

## (1) Time Data

GPS time distributed from DMS (GPS Week: 16 bits, GPS Second: 24 bits)

## (2) Line Counter

Value of a 12-bit counter counts up each line. It is reset synchronously to the 1PPS reference signal once per second. Imaging time is calculated from the line counter as follows:

a) Time Determination of Image Data (see Figure 3.4-18)

1) The time tag is the reference signal time itself distributed from the spacecraft system, and the same time tag is given to each line until it is updated by the reference signal. It takes up to 2 seconds until a reference signal time is distributed from the satellite system after DSP ON. The line counter is used to interpolate between time tags, and it expresses the accumulated number of lines after receiving a reference signal. The line counter is reset to 0 at the 1st imaging cycle after reference signal reception, as shown in Figure 3.4-18. Initial value of the time tag is 0 and that of the line counter is 1.

2) The scanning start signal is output in every AVNIR-2 scanning cycle (T: 1.48ms) based on the internal clock. Since the scanning start signal and the reference signal are asynchronous, the time of the scanning start signal immediately after receiving a reference signal has the indefinite offset of a maximum of 1 scanning cycle to the reference signal time.

3) Electric charge (image data) is accumulated from the time t = t0 + Δt (t0: time of a reference signal, Δt: indefinite offset and circuit delay time) to the time t = t0 + Δt + T, and it is read from two output ports of the CCD from the time t = t0 + Δt + T to the time t = t0 + Δt + 2T, and a multiplexing output is carried out after A/D conversion. A time tag and a line counter (the line counter value is set to 1 in this example) are added to the data as auxiliary data. (The value of the line counter after the compressor is set to 1 in this example).

4) The integration time (τ) of the CCD is variable and is expressed by the following formula. The maximum integration time is T.

$$\tau = T \cdot I_{STD}(j,g) \cdot I(a,j)$$

Where,

$I_{STD}$(j,g): Standard exposure coefficient (the exposure when getting the reference gain)
I(a,j): Normalized exposure coefficient [normalize the exposure coefficient on operations by $I_{STD}$(j,g)]
j: Band Number
g: Gain Number
a: Exposure coefficient setting number

$I_{STD}$(j,g) and I(a,j) are specified in the SOOH as a database. a and g are items of telemetry.

As shown in Figure 3.4-18, the integration period is located in the backward portion of a scanning cycle. When the center of an integration period is defined as observation time, the relationship between the time tag, the line counter, and the observation time is given by Table 3.4-10. The table shows the three observation data after setting time tag to t0. The relative phase difference between a reference signal and a scanning start signal is random, and circuit delay time can be disregarded compared with a scanning cycle. Therefore the expected value of Δt becomes T/2.

Table 3.4-10 Relationship between Time Tag, Line Counter, and Observation Time

| Time Tag | $t_0$ | $t_0$ | $t_0$ |
|---|---|---|---|
| Line Counter (output from compressor) | 0 | 1 | 2 |
| Observation Time | $(t_0-1)+\Delta t_{(t_0-1)}+nT$ $-T\cdot I_{STD}(j,g)\cdot I(a,j)/2$ | $t_0+\Delta t+T$ $-T\cdot I_{STD}(j,g)\cdot I(a,j)/2$ | $t_0+\Delta t+2T$ $-T\cdot I_{STD}(j,g)\cdot I(a,j)/2$ |
| Note | The last data at time ($t_0$-1) | The first data at time $t_0$ | Data accumulated from time ($t=t_0+\Delta t+T$) to ($t=t_0+\Delta t+2T$) |

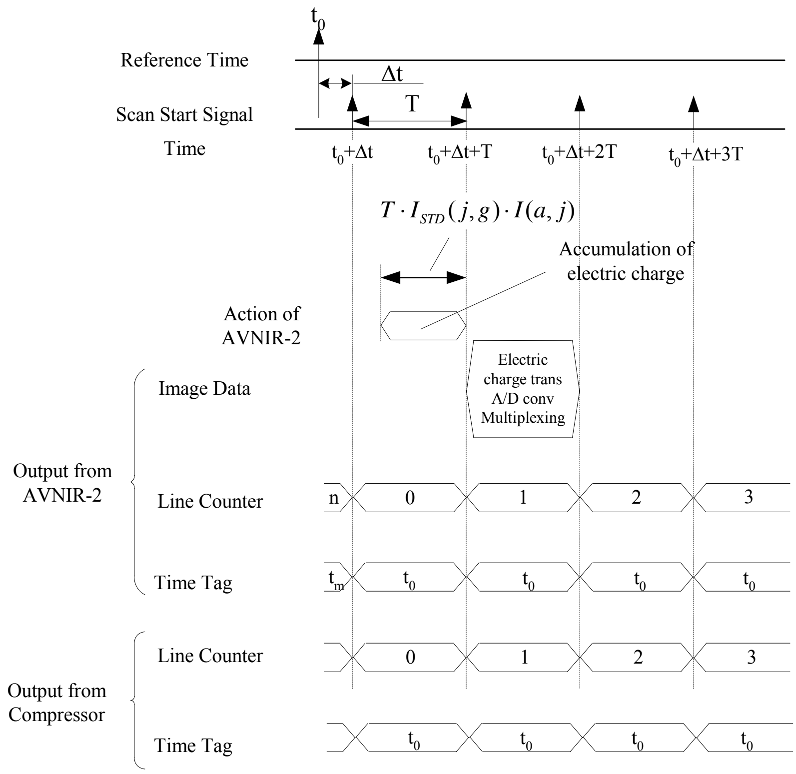



Figure 3.4-18 Time Determination of Observation Data

b) Time Determination of each Line

1) Indefiniteness

Indefiniteness (Δt) emerges since the reference signal and the scanning start signal are asynchronous, and the range of the value is 0<Δt<T. Δt can take any value in the above-mentioned range uniformly. Therefore, the expected value of Δt is T/2. Therefore, when it calculates a time,

$\Delta t = T/2$ Equation 3.4-1

$\Delta t$ is dealt with as a fixed value.

2) Time Calculation Method

Calculation of the observation time ($t_L$) of a line by the simple computing method is shown below.

$$t_L = t_n + \Delta t + T/2 + (L-1) \cdot T$$ Equation 3.4-2

$t_n$: Value of time tag (output from compressor)

L: Line counter value (output from compressor)

Where, the 3rd clause of the right-hand side of Equation 3.4-2 is a compensation clause, when the electric charge accumulation period in Figure 3.4-18 is the same as that of the scanning cycle (T) and the center of an electric charge accumulation period is regarded as the moment of observation.

From Equations 3.4-1 and 3.4-2 $t_L$ is as follows:

$$t_L = t_n + LT \quad (L > 0)$$ Equation 3.4-3

$$t_L = t_n - 1 + L_{max(t_n - 1)} T \quad (L = 0)$$

$$L_{max(t_n - 1)} : maximum\ value\ of\ the\ line\ counter\ at\ time\ t_n - 1$$

c) Quick Look Data

1) Gain Setting Value: 2-bit gain setting status for each band (8 bits)

"00": GAIN 4

"01": GAIN 3

"10": GAIN 2

"11": GAIN 1

2) Exposure Coefficient: Exposure coefficient value data of 8 bits for each band (32 bits)

Exposure coefficient value data is given by Table 3.4-12. The observation time of each line of AVNIR-2 is calculated from the Time Data for time greater than 1 second, and from the Line Counter for less than 1 second, where one line stands for 1.48msec. The band-to-band registration or misalignment is shown in Table 3.4-11 and Figure 3.4-19. The amount of errors of each band pixel to the reference pixel is less than 1 pixel in the along track and cross track directions.

Table 3.4-11 Band-to-Band Registration

| Item | Requirements |
|---|---|
| Band-to-Band Registration | Setting accuracy: within ±8μm<br>Fluctuation accuracy: within ±4μm (for fluctuation on orbit) |

Table 3.4-12 Exposure Coefficient Values

| Command data | | | Exposure time | Frame cycle | Exposure coefficient | Command data | | | Exposure time | Frame cycle | Exposure coefficient |
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| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
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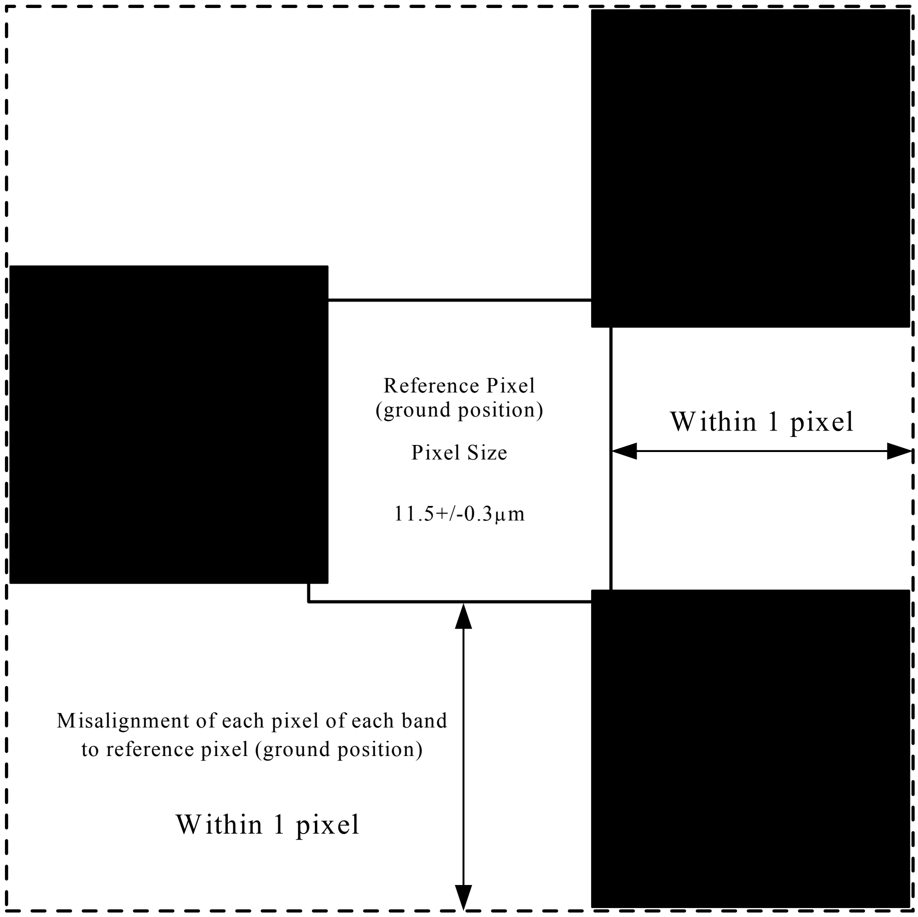



Figure 3.4-19 AVNIR-2 Band-to-Band Pixel Misalignment

### 3.4.3 PALSAR Data Format

A maximum of 8ch of 30Mbps data are output from PALSAR. Depending on the observation modes, PALSAR has two kinds of data rates: 240Mbps and 120Mbps. A VCID is assigned to each channel and transmitted to ground after being multiplexed at VMD.

Figure 3.4-20 shows the data interface of PALSAR.

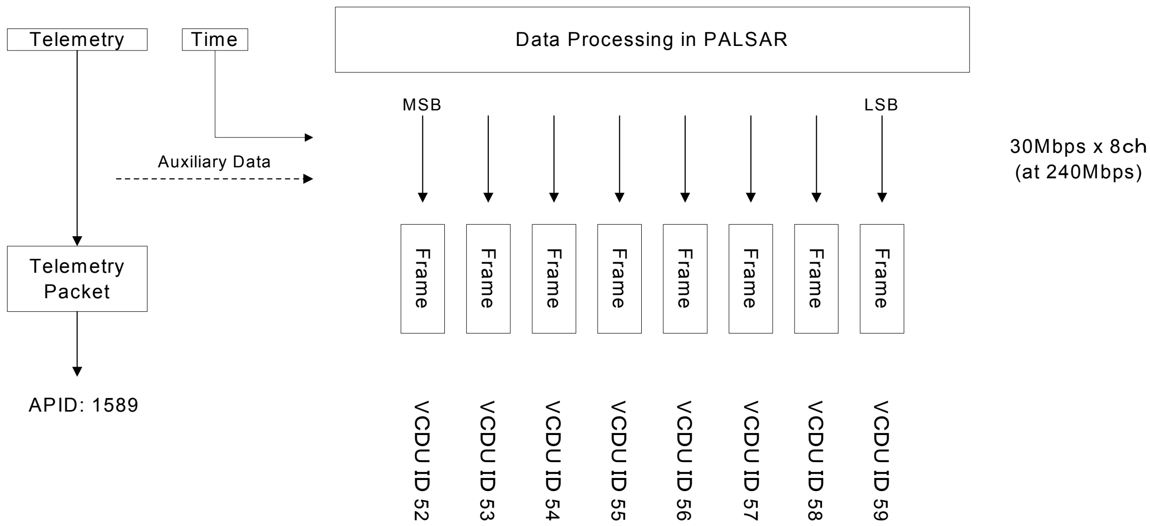
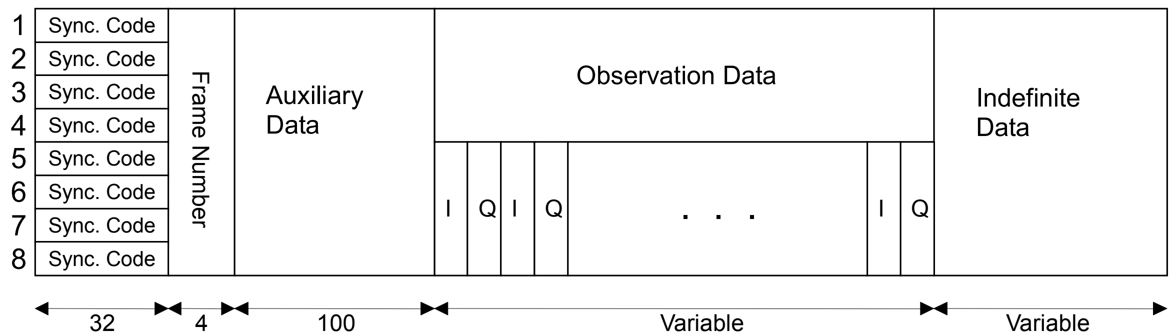



Figure 3.4-20 PALSAR Data Interface

8-bit data for 8ch are assigned in order from MSB. Therefore it is necessary to compose and process eight virtual channels of data in the data processing at ground.

## (1) Frame Format

The frame format is as follows:

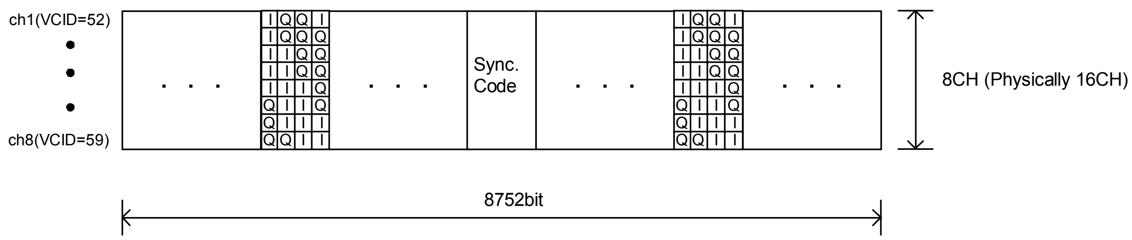



(a) Sync. Code: 256bits (32bit x 8) The same value is stored in all the channels.
FAF33400(11111010111100110011010000000000)
(b) Frame Number: 32bits (4bits x 8) counted up from 0 at each input of a PRI Synchronous trigger after Power ON.
(c) Auxiliary Data: 800bits (100bits x 8)
(d) Observation Data: Variable length (n bits x 8, ch1: MSB, ch8: LSB)
(e) Indefinite Data: Variable length

The frame format is different depending on the observation mode.

## (2) Packet Format

When high rate mission data are output from the PALSAR data processing subsystem, the data are packetized by the VCA service. The packet data format is as follows (example of 5-bit output bits):




Note) The row showing "IIIIIQQQ" is an interim row of observation data and it does not express the first row. Ch1 (VCID: 52) is in the side of MSB.

# Section 4 Overview of ALOS Mission Operations

## 4.1 Total System for ALOS Mission Operations

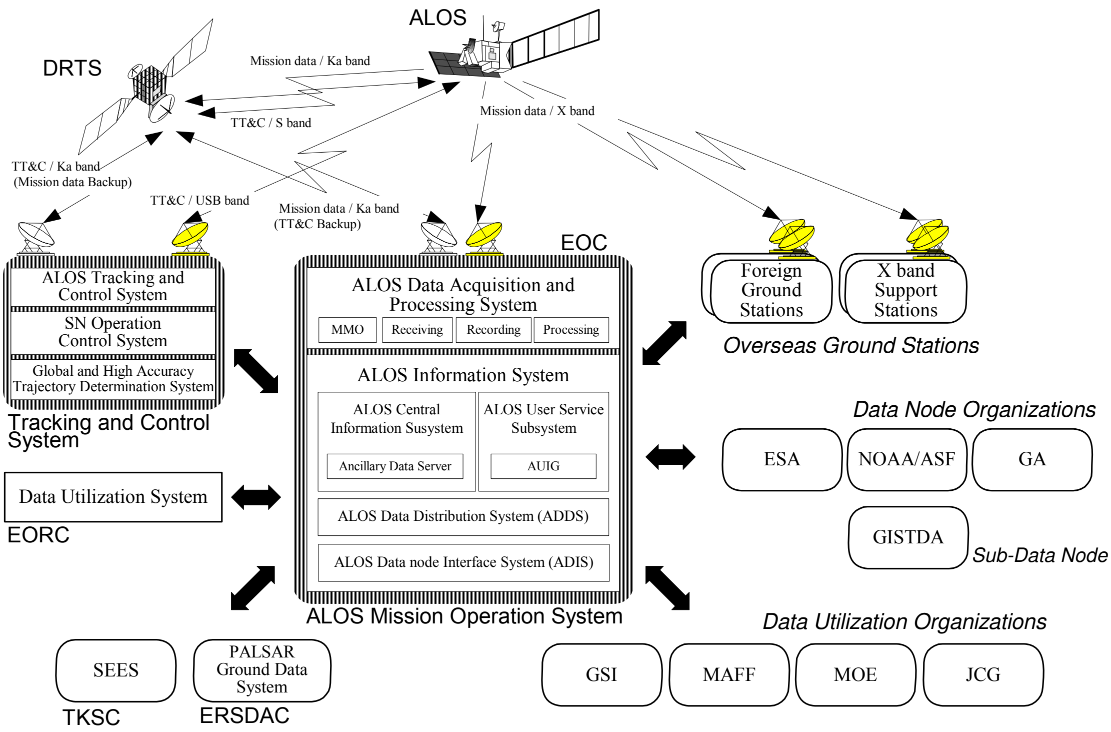



Figure 4.1-1 Total System for ALOS Mission Operations

### (1) Outline of Ground Segment

a) ALOS Mission Operation System

The ALOS Data Acquisition and Processing System is the main body of the ALOS mission operation with functions for mission operation management, data receiving, data recording, and data processing. This system will be developed in the Earth Observation Center (EOC) of JAXA with the function for Ka band data reception and X band data reception. The system consists of Data Receiving Subsystem, Data Recording Subsystem, Data Processing Subsystem, and Mission Operation Management Subsystem, etc.

b) ALOS Information System

The ALOS Information System provides the archive, catalog searching, and online data distribution functions which will be installed at EOC by JAXA. The system also provides LAN within EOC and network connections with external agencies. The system consists of ALOS Central Information Subsystem, which is the system in charge of data archive and management, ALOS User Service Subsystem, which is the system in charge of data cataloging and data order reception, and ALOS Data Distribution System (ADDS) and ALOS Data node Interface System (ADIS), which is the system providing access for online file exchange with the external agencies.

### (2) Tracking and Control System

a) ALOS Tracking and Control System

The ALOS Tracking and Control System determines satellite operation plans based on mission operation requests submitted from EOC, and performs TT&C operations for the satellite. This system will be installed at the TACC of JAXA. This system will also perform orbit determination and orbit control.

b) Space Network Operation Control System

The Space Network Operation Control System provides planning and operation of the Space Network by the DRTS which will be developed in TKSC of JAXA. The Tsukuba Station included in this system receives mission data as a backup of the Hatoyama Ka-band Station in EOC.

c) Global and High Accuracy Trajectory Determination System

This system performs high accuracy trajectory determination using GPS data, which will be installed at TKSC of JAXA. It also performs validation of accuracy by S-LR.

### (3) Data Utilization System

The Data Utilization System will be developed at EORC of JAXA, will perform Cal/Val for the onboard sensors and will be the point of contact for data distribution to validation users such as PIs. Within this system, higher level processing algorithms and data sets will be developed.

### (4) PALSAR Ground Data System

The PALSAR Ground Data System will be developed and operated by ERSDAC. This system provides PALSAR observation requests, PALSAR data processing and product distribution functions.

### (5) Space Environment & Effects System (SEES)

SEES is the system for TEDA operations developed by JAXA/TKSC. This system provides TEDA operation requests and data analysis functions.

### (6) Data Utilization Organizations

The Data Utilization Organizations are the organizations receiving ALOS data and validating the data through operational use in accordance with their agreement with JAXA.

- Geographical Survey Institute (GSI)
- Ministry of Environment (MOE)
- Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF)
- Japan Coast Guard (JCG)

### (7) Overseas Ground Stations

a) X band Support Station

X band support stations will support data reception via X band when DRTS contingency. X band support station has not been developed before launch. JAXA is planning to make a contract with SSC (Swedish Space Corporation) if DRTS contingency would occur as a tentative solution so that it may start backup reception by SSC Esrange station within three months of DRTS contingency.

The permanent solution for DRTS contingency is still under consideration, but it might be either X-band backup reception or TDRSS support.

b) Foreign Ground Station

Foreign ground stations are the ground stations for reception of low rate data (138.76Msps) via X band for their own purpose. Some stations belonging to the ALOS data node organizations are planned as the stations.

JAXA has the right to acquire a copy of the data received at Foreign ground stations, but does not routinely expect to do so.

### (8) Data Node Organization

To promote international data use and operational use of ALOS data, data node organizations will be appointed for different regions world-wide.

The data node organizations will receive ALOS Level 0 data from JAXA and generate and distribute products to regional users in accordance with their agreement with JAXA.

And also the data node organizations will be able to receive ALOS data via X band stations (regarded as Foreign Ground Station in this project) by agreement with JAXA.

