ALOS-2
Orbit Control and Determination

25. Nov. 2013 2nd CVST

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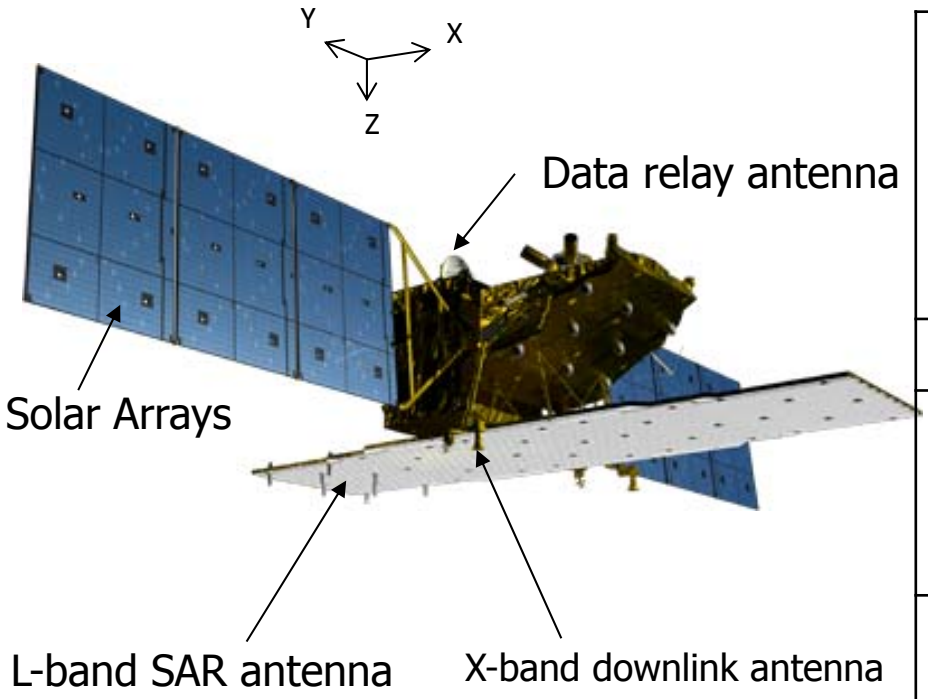
ALOS-2 satellite

ALOS-2 in-orbit configuration



Specification

L-band SAR (PALSAR-2)	Stripmap: 3 to 10m res., 50 to 70km swath ScanSAR: 100m res., 350km/490km swath Spotlight: 1×3m res., 25km swath
Life time	5 years (target: 7 years)
Agility	Earth pointing attitude to observation < 2minutes Change observation direction (right/left) < 3minutes
Downlink	X-band: 800Mbps(16QAM) 400/200Mbps(QPSK) Ka-band: 278Mbps (Data Relay)
Orbit	Sun-synchronous orbit Altitude: 628km Local sun time : 12:00 +/- 15min Revisit: 14days Orbit control: ≦+/-500m Orbit determination: ≦1m

