Advance Land Observation Satellite (ALOS) and its follow-on satellite, ALOS-2

Masanobu Shimada

JAXA/EORC

Jan. 26 2009
Launch date: 2006/1/24
Launcher: H-IIA-8
Mass: about 4,000kg
Solar power: about 7kW
Orbit: Sun synchronous
Height: 691.65km
Cycle: 46 days (2 days)

Mission objectives:
- Mapping
- Regional observation
- Disaster monitor
- Resources
- Technology development

Orbit determination: (10cm)
Yaw steering: April 25, 2006
Orbital Tube: ~500m (after Aug. 7)
Summary of the three year life on orbit

1. Satellite and the sensors are in good conditions.
2. 8000w of solar power with 1000w margin than 7000w.
3. Orbit maintenance for height in every 2 weeks and for inclination for every two year and a half using 30 kg fuel.
4. Acquire daily 11 hours for three sensors supported by DRTS.
5. The data exceeds 400TB for three years, 1.2M for PRISM, 0.6M for AVNIR-2, and 0.9 M for PALSAR.
6. Basic Observation scenario proceeds the continental scale gap free high resolution observation planning.
7. Four mission objectives have been achieved.
8. One transmitter communicating with the DRTS was lost on April/E 2007.
Subsytem (TT&C, AOCS)

- **Telemetry, Tracking & Command**: good
  Direct USB & inter-satellite SSA communications

- **Attitude and Orbit control system**: good
  All functions & mode transitions operate well.
  RSP control: within ±0.5km. (Spec. ±2.5km)
  The inclination control maneuver has completed.
  About 30kg of propellant has been used for the inclination control.
  The remaining propellant is 115kg. This quantity can achieve long-term mission more than 5 year.

![Propellant Consumption](Image)

- C/O, CAU/VAL Phase
- Normal Operation Phase
- Eccentricity control, frozen orbit
- Inclination Control maneuver

![Graph](Image)

- Jan-06 to Jul-08
Operation status of each sensor

Observation results
Duration: 2006/5/16 (CAL/VAL) ~ 2008/3/8 (17 cycles)
Following images contains all the operation modes.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Total number of scenes</th>
<th>Cloudless scenes</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRISM</td>
<td>918,144</td>
<td>316,351</td>
</tr>
<tr>
<td>AVNIR-2</td>
<td>418,092</td>
<td>127,341</td>
</tr>
<tr>
<td>PALSA</td>
<td>723,801</td>
<td>-</td>
</tr>
</tbody>
</table>

8 times global covers by PALSAR.

![FBS](image1.png)  ![FBD](image2.png)  ![PLR](image3.png)
PALSAR calibration and validation

Summary

Geometric accuracy : 9.6 m
Radiometric accuracy : 0.64 dB
NESZ is -34 dB

Shows the stability for all the characteristics and the calibrations


Updated in the SAR processor :

SCANSAR : updated on July E 2008: Maintain the linearity of the NRCS

FBS, FBS, FBD, : recalibrated using the Amazon and CRs and detected 0.3 or less value changes; FBD-HV was updated by modifying the calibration chain: Jan. B, 2009.
PALSAR Transmission power monitor

PALSAR Power monitor results (80 T/R modules)

Total Power >= 2200W (Spec=2000W)
No degradation measured.

PALSAR is very stable.
FBD HH ~ -31 dB, FBD HV ~ -34 dB
Validation of cal results: using the Amazon forest data

0.22 dB (FBS) and 0.4 dB (SCAN)

![Graph showing Sigma-naught and Gamma-naught](image)
Application examples

Forest monitoring, deforestation and forest degradation

Ice sheet monitoring

Surface deformation monitoring

Disaster monitoring, flooding, land slide, deformation, etc.

Coastal wind field monitoring

Ortho map and DEM generations

Etc.
Amazon Deforest Watch (Santarem) JERS-1 & ALOS

Acquisition Term
1993/6/26 ~ 2007/9/13

JERS-1
- 1993/6/26
- 1997/5/4
- 1997/7/31

ALOS
- 2007/6/13
- 2007/9/13

Lat : S 2°34’
Lon : W 54°45’
PALSARを用いたブラジルにおける森林違法伐採の阻止取り組み

**Law Enforcement Deforestation Assessment - Mid-term results**

**Project objectives**

The Palsar ALOS data will assist the identification of very recent deforestation activities and also where the cloud cover is a limiting factor for the use of optical remote sensing as a resource to support field activities.

