Advanced Land Observing Satellite

NASDA
NATIONAL SPACE DEVELOPMENT AGENCY OF JAPAN

PRISM, AVNIR-2, PALSAR

- ALOS's Major Mission Instruments -

at ALOS Symposium

on

27 March 2001

Yuji Osawa

Associate Senior Engineer

ALOS Project Team

NASDA

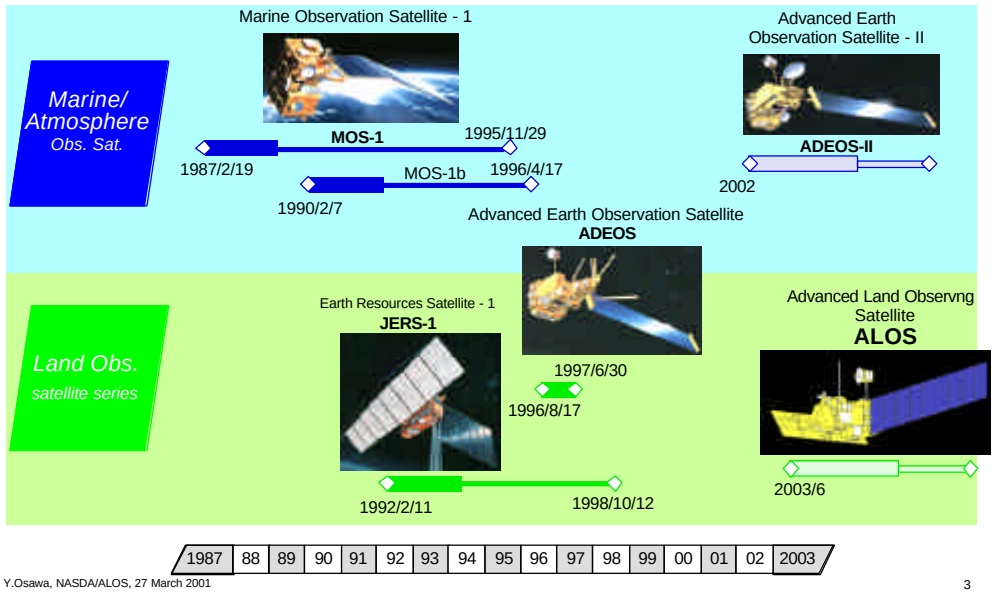
ALOS

NASDA

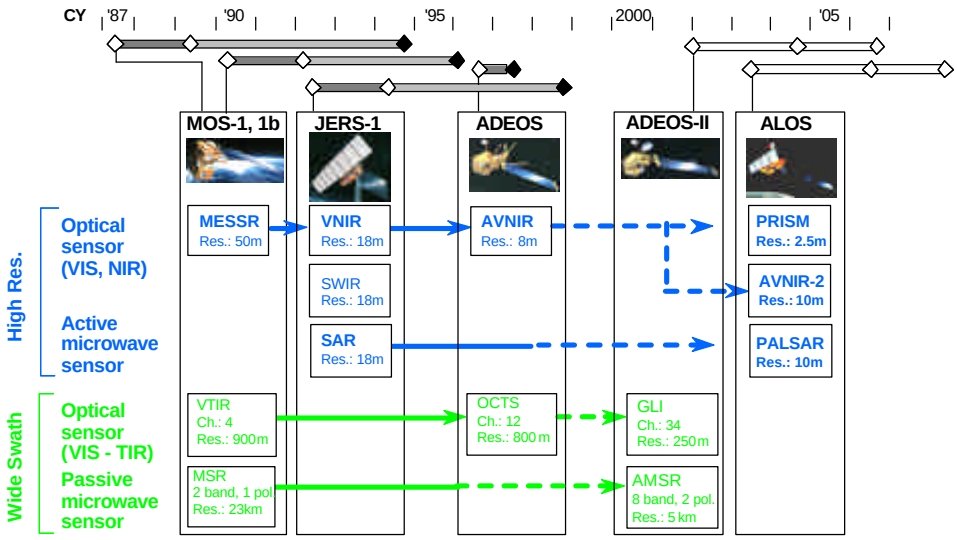
OUTLINE

- Heritage of Japanese Earth Observation Instruments
- Overview and Characteristics of Three Mission Instruments
  - PRISM
  - AVNIR-2
  - PALSAR
- Current Status of Sensors