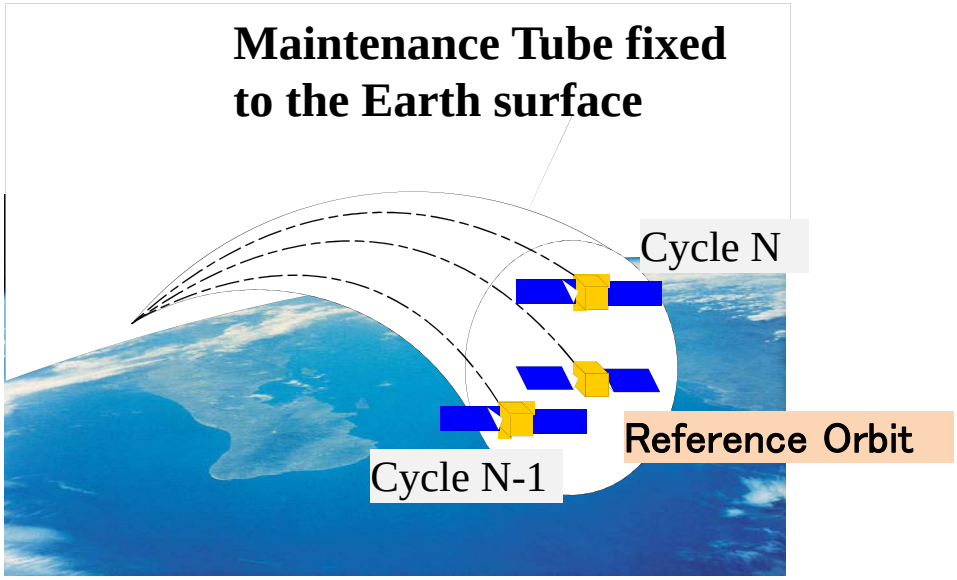
Today's contents

1. Key Elements for
   Autonomous Orbit Control
2. Key Elements for
   Precise Orbit Determination
3. System Test Status

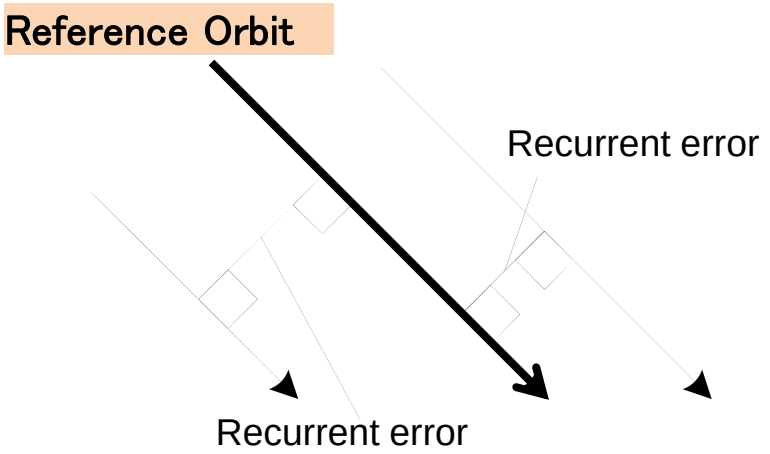
1. Key Elements for **Autonomous Orbit Control**

Precise orbit maintenance

- **Both in-plane and out-of-plane maneuvers are performed autonomously**
  - **To improve the coherency of the repeat-pass SAR interferometry observation**



Conceptual image



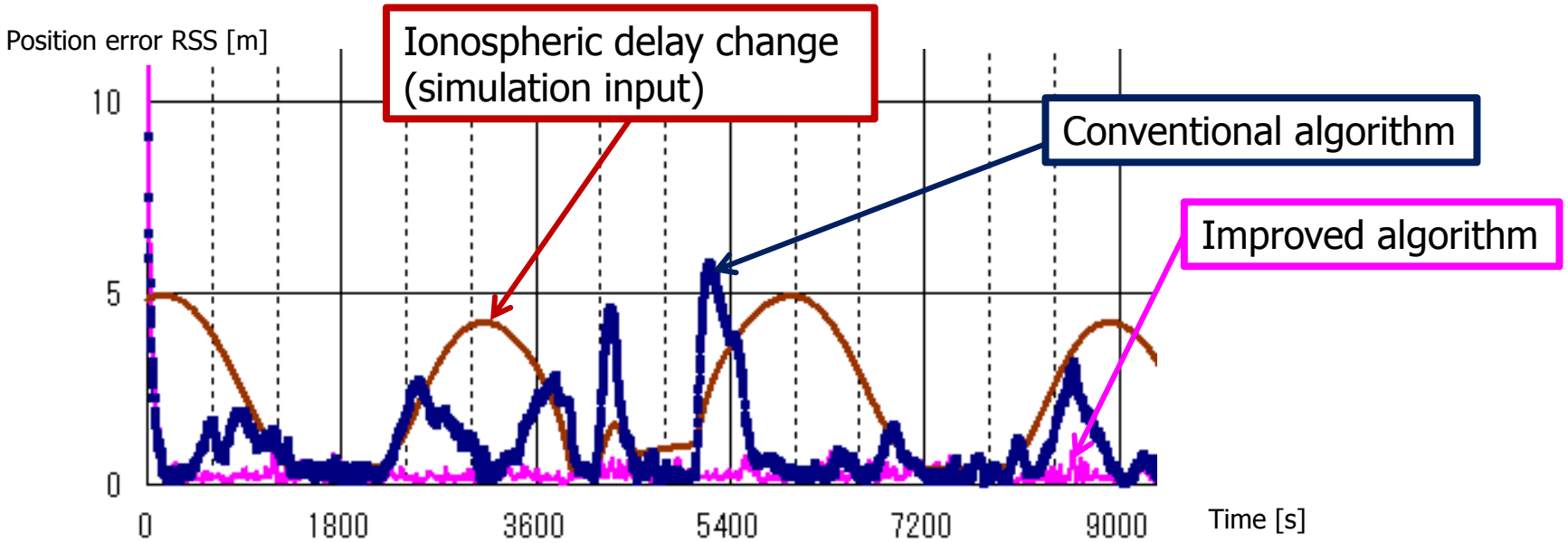
Recurrent error **< +/- 500m (95%)**
(incl. high latitude area)
with respect to reference orbit