- Data Node in charge of Asian Region : JAXA
- Data Node in charge of European and African Region : ESA
- Data Node in charge of North and South American Region : NOAA/ASF
- Data Node in charge of Oceania Region : GA

## 4.2 ALOS Mission Operation Systems

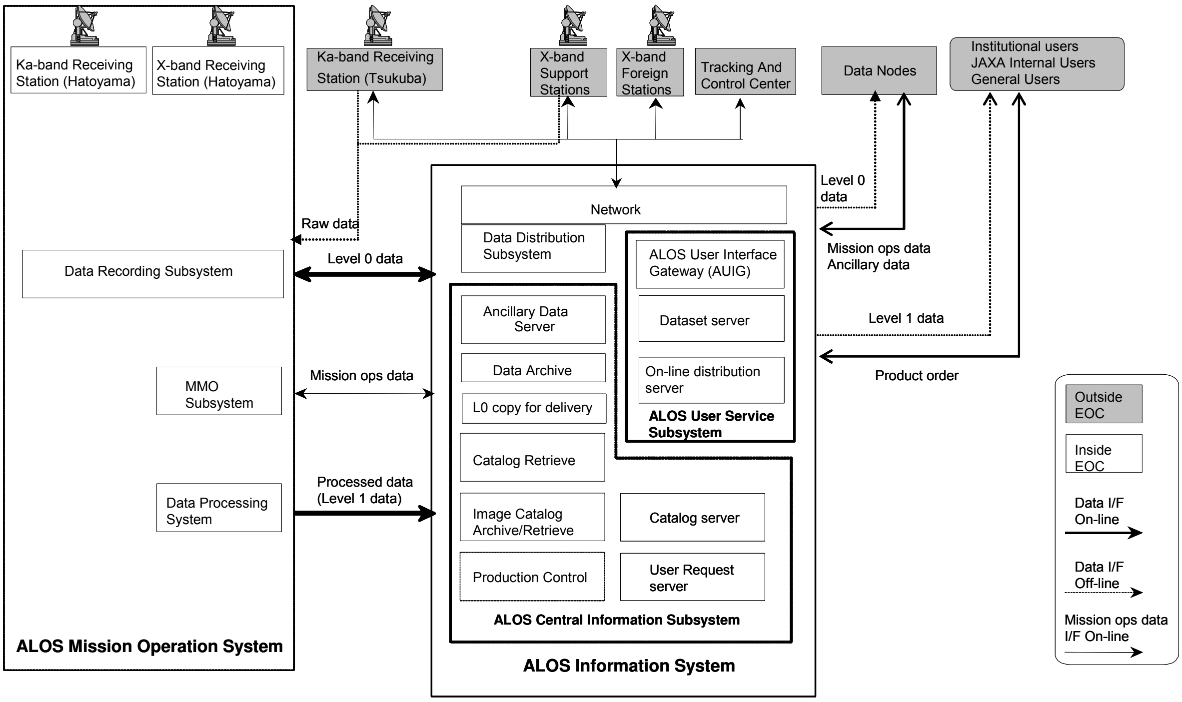



Figure 4.2-1 ALOS Ground System Overview

### (1) Acquisition of Mission Data

ALOS mission data will be mainly acquired at the EOC Ka band ground station through DRTS via the DRC system. As a backup the TKSC Ka band ground station will receive the data.

Mission data via the DT system will be received at the EOC X band ground station, X band support stations (when DRTS contingency), and foreign ground stations.

### (2) Generation/Distribution/Archiving of Level 0 Data Set

Received data at the EOC Ka band receiving subsystem and X band receiving subsystem will be demodulated, and then transmitted to the recording subsystem directly. Mission data will be depacketized and processed to

Level 0 data consisting of each set of VCIDs or APIDs. Moreover, Raw data is simultaneously recorded as a backup if needed.

After Level 0 data processing, EOC will deliver the Level 0 data to the related organizations using the appropriate predefined interface method. All ALOS Level 0 data will be sent to the data archiving subsystem via high speed LAN within EOC and stored at the subsystem.

The backup data reception and recording at the TKSC Ka band ground station is executed in addition to the EOC Ka band ground station when heavy rain is expected or when emergency observation because the influence of the rainfall attenuation for the data reception by Ka band through DRTS is not avoided.

The TKSC backup data interface to each organization will be specified in each MOIS individual part.

### (3) Generation of Standard Products

JAXA will generate standard products of the following ALOS sensors at the EOC data processing subsystem.

- PRISM
- AVNIR-2
- PALSAR

### (4) Level 0 Data/Product Request

The level 0 data and products generated by JAXA will be delivered to relevant organizations via specified interfaces. On-demand Level 0 Data Request file is prepared to submit a scene order of Level 0 data to the Central Information Subsystem. In order to utilize these interfaces to be served from the Central Information Subsystem, it is necessary for an organization to coordinate with JAXA and make an agreement in advance. On the other hand, scene order of products can be submitted via the AUIG.

# Section 5 ALOS Mission Operations

## 5.1 Definition of ALOS Operation Phase

ALOS was successfully launced on January 24, 2006. The first four months after the launch was taken as the initial checkout phase. After that, the initial Cal/Val phase for five months was performed from May 2006 and then routine observation including the basic observation scenario has been executed since October 2006.

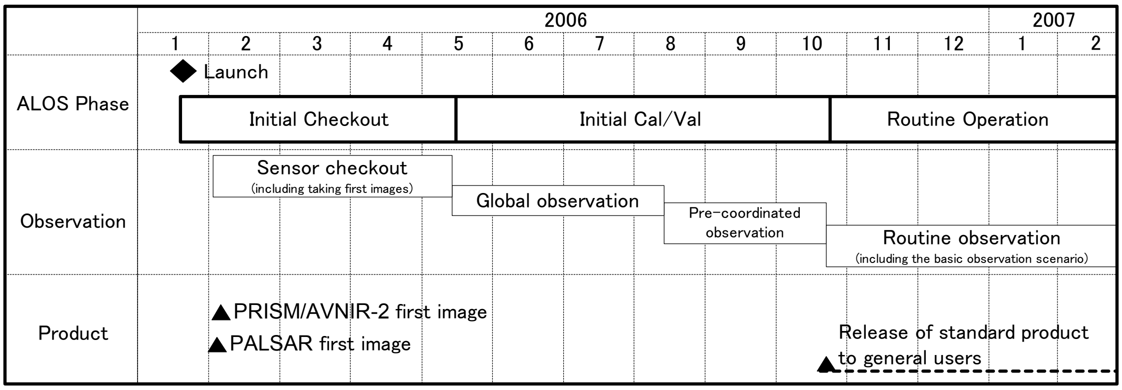



Figure 5.1-1 ALOS Operation Phases (after lunch)

## 5.2 Orbit of ALOS Satellite

Orbit of ALOS satellite is sun-synchronous sub-recurrent orbit cycling with 46 days, and an adjacent orbit spacing becomes about 59.7km on the equator. For mission operation of ALOS, delta-V maneuver will be conducted with high frequency (maximum: once per 7 days) because a precise orbit recurrent accuracy is requested. An inclination maneuver is planned at two and half years after launch to correct changes in local time of descending node.

| | |
|---|---|
| Type | Sun-Synchronous Subrecurrent |
| Local Time at DN | 10:30 AM ± 15min. |
| Altitude | 691.65km (above equator) |
| Inclination | 98.16 degree |
| Orbital Period | 98.7 min. |
| Revolution per day | 14+27/46 rev./day |
| Recurrent Period | 46 days |
| Longitude Repeatability | +/-2.5km (above equator) |
| Reference Longitude of AN: $\lambda_{A0}$ | 0.243˚E at Path 671 |
| Epoch Time | 2003/06/26 00:00:00.000 (UTC) |

Table 5.2-1 ALOS Orbit Prameters

| | |
|---|---|
| **Type** | Sun-Synchronous Subrecurrent |
| **Local Time at DN** | 10:30 AM ± 15min. |
| **Altitude** | 691.65km (above equator) |
| **Inclination** | 98.16 degree |
| **Orbital Period** | 98.7 min. |
| **Revolutions per day** | 14+27/46rev./day |
| **Recurrent Period** | 46 days |
| **Longitude Repeatability** | +/-2.5km (above equator) |

## 5.3 Operation Priorities

ALOS satellite operation will be performed in accordance with the following operation priority:

| | | |
|---|---|---|
| 1. | Satellite emergency operation | Planned by JAXA |
| 2. | Housekeeping operation | |
| 3. | Disaster area monitoring | Requested by Emergency Observation/Acquisition |
| 4. | Calibration/Validation | Requested by normal Observation/Acquisition |
| 5. | Basic observation* | |
| 6. | Japanese governmental use unique | |
| 7. | Data Node use unique | |
| 8. | Research purpose use unique | |
| 9. | Observation requests other than above | |

*: Define basic observation modes (see section 5.8) to support multiple users observation requests.

Operation priorities for direct data acquisition by foreign ground stations are as follows:

1. AVNIR-2 or ScanSAR (120M) data reception
2. PALSAR direct downlink mode (20m resolution) or PRISM high compressed mode with 120Mbps
3. HSSR reproduction of above 1.and 2.
4. Half speed reproduction with HSSR

3. and 4. are limited to disaster monitoring and joint cal/val applications. HSSR use is limited up to 80 seconds per orbit for all DT stations. In principle, JAXA will support reception of DT data by foreign ground stations whenever there is not a conflict with ALOS operations via DRTS and HSSR.

## 5.4 Outline of Sensor Operations

Basic operations for the mission instruments are planned as follows:

- Land and Day time: Observation with one to three sensors of PRISM, AVNIR-2 and PALSAR
- Land and Night time: Observation with PALSAR, Calibration with PRISM and AVNIR-2 (as

needed)

- Ocean, etc: Reproduction from HSSR

During nominal operations, PRISM and AVNIR-2 observe nadir mainly and PALSAR observes at 41.5 degrees of off-nadir typically.

When disaster monitoring, AVNIR-2 and PALSAR quickly observe target area with the cross track pointing function of AVNIR-2 and the variable off-nadir angle function of PALSAR.

Table 5.4-1 Basic Operation of each Sensor and HSSR

<table>
<tr><th rowspan="3"></th><th colspan="3">Observation Condition</th><th colspan="5">Output</th></tr>
<tr><th colspan="2">Land</th><th rowspan="2">Ocean</th><th rowspan="2">DRC</th><th colspan="3">DT</th><th rowspan="2">HSSR Recording</th></tr>
<tr><th>Night time</th><th>Day time</th><th>EOC</th><th>X band support stations</th><th>FGS</th></tr>
<tr><td>PRISM</td><td>x</td><td>H</td><td>L</td><td>H</td><td>L</td><td>L</td><td>L</td><td>H</td></tr>
<tr><td>AVNIR-2</td><td>x</td><td>H</td><td>L</td><td>M</td><td>H</td><td>M</td><td>M</td><td>H</td></tr>
<tr><td>PALSAR</td><td>H</td><td>M</td><td>L</td><td>H</td><td>L</td><td>L</td><td>L*</td><td>H</td></tr>
<tr><td>HSSR Reproducing</td><td>H</td><td>M</td><td>H</td><td>H</td><td>M</td><td>M</td><td>L</td><td>N/A</td></tr>
</table>

H: High Priority, M: Mid Priority, L: Low Priority, x: Calibration
*: ScanSAR 120Mbps mode and PASAR direct downlink mode are Mid Priority for FGS.

Concerning the main three sensors and the HSSR reproduction, the main constraints and conditions about parallel operations and routing setting are described below. Table 5.4-2 lists up the data sources and the data output systems.

(Source Data)

- The three sensors are simultaneously operational.
- Two kinds of data rates for one sensor such as 120Mbps and 240Mbps are operational exclusively.
- Only the combination of AVNIR-2 and PALSAR (120Mbps) can be multiplexed (output to a 240Mbps output system). But this combination is not used for the routine operation.

(HSSR)

- HSSR has two channels for recording and one channel for reproducing.
- Two-channel simultaneous recording is possible up to 360Mbps, that consists of 240Mbps recording and 120Mbps recording, or 120Mbps recording for both channels (2 channels x 240Mbps recording is not possible). But the two channel recording of 120Mbps data is not used for the routine operation.

Because CH1 is fixedly used for 120Mbps data recording, and CH2 is for 240Mbps data recording.

- Simultaneous recording and reproducing is operational up to a total of 360Mbps.
- Simultaneous HSSR recording and DT or DRC transmission is possible (But in order to improve total success rate of data acquisition, simultaneous HSSR 240M recording and DRC transmission is not planned).
- Simultaneous reproducing via DRC and DT is not possible.

(Data Output)

- DRC transmission and DT transmission are simultaneously operational.
- 120Mbps source data can be output to a 120Mbps output system, or to a 240Mbps output system with FILL data.
- 240Mbps source data can be output to a 240Mbps output system.
- AVNIR-2 and PALSAR (120Mbps) can be output to a 240Mbps output system after multiplex, or to separate 120Mbps output systems respectively.
- Nominally, it is not anticipated to output identical data to different output systems redundantly (this is a ground system constraint; see section 4.6 about an exception).

Table 5.4-2 Source Data and Output Systems concerning the Three Sensors and HSSR Operations

| | **Data/Systems** | **Rate** | **Comments** |
|---|---|---|---|
| Source Data | PRISM Real | 240Mbps | 1/4.5 compressed data (independent from kinds of observation modes) |
| | | 120Mbps | 1/9 compressed data (independent from kinds of observation modes) |
| | AVNIR-2 Real | 120Mbps | All modes of AVNIR-2 |
| | PALSAR Real | 240Mbps | All observation modes except following 120Mbps mode |
| | | 120Mbps | Direct Downlink mode and ScanSAR mode (Burst Type 1) |
| | HSSR Reproducing | 240Mbps | Double speed reproduction of 120Mbps recorded data, or Reproduction of 240Mbps recorded data |
| | | 120Mbps | Reproduction of 120Mbps recorded data, or Half speed reproduction of 240Mbps recorded data |
| Output Systems | DRC Transmission | 240Mbps | Via DRTS<br>In case of 120Mbps data, output as 240Mbps by inserting FILL data. |
| | DT Transmission | 120Mbps | |
| | HSSR Recording (CH1) | (240Mbps)* | 240Mbps sensor data recording, or Multiplexed data of AVNIR-2 and PALSAR (120Mbps) recording** |
| | | 120Mbps | 120Mbps sensor data recording |
| | HSSR Recording (CH2) | 240Mbps | 240Mbps sensor data recording, or Multiplexed data of AVNIR-2 and PALSAR (120Mbps) recording** |
| | | (120Mbps)* | 120Mbps sensor data recording |

*: In the routine operation, MMO will fixedly plan to use CH1 for 120Mbps data recording and CH2 for 240Mbps data recording.
**: The multiplexed operation of AVNIR-2 and PALSAR (120Mbps) is not used for the routine operation.

## 5.5 Data Recording and Transmission

High rate data generated by the three sensors onboard ALOS are processed by the VCA service of the CCSDS, multiplexed, and transmitted to ground stations via Ka band or X band. Data of PRISM and AVNIR-2 are compressed before being multiplexed.

Low rate data such as mission telemetry of each mission instruments, TEDA data, STT/GPSR data of AOCS are multiplexed by the multiplex service.

### (1) Data Compression

PRISM data is compressed by an irreversible compression with a compression rate of 1/4.5 or 1/9.

AVNIR-2 data is compressed by a reversible compression with a compression rate of 3/4.

### (2) Data Recording and Reproducing

a) High Speed Solid State Recorder (HSSR)

ALOS has a high speed solid state recorder (HSSR) via which compressed and multiplexed data is recorded and reproduced. HSSR reproduced data has an identical data format to the direct downlink data.

HSSR can manage all areas of recording memory. The memory consists of four partitions: as the nominal partitions to use normally (1 and 2) and the emergency partitions (1 and 2) (see Figure 5.5-1).

HSSR has two recording channels and one reproducing channel. Input data to the recording channel 1 or channel 2 can be set to record in any partition by commanding. Replaying is possible from any partition - selectable by command.

Data recording and reproducing will be performed by specifying addresses of the memory so that data losses never occur.

Depending on the data rates of recording or reproducing, the following operations are possible:

- 240Mbps Reproducing: Double speed reproducing of 120Mbps recorded data, or reproducing of 240Mbps recorded data.
- 120Mbps Reproducing: Reproducing of 120Mbps recorded data, or half speed reproducing of

240Mbps recorded data.

In the case of downlink to DRTS, the reproducing rate is set to 240Mbps, and in the case of DT transmission it is set to 120Mbps.

Nominal partitions will be used to record data by weekly observation requests or standing observation requests. Emergency partitions will be used for data acquisition requests (limited to near real-time use) and emergency observation requests. So when using HSSR reproduction for acquisition requests, the recordable amount of effective observation data is restricted to 80 seconds maximum per orbit based on the capacity of the emergency partitions.

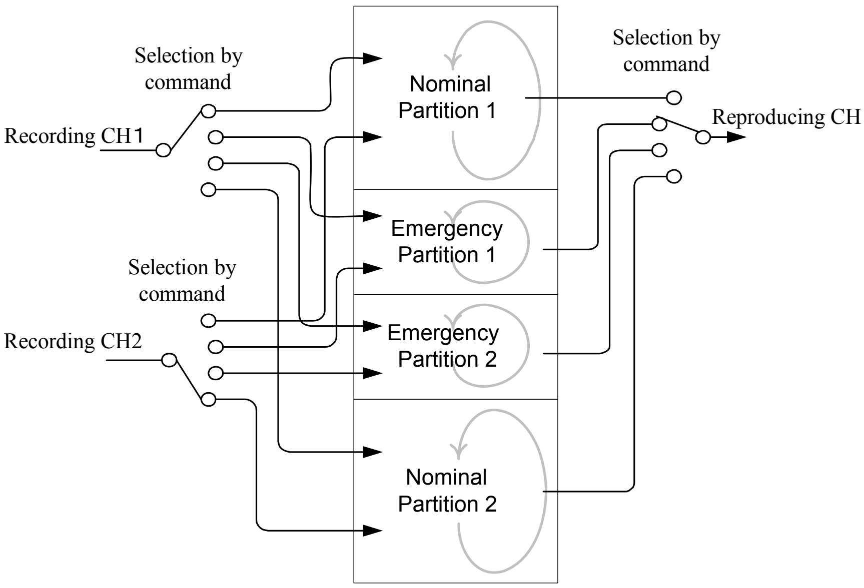



Figure 5.5-1 HSSR Recording Memory Partitions

b) Low Speed Solid State Data Recorder (LSSR)

ALOS carries the Low Speed Solid State Data Recorder (LSSR) for recording and reproducing of multiplexed low rate mission data – in addition to the HSSR functions.

LSSR can record 24 hours continuously by alternate use of two partitions in which recording memory area is divided. When changing recording area and reproducing area, it records the same data for 2 seconds in both partitions.

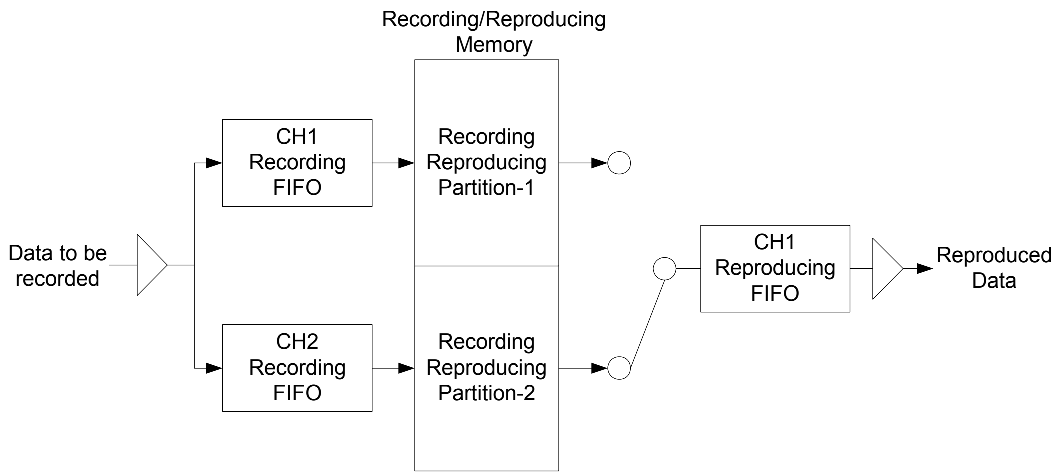



Figure 5.5-2 LSSR Recording Memory Partitions

(3) Data Transmission

There are Ka band links through data relay satellites, X band link of direct transmission, and S band link mainly for TT&C for the communication links between ALOS and ground stations.

As mentioned above, ALOS data are multiplexed with the VCA service or the multiplex service of the CCSDS. The data are transmitted to ground as a transfer frame at the symbol rate shown in Table 5.5-1 after attaching header information, encoding of error correction, attaching synchronous codes, and finally pseudo randomizing.

Table 5.5-1 ALOS Communication Link

| | Link | Band | Rate | | Note |
|---|---|---|---|---|---|
| | | | Symbol | Information | |
| 1 | Through DRTS | Ka band | 277.52Msps | 240Mbps | Primary |
| 2 | DT | X band | 138.76Msps | 120Mbps | Backup |

## 5.6 Data Acquisition

ALOS mission data will be principally acquired as multiplexed data of each VCID or APID through the DRTS by the Data Relay Communication (DRC) System. As a complement of the DRC system, data will be received by the DT system.

Mission data of the DRC system through the DRTS will be acquired at the EOC Ka band ground station typically. The TKSC Ka band ground station will be used as a backup to receive mission data through the

DRTS.

As a complement of the DRTS, firstly data acquisition of the DT system will be performed at the EOC X band ground station. And then mission data acquisition by the DT system at the X band support stations will also be planned as a tentative solution when DRTS contingency.

The foreign ground stations will also receive data via X band for their own data utilization purposes.

Table 5.6-1 ALOS Mission Data Acquisition Operations

| Priority | Link | Rate / Band | Receiving Station | Note |
|---|---|---|---|---|
| 1 | Through DRTS | 240Mbps / Ka band | EOC Ka band ground station | Primary |
| 2 | Through DRTS | 240Mbps / Ka band | TKSC Ka band ground station | Backup |
| 3 | DT | 120Mbps / X band | EOC X band ground station | Backup |
| 4 | DT | 120Mbps / X band | X band Support Stations | Backup when DRTS contingency |
| 5 | DT | 120Mbps / X band | Foreign Ground Stations | |

Typical case of ALOS data acquisition is shown in Table 5.6-2. In this table, sensor operations are based on the nominal maximum load operations shown in Table 5.6-3.

Table 5.6-2 Nominal Max Load Operation of ALOS Data Acquisition (per day)

| Receiving Station | Rate | One DRTS |
|---|---|---|
| EOC (DRTS) | 240Mbps | 560 minutes |
| TKSC (DRTS)* | 240Mbps | 0 |
| EOC (DT) | 120Mbps | 40 minutes |

*When EOC (DRTS) cannot be used, TKSC (DRTS) will be used.

Table 5.6-3 Nominal Max Load Operation of ALOS Sensors

| Sensor | Operations |
|---|---|
| PRISM | Day Time and Land 220 minutes |
| AVNIR-2 | Day Time and Land 250 minutes |
| PALSAR | Night Time and Land 250 minutes |

## 5.7 Command and House Keeping Operations

### 5.7.1 Commanding

As for the ALOS satellite system, operations will be carried out based on automatic commands in principle.

In the Tracking and Control System, operation plans of the satellite will be determined and commanding will be carried out based on operation requests of the mission instruments that EOC has integrated. Transmission of the automatic commands to ALOS by the Tracking and Control System will be performed twice per day. In addition, the system carries out creation and transmission of the orbital commands for DRC and the orbital commands for AOCS routinely.

### 5.7.2 HK Telemetry Monitoring

Real time HK telemetry data will be dumped to the Ka band ground station at TKSC, or directly to GN (Ground Network) via USB band. The real time HK TLM data will be transferred to the Tracking and Control System in real time and recorded on disk.

The Tracking and Control System will monitor the real time HK TLM data and check spacecraft conditions according to the rules given by the SOOH. The monitoring system will provide functions such as Trend Display and Limit Detection. If any anomalies are detected, the operator will respond according to the rules given by the SOOH.

Stored HK TLM data for an orbit will also be transferred to the Tracking and Control System though the Ka band ground station at TKSC or GN, and recorded on disk. And then the recorded data will be used for offline processing on trend analysis, etc.

### 5.7.3 Orbit Determination and Control

(1) Nominal Orbit Parameters

| | |
|---|---|
| Type | Sun-Synchronous Subrecurrent |
| Local Time at DN | 10:30 AM ± 15min. |
| Altitude | 691.65km (above equator) |
| Inclination | 98.16 degree |
| Orbital Period | 98.7 min. |
| Revolution per day | 14+27/46 rev./day |
| Recurrent Period | 46 days |
| Longitude Repeatability | +/-2.5km (above equator) |
| Reference Longitude of AN: $\lambda_{A0}$ | 0.243˚E at Path 671 |
| Epoch Time | 2003/06/26 00:00:00.000 (UTC) |

Although special perturbations (the Earth gravity, the gravity of the moon and the sun, solar radiation pressure, and atmospheric drag) should be taken into consideration when simulating the orbit nominally, concerning the nominal orbit element, longitude of AN; Ω argument of perigee; ω and mean anomaly; M can be set up based on the above-mentioned conditions without consideration of them (eccentricity; e is 0.001).

In this method, the orbit is theoretically always fixed and is located on RSP ± 0 km in order not to take each perturbation into consideration.