Japanese Earth Obs. Satellite Series



Japanese Earth Obs. Sensors



Heritage of Japanese High Res. Optical Sensor

- MOS-1/MESSR: 50 m, 100 km, 4 bands (VIS - NIR)
- JERS-1/OPS(VNIR): 18 m, 75 km, 3 bands (VIS - NIR)
- ADEOS/AVNIR: 8 m, 80 km, 1 band (Pa)
  16 m, 80 km, 4 bands (VIS - NIR)

- ALOS/PRISM: 2.5 m, 70 km, 1 band (Pa)
- ALOS/AVNIR-2: 10 m, 70 km, 4 bands (VIS - NIR)

Mapping Requirements (1)

1) Providing 3 to 5 m altitude accuracy Digital Elevation Model (DEM):
   - (a) 2.5 m resolution panchromatic image,
   - (b) triplet stereoscope image with nadir, forward and backward sensors,
   - (c) base to height ratio between fore and aft telescopes is equal to 1.0.
2) Providing "mapping without any ground control points" capability:
   - (d) exact satellite position information within 2.5 m accuracy,
   - (e) exact satellite attitude information within 0.0002 degree accuracy,
   - (f) absolute time information for each pixel within 370 msec accuracy.

Mapping Requirements (2)

3) Providing "distortion free image":

(g) Long term attitude stability shall be within 0.0002 degree/sec.

4) Requirement for 1), 2) and 3):

(h) to minimize thermal distortion among three telescopes' optical axes, and between telescope's optical axes and attitude sensors (Star Tracker, Inertial Reference Unit) in orbital period (100 minutes).

"Mapping without any GCPs"

- Ground Control Point (GCP):
  - GCP is used for determining exact location of each pixel and/or compensation of distorted image.
  - Sharp-edged objects (artificial or natural) are desirable for GCPs,
    - ✓ building, bridge, airport runway, cape,…
  - Five to ten GCPs are required in each scene.
- Not applicable for unmapped region when ground surveying is not available.
  - 69% of the world is unmapped in 1/25,000 scale. (United Nations' statistics, 1995)
- "Mapping without any GCPs" is at the top of Surveyor's wish list.
- ALOS is the first satellite to achieve this goal.

PRISM Features

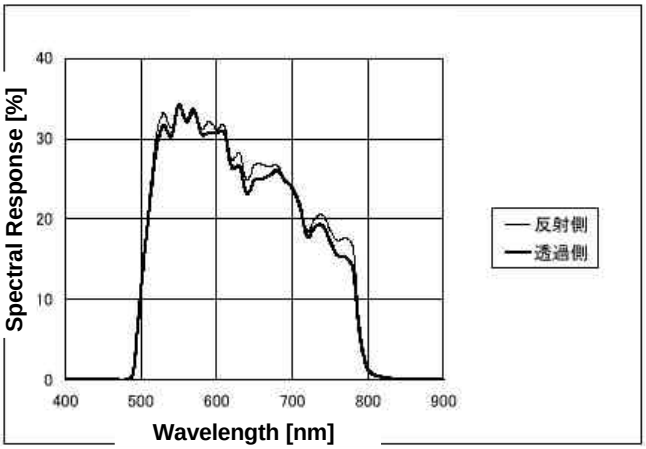
Panchromatic Remote-sensing Instrument for Stereo Mapping

- ☑ **Three independent telescopes**
  - ◆ Better stereoscope capability (B/H=1)
  - ◆ Gathering global data promptly (along track/ one-orbit stereo)
- ☑ **Three mirror optics**
  - ◆ Wide FOV
  - ◆ No chromatic aberration
  - ◆ Good image quality
- ☑ **Moderate swath width and high resolution**
  - ◆ up to 70 km
  - ◆ 2.5 m

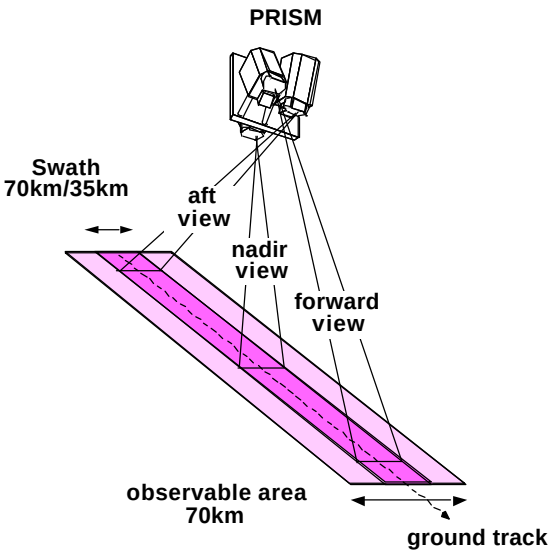
PRISM Characteristics (nominal)