**Results**

The first operational results are presented, it is the beginning of use of PALSAR data to identify new polygons of deforestation.

**K&C Science Team members**

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Dr. Guilherme H. de Almeida
Federal Police Department - DF, Brazil.

**Image captions**

<table>
<thead>
<tr>
<th>Month</th>
<th>ALOS x DETE</th>
<th>Overall</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>40</td>
<td>45</td>
<td>6.07%</td>
</tr>
<tr>
<td>February</td>
<td>30</td>
<td>36</td>
<td>7.69%</td>
</tr>
<tr>
<td>March</td>
<td>10</td>
<td>19</td>
<td>19.00%</td>
</tr>
<tr>
<td>April</td>
<td>65</td>
<td>124</td>
<td>16.77%</td>
</tr>
<tr>
<td>May</td>
<td>13</td>
<td>137</td>
<td>18.40%</td>
</tr>
<tr>
<td>Total</td>
<td>137</td>
<td>423</td>
<td></td>
</tr>
</tbody>
</table>

**Analysis**

- ALOS PALSAR data used
  - WB1 & FBS HH (50m)

- Other data sources
  - CBERS-2, 2b & Landsat TM
POLINSAR 2009 WORKSHOP

JERS-1 SAR

PALSAR

1km/year

Jakobshavn Glacier

PALSAR Polarimetric mapping of Greenland and easting of glacier braking

26-30 January 2009 | ESA-ESRIN | Frascati (Rome) Italy
北極圏画像
Neal real time info distribution

Contents:

10:30
Reception of ScanSAR
At EOC受信処理
TKSC画像作成

14:00
Data distribution to
Japan Coastal Guard of Hokkaido
Sea Ice Quick Info.

17:00
Open the Sea Ice Info.

Sea Ice monitoring at the Okhotsuku using PALSAR SCANSAR
May 12 2008
M. 7.9

Wenchuan Earthquake

Observation
May 14~Jul E 2008
Solomon Earthquake

M8.1
April 2 2007

Three DinSAR
344:4/10-2/23
345:5/3-1/31
343:5/10-2/12

FBS343HH

No orbit tuned.
No further corrected.
Three paths overlaid.
Wind speed distribution measured by PALSAR
Mステレオ画像を用いた数値地表モデル(DSM)および正射投影画像（精度5

Tarumi City, Kagoshima Prefecture, Japan
Obs. Date: PRISM, AVNIR-2 Nov. 8, 2006
PALSAR InSAR DEM: 3D view of the PALSAR FBD images ortho rectified using the PLASRA INSAR DEM. Yoshino river and the surrounded area, Shikoku, Japan.
Flooding in Nepar (Water Reserver Broken down)

- Aug. 18 2008 Dam (Water Reserver) was broken
- Aug. 24 2008, Urgent observation (PALSAR FBD)
  - Reference image July 21, 2008 (PALSAR/FBS)

\[ R:G:B = A-HH:A-HV:B-HH \]

↓ Before  ↓ After

![Before and After Images with Dam and Flood indications]
JAXA Operating and Planned Satellites

- GCOM-C
- GCOM-W
- GPM/DPR
- Daichi
- GOSAT
- AOM/AMSR-E
- ALOS-2 (SAR)
- TRMM/PR
- KIKU-8
- KIZUNA
- Earth CARE/CPR
- ALOS-3 (Optical)
- QZSS
- KODAMA
- QOSAT
- 26-30 January 2009 | ESA-ESRIN | Frascati (Rome) Italy
ALOS-2 program

JAXA seeks to launch the ALOS-follow-on satellite several years ago.

It was finally approved by the Japanese government as the ALOS-follow-on aiming the high resolution earth observation -

Disaster monitoring
Environmental monitoring
Comparison of the Pi-SAR (L) with Optical Image over the Tokyo Bay
Pi-SAR(2x5m:HV) shows almost the same visibility with the optical sensor under
the same resolutions condition and applicable for the earth monitoring.
**ALOS-2**

**Main target areas**
- Forest
- Sea ice
- River
- Rice field monitoring

**Main observation modes**
- High resol.: 1 ~ 3m, swath 25km
- Basic obs.: 3m, swath: 50km
- Wide obs.: 100m, swath: 350km