Autonomous control algorithm

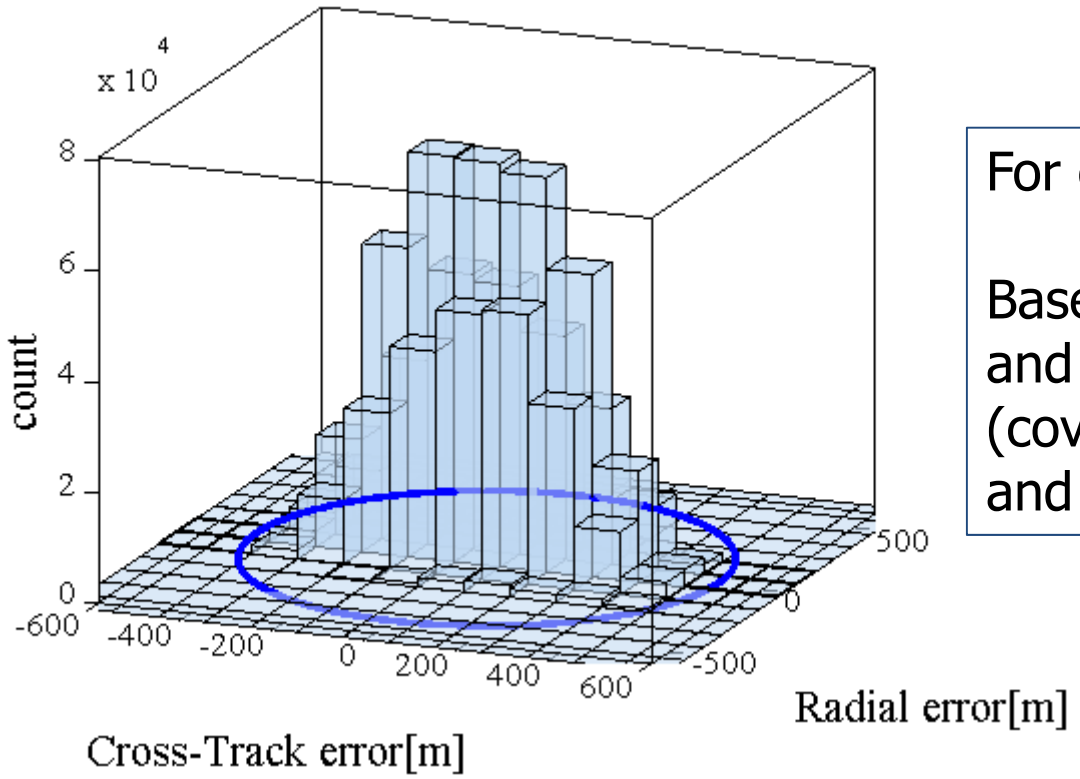
- Reference trajectory of orbit is generated on the ground in advance
  - Consider detailed orbit perturbation model to avoid unnecessary orbital maneuvers
- “maneuver slot” concept is applied
  - Avoid unexpected conflicts between mission observations and maneuver executions
- The onboard flight computer selects the most proper “maneuver slot”, and calculates the amount of delta-V just before the execution.
  - To extend the interval between maneuvers
  - To avoid a deceleration maneuver