Item	Characteristics	Remarks
Wavelength	0.52 - 0.77 μm	
Field-of-View	7.6 deg	
Swath Width	70 km	Nadir
	> 35 km	Fore and Aft
Instantaneous FOV	3.61 μrad	
Spatial Resolution	2.5 m	Nadir
Scanning Method	Push broom	using multiple CCDs
Base-to-Height Ratio	1.0	between fore and aft
MTF	0.27 (cross-track)	@Nyquist freq.
	0.21 (along-track)	
S/N	80	
Quantization	8 bits	

PRISM Spectral Response

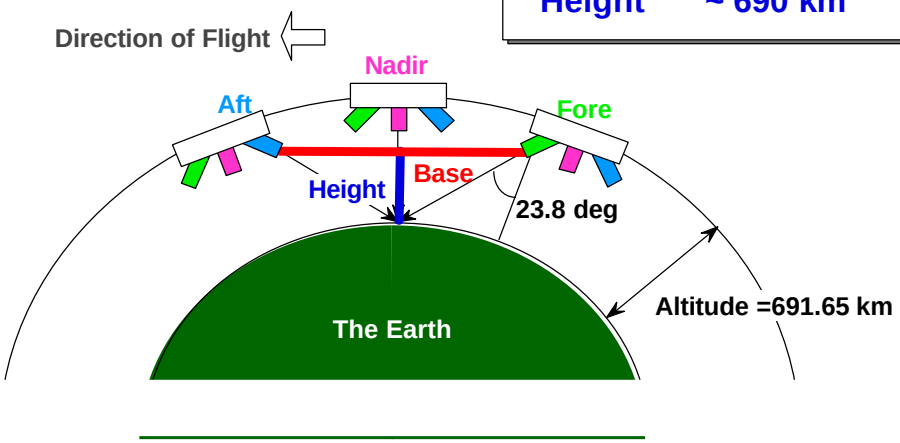


PRISM Observation Geometry

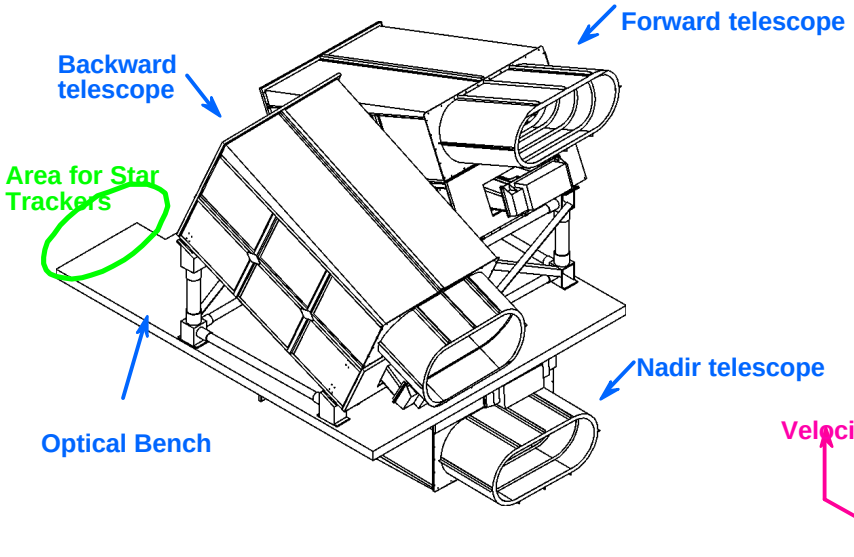


Geometry of Stereoscope

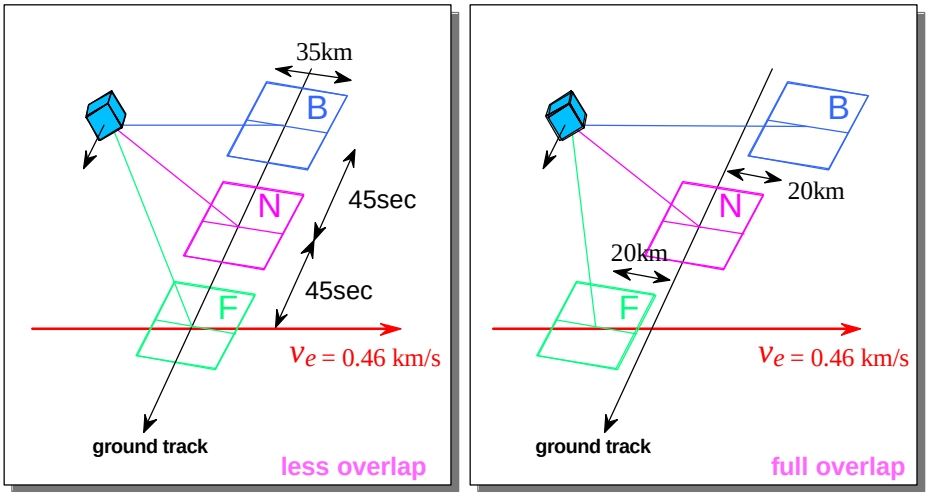
$$\frac{\text{Base}}{\text{Height}} = \frac{\sim 690\ \text{km}}{\sim 690\ \text{km}} = 1$$