**Mission data**
- Direct transmission and Ka band DRTS

**Launch**
- Time: Winter, JFY2012
- Launcher: H-2A

**Satellite**
- Mass: 2 ton type
- Paddle: 2 paddles

**Orbit**
- Type: Sun synchronous
- Height: ~630km
- LST: 12:00 (local noon)
- Designed life: Five years
- Descending

**SAR frequency**
- Lband (1.2 GHz)

**Artistic view**

Moving direction
## ALOS-2 SAR observation modes

### SAR observation modes and performance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Spotlight</th>
<th>Strip map (High Resolution)</th>
<th>Strip map (High Sensitivity)</th>
<th>Strip map (Conventional)</th>
<th>ScanSAR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>84MHz</td>
<td>84MHz</td>
<td>42MHz</td>
<td>28MHz</td>
<td>14MHz</td>
</tr>
<tr>
<td>Incident Angle</td>
<td>8 to 70 degrees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bandwidth</td>
<td>84MHz</td>
<td>84MHz</td>
<td>42MHz</td>
<td>28MHz</td>
<td>14MHz</td>
</tr>
<tr>
<td>Res. Rg</td>
<td>3m</td>
<td>3m</td>
<td>6m</td>
<td>10m</td>
<td>100m</td>
</tr>
<tr>
<td>Res. Az</td>
<td>1m</td>
<td>1m</td>
<td>6m</td>
<td>10m</td>
<td>100m</td>
</tr>
<tr>
<td>Swath</td>
<td>25km(Rg)*25km (Az)</td>
<td>50km</td>
<td>50km</td>
<td>70km</td>
<td>350km</td>
</tr>
<tr>
<td>Polarimetry</td>
<td>single</td>
<td>single,dual</td>
<td>single,dual,CP,FP</td>
<td>single,dual,CP,FP</td>
<td>single,dual</td>
</tr>
<tr>
<td>NESZ Rg</td>
<td>-26dB</td>
<td>-24dB</td>
<td>-28dB</td>
<td>-26dB</td>
<td>-26dB</td>
</tr>
<tr>
<td>NESZ Az</td>
<td>-26dB</td>
<td>-24dB</td>
<td>-28dB</td>
<td>-26dB</td>
<td>-26dB</td>
</tr>
<tr>
<td>S/A Rg</td>
<td>25dB</td>
<td>25dB</td>
<td>23dB</td>
<td>25dB</td>
<td>25dB</td>
</tr>
<tr>
<td>S/A Az</td>
<td>20dB</td>
<td>20dB</td>
<td>20dB</td>
<td>20dB</td>
<td>20dB</td>
</tr>
</tbody>
</table>

Performance @ incident angle 37deg

- **CP**: Compact Polarimetry (Linear+circular)
- **FP**: Full Polarimetry (HH+HV+VV+VH)

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**Note:**

- **Observation area**
  - **ScanSAR**: 25 km x 25 km
  - **Spotlight**: 1160 km x 50 km

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**26-30 January 2009 | ESA-ESTRIN | Frascati (Rome) Italy**
One day observation area by ALOS-2 (one day)

ALOS-2 can observe Japan 1~4 times per day.

- (1): ~11am
- (2): ~13:00
- (3): ~23:00
- (4): ~1:00

• 観測可能範囲（ピンク）の内、50km幅を観測可能
• 観測可能範囲は日によって東西に平行移動するため、左図は一例である。
Summary

ALOS is well conditioned and may be on the orbit more than 7 years. PALSAR and the other two optical sensors show the well stability as well, and being used for the land surface monitoring.

ALOS-2 program was recently approved as the ALOS folwon satellite to carry only SAR for continuos earth monitoring.
Features of ALOS-2

- High resolution SAR based observation system
- Similar Observation duties of \(~30\%\) to ALOS/PALSAR.
- Improving the observation response (once per day)
  - Both side capability
  - Enlarged incidence angle of 8\(^\circ\) to 70\(^\circ\)
- Frequent orbit inclination maintenance for successive interferometry
  - All the orbits will be within 500m tube of the reference orbit
- Reducing the RA by
  - up/down chirp and phase modulation for \((0/\pi)\)
- High band data transmission
  - Direct transmission: 840Mbps (6 times of ALOS)
  - Communication with DRTS: 278Mbps (similar to ALOS)
Mt. Fuji
Japan

Google Earth
OPS (left)
and

ALOS-PALSAR
Quad. Pol.
Power
decomposed
image
(right)
ニューオーリンズ洪水（グスタフ被
害）

• 2008年8～9月ハリケーン・グスタフによる浸水被害
• 2008年9月3日（UT）緊急観測（PALSAR/FBS）
  参照用画像 2008年4月6日（PALSAR/FBS）

災害前後のPALSAR画像によるカラー合成
RG:B = 災害後:災害前
青色は浸水の可能性が高い領域
A purpose to reduce a change width of Local sun time at descending node (Ts).