Real-time GPS L1 navigation

- For autonomous orbit control, real-time onboard navigation using L1 signal is important.
- Algorithm of enhancing navigation accuracy is developed
  - Estimate both ionospheric delay and its change
- Measurement accuracy < 10 m (95%)



Numerical simulation of orbit maintenance



For eight years from 2000.

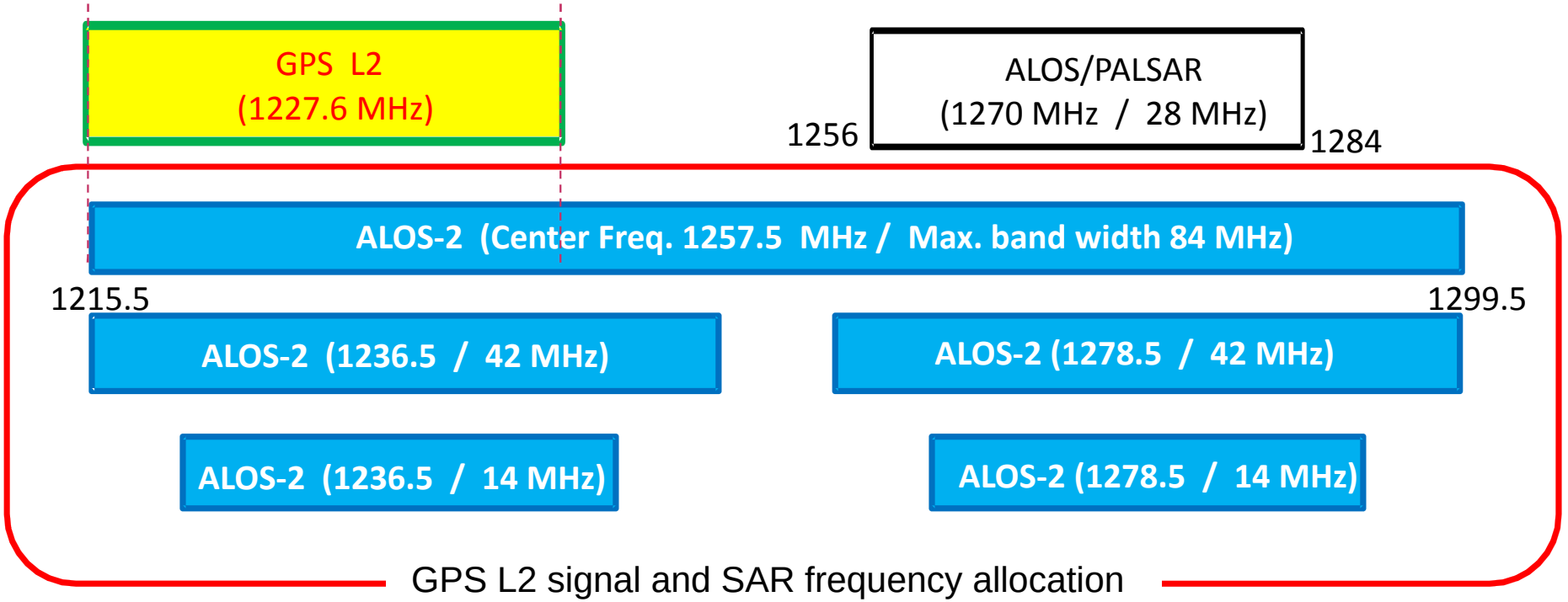
Based on the actual solar and geomagnetic storm (covers both the active solar and inactive solar periods).