(2) Orbit Determination

The ALOS Tracking and Control System determines satellite orbit by using SN or GN.

Although the timing which carries out orbit determination is a nominal 4 times per week (Tuesday, Thursday, Saturday, Sunday), it will judge whether it considers as either of three patterns carried out 3 times per week (Tuesday, Thursday, Sunday), or every day based on the accuracy evaluation result of the orbital determination error during the initial phase.

(3) Orbit Control

Maneuvers will be performed so that ALOS can keep the following orbit accuracy

- Longitude Repeatability: +/-2.5km above equator
- Local Time at DN: 10:30 AM ± 15min.

A maneuver (delta V) will be performed every Saturday. However, the maneuver will be canceled if deemed unnecessary during an evaluation conducted every Tuesday. The plan of orbit control of the following day is made available to the related organizations via EOC every Friday.

Inclination will reduce at the rate of about 0.033 deg. / year by solar gravity mainly and will vary local crossing time at the descending node. To correct this error, an inclination maneuver will be performed around the middle of the mission period (2.5 years after launch). The inclination maneuver is a $\Delta Vy$ maneuver accompanying a 90 deg. yaw around maneuver.

In addition, the orbit control of ALOS will be carried out as that it keeps the nadir of the satellite less than 0.1 degrees (TBD) to the geocentric.

Table 5.7-1 Nominal Orbit Maneuver Plan

| Item | Requested ΔV (m/s) | Number of Stages | Requested Time/ 1 Stage | Frequency | Remarks |
|---|---|---|---|---|---|
| Altitude Maneuver | 4.32 | 2 for each | 5 - 10s | As needed | Orbit position to perform maneuver depends on a vector of eccentricity.<br>At two positions 180 degrees away, it will be done nominally. |
| Inclination Maneuver | 10.7 | 13 | 500s | Once /5 years | At ascending node not depending on sunlight condition, it will be done basically. |

Operation modes of each sensor during maneuvers are specified in Table 3.6-3.

## 5.8 ALOS Observation Scenario[1]

ALOS is one of the largest earth observation satellites in the world. Its purposes are a global monitoring, cartography, regional observation, disaster monitoring, resources surveying, and technology development by collecting globally land observation data with high resolution. A lot of observation requests are suggested by Earth Remote Sensing Data Analysis Center (ERSDAC), Geographical Survey Institute, ALOS data node organizations and JAXA to achieve the mission above. Other many observation proposals in the area of Japan and its neighborhood are produced by Agriculture, Forestry and Fisheries Ministry, Ministry of the Environment and Japan Coast Guard. The requests selected from the first Research Announcement conducted by JAXA/EORC play a very large part in ALOS observation requests at present.

Basic observation scenario is established as a joint observation plan, which aims to reduce a whole request by choosing a common mode meeting many user's requests and by conducting a joint observation and to improve the achievement of the requests.

To satisfy the many users' requests, provision of systematic and regionally consistent data observations over all land areas on a repetitive basis is an explicit objective. Based on this concept, global observations 2-3 times/year are planned with PALSAR high resolution mode, 1 time/year in ScanSAR mode, and 1 time/year with PRISM and AVNIR-2, respectively. Special observation plans apply to Japan and some other specific areas. Basic concepts, observation frequency, and observation areas of the scenario are summarized in the following tables.

[1] Refer to http://www.eorc.jaxa.jp/ALOS/obs/overview.htm for details.

Table 5.8-1 ALOS Basic Observation Scenario (World)

| Sensor | Area | Frequency | Mode | Basic concepts |
|---|---|---|---|---|
| PALSAR (Ascending) | Global | 2 times/year | FBD (HH+HV, 41.5) | * Global monitoring, Forest monitoring<br>* Two consecutive cycles(*1) are required for InSAR. |
| | | 1 time/year | FBS (HH, 41.5) | * Forest monitoring, Resource surveying |
| | Selected areas | 1 time/2 years | Polarimetry (21.5) | * Pol-InSAR campaigns every 2 years |
| | Selected areas | 7 times/2 years | FBS (HH, 41.5) & FBD (HH+HV, 41.5) | * Crustal deformation monitoring |
| PALSAR (Descending) | Global | 1 time/year | ScanSAR (HH, 5-beam) | * Global monitoring |
| | Selected areas | Irregular | FBS (HH, 34.3) | * Crustal deformation monitoring<br>* To maintain continuity with JERS-1<br>* 34.3 deg. default angle selected for optimal radiometric performance |
| | Wetland focus areas | 8 times during 12 months | ScanSAR (HH, 5-beam) | * Wetlands monitoring |
| PRISM | Global | 1 time/year | Triplet mode | * Cloud probabilities data are considered for each area(*2).<br>* Two observations by +/-1.5 deg. pointing angle are necessary for obtaining full regional coverage. |
| AVNIR-2 | Global | 1 time/year | Nadir | * Cloud probabilities data are considered for each area(*2). |
| PALSAR +AVNIR-2 | Selected areas | 1 time/year | FBS (HH, 34.3) & 34.3 | * PALSAR and AVNIR-2 simultaneous observations at 34.3 deg. |

Table 5.8-2 ALOS Basic Observation Scenario (Japan)

| Sensor | Area | Frequency | Mode | Basic concepts |
|---|---|---|---|---|
| PALSAR (Ascending) | Japan | 6 times/2 years | FBD (HH+HV, 41.5) | * Two consecutive cycles(*1) are required for InSAR.<br>* Forest monitoring, Crustal deformation monitoring |
| | | 5 times/2 years | FBS (HH, 41.5) | * Crustal deformation monitoring, Resource surveying |
| | | 1 time/2 years | Polarimetry (21.5) | * Pol-InSAR campaigns every 2 years |
| PALSAR (Descending) | Japan | 1 time/year | ScanSAR (HH, 5-beam) | * Global monitoring |
| | East Japan | 3 times/year | ScanSAR (HH, 5-beam) | * Sea ice monitoring |
| | | 3 times/year | FBS (HH, 41.5) | * Crustal deformation monitoring |
| PRISM | Japan | 3.5 times/year | Triplet mode | * Cloud probabilities data are considered for each area(*2).<br>* Two observations by +/-1.5 deg. pointing angle are necessary for obtaining full regional coverage. |
| AVNIR-2 | Japan | 7 times/year | Nadir | * Cloud probabilities data are considered for each area(*2). |
| PALSAR +AVNIR-2 | Japan | 1 time/year | FBS (HH, 41.5) & 41.5 | * PALSAR and AVNIR-2 simultaneous observations at 41.5 deg. |

# Section 6 ALOS Data Products

Mission data refers to sensor data transmitted from the ALOS satellite, and its processed data - including the following data:

- Raw data
- Level 0 data set
  - Mission data level 0 data, Low rate mission data level 0 data (consists of signal data file and status report file respectively)
- Processed products

The processing level definitions of ALOS sensors are shown in following sub-sections.

## 6.1 PRISM Product Specification[2]

### 6.1.1 Level Definition of PRISM Data Products

Standard processing levels of PRISM are shown in Table 6.1-1.

Table 6.1-1 Level Definition of PRISM Standard Data Products

| Level | Definition | Option | Note |
|---|---|---|---|
| 1A | Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied)<br>Individual files for forward, nadir and backward looking data | | Separate image files for each CCD |
| 1B1 | Radiometrically calibrated data at sensor input | | Separate image files for each CCD |
| 1B2 | Geometrically corrected data<br>Option<br>G: Systematically Geo-coded<br>R: Systematically Geo-referenced<br>Option G or R is alternative | Map projection<br>Resampling<br>Pixel spacing | Single image file. |

### 6.1.2 Scene Definitions

PRISM scene is defined by RSP (Reference System for Planning) number (Path, Frame) and scene shift distance. Each path is separated into 7200 frames on the basis of the argument of latitude of satellite. Frame

[2] Refer to "ALOS PRISM Level 1 Product Format Descriptions" (http://www.eorc.jaxa.jp/ALOS/doc/format.htm) for details.

number is allocated every 5 scene (approximately 28 km).

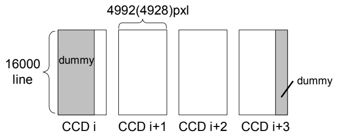
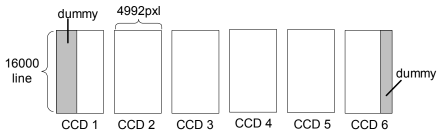
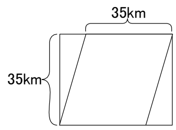
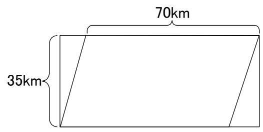
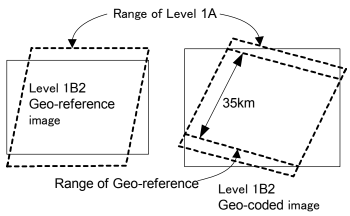
Scene shift can be carried out in the processed data, and distance of the scene shift is specified by the number of frames.

In the ALOS Data Processing Subsystem, the scene of a Raw product (geometrically uncorrected) and a Geo-reference product (map-projected based on the flight direction) are defined by determining image position and image range using input data according to the RSP.

And the scene of a Geo-coded product (projected based on the direction on the map) is defined by rotating the same range of the Geo-reference image to map-north.

Table 6.1-2 shows the PRISM scene definitions and scene size.

Table 6.1-2 Scene Size and Scene Definition (PRISM)

| Level | Observation mode | Scene Size | Scene Definitions and Extraction method |
|---|---|---|---|
| 1A, 1B1 | Nadir<br>normal mode,<br>forward, backward view | Approximately 35 km x 35 km<br>(4,992 pxls x 16,000 lines x 4 = 305 Mbyte : Nadir<br>4,928 pxls x 16,000 lines x 4 = 301 Mbyte : Forward / Backward<br>: Effective 4,864 pxls x 3 x 16,000 lines)<br> | Scene position is defined by satellite RSP No. (Path and Frame) and scene shift distance. Calculate the scene center time corresponding to the frame number, and extract equidistant lines above and below from the calculated time.<br>When scene shift is specified, the center time corresponding to the shifted frame number is calculated.<br>Image file is created per CCD unit.<br>Size of each file is 4992 pixels (nadir view) and 4928 pixels (forward, backward view), and areas with no data would be left as dummy data.<br>Do not delete overlapped areas between CCDs.<br>Even and odd pixel numbers have been already re-ordered. Usually there are 4 CCDs (4 files), but it may be occasionally 3 CCDs (3 files). |
| 1A, 1B1 | Nadir 70 km<br>Observation mode | Approximately 70 km x 35 km<br>(4,992 pxl x 16,000 line x 6 = 457 Mbyte<br>: Effective 4,864 pxls x 6 x 16,000 lines)<br> | Same as above. |
| 1B2R<br>(Geo-reference) | Nadir<br>normal mode,<br>forward, backward view | 35 km x 35 km (Except skew area)<br>((14,000+α) pxl x 14,000 lines = 187 Mbyte)<br> | Scene position is defined by satellite RSP No. (Path and Frame) and scene shift distance. Calculate the scene center time corresponding to the frame number, and extract equidistant lines above and below from the calculated time.<br>When scene shift is specified, the center time corresponding to the shifted frame number is calculated.<br>There is only one image file in total, since each CCD was combined to make one scene. |
| 1B2R<br>(Geo-reference) | Nadir 70 km<br>Observation mode | 70 km x 35 km (Except skew area.)<br>((28,000+α) pxl x 14,000 lines = 374 Mbyte)<br> | Same as above. |
| 1B2G<br>(Geo-coded) | Nadir<br>normal mode,<br>forward, backward view<br><br>Nadir 70 km<br>Observation mode | Variable size<br>(Rotated Geo-reference)<br> | Scene position is Map north.<br>Geo-coded is an image that rotated a Geo-reference.<br>Each corner of the Geo-reference image touches each side of Geo-coded image.<br>The image size will be variable and double at the maximum.<br>There is only one image file in total, since each CCD was combined to make one scene.<br>In the case that image size exceeds an available CD-ROM space, image will be stored into separated CDRs. |

### 6.1.3 Processing Parameter

This section describes the processing parameters that can specify to PRISM products.

(1) 1B2 option

This option can apply to the geometric correction for Level 1B2.

It is specified by product ID.

It is mandatory that operator choose G or R.

R: Geo-reference

G: Geo-corded

There is a possibility that DEM correction error will occur in the place of rough terrain. In this case, processing which does not select option D is carried out.

(2) Map projection

Operator chooses UTM (Universal Transcerse Mercator) or PS (Polar Stereographic).

It is specified by product ID.

(3) Resampling

Operator chooses NN (Nearest Neighbor), CC (Cubic Convolution) or BL (Bi-Linear).

(4) UTM zone number

This is a zone number where UTM was chosen in the map projection method.

The default is the zone number corresponding to the latitude and longitude of the scene center.

(5) PS projection parameter

This is a projection parameter where PS was chosen in the map projection method.

The default is the projection parameter corresponding to the latitude and longitude of the scene center.

(6) Map direction

This is an imagery direction on map projection.

True north or Map north. (It is valid for Geo-coded only)

(7) Accuracy of the used orbit data

It is mandatory that operator choose the precision orbit determination value only or the very accurate value from all available data.

(8) Accuracy of used orbit attitude data

It is mandatory that operator choose the precision attitude determination value, the high-frequency attitude determination value or the very accurate value from all available data.

(9) Reference ellipsoid

This is a reference ellipsoid for map projection.

Geodetic coordinates system ITRF97, Ellipsoid model GRS80. (fixed)

(10) Scene shift (along track)

This is a scene shift in the along-track direction, and it is specified by frame number.

There are 5 steps from –2 to +2.

### 6.1.4 Product Types

Table 6.1-3 describes the products of PRISM.

Table 6.1-3 PRISM Data Products

| Level | Scene Specification | Number of files/Contents | Unit | Size |
|---|---|---|---|---|
| 1A,1B1 (Nadir normal mode, forward, backward view) | RSP (Path, Frame) +Shift | 8/CCDi to CCDi+3 or CCDi+2) | Geo-reference | 1*4992*16000*4 = 305M(nadir) 1*4928*16000*4 = 301M(forward, backward view) (For 4 files) |
| 1A,1B1 (Nadir 70 km Observation mode) | | 10/CCD1 to CCD6 | Geo-reference | 1*4992*16000*6 = 457M |
| 1B2R (Geo-reference nadir normal mode, forward, backward view) | | 4/CCD (combined) | Geo-reference | 1*(14000+ $\alpha$ )*14000 = 187M |
| 1B2R (Geo-reference nadir 70 km observation mode) | | 4/CCD (combined) | Geo-reference | 1*(28000+ $\alpha$ )*14000 = 374M |
| 1B2G | | 4/CCD (combined) | Geo-coded | Variable Twice as large as Geo-reference at the maximum = 374M*2 ＝ 748M |

### 6.1.5 Structure of Product Format

PRISM product is composed of five different files; Volume directory, Leader, Image, Trailer and Supplemental, and each file consists of multiple records.

In the geometric uncorrected image of PRISM, image file is created per CCD unit. Therefore, there are four image files at the normal observation and six image files at the 70 km observation mode.

Overlapped data (approximately 32 pixels), which have been taken at the same area of the Earth's surface, are stored in the observation data of neighboring CCDs, but these data are kept without deleting.

The number of pixels in one line of each image file will be fixed as 4992 pixels (forward and backward view: 4928 pixels); this is the same as that of the number of the elements used in CCDs, and the pixels which are not transferred are kept as dummy data.

Figure 6.1-1 shows the file structure of the PRISM products.

<table>
<tr><td colspan="2">Volume Directory</td></tr>
<tr><td colspan="2">Leader</td></tr>
<tr><td rowspan="4">Image</td><td>CCD i</td></tr>
<tr><td>CCD i+1</td></tr>
<tr><td>CCD i+2</td></tr>
<tr><td>CCD i+3</td></tr>
<tr><td colspan="2">Trailer</td></tr>
<tr><td colspan="2">Supplemental</td></tr>
</table>

PRISM Level1A, 1B1
(For 4 files)
(CCD: 1 to 6 in case of 70 km mode)

<table>
<tr><td colspan="2">Volume Directory</td></tr>
<tr><td rowspan="3"></td><td>Leader</td></tr>
<tr><td>Image</td></tr>
<tr><td>Trailer</td></tr>
</table>

PRISM Level 1B2

Figure 6.1-1 File Structure of PRISM Products

## 6.2 AVNIR-2 Data Products[3]

### 6.2.1 Definition of Processing Levels

Standard processing levels of AVNIR-2 are shown in Table 6.2-1.

Table 6.2-1 Level Definition of AVNIR-2 Standard Data Products

| Level | Definition | Option | Note |
|---|---|---|---|
| 1A | Uncompressed, reconstructed digital counts appended with radiometric calibration coefficients and geometric correction coefficients (appended but not applied) | | Separate image files for each band |
| 1B1 | Radiometrically calibrated data at sensor input | | Separate image files for each band |
| 1B2 | Geometrically corrected data<br>Option<br>G: Systematically Geo-coded<br>R: Systematically Geo-referenced<br>D: Correction with coarse DEM (Japan area only)<br>Option G or R is alternative | Map projection<br>Resampling<br>Pixel spacing | Separate image files for each band |

### 6.2.2 Scene Definitions

AVNIR-2 scene is defined by RSP (Reference System for Planning) number (Path, Frame) and scene shift distance. Each path is separated into 7200 frames on the basis of the argument of latitude of satellite. Frame number is allocated every 10 frame (approximately 56 km) in AVNIR-2. Scene shift can be carried out in the processed data, and the distance of scene shift is specified by distance of the scene shift is specified by the number of frames.

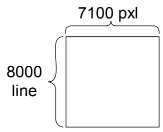
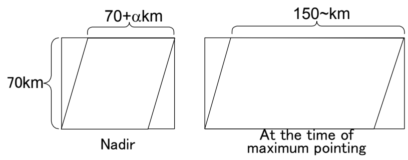
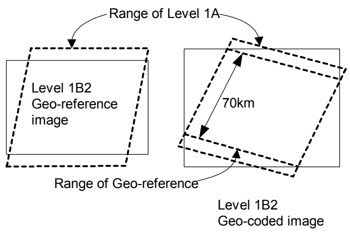
In the ALOS Data Processing Subsystem, the scene of a Raw product (geometrically uncorrected) and a Geo-reference product (map-projected based on the flight direction) are defined by determining image position and image range using input data according to the RSP.

And the scene of a Geo-coded product (projected based on the direction on the map) is defined by rotating the same range of the Geo-reference image to map-north.

Table 6.2-2 describes the scene definitions and scene size of AVNIR-2.

[3] Refer to "ALOS AVNIR-2 Level 1 Product Format Descriptions" (http://www.eorc.jaxa.jp/ALOS/doc/format.htm) for details.

Table 6.2-2 Sene Size and Scene Definition (AVNIR-2)

| Processing Level | Scene Size | Scene Definitions and Extraction method |
|---|---|---|
| 1A, 1B1 | Approximately 70 km x 70 km (Nadir)<br>(7,100 pxls x 8,000 lines x 4 bands = 217 Mbyte)<br> | Scene position is defined by satellite RSP No. (Path and Frame) and scene shift distance. Calculate the scene center time corresponding to the frame number, and extract equidistant lines above and below from the calculated time. When scene shift is specified, the center time corresponding to the shifted frame number is calculated. The image file is composed of the data for each band, and these files are not divided by odd and even number pixel.<br>Simple stagger liner correction is not performed in level 1B1. |
| 1B2R (Geo-reference) | 70 km x 70 km (Nadir)<br>(Size of cross-struck direction is increased at pointing)<br>((7,100+α) x 7,000 lines x 4 bands = 190 Mbyte<br>:Default: Pixel Spacing 10m)<br>((4,730+α) x 4,667l ines x 4 bands = 84 Mbyte<br>: Pixel Spacing 15m)<br>((3,550+α) x 3,500 lines x 4 bands = 47 Mbyte<br>: Pixel Spacing 20m)<br> | Scene position is defined by satellite RSP No. (Path and Frame) and scene shift distance. Calculate the scene center time corresponding to the frame number, and extract equidistant lines above and below from the calculated time. When scene shift is specified, the center time corresponding to the shifted frame number is calculated. The image file is composed of the data for each band. |
| 1B2G (Geo-coded) | Variable size<br>(Rotated Geo-reference)<br> | Scene position is Map north.<br>Geo-coded is an image that rotated a Geo-reference.<br>Each corner of the Geo-reference image touches each side of Geo-coded image.<br>The image size will be variable and double at the maximum.<br>The image file is composed of the data for each band. |

## 6.2.3 Processing Parameters

This section describes the processing parameters that can specify to AVNIR-2 products.

(1) 1B2 option

This option can apply to the geometric correction for Level 1B2. It is specified by product ID. It is mandatory that operator choose G or R.

R: Geo-reference

G: Geo-corded

D: Rough DEM (Digital Elevation Model) correction

Effective only in Japanese region. When DEM correction error occurred, accuracy is not guaranteed because interpolation is carried out in the error area. If specifying this option outside the Japanese region, D option becomes effective, however, DEM applied product is not generated. That is; the product, which is defined as altitude = 0m, will be generated.

(2) Map projection

Operator chooses UTM (Universal Transcerse Mercator) or PS (Polar Stereographic). It is specified by product ID.

(3) Resampling

Operator chooses NN (Nearest Neighbor), CC (Cubic Convolution) or BL (Bi-Linear).

(4) UTM zone number

This is a zone number where UTM was chosen in the map projection method. The default is the zone number corresponding to the latitude and longitude of the scene center.

(5) PS Projection parameter

This is a projection parameter where PS was chosen in the map projection method. The default is the projection parameter corresponding to the latitude and longitude of the scene center.

(6) Map direction

This is an imagery direction on map projection.

True north or Map north. (It is valid for Geo-coded only)

(7) Accuracy of the used orbit data

It is mandatory that operator choose the precision orbit determination value only or the most accurate value from all available data.

(8) Accuracy of the used orbit attitude data

It is mandatory that operator choose the precision attitude determination value or the very accurate value from all available data.

(9) Reference ellipsoid

This is a reference ellipsoid for map projection. Geodetic coordinates system ITRF97, Ellipsoid model GRS80. (fixed)

(10) Scene shift (along track)

This is a scene shift in the along-track direction, and it is specified by frame number. There are 10 steps from –5 to +4.

(11) Pixel spacing

Operator chooses the pixel spacing from 10m, 12.5m, 15m, 20m.

Default of the pixel spacing depends on the pointing angle.

| Pointing angle | 0 to 31.6 degrees | 31.6 to 40.3 degrees | More than 40.3 degrees |
|---|---|---|---|
| Pixel spacing | 10m | 15m | 20m |

### 6.2.4 Production Types

Table 6.2-3 describes the products of AVNIR-2.

Table 6.2-3 AVNIR-2 Data Products

| Level | Scene Specification | The number of files/ Contents | Unit | Size |
|---|---|---|---|---|
| 1A | RSP (Path, frame) + Shift (Frame No.) | 8/B1 to B4 | Geo-reference | 1*7100*8000*4 = 217M |
| 1B1 | | 8/B1 to B4 | Geo-reference | 1*7100*8000*4 = 217M |
| 1B2R (D) | | 7/B1 to B4 | Geo-reference | 1*7100*7000*4= 190M (Standard)<br>max.: about 450M<br>Pixel spacing 10-15-20m: max<br>1*8876*7000*4 = 273M<br>Pixel spacing 10m (Fixed): max<br>1*16679*7000*4 = 445.4M |
| 1B2G (D) | | 7/B1 to B4 | Geo-coded | Variable<br>Twice as large as Geo-reference at the maximum = 891M |

* size = (byte) x (pixel) x (line) x (band)

### 6.2.5 Product Format

AVNIR-2 products are in CEOS format (BSQ). AVNIR-2 product is composed of five different files as shown below, and each file consists of multiple records.