PRISM Three-telescope System

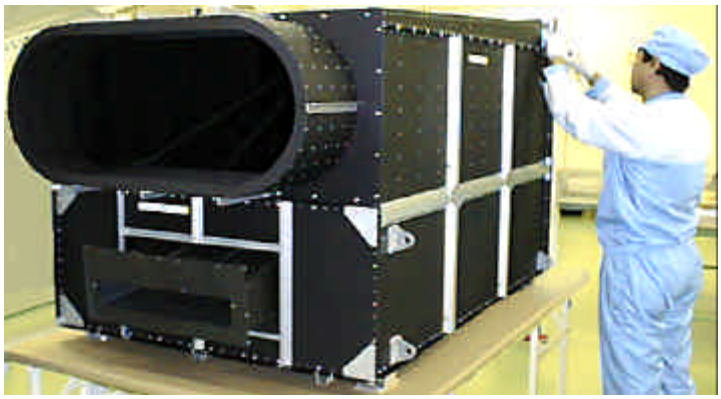


PRISM's On-board Earth Rotation Correction for fully overlapped triplet image



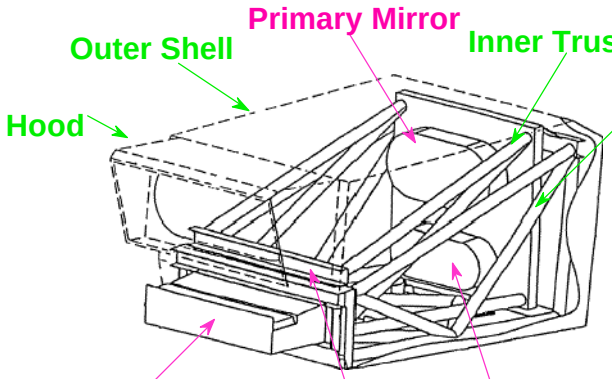
No Correction | **On-board Correction**

PRISM's Bread Board Model



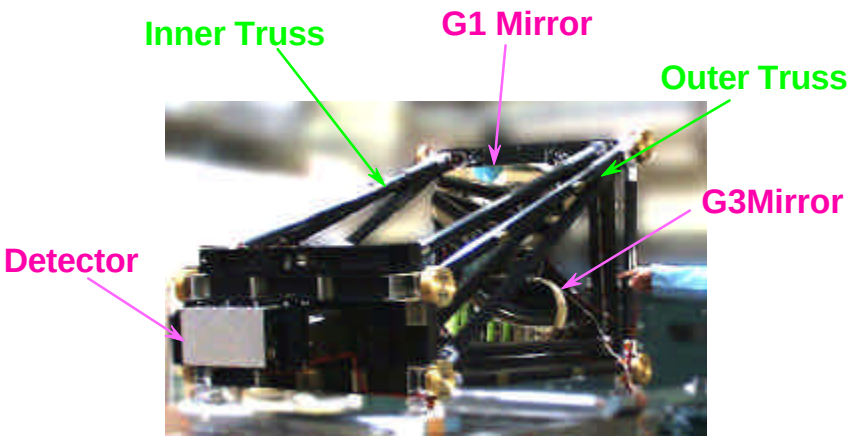
2.0m x 1.0m x 1.0m

Structure of PRISM

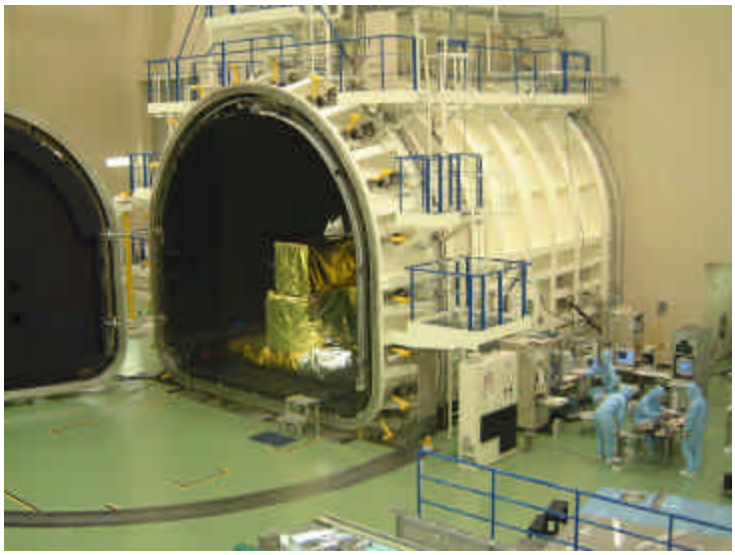


- Advantage of Three-Mirror Optics
  - ☑ Wide FOV
  - ☑ No Chromatic Aberration
  - ☑ Good MTF

PRISM Optics (BBM)



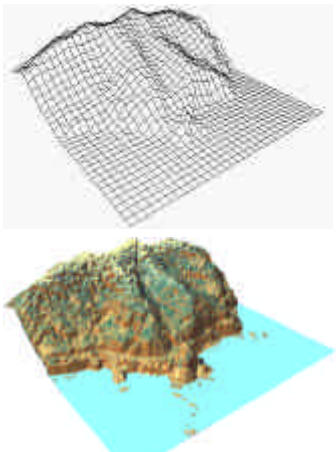
Thermal Vacuum Test of PRISM at NASDA's Space Simulated Chamber



PRISM Simulation Image

- DEM Extraction from 2.5 m triplet images.

Simulated image of nadir-looking



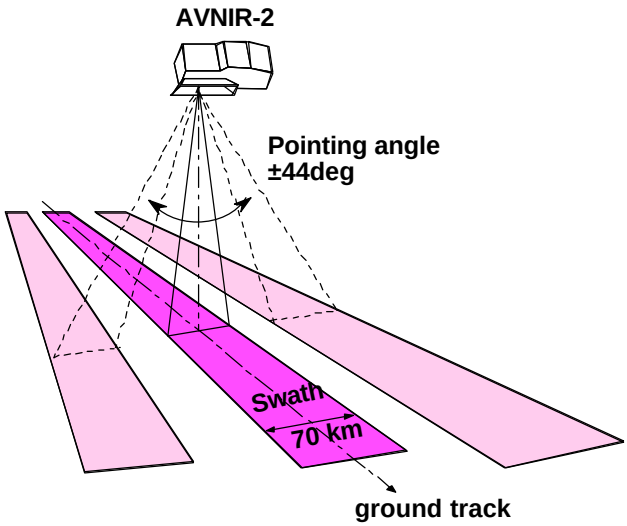
Generated DEM

AVNIR-2 Features

Advanced Visible and Near-Infrared Radiometer type 2

- ☑ Succesor to ADEOS/AVNIR
  - ◆ Same observation bands
  - ◆ Inherited optics from “space proven” AVNIR
- ☑ Wide observable area
  - ◆ Pointing angle: ±44 degrees
  - ◆ Prompt observation of e.g. disaster struck area
- ☑ Moderate swath width and spatial resolution
  - ◆ 70 km
  - ◆ 10 m