- **Maintained inside 500m tube > 99.7%**
- **During the active solar period, the minimum interval between maneuvers is 1.5days.**
  - **The autonomous orbit control method is indispensable**

2. Key Elements for **Precise Orbit Determination**

Off-line precise positioning

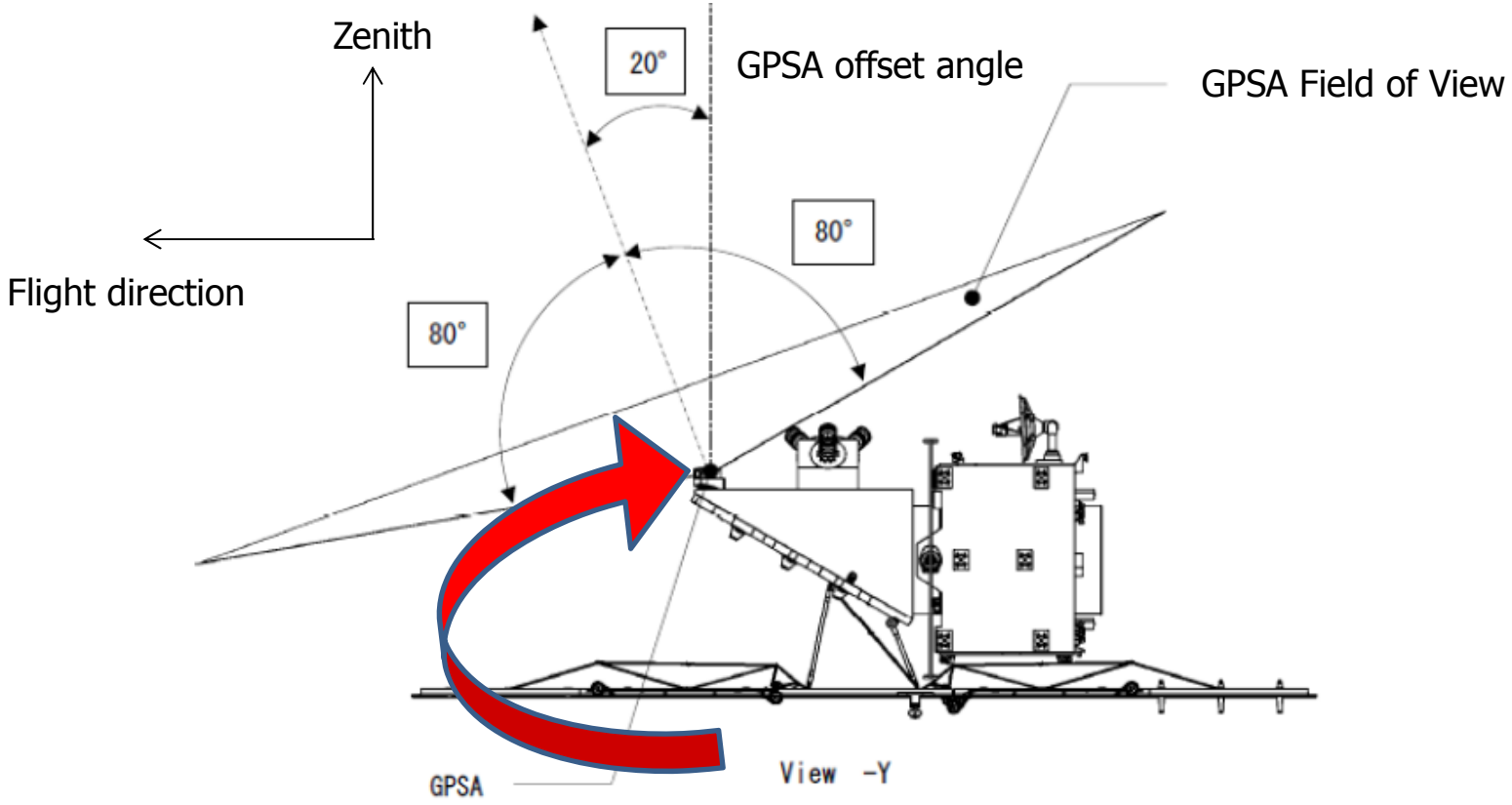
- Precise orbit determination is expected from ALOS-2 data users.
- Dual GPS (L1 and L2) receiver is equipped onboard.
- However, ALOS-2 SAR frequency is overlapped with L2 signal.