In the geometrically uncorrected image of AVNIR-2, image file is not separated into odd number pixels and even number pixels, and simple correction for stagger-linear between odd and even number pixel is not performed. That is, the data on the same line consist of the same observation time.

| | |
|---|---|
| Volume Directory | |
| Leader | |
| Image | Band 1 |
| | Band 2 |
| | Band 3 |
| | Band 4 |
| Trailer | |
| Supplemental | |

AVNIR-2 Level 1A, 1B1

| | |
|---|---|
| Volume Directory | |
| Leader | |
| Image | Band 1 |
| | Band 2 |
| | Band 3 |
| | Band 4 |
| Trailer | |

AVNIR-2 Level 1B2

Figure 6.2-1 File Structure of AVNIR-2 Products

## 6.3 PALSAR Data Products[4]

### 6.3.1 Definition of PALSAR Processing Level

Standard processing levels of PALSAR are shown in Table 6.3-1.

Table 6.3-1 Level Definition of PALSAR Standard Data Products

| Level | Definition | Option | Note |
|---|---|---|---|
| 1.0 | Reconstructed, unprocessed signal data appended with radiometric and geometric correction coefficients (appended but not applied) | | Separate image files for each polarization (HH, VV, HV, VH) |
| 1.1 | Range and azimuth compressed<br>Complex data on slant range | | Separate image files for each polarization (HH, VV, HV, VH) |
| 1.5 | Multi-look processed image projected to map coordinates. Latitudes and longitudes in the product are calculated without considering the altitude.<br>[Option] G: Systematically Geo-coded<br>R: Systematically Geo-referenced<br>Option G or R is alternative | Map projection<br>Resampling<br>Pixel spacing | Only either of options G and R is selectable.<br>Separate image files for each polarization (HH, VV, HV, VH) |

Table 6.3-2 Processing Levels of Observational Modes

| Observation Mode | | Processing Level 1.0 | 1.1 | 1.5 | Remarks |
|---|---|---|---|---|---|
| Fine mode | Single polarization | O | O | O | 18 beams |
| | Dual polarization | O | O | O | 18 beams |
| ScanSAR mode | Burst mode 1 | O | - | O | 3 scans, 4 scans, 5 scans |
| | Burst mode 2 | O | - | O | 3 scans, 4 scans, 5 scans |
| Direct Downlink mode | | O | O | O | 18 beams |
| Polarimetry mode | | O | O | O | 12 beams |

Remark: Level 1.0 data sometimes includes calibration data as well as observation data.

### 6.3.2 Processing Level and Data Type

The data type for each processing level is shown in Table 6.3-3.

Table 6.3-3 Processing Levels and Their Data Types

| Processing level | DATA Formats | Data coordinate | Data meanings | Remarks |
|---|---|---|---|---|
| 1.0 | 8 bit(I) + 8 bit(Q) | - | - | |
| 1.1 | 32 bit(I) + 32 bit(Q) (*1) | Slant range coordinate | - | Except ScanSAR mode |
| 1.5 | 16 bit unsigned integer (*2) | Map coodinate | Amplitude | |

(*1) I and Q are real data based on IEEE.  Byte order is Big Endian.
(*2) Byte order is Big Endian

[4] Refer to “ALOS PALSAR Level 1 Product Format Description (Vol.1: Level 1.0)” and “ALOS PALSAR Level 1 Product Format Description (Vol.2: Level 1.1/1.5)” (http://www.eorc.jaxa.jp/ALOS/doc/format.htm) for details.

### 6.3.3 Pixel Spacing

Table 6.3-4 shows the pixel spacing of level 1.5 products for each observational mode.

Table 6.3-4 Pixel Spacing of Level 1.5 Products

| Processing Level | Fine mode | | ScanSAR mode | | Direct Downlink mode | Polarimetry mode |
|---|---|---|---|---|---|---|
| | Single polarization | Dual polarization | Burst mode 1 | Burst mode 2 | | |
| 1.5 | 6.25m(2look)<br>12.5m(4look) | 12.5m(4look) | 100m | 100m | 12.5m(4look) | 12.5m(4look) |

### 6.3.4 Products Size

The definitions of the scene size are summarized in Table 6.3-5, the image frame sizes of level 1.5 are shown in Table 6.3-6. And shows sample numbers for each observational mode, off-nadir angle and others.

Table 6.3-5 Definitions of Scene Size

| Processing level | Scene Size Range direction | Scene Size Azimuth direction | Remarks |
|---|---|---|---|
| 1.0 | Input signal data length [corresponds to signal gate width] | The size corresponds to the following length (includes synthetic aperture length)<br>- Except ScanSAR mode:<br>16.4 sec (corresponding to 110km)<br>- ScanSAR mode:<br>57.0 sec (corresponding to 385km) | In the case of ScanSAR mode, data is extracted at burst boundaries |
| 1.1 | Valid signal data length [corresponds to signal gate width - pulse width] | Fine/Direct Downlink modes: 51 to 79 km<br>Polarimetry mode: 62 to 83km | Except ScanSAR mode |

Remark: For level 1.0, the number of records and the record length are fixed according to observational modes and off-nadir angles.

Table 6.3-6 Image Sizes of Level 1.5 Data

| Observation mode | | Image Size Range direction | Image Size Azimuth direction |
|---|---|---|---|
| Fine/Direct Downlink modes | off-nadir angle 9.9 deg. - 43.4 deg. | 70 km | Remark |
| | off-nadir angle 45.2 deg. - 50.0 deg. | 50 km | |
| | off-nadir angle 50.8 deg. | 40 km | |
| Polarimetry mode | off-nadir angle 9.7 deg. - 26.2 deg. | Remark | Remark |
| ScanSAR mode | 5 scan | 350 km | 350 km |
| | 4 scan | 300 km | |
| | 3 scan | 250 km | |

Remark: Image size of azimuth direction is variable according to PRF and off-nadir angle.
Fine mode and Direct Downlink mode: 51 – 79 km (Azimuth direction)
Polarimetry mode: 20 – 65 km (Range direction), 62 – 83 km (Azimuth direction)

### 6.3.5 Processing Parameters

Table 6.3-7 Summary of Processing Parameters

| Items | Processing level | | |
|---|---|---|---|
| | 1.0 | 1.1 | 1.5 |
| Map projection | - | - | UTM, PS, MER, LCC(*3) |
| Framing (*1) | - | - | GR, GC |
| Image direction (*2) | - | - | Map |
| Resampling | - | - | NN,BL,CC |
| Geodetic coordinate (Earth model) | - | - | ITRF97(GRS80) |
| Scene Shift | -5 to 4 | -5 to 4 | -5 to 4 |
| Window Function | - | rectangle | rectangle |
| Multi-look Number | - | 1 | depending on observation mode |
| Pixel Spacing | - | - | depending on observation mode and multi-look number |

(*1) GR: Georeference, GC: Geocoded
(*2) Valid in the case of Geo-coded
(*3) UTM, PS, MER or LCC can be chosen in the case of ScanSAR mode and UTM or PS can be chosen in other cases.

### 6.3.6 Product Formats

PALSAR product formats are based on the CEOS (Committee on Earth Observation Satellites) SAR data format with some modification.

PALSAR level 1.0 data is consists of one Volume Directory File, one SAR Leader File, some SAR Data Files and one SAR Trailer File as shown in Figure 6.3-1. SAR Data File is divided for each polarization in case of dual polarization in high resolution mode or polarimetry mode. On the other hand, it is not divided for each scan in case of ScanSAR mode. The order of image data is BSQ format.

Table 6.3-8 shows the contents of PALSAR level 1.0 product files for each operation mode.

Table 6.3-8 PALSAR level 1.0 Products Summary

| PALSAR Operation Mode | Polarization | Number of Data Files Contents | Contents |
|---|---|---|---|
| High Resolution | Single Polarization | 1 | HH (or VV) Pol-Data |
| | Dual Polarization | 2 | HH (or VV) Pol-Data<br>HV (or VH) Pol-Data |
| Direct Down link | Single Polarization | 1 | HH (or VV) Pol-Data |
| Wide Observation (ScanSAR) | Single Polarization | 1 | First scan data<br>Second scan data<br>-----<br>N th scan data |
| Polarimetry | 4 Polarization<br>HH+HV+VH+VV | 4 | HH Pol-Data<br>HV Pol-Data<br>VH Pol-Data<br>VV Pol-Data |

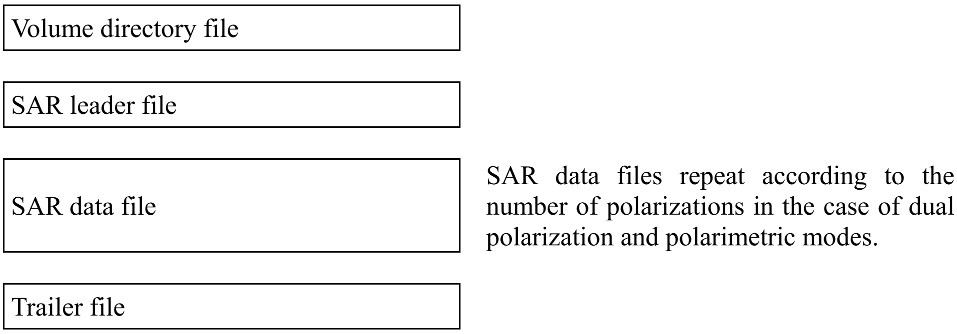



Figure 6.3-1 File Composition of Product Format

# Section 7 Overview of Processing Algorithms

## 7.1 Preconditions

### 7.1.1 Time Distribution System

In ALOS, spacecraft time is managed on the basis of the GPS time system. 1PPS (pulse per second) reference pulse which is a base and constitutes the spacecraft time is distributed in timing to synchronize with an integer second of the GPS time. The time data is distributed in the format of the GPS time (GPS week number, accumulated seconds of week). Time management in ALOS is unified as follows:

1) The DMS (Data Management System) distributes 1PPS reference pulse / 1MPPS reference pulse to the mission instruments. This reference pulse is set to the spacecraft time.
2) 1PPS reference pulse and 1MPPS reference pulse are distributed to the DMS from the GPSR (GPS receiver).
3) The DMS distributes the reference pulse after calibrating its pulse by the reference pulse distributed from the GPSR.
4) The DMS distributes the spacecraft time to the AOCS (Attitude and Orbit Control System) and other mission instruments.
5) If an anomaly occurs in the GPSR, the DMS distributes the reference pulse based on the DMS internal clock, not performing calibration by the reference pulse from the GPSR.
6) It is judged by “time system status” in the TT&C system telemetry whether the DMS is calibrating the spacecraft time by the reference pulse distributed from the GPSR or not.
7) Even if the 1PPS reference pulse which is distributed from the GPSR shifts to the DMS internal clock, time data is distributed as a continuous sequence data before shifting the reference pulse.
8) If the GPSR is recovered to a normal state while the DMS time system is in use, the time system of the reference pulse is switched automatically to the GPS time system from the DMS time system. If the operation by the DMS time system continues for a long time, a time lag may occur, but returning to the GPS time system from the DMS time system is carried out by a command according to the operation constraints. Since this is done manually, an automatic switch of the time system from the DMS to the GPS during observation does not exist.

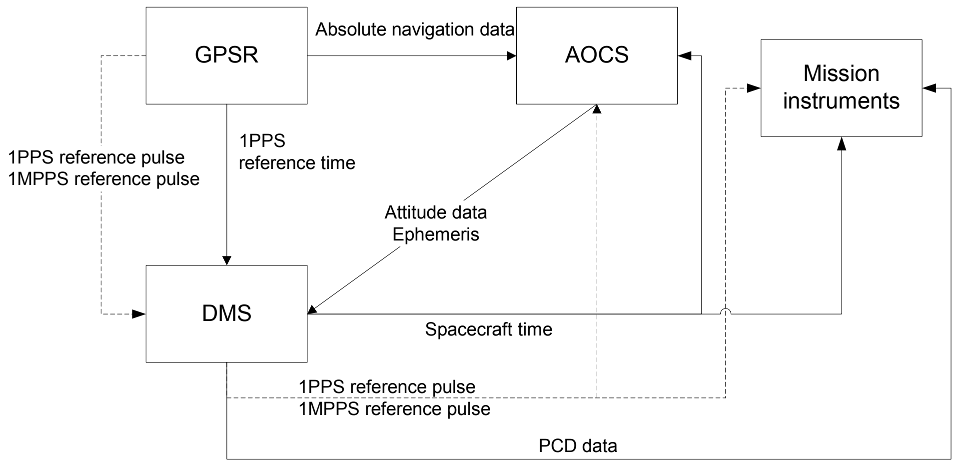



Figure 7.1-1 ALOS Time Distribution

### 7.1.2 Coordinates System

Coordinate systems used by ALOS are shown in the Table below.

Table 7.1-1 ALOS Coordinate Systems (1/2)

| Name of Coordinate | Abbr. | Origin & Axes | Definition | |
|---|---|---|---|---|
| Internal Coordinate System (J2000.0) | $\Phi_I$ | $O_I$ | Center of the Earth | |
| | | $X_I$ | Direction of true vernal equinoctial point at 0:00 A.M. on Jan. 1st of 2000. | |
| | | $Y_I$ | $Z_I$ x $X_I$ direction | |
| | | $Z_I$ | Direction vertical to true equatorial plane at 0:00 A.M. on Jan. 1st of 2000. (north pole direction is positive) | |
| Orbital Reference Coordinate System | $\Phi_R$ | $O_R$ | Ascending node | |
| | | $X_R$ | It coincides to the orbital coordinate at ascending node. | |
| | | $Y_R$ | | |
| | | $R_R$ | | |
| Orbital Coordinate System | $\Phi_O$ | $O_O$ | Satellite Barycenter | |
| | | $X_O$ | $Z_{O\ x}$ $X_O$ direction | |
| | | $Y_O$ | Opposite direction to orbital plane vector | |
| | | $Z_O$ | Origin direction of the inertial coordinate | |
| Satellite Coordinate System | $\Phi_B$ | $O_B$ | Satellite Barycenter | When there is no error of attitude, it coincides to the orbital coordinate. |
| | | | Roll-axis | |
| | | | Pitch-axis | |
| | | | Yaw-axis | |
| Satellite Fixed Coordinate System | $\Phi_S$ | $O_S$ | Intersection point of the center line and the separation plane the satellite separation part | |
| | | $X_S$ | It is parallel to each axis of the Satellite barycentric coordinate. | |
| | | $Y_S$ | | |
| | | $Z_S$ | | |
| TOD Coordinate System | $\Phi_{TOD}$ | $O_{TOD}$ | Center of the Earth | Current inertial coordinate system taking account of precession and nutation of the Earth for $\Phi_I$ |
| | | $X_{TOD}$ | Direction of the current true vernal equinoctial point | |
| | | $Y_{TOD}$ | $Z_{TOD}$ x $X_{TOD}$ | |
| | | $Z_{TOD}$ | Direction vertical to the present true equatorial plane (north pole direction is positive) | |

Table 7.1-2 ALOS Coordinate Systems (2/2)

| Name of Coordinate | Abbr. | Origin & Axes | Definition |
|---|---|---|---|
| PRIMS Forward Viewing Radiometer Coordinate System | $\Phi_{PRI\_f}$ | $O_{PRI\_f}$ | TBD |
| | | $X_{PRI\_f}$ | Position vector at $\Phi_{PRI\_f}$ [0, 0, 1]: |
| | | $Y_{PRI\_f}$ | Position vector at $\Phi_S$ [+0.4035, + 0.0137, + 0.9149] |
| | | $Z_{PRI\_f}$ | Transformation constant from $\Phi_{PRI\_f}$ to $\Phi_S$<br>$\theta_X$ = -0.86 deg., $\theta_Y$ = +23.8 deg. |
| PRIMS Nadir Viewing Radiometer Coordinate System | $\Phi_{PRI\_n}$ | $O_{PRI\_n}$ | TBD |
| | | $X_{PRI\_n}$ | Position vector at $\Phi_{PRI\_n}$ [0, 0, 1]: |
| | | $Y_{PRI\_n}$ | Position vector at $\Phi_S$ [+0.0000, + 0.0176, + 0.9998] |
| | | $Z_{PRI\_n}$ | Transformation constant from $\Phi_{PRI\_n}$ to $\Phi_S$<br>$\theta_X$ = - 1.01 deg., $\theta_Y$ = 0.0 deg. |
| PRIMS Backward Viewing Radiometer Coordinate System | $\Phi_{PRI\_b}$ | $O_{PRI\_b}$ | TBD |
| | | $X_{PRI\_b}$ | Position vector at $\Phi_{PRI\_b}$ [0, 0, 1]: |
| | | $Y_{PRI\_b}$ | Position vector at $\Phi_S$ [+0.4035, + 0.0137, + 0.9149] |
| | | $Z_{PRI\_b}$ | Transformation constant from $\Phi_{PRI\_b}$ to $\Phi_S$<br>$\theta_X$ = +0.86 deg., $\theta_Y$ = 23.8 deg. |
| AVNIR-2 Reference Coordinate System | $\Phi_{AV}$ | $O_{AV}$ | Position vector at $\Phi_S$ [0, 0, 1]<br>$X_S$ = +2320.0 mm tolerance ±5 mm (TBD)<br>$Y_S$ = +442.5 mm tolerance ±5 mm (TBD)<br>$Z_S$ = +909.4 mm tolerance ±5 mm (TBD) |
| | | $X_{AV}$ | Parallel to $X_S$ |
| | | $Y_{AV}$ | Parallel to $Y_S$ |
| | | $Z_{AV}$ | Parallel to $Z_S$ |
| GPS-A Antenna Coordinate System | $\Phi_{GPSA-A}$ | $O_{GPSA-A}$ | Position vector at $\Phi_S$<br>XS = +4370 mm<br>YS = -1520 mm<br>ZS = -1660 mm |
| | | $X_{GPSA-A}$ | Parallel to $X_S$ |
| | | $Y_{GPSA-A}$ | Parallel to $Y_S$ |
| | | $Z_{GPSA-A}$ | Parallel to $Z_S$ |
| GPS-B Antenna Coordinate System | $\Phi_{GPSA-B}$ | $O_{GPSA-B}$ | Position vector at $\Phi_S$<br>XS = +4170 mm<br>YS = -1520 mm<br>ZS = -1660 mm |
| | | $X_{GPSA-B}$ | Parallel to $X_S$ |
| | | $Y_{GPSA-B}$ | Parallel to $Y_S$ |
| | | $Z_{GPSA-B}$ | Parallel to $Z_S$ |

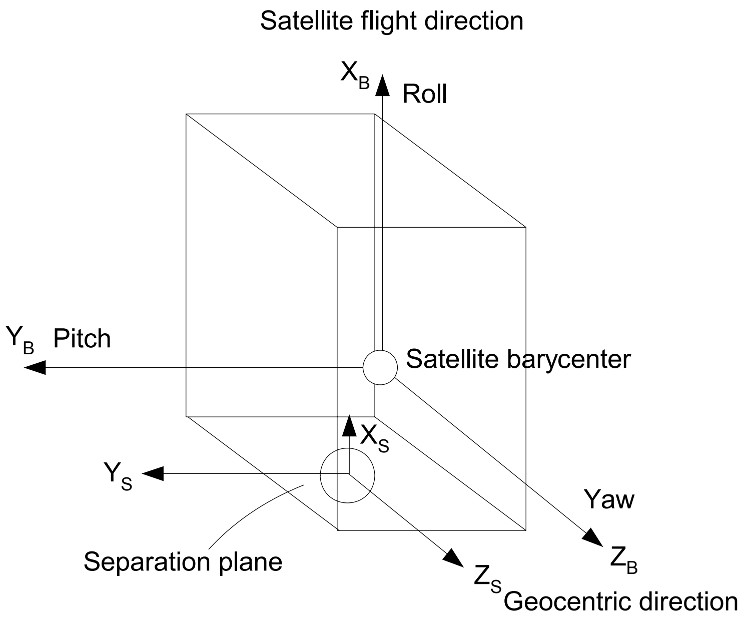



Figure 7.1-2 ALOS Satellite Coordinate and Satellite Fixed Coordinate

### 7.1.3 Orbit Data

In addition to the conventional orbit data of RARR, ALOS uses the GPSR data on the spacecraft and the precision orbit data generated from this GPSR data conducting off-line processing at ground.

Table 7.1-3 describes the definition and precision about the orbit data to be used in the rocessing subsystem.

Table 7.1-3 Orbit Data Type

| Type | From | Definition | Content | Coordinate system | Time System | Interval | Accuracy | When it is used |
|---|---|---|---|---|---|---|---|---|
| Onboard orbit data | Low rate mission data | Central of GPS antenna phase | Absolute position Absolute speed 1PPS reference time clock biase | WGS-84*1 | GPS | 1 sec. | 200m (95%) | Emergency processing |
| ALOS precision orbit data (ECI) | GYTS | Satellite barycenter | Position data speed data | TOD | UTC | 60 sec. | Less than 1m | Routine processing |
| ALOS precision orbit data (ECR) | ditto | ditto | ditto | ITRF97 | ditto | ditto | ditto | ditto |
| ALOS conventional orbit data (definitive) (ECI) | FDS | ditto | ditto | TOD | ditto | ditto | 150m (3σ) | GPS data is not available |
| ALOS conventional orbit data (definitive) (ECR) | ditto | ditto | ditto | True Earth fixed coordinate system *2 | ditto | ditto | ditto | ditto |
| ALOS conventional orbit data (predictive) (ECI) | ditto | ditto | ditto | TOD | ditto | ditto | 3 days later 1 km (3σ) | Emergency processing |
| ALOS conventional orbit data (predictive) (ECR) | ditto | ditto | ditto | True Earth fixed coordinate system *2 | ditto | ditto | ditto | ditto |

*1 Since differences between WGS-84 and ITRF97 are very small, they are treated as the same coordinate in the processing subsystem, and transformation between two coordinates is not taken into account.

*2 Since differences between true Earth fixed coordinate system and ITRF97 are very small, they are treated as the same coordinate in the processing subsystem, and transformation between two coordinates is not taken into account.

### 7.1.4 Attitude Data

The premise of the ALOS attitude data is as follows:

1) There are two kinds of onboard attitude determination systems, one is a precision attitude determination system and the other is a standard attitude determination system.
2) In the standard attitude determination system, the attitude data is output by three-axis attitude angle (roll, pitch, and yaw) to the orbital coordinate system. This coordinate system is generated by propagating in the satellite. The orbit model of it is not downlinked.
3) In the precision attitude determination system, the attitude data is output even if this data is quaternion. This quaternion is the one which shows the rotation between the satellite coordinate system and ECIJ2000), and the reference coordinate system is ECI (J2000).

4) Identification of two attitude determination systems is decided by the attitude determination flag of PCD. The Standard attitude determination system: LSB 0, the precision attitude determination system: LSB 1.

5) With respect to data that exists immediately before switching to the standard attitude determination system, the reliability of the attitude accuracy is low.

Table 7.1-4 Type of Attitude Data

| Data | Data Type | Definition | Cycle | Accuracy | Stored Telemetry | Remarks |
|---|---|---|---|---|---|---|
| Precision attitude data | Quaternion | Transformation parameter between the internal coordinate system (J2000) and the satellite coordinate system.<br>Standard coordinate system is J2000. | 100 msec | 2.0 x 10-4 deg. | N/A | Generated at the off-line processing at the ground |
| Attitude data of the precision attitude determination system | Quaternion | Transformation parameter between the internal coordinate system (J2000) and the satellite coordinate system.<br>Standard coordinate system is J2000. | 0.1 sec | 2.0 x 10-4 deg. | Attitude determination 3 | |
| Attitude data of the standard attitude determination system | Attitude error angle | Attitude angle calculated from the Earth sensor. | 1 sec | 0.08 deg. | PCD auxiliary data | |

## 7.2 Optical Sensors

### 7.2.1 Processing Flow

The outline of the data processing for PRISM and AVNIR-2 is described as follows.

#### (1) Scene framing

The time of the scene center is recalculated using scene ID, scene shift, and orbit data.

#### (2) Judgment of time system

The time system status is extracted from the system telemetry within the specified time by threshold from the time of the scene center calculated by the scene framing. Depending on the number of the extracted time system status, the time system is decided by its majority. At this time, time error information is used to transform the time from the ground time to the spacecraft time.