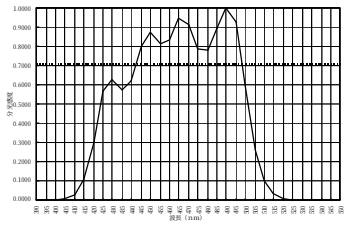
AVNIR-2 Observation Geometry



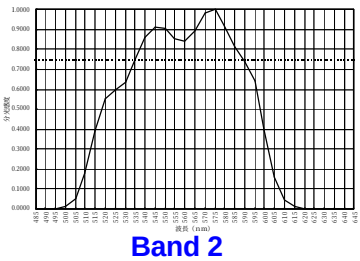
AVNIR-2 Characteristics
(nominal)

Item	Characteristics	Remarks
Wavelength	band1: 0.42 - 0.50 μm band2: 0.52 - 0.60 μm band3: 0.61 - 0.69 μm band4: 0.76 - 0.89 μm	
Field-of-View	5.8 deg	
Swath Width	70 km	
Instantaneous FOV	14.28 μrad	
Spatial Resolution	10m	Nadir
Pointing Angle	±44 deg.	Cross-track
Scanning Method	Push broom	
MTF	>0.25	@Nyquist freq.
S/N	>240	
Quantization	8 bits	

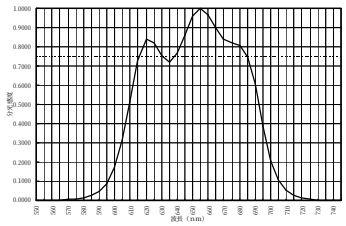
AVNIR-2 Spectral Response
(center pixels of each band)