GPS L2 signal and SAR frequency allocation

Interference between GPS and SAR

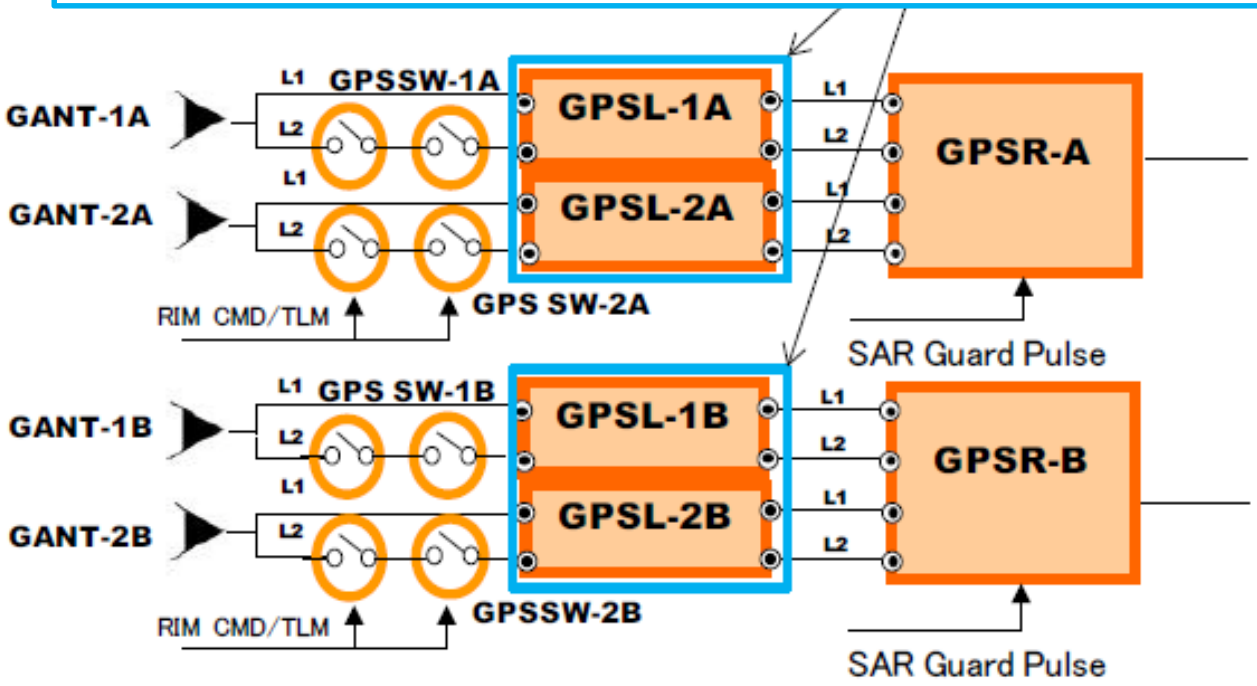
- **Strong RF signal will be input into GPS Antenna from SAR antenna.**
- **Nominal operation plan: GPS L2 input is switched off during SAR observation.**



Orbit Determination (analysis)

- Requirement of orbit determination: 1m (95%)
- Analysis result
  - During SAR observation (L2 loss): 0.5m – 0.8m
  - GPS L2 signal is used all time: better than 0.2m

Enhanced low-noise amplifier for GPS receiver with endurance against SAR signal was developed