As a result of the majority, only in case where the time system is decided to the GPS, by using the TAI-UTC included in the coordinate transformation information, the time of the scene center is re-transformed to the spacecraft time. According to this result, processing is carried out using a decided time system; if it is decided as the GPS time system, its time system is regarded as the GPS. If the DMS time system is decided the processing is as well.

#### (3) Line generation

An extension processing is carried out to the range to be determined by the time of the scene center and the number of the extracted lines, and the image data per CCD (in case of PRISM) or per band AVNIR-2) are generated. Obtain the time data added in the JPEG header in Level 0 and output them.

The VCDU frame loss, the JPEG frame loss, and saturation rate can be obtained during this processing.

#### (4) Pre-processing

This processing checks the orbit data, the attitude data and the telemetry data.

a) Primary check of the Level 0 image and the imaging time determination

The preliminary check of the extended image is carried out and the relation equations between imaging time and line number are determined.

b) Telemetry packet processing

The low rate mission telemetry data is extracted from the CCSDS packet to generate a set of telemetry data.

c) Transformation of the engineering value of telemetry

The telemetry data is transformed to the engineering value.

d) GPSR data processing

This processing is carried out only when the GPSR data is used. Position and speed data are obtained from the GPSR telemetry to conduct the primary check. The time data at the time when absolute navigation was carried out is generated.

e) Attitude data processing

The primary check of the attitude data is carried out. In case of the standard attitude determination system, a quaternion is generated. The time data at the time when the attitude determination was carried out is generated. If the data deficit occurs due to the VCDU frame loss, the attitude data is generated by interpolation.

f) Automatic check

The sensor telemetry, the orbit and the attitude data, and image quality are checked automatically.

g) Orbit data setting

The orbit data to be used is selected from an ALOS precision orbit data or an ALOS conventional orbit data (definitive / predictive).

h) Attitude data setting

The attitude data to be used is selected from an onboard attitude data or a precision attitude data.

i) Detection of the pointing angle switchin

Deciding whether the pointing angle was switched or not during the one scene from the starting pixel value of the extraction in case of PRISM, and from the encoder data of the pointing angle in case of AVNIR-2. If it has been switched, the processing is ended.

j) Detection of the attitude determination system switching

Detecting whether the attitude determination system was switched or not by the attitude determination system flag included in the PCD auxiliary data. If it has been switched, the processing is ended.

### (5) Generation of the radiometric correction information

Coefficient of the radiometric correction is calculated from the engineering value of telemetry and the constant data for the radiometric correction.

### (6) Generation of the geometric correction information

Necessary information for the geometric correction is calculated. The items to be calculated are follows:

- Size of the output image
- Geometric correction coefficient (Address on the input image corresponding to the grid point on the output image)
- Information for storing products

### (7) Distortion correction

The radiometric correction and the geometric correction are performed to the uncorrected data to generate the corrected image. And histogram is generated.

### (8) Calculation of the cloud coverage information

The cloud coverage information is calculated from the uncorrected image.

### (9) Product generation

Product is generated by editing various information such as the uncorrected image data.

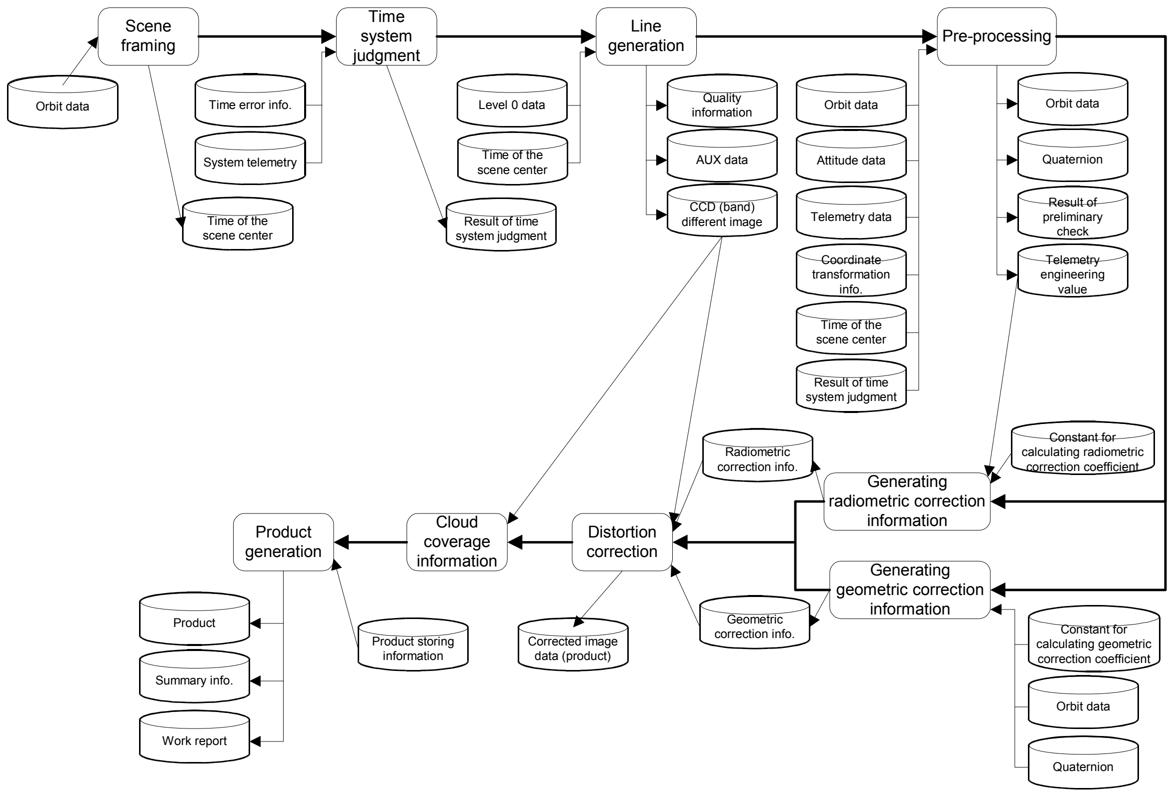



Figure 7.2-1 Proccessing Flow for Optical Sensor

## 7.2.2 Radiometrically Corrected Processing

### 7.2.2.1 PRISM

(1) Block diagram

Figure 7.2-2 shows the elements of the radiometric model.

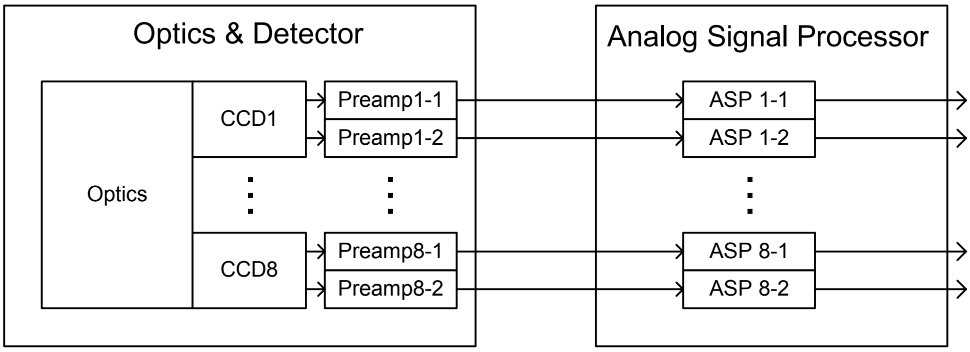



Figure 7.2-2 Block Diagram of the Radiometric Model

(2) Basic Equation

A basic equation expressing the relation between the radiance for observation and the sensor output is described as follows.

$$O = A \times L + B \qquad \text{Equation 7.2-1}$$

O: Sensor output [DN]
L: Radiance for observation (Luminance) [w/m2/sr/μm]
A: Sensitivity [/(w/m$^2$/sr/μm)]
B: Offset

According to the above relation, the basic equation for the processing of sensor output is as follows.

$$L = (O - B) / A \qquad \text{Equation 7.2-2}$$

(3) Radiometric Model Equation

$$\begin{aligned} &O(g,i,n,k,T_{CCD},T_{ASP}) = \\ &A(g,i,n,k,T_{CCD0}(i),T_{ASP0}(i)) \times D_{CCD}(i,n,k,T_{CCD}(i)) \times D_{ASP}(g,i,n,j,T_{ASP}(i)) \times L \\ &+ OB(g,i,n,j) + B(g,i,n,j) + \Delta B(g,i,n,k) \end{aligned} \qquad \text{Equation 7.2-3}$$

Where, each element in the above equation is described in Table 7.2-1. The required parameters for the elements of the radiometric model are described in Table 7.2-2.

Table 7.2-1 Elements of Radiometric Model

| Item | Contents | Symbol | Value | Remark |
|---|---|---|---|---|
| Radiometer | Reference sensitivity | A | Calibration value at the ground | Sensitivity at the reference temperature Each radiometer, each gain, each CCD, each pixel |
| | Offset | B | Calibration value at the ground | Offset bias amount Each radiometer, each gain, each CCD |
| | | ΔB | Calibration value at the ground | Offset deviation in CCD Each radiometer, each gain, each CCD, each pixel. |
| | | OB | Fluctuation on the orbit | Optical black value |
| Detector | Temperature fluctuation deviation of sensitivity | $D_{CCD}$ | Fluctuation on the orbit | Temperature fluctuation from the reference temperature |
| Analog Signal Processor | Temperature fluctuation deviation of sensitivity | $D_{ASP}$ | Fluctuation on the orbit | Temperature fluctuation from the reference temperature |

Table 7.2-2 Parameter for Radiometric Model

| Item | Contents | Symbol | Value | Remark |
|---|---|---|---|---|
| Detector | CCD number | n | 1 ~ 8 | |
| | Pixel number in CCD | k | 1 ~ 4928: Forward, backward<br>1 ~ 4992: Nadir | |
| | CCD output channel | j | 1, 2 | ODD/EVEN |
| | CCD temperature | $T_{CCD}$ | Measured value | |
| | CCD reference temperature | $T_{CCD0}$ | | Measurement environment at the ground |
| Signal Processor | Gain | g | 1 ~ 4 | Per radiometer |
| | Temperature at the Signal Processor | $T_{ASP}$ | Measured value | |
| | Reference temperature at the Signal Processor | $T_{ASP0}$ | | Measurement environment on the ground |
| Radiometer | Radiometer type | i | 1 ~ 3 | Forward, nadir, backward |

### (4) Radiometrically Corrected Processing

When the radiometric model is expressed in linear equation $y = \frac{x-b}{a}$, calculate the correction coefficient corresponding to '*a*' and '*b*', and the radiometric correction is carried out. Where, 'x' is defined as an input value before performing the radiometric correction. 'y' is a radiometrically corrected output value.

a) Calculation of the correction coefficient '$a$'

$$a(g,i,n,k) = A(g,i,n,k) \cdot D_{CCD}(i,n,k,T_{CCD}(i)) \cdot D_{ASP}(g,i,j,T_{ASP}(i))$$
$$= A(g,i,n,k) \cdot (1+\alpha(i,n,k) \cdot (T_{CCD}(i) - T_{CCD0}(i))) \cdot (1+\beta(g,i,n,j)(T_{ASP}(i) - T_{ASP0}(i)))$$

Equation 7.2-4

b) Calculation of the correction coefficient '$b$'

'$b$' is composed of optical black, offset bias amount, and offset deviation in CCD. The correction coefficient'b' corresponding to each radiometer of each CCD and each pixel number is calculated on the basis of CCD temperature and signal processor temperature in system telemetry data and optical black in PRISM mission telemetry data.

$$b(g,i,n,k) = OB(g,i,n,j) + B(g,i,n,j) + \Delta B(g,i,n,k)$$

Equation 7.2-5

c) Radiometrically corrected processing

If expressing the sensor output by $O(g,n,i,k,T_{CCD},T_{ASP})$, and the incident light by $L$, the Radiometric correction equation is expressed as follows using the correction coefficient '$a$' and '$b$' calculated from the above equation.

$$L = \frac{O(g,n,i,k,T_{CCD},T_{ASP}) - b}{a}$$

Equation 7.2-6

### 7.2.2.2 AVNIR-2

(1) Basic Concept of the Radiometric Distortion Correction

Figure 7.2-3 shows the output component of AVNIR-2 at the observation.

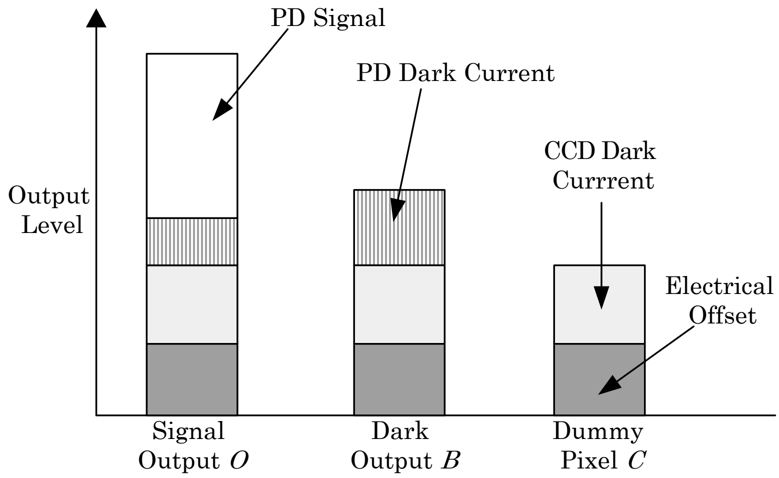



Figure 7.2-3 Output Component of each Pixel

It is only the PD signal component of the effective pixel signal output *O* that correlates with the radiance L of the object. Therefore, it needs to deduct the offset component (PD dark current, CCD dark current and electrical offset) from the signal output *O* when the radiometric correction is performed. Since this offset component is the same as the output B at the dark, the PD signal output can be determined by deducting the output *B* at the dark from the signal output *O* in theory.

However, since the signal output *O* and the output *B* at the dark time are not the data obtained simultaneously, the temperature condition of each equipment is different. According to this temperature difference, the offset component varies. Therefore, if only finding the differences between *O* and *B*, its difference is still large depending on the above reason. Then the dummy pixel output *C* obtained simultaneously along with the effective pixels is used in the offset correction. Since there is a possibility that offset of the exposure coefficient is added to the signal output *O*, it also should be given a consideration.

(2) Equation of the Radiometric Correction

A basic Equation of the radiometric distortion correction which calculates the incidence radiance from the digital output of AVNIR-2 is shown as follows.

$$L = \frac{1}{R} \cdot \{( O - B_{\alpha} - B_{NL} - C ) - ( B - B'_{\alpha} - C' )\}$$ Equation 7.2-7

Where,

$L$: Incidence radiance $\left[W \cdot m^{-2} \cdot sr^{-1} \cdot \mu m^{-1}\right]$

$R$: Equipment sensitivity $\left[DN / \left(W \cdot m^{-2} \cdot sr^{-1} \cdot \mu m^{-1}\right)\right]$

$O$: Signal output digital value $\left[DN / \left(W \cdot m^{-2} \cdot sr^{-1} \cdot \mu m^{-1}\right)\right]$

$C$: Dummy pixel output mean value at the time when the signal output value $O$ is obtained $\left[DN\right]$

$B_{\alpha}$: Offset of the exposure coefficient pulse at the time when the signal output value $O$ is obtained $\left[DN\right]$

$B_{NL}$: Non-linear offset of output to the incidence radiance $\left[DN\right]$

$B$: Output digital value at the dark $\left[DN\right]$

$C'$: Dummy pixel output mean value at the time when the output value $B$ at the dark is obtained $\left[DN\right]$

$B_{\alpha}'$: Offset of the exposure coefficient pulse at the time when the output value $B$ at the dark is obtained $\left[DN\right]$

The detail each parameter expressed in the above expression is described as follows.

### (3) Radiometrically Corrected Processing

When the radiometric model equation is expressed by $y = \frac{x - b - c}{a}$, calculate the correction coefficient corresponding to '$a$', '$b$', '$c$', and the radiometric correction is carried out. Where, '$x$' is defined as an uncorrected input value before performing the radiometric correction. '$y$' is defined as a radiometrically corrected output value for every band and pixel number.

a) Calculation of the correction coefficient '$a$'

'$a$' is composed of the reference sensitivity, the pixel-to-pixel sensitivity deviation, the normalized exposure coefficient, fluctuation of reflection rate of the pointing mirror, and sensitivity correction coefficient. It is calculated based on the encoder data in the TT&C system telemetry data, the Detector temperature, Detector module temperature, and Signal Processor temperature.

$$a = A( j,k,g ) \cdot D( i,j,k,g ) \cdot I( a,j,g ) \cdot P( i,j,\theta ) \cdot K( i,j,k,g,T_D,T_{PRE},T_{SP} )$$ Equation 7.2-8

Where, $K( i,j,k,g,T_D,T_{PRE},T_{SP} )$ is sensitivity correction coefficient.

b) Calculation of the correction coefficient '$b$'

'$b$' is composed of the offset level and the PD dark current. It is calculated based on the Detector temperature in the TT&C System telemetry data for every band and pixel number.

$$b = B_{\alpha}(i, j, k, g) + B_{NL}(i, j, k, g) + B_{PD}(i, j, k, g) \qquad \text{Equation 7.2-9}$$

Where, $B_{\alpha}(i, j, k, g)$ is offset of the exposure coefficient pulse, and $B_{PD}(i, j, k, g)$ is PD dark current.

c) Calculation of the correction coefficient '*c*'

'*c*' is a dummy pixel output, and it is calculated for every band. It takes an average of dummy pixels in one scene, however, the number of standardized lines is defined as one scene.

$$c = C(j,l) \quad l\text{: line number} \qquad \text{Equation 7.2-10}$$

d) Radiometrically corrected processing

Expressing the sensor output by *O*, and the amount of the incidence radiation by *L*, Equation for the radiometric correction is expressed as follows using coefficient '*a*', '*b*' and '*c*' calculated from above sections.

$$L = \frac{O - b - c}{a} \qquad \text{Equation 7.2-11}$$

### 7.2.3 Geometric Correction

The geometric correction processing of ALOS optical sensor is performed by system correction (bulk correction) as well as the conventional sensors.

It is performed in the following procedures.

(1) Preparation of the coordinate transformation function

Correspondences between each pixel position of the input image (uncorrected image) and addresses in the coordinate of the output image (map projection image) are determined by using geometric model for sensor, orbit and attitude data, earth model, map projection, and framing method.

That is, the coordinate transformation function from the coordinate system of the input image to the coordinate of the output image is generated.

Table 7.2-3 describes the function to be used in this transformation calculation. For the following geometric correction coefficients calculation, the input image address (column and line) is extended to a real number to be capable of calculating the output image coordinate corresponding to the given input image coordinate.

(2) Calculation of the geometric correction coefficient

The output image is divided into the proper sized blocks which can perform linear approximation geometrically to the corresponding address of the input image, and finds the input image address corresponding to each grid of these blocks. Inverse function for the coordinate transformation functions F1 through F4 is needed in this calculation. However, the output image address is calculated from the input image address by using normal transformation functions F1 through F4, since it is not possible to solve the inverse function of F1 function.

The input image address corresponding to the block grids of the output image is approximated by pseudo affine transformation by the relations between these input and output image addresses. And using convergence calculation can calculate the more accurate input image address for the geometric correction coefficient. During the calculation, function F1 is called per one calculation and the view vector is calculated.

(3) Resampling

For each pixel on the map projection coordinate to be output, linear interpolation is performed to the input image address at those grids calculated in (b). Each pixel value of output image is calculated by interpolation from the surrounding pixel values on the input image, and output image is created by using the re-sampling method like this interpolation. (Radiometric correction is performed simultaneously) NN (Nearest Neighbor), BL (Bi-Linear) or CC (Cubic Convolusion) is used as a re-sampling method. Figure 7.2-4 shows the concept of the system.

Table 7.2-3 Coordinate Transformation Function

| No. | Name | Content |
|---|---|---|
| 1 | F1 | It transforms the address of the input image (Level 1A/1B1 image) into the ECR coordinate at the imaging point |
| 2 | F2 | It transforms the ECR coordinate into the geodetic latitude and longitude |
| 3 | F3 | It transforms the geodetic latitude and longitude into the map coordinate |
| 4 | F4 | It transforms the map coordinate into the image address of the output image (map projected) |

The coordinate system to be used in the PRISM geometric model is described as follows.

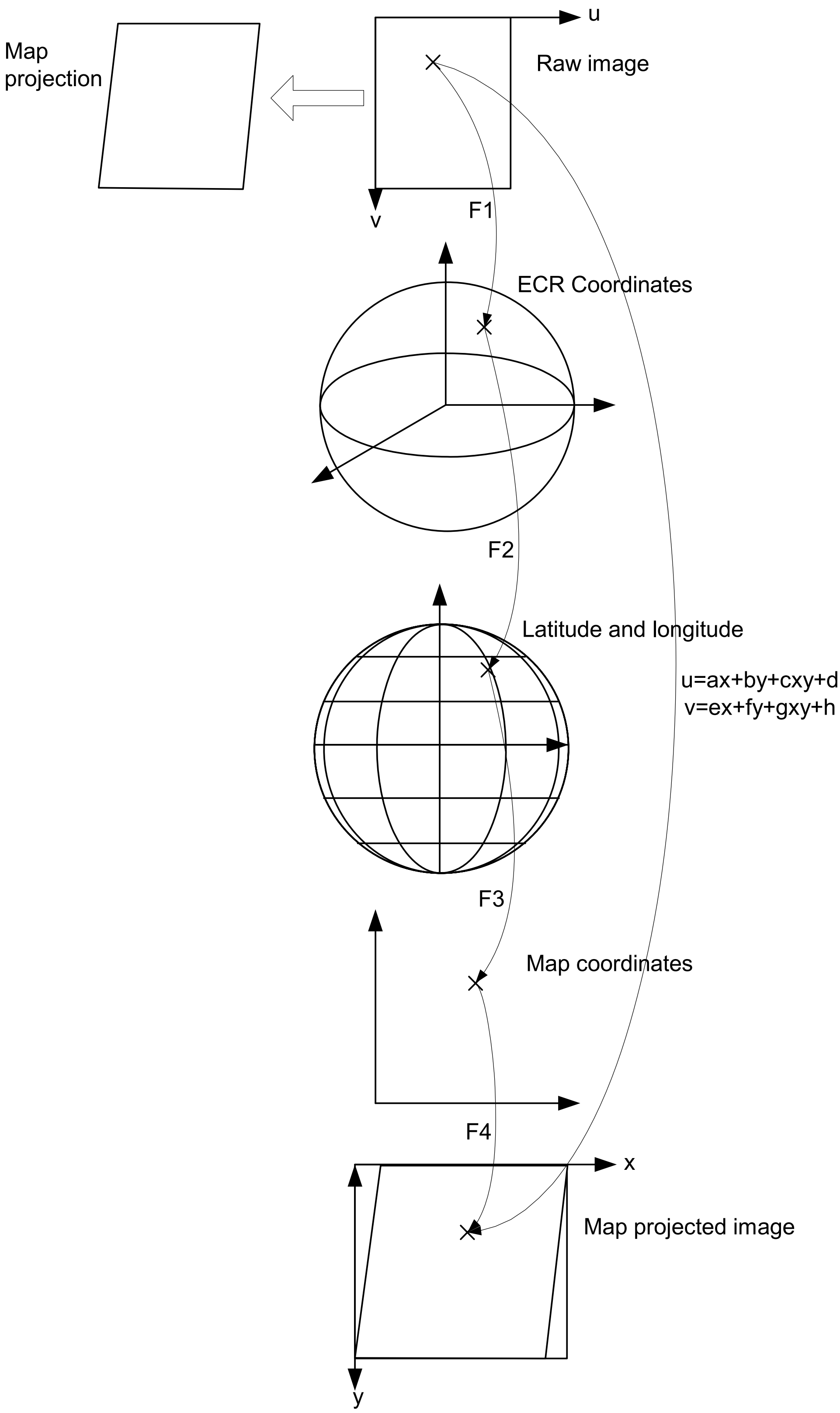



Figure 7.2-4 Concept of the System Correction

Table 7.2-4 Coordinate System to be Used in the PRISM Geometric Model

| No | Name | Abbr. | Definition | Remarks |
|---|---|---|---|---|
| 1 | STT Reference Coordinate | $\Phi_{STT}$ | X: roll-axis on the orbit<br>Y: pitch-axis on the orbit<br>Z: yaw-axis on the orbit<br>Origin: STT reference mirror | |
| 2 | Satellite Coordinate | $\Phi_{B}$ | X, Y, Z: parallel to each axis of the STT reference coordinate system<br>Origin: satellite center of mass | |
| 3 | Satellite Fixed Coordinate | $\Phi_{S}$ | X: mechanical roll-axis<br>Y: mechanical pitch-axis<br>Z: mechanical yaw-axis<br>Origin: intersection point of the centerline of the separation part and separation plane. | |
| 4 | PRISM Forward View Radiometer Fixed Coordinate | $\Phi_{PRI\_FS}$ | X: vertical to the mounted surface<br>Y: Same as Y in the forward viewing radiometer coordinate system<br>Z: X x Y<br>Origin: alignment mirror | Alignment mirror reference |
| 5 | PRISM Nadir View Radiometer Fixed Coordinate | $\Phi_{PRI\_NS}$ | X: vertical to the mounted surface<br>Y: Same as Y in the nadir viewing radiometer coordinate system<br>Z: X x Y<br>Origin: alignment mirror | Alignment mirror reference |
| 6 | PRISM Backward View Radiometer Fixed Coordinate | $\Phi_{PRI\_BS}$ | X: vertical to the mounted surface<br>Y: Same as Y in the backward viewing radiometer coordinate system<br>Origin: alignment mirror | Alignment mirror reference |
| 7 | PRISM Forward View Radiometer Coordinate | $\Phi_{PRI\_F}$ | X: Y x Z<br>Y: CCD layout reference direction<br>Z: FOV central direction of forward optical system (optical axis direction)<br>Origin: forward reference mirror | |
| 8 | PRISM Nadir View Radiometer Coordinate | $\Phi_{PRI\_N}$ | X: Y x Z<br>Y: CCD layout reference direction<br>Z: FOV central direction of the nadir optical system<br>Origin: nadir reference mirror | Nominally consistent with the radiometer fixed coordinate system |
| 9 | PRISM Backward View Radiometer Coordinate | $\Phi_{PRI\_B}$ | X: Y x Z<br>Y: CCD layout reference direction<br>Z: FOV central direction of the nadir optical system (optical axis direction)<br>Origin: backward reference mirror | |

The coordinate systems to be used in the geometric model of AVNIR-2 are as follows.