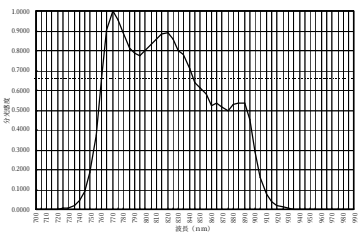
Band 1



Band 2

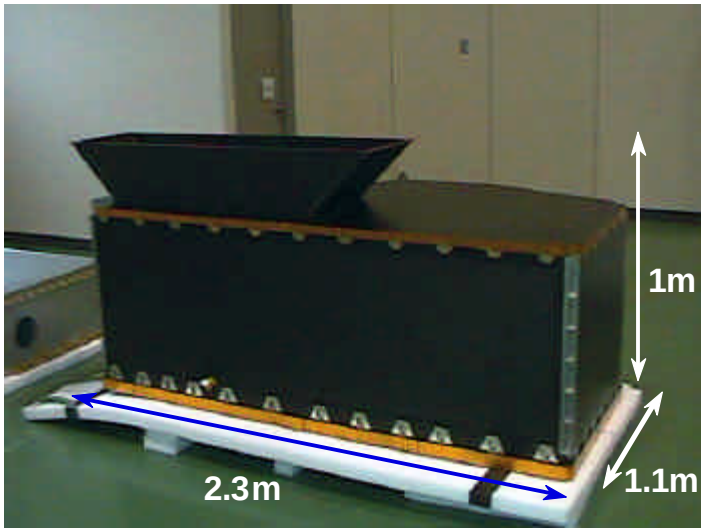


Band 3



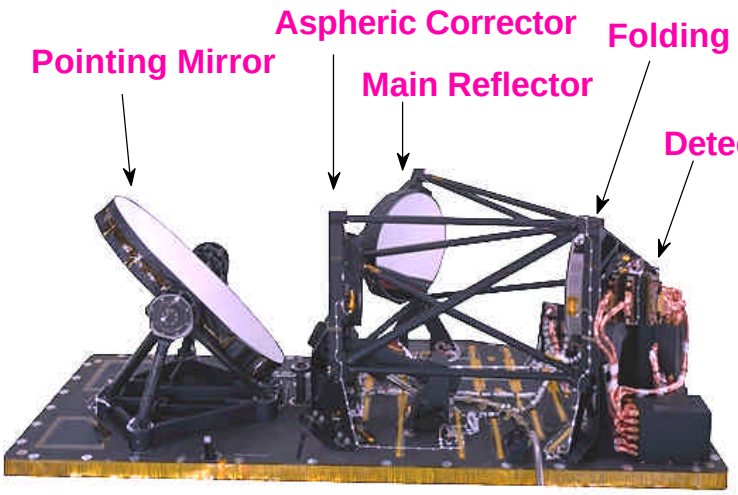
Band 4

AVNIR-2 Mechanical Test Model

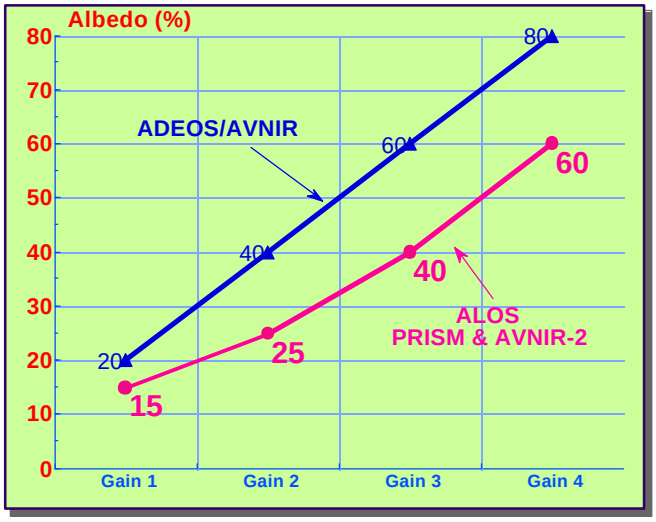


AVNIR-2 Optics

- Folding Schmidt



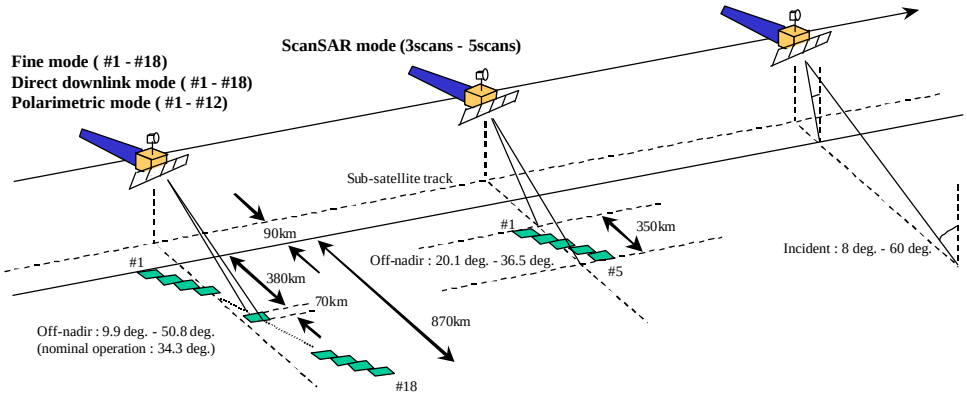
PRISM and AVNIR-2 Dynamic Range



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

- **A Follow-on Sensor of JERS-1 SAR. (L-band)**
- **Higher Performance and Multi-function**
  - **such as spatial resolution, variable off-nadir capability,**
  - **multi-polarization, ScanSAR observation.**

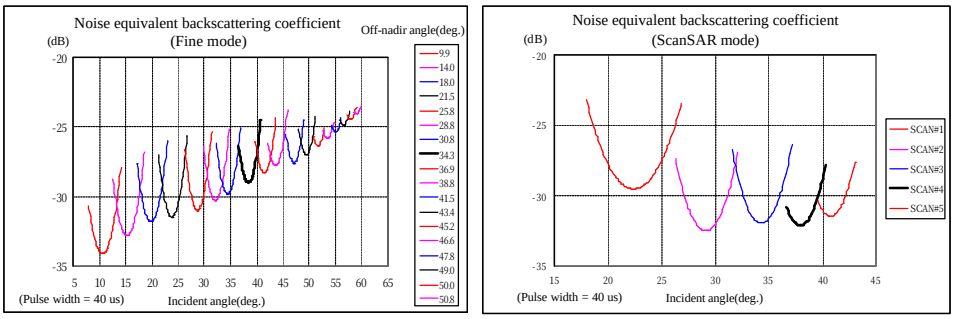
PALSAR Observation Mode



PALSAR Characteristics

Operation mode	Fine		Direct downlink	ScanSAR	Polarimetric
Center frequency	L band (1270MHz)				
Chirp bandwidth	28MHz	14MHz	14MHz	14MHz, 28MHz	14MHz
Polarization	HH, VV	HH+HV, VV+VH	HH, VV	HH, VV	HH+VV+HV+VH
Incident angle	8 - 60 deg.	8 - 60 deg.	8 - 60 deg.	18 - 43 deg.	8 - 30 deg.
Range resolution	7 - 44 m	14 - 88 m	14 - 88 m	100 m (multi Look)	24 - 89 m
Observation swath	40 - 70 km	40 - 70 km	40 - 70 km	250 - 350 km	20 - 65 km
Bit length	5 bits	5 bits	3 / 5 bits	5 bits	3 / 5 bits
Data rate	240 Mbps	240 Mbps	120 Mbps	120Mbps, 240 Mbps	240 Mbps
Radiometric accuracy	scene : 1 dB / orbit : 1.5 dB				
Antenna size	Az : 8.9 m / El : 3.1 m				