It was conducted twice in June and July, 2008.

Although the ALOS orbit was deviated from RSP $\pm 2.5$km for a week (Spec. RSP $\pm 2.5$km) after inclination maneuver, it has successfully returned within RSP $\pm 500$m.

<table>
<thead>
<tr>
<th></th>
<th>$\Delta i$ START</th>
<th>Deviate from RSP $\pm 2.5$Km</th>
<th>within RSP $\pm 500$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>2nd</td>
<td>30 Jul.</td>
<td>31 Jul. ~ 5 Aug.</td>
<td>4 Sep. ~</td>
</tr>
</tbody>
</table>
ALOS follow-on (2 SAR + 2 OPT)

- **Satellite**
  - SAR satellite
    - GSD: 3m (strip map), 3m*1m (spotlight),
    - Swath: 50km
    - L-band
  - Optical satellite
    - GSD: 1m (Pan), 4m (Multi-spectral)
    - Swath: 50km
  - First satellite: launch target JFY2012

- **Goal**: High resolution land observation
高分解能画像の災害への応用（長岡市土砂崩れ（分解能の比較））

長岡市
切り出し位置
土砂崩れ現場（円内）

2004年10月2日
観測Pi-SAR(L)

2.5m分解能
1500m

5m分解能
10m分解能

集落
土砂崩れ
国道589号線

小千谷市

2004年10月2日
観測Pi-SAR(L)
Flooding of Gifu Prefecture

- Flooding occurred due to the concentrated rain of Sept 2 and 3, 2008
- Urgent observation of PALSAR on Sept. 2 and 3, 2008
- Provision of the analyzed data to Gifu prefecture.

Estimated flooding region using the PALSAR (Sept. 3 2008)
Light blue: flooded region
Background image: PALSAR image after the disaster
<table>
<thead>
<tr>
<th>項目</th>
<th>高分解能モード</th>
<th>基本モード</th>
<th>高感度モード</th>
<th>中分解能モード</th>
<th>広域観測モード</th>
</tr>
</thead>
<tbody>
<tr>
<td>中心周波数</td>
<td>1257.5MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>観測入射角</td>
<td>8 ～ 70deg</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>観測帯域幅</td>
<td>Rg     84MHz  84MHz  42MHz  28MHz  14MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>空間分解能</td>
<td>Rg     3m以内 3m以内 6m以内 10m以内 100m以内</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>観測幅</td>
<td>Rg x Az 50km以上 50km以上 50km以上 70km以上 30km以上 350km以上</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>偏波</td>
<td>単偏波</td>
<td>単偏波/2偏波</td>
<td>単偏波/2偏波/CP</td>
<td>FP</td>
<td>FP</td>
</tr>
<tr>
<td>偏波分離度 (暫定)</td>
<td>N/A</td>
<td>30dB以上</td>
<td>30dB以上</td>
<td>30dB以上</td>
<td>30dB以上</td>
</tr>
<tr>
<td>データレート</td>
<td>800Mbps以下</td>
<td>800Mbps以下</td>
<td>800Mbps以下</td>
<td>800Mbps以下</td>
<td>800Mbps以下</td>
</tr>
<tr>
<td>S/A 規格偏波</td>
<td>Rg     25dB以上 25dB以上 23dB以上 25dB以上 25dB以上</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Az規定偏波</td>
<td>Rg     20dB以上 25dB以上 20dB以上 23dB以上 23dB以上</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

空間分解能：赤道上、観測入射角37degを含むシーン内での性能。広域観測モード以外は1ルックで定義。
観測幅：基本モードのみ全入射角範囲で50km以上。それ以外のモードは赤道上、観測入射角37degを含むシーン内で規定。
偏波：CP：45deg直線偏波あるいは円偏波を送信し、H,Vで受信。FP：HH+HV+VH+VV。
データレート：DS-PAC方式（暫定）を用いたデータ圧縮後のデータレートで規定。
NESZ：赤道上観測入射角37degを含むシーン内中心で規定。
S/A：赤道上、観測入射角37degを含むシーンで既定。
「だいち」による岩手宮城内陸地震の変動

発生：2008年6月14日  M7.2

Unwrapped deformation
in lie of sight

距離（ピクセル）

高さ（cm）

76.7 cm

-127 cm

3,000ピクセル