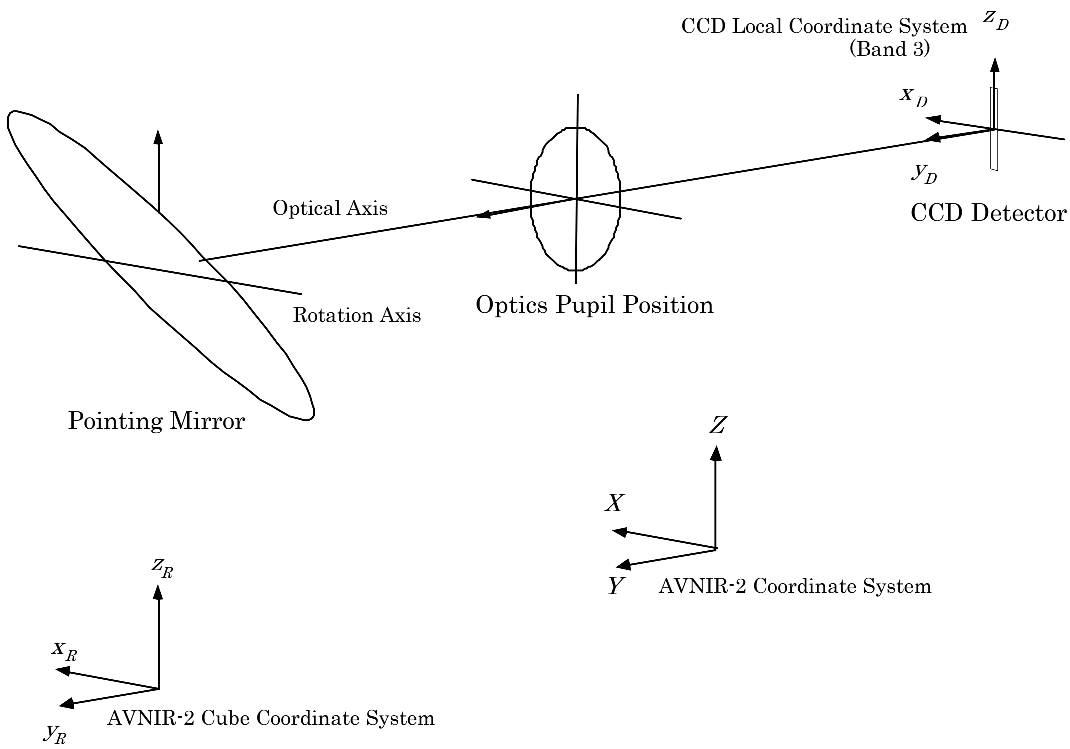



Figure 7.2-5 Coordinate System for AVNIR-2

## 7.3 PALSAR

### 7.3.1 Outline of PALSAR Level 1.0 Processing Algorithm

In the PALSAR Level 1.0 processing, Level 1.0 data is generated from Level 0 data. Level 1.0 processing consists of pre-processing, CCSDS processing, PALSAR unpacking processing, PALSAR data split processing and CEOS format generation processing as shown in Figure 7.3-1.

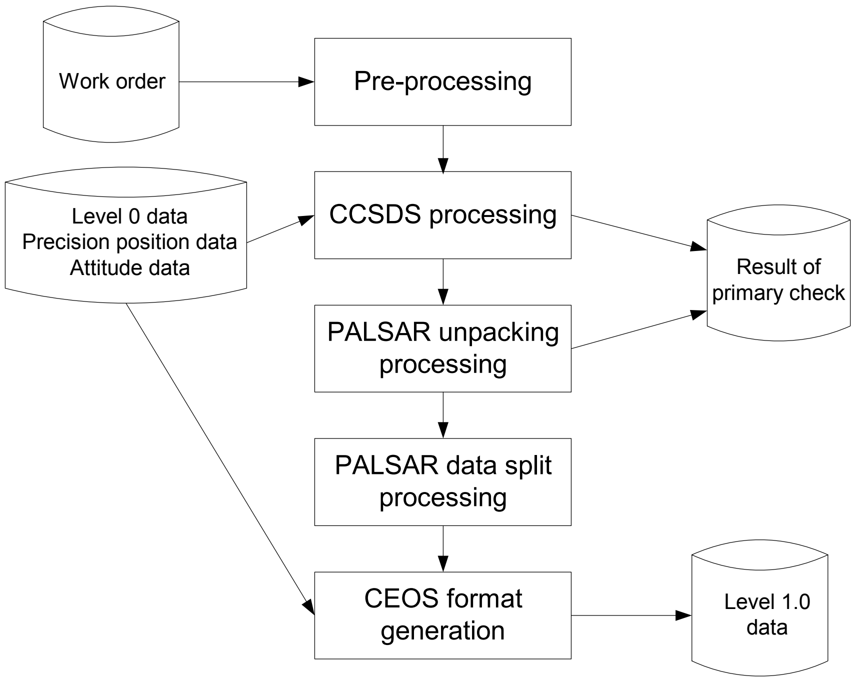



Figure 7.3-1 PALSAR Level 1.0 Processing Flow

#### 7.3.1.1 Pre-processing

Pre-processing is executed before all processing tasks. The size of one scene is defined as ± 8.2 second from the scene center time instructed by the work order (± 28.5 second in the ScanSAR mode). In the ScanSAR mode, an extraction point is defined as the border of each burst in order to avoid starting the extraction before one burst is completed. The data is started from the beginning of the next burst in the starting side and is ended at the end of the given burst.

#### 7.3.1.2 CCSDS Processing

CCSDS Processing is as follows;

- Input the PALSAR level 0 data set from a data server in PALSAR Data Processing system.
- Extract the PALSAR frame data from the PALSAR level 0 data set.
- Extract the PALSAR mission telemetry data from the PALSAR level 0 data set.
- Conduct primary check of packet loss, the number of lost lines and limit check.

PALSAR level 0 data set consists of the following:

- Eight VCDU services (VCID: 52 ~ 59), which were divided from original frame data.
- PALSAR mission telemetry, which is the source packet (APID = 1589) in the low-rate mission data (VCID = 32).

The Level 0 data in CCSDS format is composed of files collecting the same VCID record. These files are identified per VCID by file name.

#### 7.3.1.3 PALSAR Unpacking Processing

Table 7.3-1 describes the parameter of each observation mode. PALSAR frame data consists of some sample data. Number of quantization means number of bits of one sample data. By an unpacking processing, these data are converted to the eight-bit data.

Table 7.3-1 Extraction Width, Number of Quantization Bits and Polarization on each Observation Mode

| Observation mode | Polarization mode | Data rate | Extraction time for level 1.0 (second) | Number of quantization |
|---|---|---|---|---|
| Fine (High resolution) | HH or VV Polarization | 240Mbps | 16.4 | 5 |
| | HH+HV or VV+VH Polarization | 240Mbps | 16.4 | 5 |
| ScanSAR | HH or VV Polarization | 240Mbps | 57.0 | 5 |
| Direct downlink | HH or VV Polarization | 120Mbps | 16.4 | 3/5 |
| Polarimetric | HH+HV+VV+VH Polarization | 240Mbps | 16.4 | 3/5 |

#### 7.3.1.4 PALSAR Data Split Processing

This processing is performed when the high resolution mode (dual polarization: HH+HV or VV+VH) or polarimetric mode is selected. In the fine (HH+HV or VV+VH) mode and the polarimetric mode, split frame data are separated into each polarization.

(1) Dual polarization modes in High resolution mode

In HH＋HV polarization mode, I and Q data of the HH polarization and I and Q data of the HV polarization are stored alternately in each frame. These data are separated into two groups; I and Q data of the HH polarization and I and Q data of the HV polarization, and divided into each polarization data.

In VV + VH polarization mode, I and Q data of the VH polarization and I and Q data of the VV polarization are stored alternately in each frame. These data are separated into two groups like the above; I and Q data of the VV polarization and I and Q data of the VH polarization, and divided into each polarization data.

(2) Polarimetric mode

In this mode, two different type frames are recorded alternately: one stores receiving data from transmission data of H polarization, and other stores receiving data from transmission data of V polarization data. Moreover, I and Q data received in the H polarization and I and Q data received in the V polarization are stored in each frame alternately. And these data are divided into each polarization data; the HH polarization, the HV polarization, the VH polarization, the VV polarization.

## 7.3.1.5 CEOS Format Generation Processing

The PALSAR level 1.0 data format is based on the CEOS format.

The PALSAR level 1.0 data set consists of four different files; volume directory, SAR leader, SAR image and SAR trailer, as shown in Table 7.3-2. The SAR image file consists of SAR image file of each separated polarization data.

In this processing, the data which were unpacked and performed the data split processing (if necessary) are stored in the SAR image file, and the SAR leader file is generated from high precision position data,PALSAR low-rate mission data, etc. If there are no high precision position data, platform position data is generated from predict position data. Attitude data is extracted from the PALSAR mission telemetry data.

Table 7.3-2 Record Construction of CEOS Format

| Record No. | Record length | Number of records | Record name | File name |
|---|---|---|---|---|
| 1 | 360 | 1 | Volume descriptor | Volume directory |
| 2 | 360 | Number of polarization+2 | File pointer | |
| 3 | 360 | 1 | Text record | |
| 4 | 720 | 1 | File descriptor | SAR leader |
| 5 | 4,096 | 1 | Data set summary | |
| 6 | 4,680 | 1 | Platform position data | |
| 7 | 8,192 | 1 | Attitude data | |
| 9 | 13,212 | 1 | Calibration Data | |
| 10 | Variable length* | 10 | Facility related data | |
| 11 | 720 | 1 | File descriptor | SAR image |
| 12 | Variable length | n | Signal data | |
| 13 | 720 | 1 | File descriptor<br>SAR trailer | SAR trailer |

*: Record lengths among the 10 records of Facility related data are different, but each record has fixed length.

## 7.3.2 Outline of PALSAR Level 1.1/1.5 Processing Algorithm

This software inputs PALSAR Level 1.0 data, executes imaging distortion correction processing and outputs the processed data.

PALSAR data processing is constituted of imaging processing from the Level 1.0 data and distortion correction processing for correcting the radiometric distortions and the geometric distortions. Figure 7.3-2 shows the data processing flow.

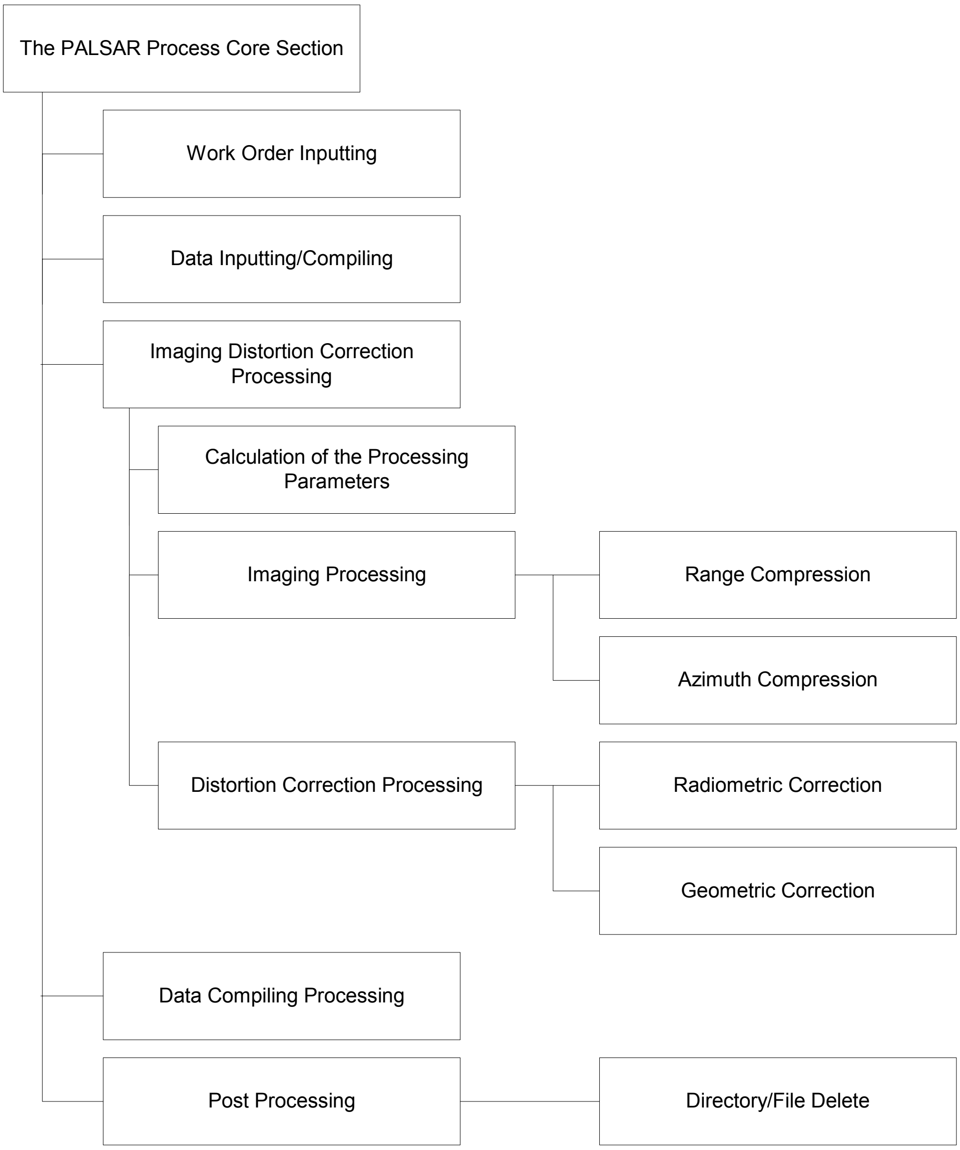



Figure 7.3-2 PALSAR Data Processing Flow

### 7.3.2.1 Imaging Processing (High resolution/Direct downlink/Polarymetric modes)

(1) Range Compression Processing

Range compression is conducted by converting the input SAR raw data into the frequency domain using an FFT and by a correlating operation in the range direction. The processing flow of the range compression is shown in Figure 7.3-3 below.

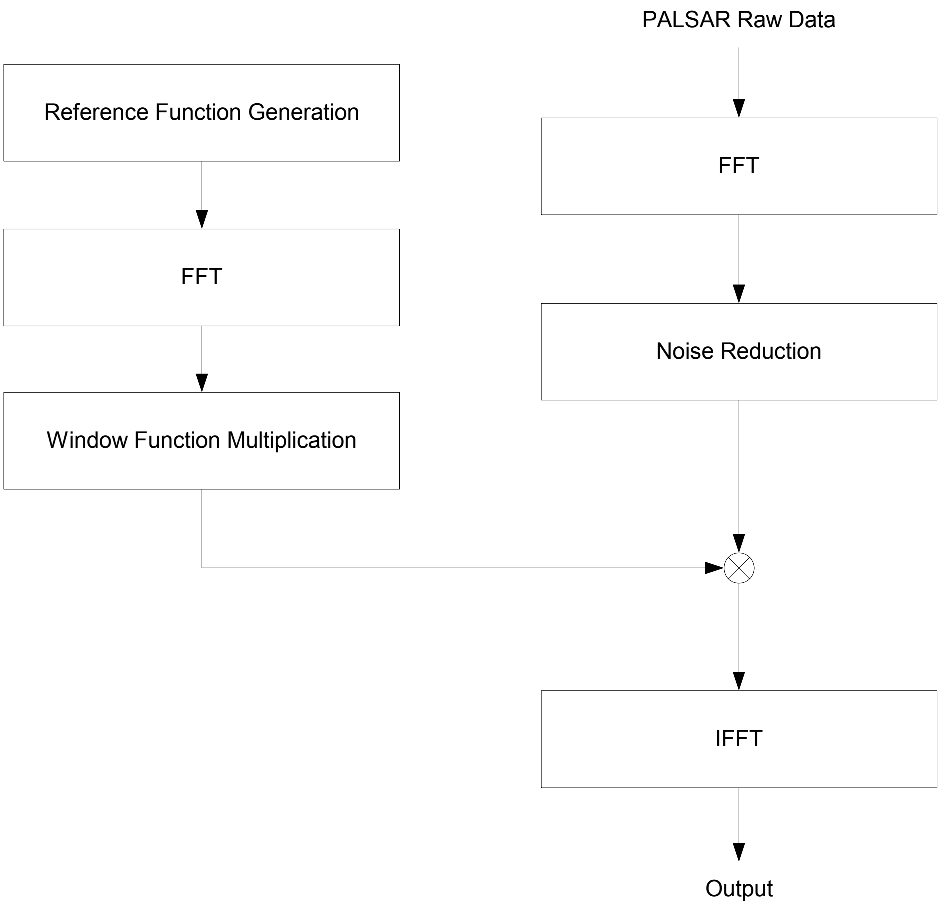



Figure 7.3-3 PALSAR Data Processing Flow

The transmission section transmits the linear-chirp-modulated signal having a transmission carrier frequency $F_c$, synchronizing the pulse repeat frequency PRF.

The transmission section outputs a transmission signal as shown in Figure 7.3-3 for the transmission signal pulse width $\tau$ for each PRF. Assuming the center of each transmission pulse width as $t = 0$, the transmission signal is represented by the following equation.

$$f(t) = \cos 2\pi\left(F_c + \frac{k}{2}t\right)\cdot t$$
$$-\frac{\tau}{2} \le t \le \frac{\tau}{2}$$
Equation 7.3-1

Where,
$F_c$ denotes the transmission carrier frequency,
$k$ denotes the chirp rate (a function of temperature) and
$\tau$ denotes the transmission pulse width.

For the above transmission signal, the received signal $f_R(t)$ is represented approximately by the following equation.

$$f_R(t) = \exp 2\pi j\left\{\frac{k}{2}(t-T_r)^2 - F_c T_r + F_d(t)\cdot(t-T_r)\right\}$$
$$-\frac{\tau}{2}+T_r \le t \le \frac{\tau}{2}+T_r$$
Equation 7.3-2

Where, $F_d(t)$ denotes the Doppler frequency, $T_r$ denotes the time necessary for electromagnetic wave propagation.

In the term for the phase in the above equation, the first term denotes the transmission chirp wave component and the second term denotes the phase delay created by the time necessary to make a round trip between the satellite and the target. Since the distance between the satellite and the target varies for every pulse repeat cycle, the phase in the second term varies and this becomes the Doppler component in the azimuth direction. The third term denotes the phase shift component created because the transmitting position and the receiving position of the electromagnetic wave differ since the satellite is moving when it transmits and receives the electromagnetic wave.

This received signal becomes the input signal of the range compression. The correlation operation in the range direction is conducted in the frequency domain by FFT. Thus, the received signal $F(f)$ in the frequency domain is represented as follows.

$$F(f) = \int f_R(t)\cdot\exp(-2\pi jft)dt$$
Equation 7.3-3

Where reference function of this is shown as Equation 7.3-4 and the complex conjugate in the frequency domain is represented by $G(f)^*$, the range-compressed signal $h(t)$ is obtained by conducting a reverse FFT on the product of $F(f)$ and $G(f)^*$ and represented as follows.

$$h(t) = \int F(f)\cdot G^*(f)\cdot\exp(2\pi jft)dt$$
Equation 7.3-4

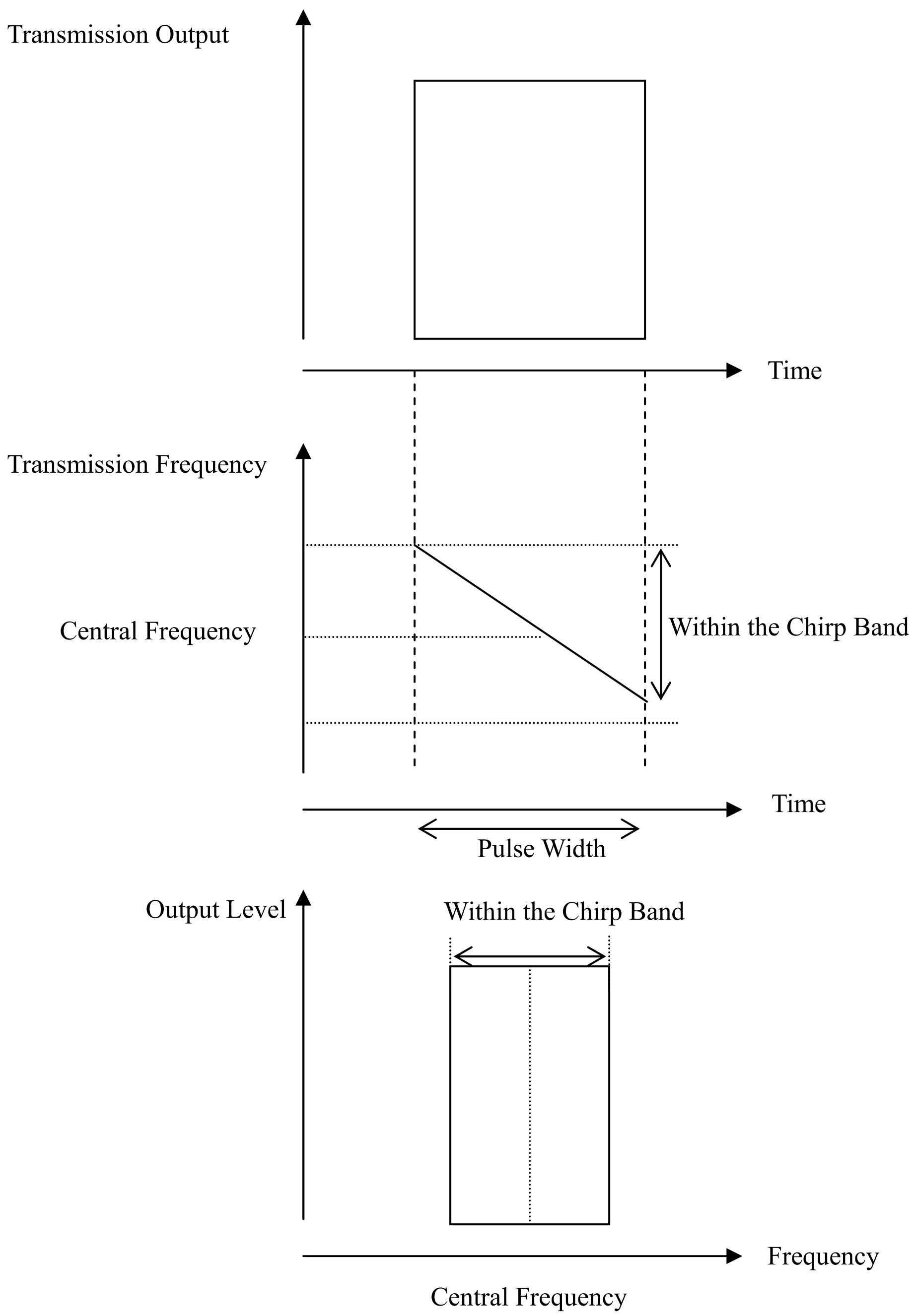



Figure 7.3-4 Schematic Diagram of the Transmission Pulse

When there is an irregularly strong line spectrum distributing at a specific frequency, it is expected that the line spectrum will degrade the image as noise while reproducing the image. The necessary noise reduction is conducted on the SAR data converted into the frequency domain.