Noise Equivalent Backscattering Coefficient (Fine mode and ScanSAR mode)

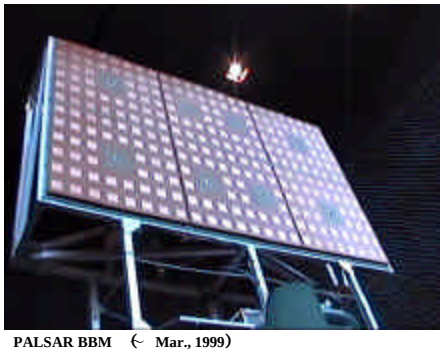


Calibration

- **Internal (Onboard) calibration**
  - **T/R modules: Temperature measurement, Transmission power monitor**
  - **Transmitter: Chirp replica**
  - **Receiver: Noise level, Gain monitor**
- **External calibration and validation**
  - **Antenna elevation pattern : Amazon rain forest**
  - **Backscattering coefficient: Corner Reflector, Active Radar Calibrator**
  - **Simultaneous air-borne SAR observation**

PALSAR Breadboard Model (BBM)

PALSAR BBM （～ Dec., 1998）
・Mechanical Model (Deployment, Acoustic, Separation Shock)



PALSAR BBM （～ Mar., 1999）
・Electrical Model (Electric, Antenna pattern)

Far Field Antenna Pattern Measurement at NASDA/TKSC using PALSAR BBM (Electric model）

Reference Antenna

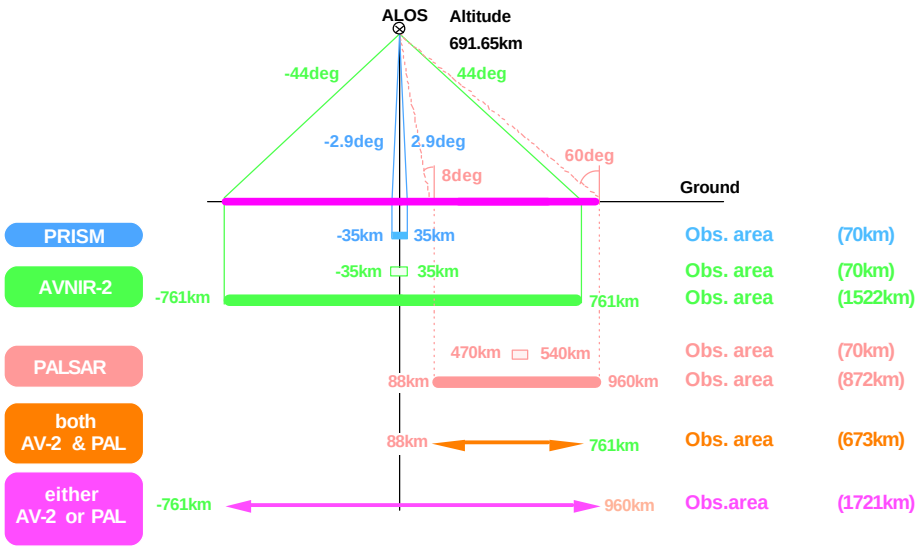
One Antenna Panel of PALSAR (Azimuth Pattern Measurement)

PALSAR Engineering Model
(for mechanical and thermal test)

Four Antenna Panels fully deployed

Opposite side
(T/R modules and RF Dividers)

Observable Area of ALOS



Summary and Conclusion

- PRISM's, AVNIR-2's and PALSAR's specifications are fully met ALOS mission requirements:
  - mapping,
  - regional observation,
  - disaster observation,
  -Earth resources surveying.
- Several tests of these instruments using engineering models have been done with successful results.
- Calibration/validation plan will be established by the end of this year.