When there is a line spectrum having a power exceeding a threshold value in the data in the frequency domain, the noise is reduced by assuming the component of the line spectrum as zero (0).

### (2) Azimuth Compression Processing

In azimuth compression, the data located in a line in the range direction are firstly rearranged so that it may stand in a line in the azimuth direction on a memory. Then, the azimuth compression is executed by a correlating operation in the frequency domain as well as the range compression. The processing flow of the azimuth compression is shown in Figure 7.3-5 below.

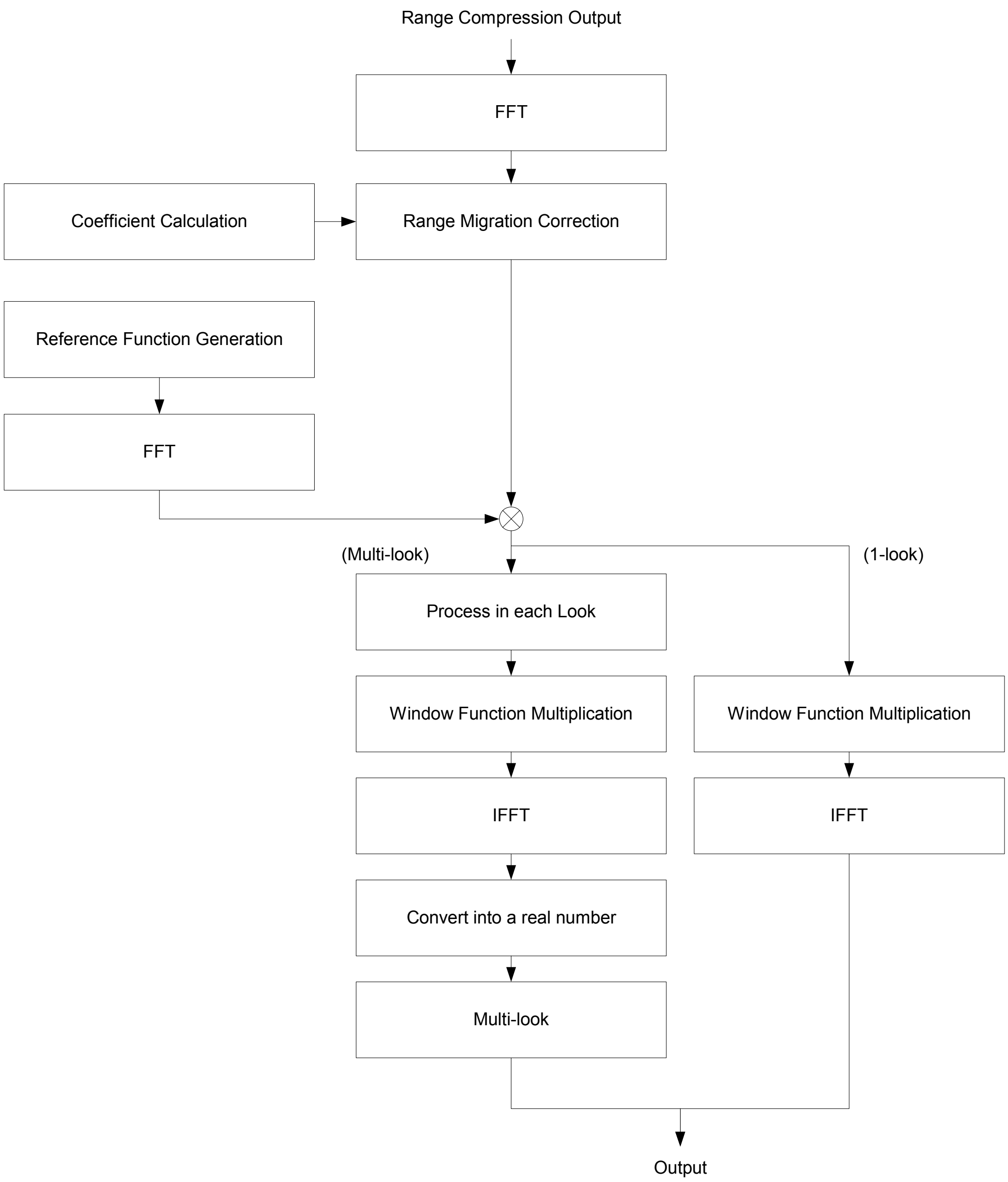



Figure 7.3-5 The Flow of Azimuth Compression Processing

a) Range Migration Correction

It rearranges the data after FFT according to the range migration function calculated.

The range migration correction coefficient calculated is the amount of movements of a range sample (RS). Based on the amount of movements the value of A(I), which is the $I^{th}$ data, is moved as the value of $(I\text{-}RS)^{th}$ data. Since RS is a real numerical value, I of A(I) does not always coincide with its range sampling position. Therefore, it interpolates the value of A(I) using a total of four points in the range direction, which are back two points and forth two points of A(I), by cubic convolution. The interpolated value is regarded as the value at the position shifted only by RS.

b) Azimuth Compression

The azimuth compression is executed by multiplying X(*f*) after the range migration correction in the frequency domain by *Y(f)* which converted *y(t)* into complex conjugate (*y(t)*; azimuth compression reference function) as well as the range compression.

$$y(t) = \exp(2\pi j F_{dd} t^2) \quad \text{Equation 7.3-5}$$

$$Y(f) = \int y(t)^* \cdot \exp(-2\pi j f t) dt \quad \text{Equation 7.3-6}$$

$$Z(f) = X(f) \cdot Y(f) \quad \text{Equation 7.3-7}$$

c) 1-look Processing

Chirp band ($f_W$) is calculated using $F_{dd}$ and synthetic aperture time ($T_d$) by the following equation.

$$f_w = F_{dd} \cdot T_d \quad \text{Equation 7.3-8}$$

Where synthetic aperture distance ($R_d$) of 1-look and synthetic aperture time ($T_d$) is determined using satellite altitude (H), off-nadir angle ($O_f$), azimuth beam width ($B_W$) and ground speed of imaging ($V_E$) by the following equation.

$$R_d = 2 \cdot \frac{H}{\cos O_f} \cdot \tan\left(\frac{B_w}{2}\right) \quad \text{Equation 7.3-9}$$

$$T_d = \frac{R_d}{V_E} \quad \text{Equation 7.3-10}$$

In 1-look processing, when the number of sampling points (size of FFT) is N, the number of chirp points in frequency space (M; reference function length) is represented by the following equation.

$$M = N \cdot \frac{f_W}{PRF}$$ Equation 7.3-11

When it calculates in time domain, the reference function time length ($N_D$; the number of points) is as follows by Equation 7.3-8.

$$N_D = \frac{f_W}{F_{dd}} \cdot PRF$$ Equation 7.3-12

Then output valid data ($N_{out}$) is represented as follows.

$$N_{\mathrm{OUT}} = N - N_{\mathrm{D}}$$ Equation 7.3-13

d) 2-look and 4-look Processing

In 2-look processing, it multiplying the reference function after FFT of N points, and then processes the aperture length (less than M points) in two looks.

In 4-look processing, it multiplying the reference function after FFT of N points, and then processes the aperture length (less than M points) in four looks.

To process in two looks or four looks in frequency domain is equivalent to having synthetic aperture length divided into two or four. The resolution in the azimuth direction is degraded twice or four times, but speckle noise is improved by $1/\sqrt{4} = 1/2$ in case of 4-look processing.

e) Imaging

Since the data after multi-look processing is a complex number, it coverts the data into a real number in each look and superimposes the corresponding pixels from all looks for imaging.

#### 7.3.2.2 Distortion Correction Processing (High resolution/Direct downlink/Polarymetric modes)

(1) Radiometric Correction

The radiometric correction comprises the following four (4) processes.

- AGC correction
- STC correction
- Correction on antenna pattern
- Correction on the difference in propagation path length

(2) Geometric correction

a) Map Coordinate System Conversion

The PALSAR image (Level 1.5 image) by the map projection designated by the work order is obtained by determining the coefficients "a" to "h" of the following bi-linear conversion equation and by using the next equations.

$$u = ax + by + cxy + d$$
$$v = ex + fy + gxy + h$$

Equation 7.3-14

Where,
($u$, $v$) denotes the address of the input data (pixel, line) and
($x$, $y$) denotes the address of output data (pixel, line).

b) Histogram Conversion

The SAR image after reproduction has a wide dynamic range and, when it is normalized using the maximum data, the data concentrates to the low level area when the histogram is displayed. Therefore, it is necessary that the histogram of the image is manipulated using a proper function and the data is displayed with a contrast as effective as possible.

In this processing, the histogram conversion is conducted with non-linear-type function by square root.

The function is shown as follows. The non-linear-type function is as follows:

$$y = a\sqrt{x/b}$$

Equation 7.3-15

Where, $a$ and $b$ are constants.

# Section 8 Data Distribution Services

## 8.1 Basic Policy for ALOS Data Services

Observation data from ALOS mission will be provided globally using the Data Relay Satellite Communication system and the volume of observation data to be obtained is enormous. JAXA will archive those data in a usable manner, and provide them to users rapidly upon request. In more concrete terms,

- To provide services that are most appropriate to the characteristics and the purposes of using high-resolution optical sensors (PRISM and AVNIR-2) and a radar sensor (PALSAR).
- To provide user-friendly services corresponding to different types of user.
- To provide global services for users throughout the world, considering that the areas covered by observation are worldwide.
- To provide flexible services corresponding to the progress of research and development on products.
- To provide services mutually usable with the data from existing land observation satellites like JERS-1.

## 8.2 Definition of Data Users

The following table shows categories of ALOS data users.

Table 8.2-1 Categories of ALOS Data Users

| User Categories | | Definition |
|---|---|---|
| Institutional Users | Free | Users who receive limited volume data from JAXA at free based on the agreement with JAXA.<br>Level 0: ERSDAC, Geographical Survey Institute, JAXA internal, ALOS data node organizations<br>Level 1: Geographical Survey Institute, Ministry of the Environment, Ministry of Agriculture, Forestry and Fisheries, Japan Coast Guard, PI, and JAXA internal |
| | Nonfree (marginal cost) | Users who receive data from JAXA at marginal cost for data reproduction based on the agreement with JAXA.<br>Level 0: Geographical Survey Institute, ALOS data node organizations<br>Level 1: Geographical Survey Institute |
| Commercial Users | | Users who receive level 1 and higher level data products from data distributors around the world.<br>Data are not directly distributed from JAXA. |

## 8.3 Definition of Data Distributing Organizations around the World

Shown in the following table are ALOS data distributing organizations around the world.

Table 8.3-1 Definition of Data Distributing Organizations around the World

| Category | Definition |
|---|---|
| ALOS Data Node Organizations | Based on the division of the world in 4 zones, to receive level 0 data from JAXA for own zone, and to conduct tasks of data archiving, processing and distribution. The following 3 zones other than Asia are managed by foreign data node organizations.<br>・Data Node responsible for Europe and Africa: ESA<br>・Data Node responsible for North and South America: NOAA/ASF<br>・Data Node responsible for Oceania: Geoscience Australia<br>As for Asia, JAXA serves as a Data Node. |
| Data Distributor | Data distributing organizations that receive level 0 data from JAXA, and distribute ALOS data worldwide for data commercial use. |
| METI/ERSDAC | To distribute PALSAR level 0 data. |

## 8.4 Definition of Data Products

The following table shows the definition of each data provided by JAXA to ALOS users.

Table 8.4-1 Definition of ALOS Data (mission data)

| Level | Definition | |
|---|---|---|
| 0 | AVNIR-2 Level 0 data set<br>Data set of AVNIR-2 level 0 data, TT&C system telemetry level 0 data, AOCS attitude level 0 data, STT level 0 data, GPSR level 0 data, and TT&C PCD level 0 data | |
| | PRISM Level 0 data set<br>Data set of PRISM level 0 data, TT&C system telemetry level 0 data, AOCS attitude level 0 data, STT level 0 data, GPSR level 0 data, and PRISM mission telemetry level 0 data | |
| | PALSAR Level 0 data set<br>Data set of PALSAR level 0 data, TT&C system telemetry level 0 data, AOCS attitude level 0 data, STT level 0 data, GPSR level 0 data, and PALSAR mission telemetry level 0 data | |
| 1 (Processed Data) | Processed data from AVNIR-2 and PRISM | |
| | 1A | Uncorrected data extracted by scene unit |
| | 1B1 | Radiometrically calibrated data |
| | 1B2 | Geometrically corrected data |
| | Processed data from PALSAR | |
| | 1.0 | Uncorrected data extracted by scene unit |
| | 1.1 | Range and single look azimuth compressed complex data on slant range |
| | 1.5 | Data after map projection |
| Summary Information | Summary information of processed data | |

Note: Processed data are defined as "Products" by accompanying the summary information.

## 8.5 Outline of User Services

User services related to ALOS data distribution are defined below.

Categories of ALOS data distribution are shown in Table 8.5-1. PI can utilize only the normal data distribution services.

Table 8.5-1 Table Types of ALOS Data Distribution

| Type | Distribution Method |
|---|---|
| Standard data distribution | Method to distribute level 0 data and processed data products to users through media (DTF-2 for level 0 data and CD-R for processed data) or on-line within the capacity.<br>As for the required inputting when operators make registration in advance, there are two ways, namely one through file interface and the other by inputting directly from WWW interface (AUGI). Requests for observation are accepted by Friday (UT 8:00) of the week, which is two weeks before the week of observation. Priority comes after requests for emergency and near realtime observation. Furthermore, priority is determined for different types of observation within "provision under normal conditions". Data provision quota is determined for each user. |
| Emergency data distribution | First priority is given to the flow from a request for observation of a disaster till its official order. Inputting of a request for observation is done by the operator and requests for observation are automatically accepted till the point of 72 hours before the actual observation. (Requests thereafter are handled through communication and coordination by intervention of the operator.) Processed data are prepared within 3 hours from the time of data acquisition, and image catalog is made public within 1 hour and a half from the time of data acquisition (within 3 hours and a half in case of PALSAR). The provision method supports both on-line and media (CD-R). Requests for urgent observation from outside organizations are handled in the same manner. |
| Near realtime data distribution | Institutional users should make coordination with JAXA in advance with respect to requests for observation of specific locations, periods and time. Specific data are input before the starting time of operation and provided within the timeframe requested by users. Inputting of requests for observation is done by the operator, and processed data are provided by on-line. |

The table below shows detailed services contents of the standard data distribution. Figures 8.5-1 to 3 show the data distribution services flow.

Table 8.5-2 Detaled Services Contents of the Standard Data Distribution

| **Name of Services** | | **Contents of Services** |
|---|---|---|
| Level 0 Data distribution | Standing Request (including observation request) | Request for data by advance ordering (Future data are ordered in advance). At the time of request, certain specific items such as sensors, latitude and longitude, period, and sensor operating mode are designated. Inputting of request is done by the operator. Status of request is notified by WWW (AUIG). |
| Data Product distribution | Standing Request (including observation request) | Request for data by advance ordering (Future data are ordered in advance). At the time of request, certain specific items such as sensors, latitude and longitude, period, and sensor operating mode as well as options for various orders are designated. Inputting of request is done by the operator. Status of request is notified by WWW (AUIG). |
| | Services by AUIG | AUIG (ALOS User Interface Gateway) performs on-line services by the WWW for observation request and research/order of processed data. By utilizing this AUIG, users make request for observation, advance request for future data, request for catalog research/ordering for archived data of each scene of processed data by on-line directly. Status of request is notified to AUIG for each request unit. In addition, ordered data as well as the data without cloud in Japan's land area are available by on-line. (Excerpting function is attached.) In addition, supplemental information on making request for observation is provided. |
| Supply of Utility Information | | Following information for usage of ALOS data is available through the WWW.<br>- Data format, sample data<br>- Processing software (for level 1; in execution file form)<br>- Tool kit for data input and output (Geo TIFF transforming tool, etc.)<br>- Calibration coefficients.<br>- Observation plans, observation experiences, satellite orbit indication.<br>- Other documents related to data use method, etc, corresponding to the levels of users. |

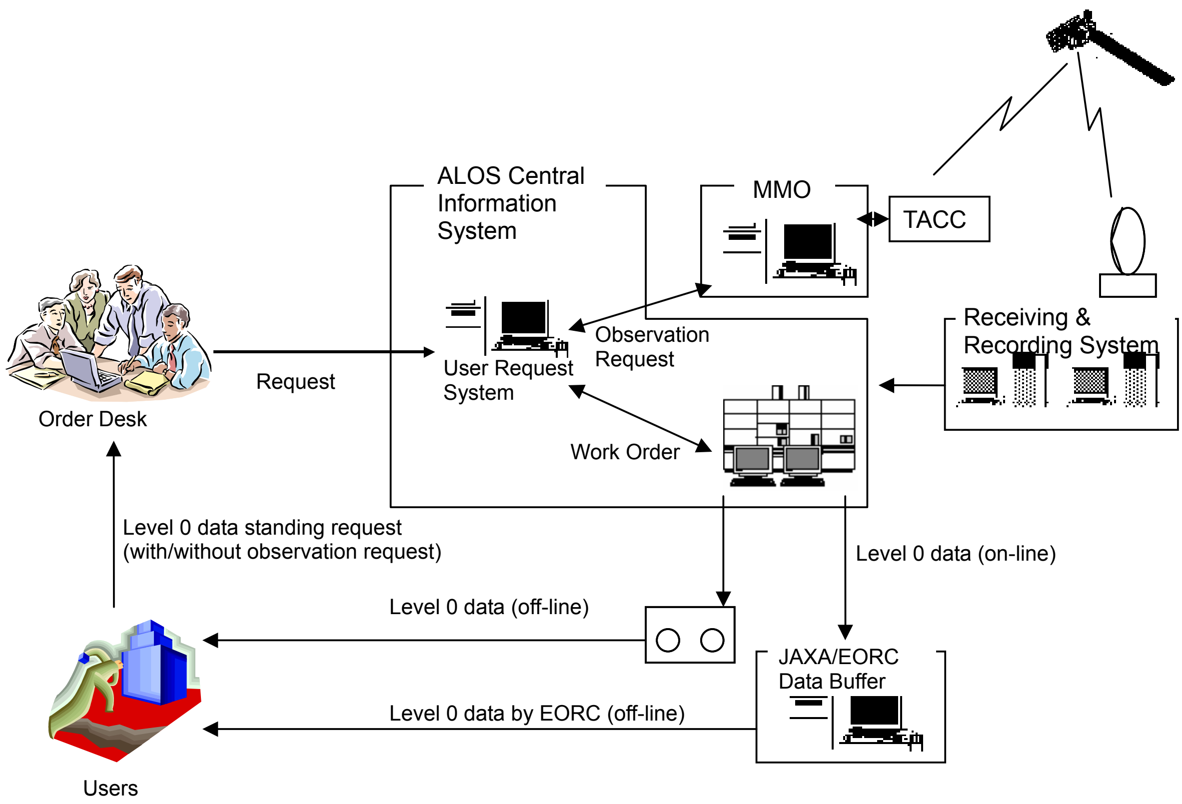



Figure 8.5-1 Level 0 Data Distribution Flow (Standing Request (with/without observation request))

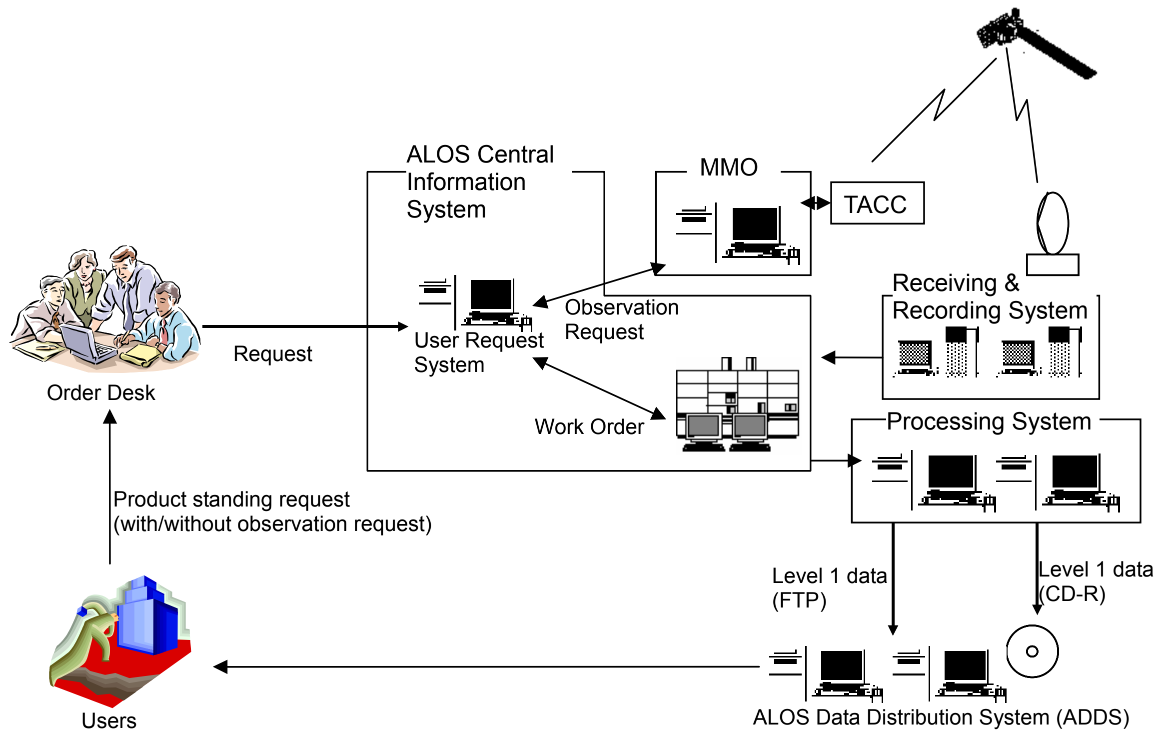



Figure 8.5-2 Product Distribution Flow (Standing Request (with/without observation request))

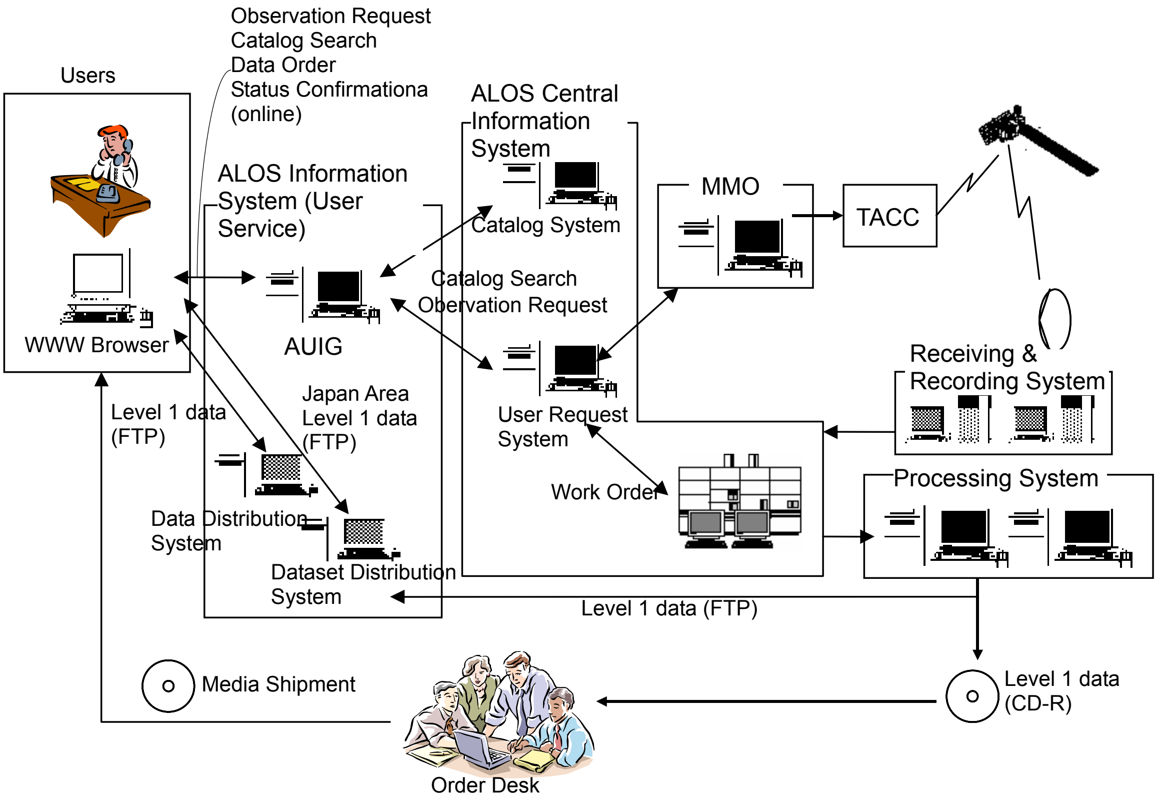



Figure 8.5-3 Product Distribution Flow (by AUIG)

With respect to standard data distribution at the time of inputting requests from users are shown in Table 8.5-3.

Table 8.5-3 Designated Items for Requests (Standard Distribution)

| | **Designated Items** | **Level 0** | **Products** | |
|---|---|---|---|---|
| | | **Standing Request** | **Standing Request** | **AUIG** |
| Common to All sensors | Name of Sensor | [O] | [O] | [O] |
| | Range | [O] (latitude/ longitude) | [O] (latitude/ longitude) | [O] (latitude/ longitude, Path-frame) |
| | Period | [O] | [O] | [O] |
| | Ascending/Descending Designation | O | O | O |
| | Purpose of Observation | O | O | O |
| | Shifting of Scene | — | O | O (only after observation) |
| | Direction of Map | — | O | O |
| | Map Projecting Method | — | O | O |
| | UTM Zone Number | — | O | O |
| | Resampling Method | — | O | O |
| | Orbit Data Accuracy | — | O | O |
| | AttitudeData Accuracy | — | O | O |
| | Compression Option (on-line only) | — | O | O |
| | PS Baseline Latitude and Longitude | — | O | O |
| | Satellite Data Provision Method | O (on-line, DTF-2) | O (CD-R) | O (on-line, CD-R) |
| PRISM | Observation Mode (3 directions, nadir view 70 km etc.) | O | O | O |
| | Pointing Angle (Left, Middle, Right) | O | O | O |
| | Amount of Cloud | — | O | O |
| | Gain | O | O | O |
| AVNIR-2 | Pointing Angle | O | O | O |
| | Amount of Cloud | — | O | O |
| | Light Exposure Coefficient Setting Status | O | O | O |
| | Pixel Spacing | — | O | O |
| | Gain Status | O | O | O |
| PALSAR | Observation Mode, Polarization, Off-nadir Angle | O (Table number) | O (Table number) | O (Table number) |
| | LCC Baseline Latitude 1 | — | O | O |
| | LCC Baseline Latitude 2 | — | O | O |
| | LCC Original Point, Latitude / Longitude | — | O | O |
| | Pixel Spacing | — | O | O |
| | REV Correction | O | O | O |

[O]: Obrigatory items for input.
O: Optional items for input.
Note: As the option for earth ellipsoid is standardized to Bessel as the international standard, it is excluded from the options for the above.

## 8.6 Data Publication

Information which is made public by WWW is shown in Table 8.6-1.

Table 8.6-1 Table ALOS Information to be made Public

| Public Information | Content |
|---|---|
| Image Catalog | To make public image catalog and thumbnail at times of emergency on WWW, within 1 hour and a half from data acquisition (3 hours and a half for PALSAR). |
| Observation Plan<br>(Draft form) | To make public JPEG files with world map indicating observation plan, 2 weeks ahead by swath. |
| Observation Plan<br>(Final) | To make public JPEG files with world map indicating observation plan for the next day. |
| Orbit Control Window | To make public the window of orbit control 8 weeks ahead, by text format. |
| Orbit Control Program | To make public by text format the jetting time of the next day when orbit control program is to be implemented. |
| Inventory Information for Public Announcement | To make inventory information researchable on WWW. In the meantime, the following scenes are not made public (disclosure constraint).<br>Scenes with pointing changes.<br>Scenes where quality evaluation is not good.<br>Scenes where PRISM operating mode is CCD.<br>In addition to the above, for correction mode, scenes are constrained to permitted users only. |
| Flying Position | To indicate ALOS orbit information (position) on maps. |
| Observation Achievements | To indicate on maps, observation achievements by sensor during ALOS mission operation period so that the number of observations by region can be recognized. |
| Utility Information | To make public format for processed data, correction coefficients, etc. |
| Various Tools | To make it possible to download from WWW tools, which are used to transform and excerpt processed data from CEOS to Geotiff. |

## 8.7 AUIG

### 8.7.1 Overview of AUIG

AUIG (ALOS User Interface Gateway) is on-line information service for using the various services about the ALOS satellite by the WWW browser. Informational reference about a satellite, an order of observation data, etc can be performed. Moreover, anyone can use AUIG from the more general one to a specialist/researcher.

- URL of AUIG: https://auig.eoc.jaxa.jp/auigs/en/top/index.html

There are the following in typical service of AUIG. Some of satellite data offer services are required in user's registration.

Service which offers observation data

- Service which offers simple search functions, such as observed data and an observation result (No charge)
- Service which an order of observed data(image etc.) and performs an observed data and an observation request(charge)
- Service which can download the picture of a Japanese area(No charge)

Service which offers various information about ALOS satellite

- Service which indicates a satellite trajectory and the locus by the map.
- Service which indicates the place observed in the past by the map.

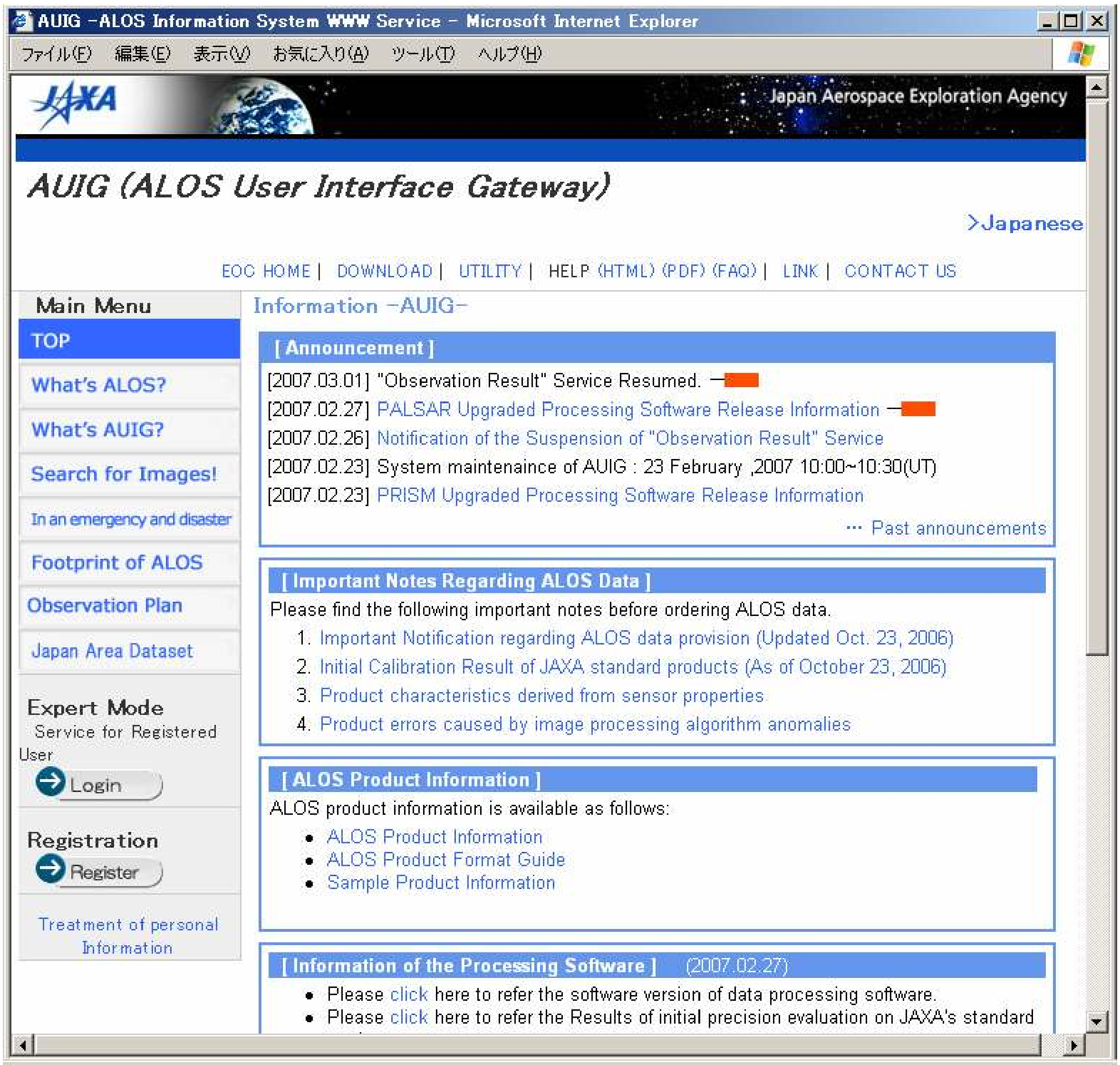



Figure 8.7-1 Front Page of AUIG

(URL: https://auig.eoc.jaxa.jp/auigs/en/top/index.html)


Figure 8.7-2 Expert Menu of AUIG

## 8.7.2 Restriction of Service

Service of AUIG has user restrictions, as shown below.

Table 8.7-1 AUIG Service Category

| Category | Service Contents | Note |
|---|---|---|
| Service which all users can use | Search of Observation/Catalog, Various information disclosure services, etc. | |
| Service which only a registration users can use | Product Order/ Observation Requests, Order Status, etc. | User registration is needed. |
| Service which only a specific users can use | Urgent request, Observation request only, Standing request | Another procedure is required. Please ask the Order Desk to know in detail. |

Table 8.7-2 Service Contents of AUIG

| No. | Service name | Outline | Use Restrictions |
|---|---|---|---|
| 1 | User Registration | There is service which only the registered use for AUIG, Use of this service will become possible, if the input and registration application of user information are made and it is recognized from "User Registration". Since the account (user ID/ password) for logging in is mailed later, use of service is attained from the point in time. | All users |
| 2 | Change User Information | The user information can be changed. | A registration user |
| 3 | Change Password | A registration password can be changed | A registration user |
| 4 | Customize | The display at the time of using AUIG can be set up and changed. –Menu, Map display, Search Criteria, Search result display item. | A registration user |
| 5 | Product Order/ Observation Request | With this service, order and observation request can be carried out to the following three date<br>-Archive Data (Acquired data of an ALOS satellite)<br>-Observation Schedule Scene (The product to observation planned ending )<br>-Observation Request (The observation request to the future which is not planned yet) | A registration user |
| 6 | Order Status | Check of status, change / demand cancellation, etc, can be performed to order performed by "product Order/Observation Request", fixed request, and direct Observation request to MMO. | A registration user |
| 7 | Japan area dataset | Reference, information perusal and download can do the newest and good (example; There is little cloud coverage) picture (processed data of a Geo Tiff format) of Japanese continental area. | All users |
| 8 | Search of Observation/Catalog | With this service, it can refer to three kinds of following data.<br>-Archive Data (Acquired data of an ALOS satellite)<br>-Observation Schedule Scene (The product to observation planned ending)<br>-Observation Request (The observation request to the future which is not planned yet)<br>However, order/observation request cannot be requested. Please use "Product Order/ Observation Request" for performing an order etc. after User Registration. | All users |
| 9 | Observation Result | The observation actual result in the operation period of an ALOS satellite can be checked per sensor. | All users |
| 10 | Observation Plan (Image) | The observation plan of an ALOS satellite can be referred to | All users |
| 11 | Orbit Maneuvering Information | The orbit maneuvering plan (change plan of a satellite's orbit) and orbit control window (information about orbit maneuvering) of an ALOS satellite can be referred to. | All users |
| 12 | Satellite Trajectory | The observation plan of an ALOS satellite can be referred to. | All users |
| 13 | Urgent Observation Image | The picture which carried out urgent observation for ALOS can be referred. | All users |
| 14 | Download | Download of various tools required for ALOS data use be performed. | All users |
| 15 | AUIG User Guide | The data accounting information, etc. are carried | All users |
| 16 | Utility | Various utility information, such as a data format and the number of calibration, etc. required for ALOS data use is carried. | All users |

### 8.7.3 NOTES

About the restriction value by the reference number of cases (Product Order / Observation Request service)

With Products Order / Observation Request service, restriction is prepared as follows about the number of scenes which can be searched at a time in consideration of time which reference takes.

- When only archive data is searched: 3000 scenes
- When other: Archive data, an observation plan scene, and observation request are 1000 scene each.

If this number of cases is exceeded, search will be interrupted automatically and the search result so far will be displayed.

About the domain specification range at the time of search (Product Order / observation request service, Observation and Catalog search service)

In AUIG, the following search results may be brought by the specification range of a search domain on the character of search logic,

- When the latitude of the appointed domain exceeds 40 degrees, the scene outside a domain is searched seemingly.
- If a long domain is specified in the direction of longitude, the result only corresponding to a request domain may not be obtained.

Please be reminded to About these points in advance.

Change and cancellation of order contents (Order Status service)

A series of processings form an order receptionist to product creation are automatically performed by the system. Therefore, while performing order contents change or cancellation from the time of being displayed on the screen of order status services, product creation may already be started. An order contents change or cancellation is not received at this time, Please be reminded to About these points in advance.

Moreover, about an observation plan scene and an observation request, when it may change or may cancel order contents, if the hold option after observation is specified at the time of an order, such a thing will no happen.

Display of an observation result (Observation Result Display service)

An observation result is displayed by two kinds, “wide mesh unit” and “GRS mesh unit”, and changes automatically according to the scale of a map. Since “wide mesh unit “is what displays the maximum which summarized the observation result in a “GRS unit mesh”, please use “wide mesh unit” as rough standard. In addition, since it differs from a scene even if it is the display of a “GRS unit”, an error is included. Please use “Observation and Catalog Search” about the check of a strict observation scene.

# APPENDIX

# Appendix 1 Acronyms and Abbreviations

## Appendix 1.1 Abbreviations

| | | |
|---|---|---|
| ADDS | : | ALOS Data Distribution System |
| ALOS | : | Advanced Land Observing Satellite |
| AOCS | : | Attitude & Orbit Control System |
| APID | : | Application Process Identification |
| ARTEMIS | : | Advanced Relay and Technology Mission Satellite |
| ASF | : | Alaska SAR Facility |
| ATT | : | Attenuator |
| AUIG | : | ALOS User Interface Gateway |
| AUSLIG | : | Australian Surveying & Land Information Group |
| AVNIR-2 | : | Advanced Visible and Near Infrared Radiometer type 2 |
| BOL | : | Beginning of Message |
| CAL/VAL | : | Calibration and Validation |
| CCSDS | : | Consultative Committee for Space Data Systems |
| CNES | : | Centre National d'Etudes Spatiales |
| CR | : | Carriage Return |
| DEM | : | Digital Elevation Model |
| DM | : | Deployment Monitor |
| DRC | : | Data Relay Satellite Communication |
| DRN | : | Data Ready Notification |
| DRTS | : | Data Relay and Tracking Satellite |
| DT | : | Direct Transmission |
| ECI | : | Earth Center Inertial coordinates |
| ECR | : | Earth Centered Rotating coordinates |
| EOC | : | Earth Observation Center |
| EOL | : | End of Life |
| EOM | : | End of Message |
| EORC | : | Earth Observation Research Center |
| ERSDAC | : | Earth Remote Sensing Data Analysis Center |
| ESA | : | Earth Sensor Assembly |
| ESA | : | European Space Agency |
| FBD | : | Fine Resolution Mode, Dual polarization |
| FBS | : | Fine Resolution Mode, Single polarization |
| FIFO | : | Fast-In Fast-Out |
| FTP | : | File Transfer Protocol |
| GA | : | Geoscience Australia |
| GISTDA | : | Geo-Informatics and Space Technology Development Agency |
| GN | : | Ground Network |
| GPS | : | Global Positioning Satellite |
| GPSR | : | GPS Receiver |
| HCE | : | Heater Control Electronics |
| HK | : | Housekeeping |
| HSSR | : | High Speed Solid State Recorder |
| ICD | : | Interface Control Document |
| IGS | : | International GPS Service |
| IRU | : | Inertial Reference Unit |
| JAXA | : | Japan Aerospace Exploration Agency |
| JERS | : | Japanese Earth Resources Satellite |
| LLM | : | Low Load Mode |
| LNA | : | Low Noise Amplifier |
| LR | : | Laser Reflector |
| LSSR | : | Low Speed Solid State Recorder |
| MDR | : | Mission Data Recorder |

| | | |
|---|---|---|
| MGC | : | Manual Gain Control |
| MMO | : | Mission operation Management Organization |
| MOIP | : | Mission Operations Implementation Plan |
| MOIS | : | Mission Operations Interface Specification |
| MTF | : | Modulation Transfer Function |
| NASDA | : | National Space Development Agency of Japan |
| PALSAR | : | Phased Array type L-band Synthetic Aperture Radar |
| PCD | : | Payload Correction Data |
| PI | : | Principal Investigator |
| PRI | : | Pulse Repetition Interval |
| PRISM | : | Panchromatic Remote-sensing Instrument Stereo Mapping |
| RARR | : | Range and Range Rate Measurement |
| RCN | : | Receipt Confirmation Notification |
| REV | : | Rotating Element Electric Vector |
| RF | : | Radio Frequency |
| RS | : | Reed-Solomon |
| RSP | : | Reference System for Planning |
| SEES | : | Space Environment & Effects System |
| SLC | : | Single Look Complex |
| SLR | : | Satellite Laser Ranging |
| SMTP | : | Simple Mail Transfer Protocol |
| SN | : | Space Network |
| STC | : | Sensitivity Time Control |
| STT | : | Star Tracker |
| TACC | : | Tracking And Control Center |
| TBD | : | To Be Determined |
| TBR | : | To Be Reviewed |
| TCP/IP | : | Transmission Control Protocol/Internet Protocol |
| TEDA | : | Technical Data Acquisition Equipment |
| TKSC | : | Tsukuba Space Center |
| TT&C | : | Tracking Telemetry and Control |
| USB | : | Unified S-Band |
| UTC | : | Universal Time Coordinated |
| VCA | : | Virtual Channel Access |
| VCID | : | Virtual Channel Identification |
| VCDU | : | Virtual Channel Data Unit |
| VMD | : | Virtual channel Multiplexer and Distributor |
| WB1 | : | Wide Area Observation Mode (Burst mode 1) |
| WWW | : | World Wide Web |

## Appendix 1.2 Terminology

- **Command Signal:**

  Orders to the spacecraft such as turn-on/off of an instrument’s switch, and start/end of observation.

- **Telemetry Data:**

  The data which shows a state of each component of spacecraft such as temperature of instrument, turn-on/off of switch, and observation mode.

- **Light Load Mode:**

  It is an operation mode which is the mode to avoid loosing functions of overall spacecraft in case of spacecraft or instruments anomaly by turning off all the instruments except the minimum ones and keeping controlling power consumption.

- **Autonomous/Automatic:**

  The function that shifts to the light load mode immediately by spacecraft onboard software without waiting for the command transmitted from the ground in case of spacecraft or instruments anomaly. This function may decrease the probability of the function loss.

- **CCSDS Advice:**

  The international standard of data processing protocol advised by Consultative Committee for Space Data Systems (CCSDS) co-established by space agencies of each countries including JAXA.

- **MIL-1553B:**

  It is a kind of data transmission method inside spacecraft and one of the standards established by US Department of Defense.

# Appendix 2　Reference Information

## Appendix 2.1　Reference Documents

- **ALOS Product Format Specification** (URL: http://www.eorc.jaxa.jp/ALOS/doc/format.htm)
  - ALOS PRISM Level 1 Product Format Descriptions, NEB-01006 (ALOS-DPFT-E01)
  - ALOS AVNIR-2 Level 1 Product Format Descriptions, NEB-01006 (ALOS-DPFT-E02)
  - ALOS PALSAR Level 1 Product Format Description (Vol.1: Level 1.0), NEB-01006 (ALOS-DPFT-E03)
  - ALOS PALSAR Level 1 Product Format Description (Vol.2: Level 1.1/1.5), NEB-01006 (ALOS-DPFT-E04)

- **ALOS Processing Algorithm**
  - ALOS PRISM/AVNIR-2 Processing Algorithm Descriptions, NEB01007（ALOS-DPAD-E01）
  - ALOS PALSAR Level 1.0 Processing Algorithm Descriptions, NEB01007（ALOS-DPAD-E02）

## Appendix 2.2　Relative Web Pages

- **Japan Aerospace Exploration Agency (JAXA) Home Page**
  - http://www.jaxa.jp/index_e.html
- **JAXA/Office of Space Applications Home Page**
  - http://www.satnavi.jaxa.jp/index_e.html
- **JAXA/Earth Observation Research Center (EORC) Home Page**
  - http://www.eorc.jaxa.jp/en/index.html
- **EORC ALOS Home Page**
  - http://www.eorc.jaxa.jp/ALOS/index.htm

## Appendix 2.3　Points of Contact

- **General Users contact point for ALOS**
  - **Europe and African Region**
    **European Space Agency (ESA)**
    E-mail: eohelp@esa.int
  - **North and South America Region**
    **Alaska Satellite Facility (ASF), User Services Office**
    E-mail: USO@aadn.alaska.edu
  - **Oceania Region**
    **Geoscience Australia (GA)**

E-mail: acres@ga.gov.au

- **Asia Regions**
  **Remote Sensing Technology Center of Japan (RESTEC)**
  E-mail: data@restec.or.jp

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TEL: +81-3-5561-9771, FAX: +81-3-5561-9540
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■ **Joint Researchers and PI contact point**

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2-1-1, Sengen, Tsukuba-city, Ibaraki 305-8505 Japan
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