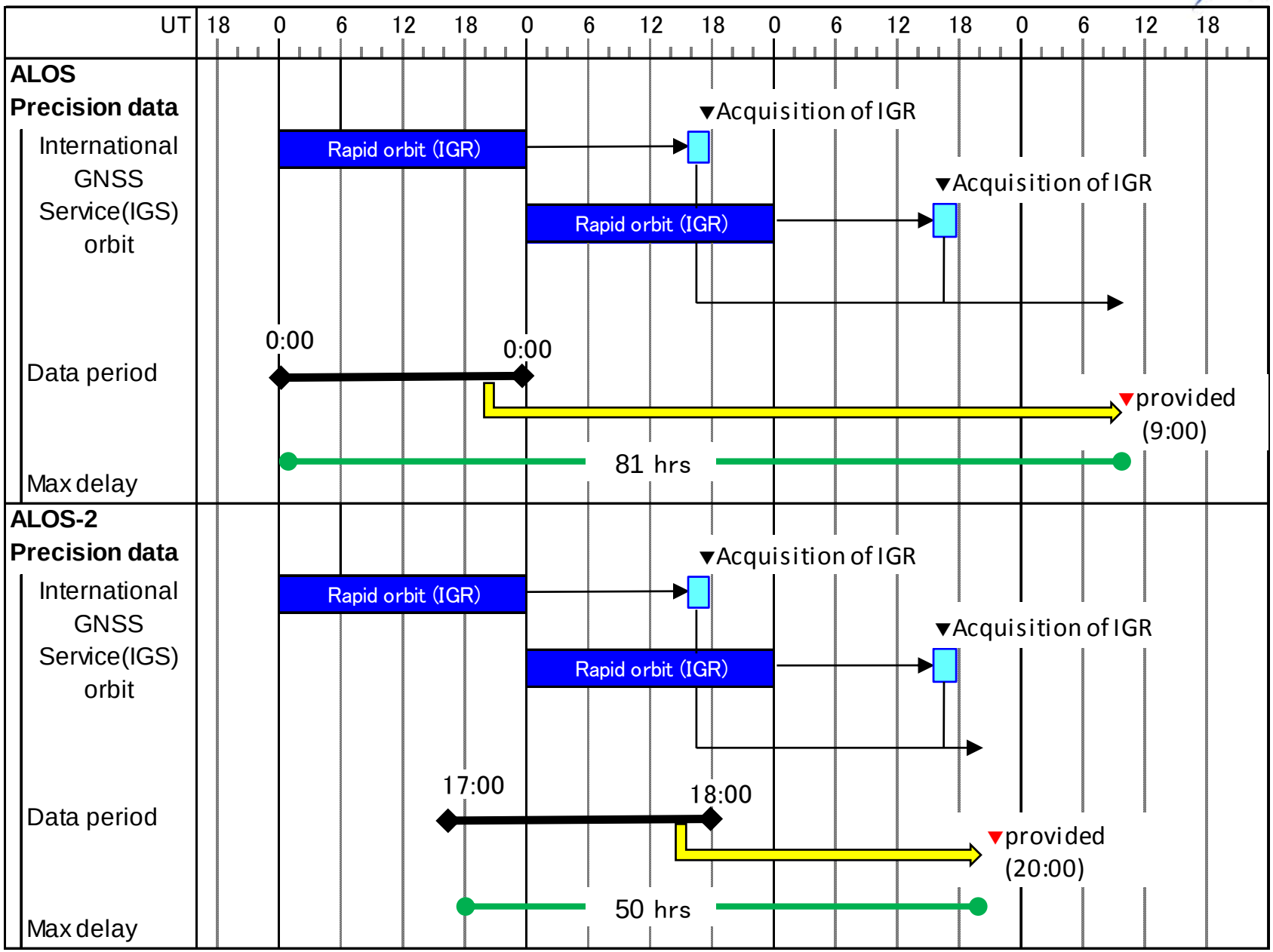
Currently, EMC test data is under evaluation

Orbit data distribution

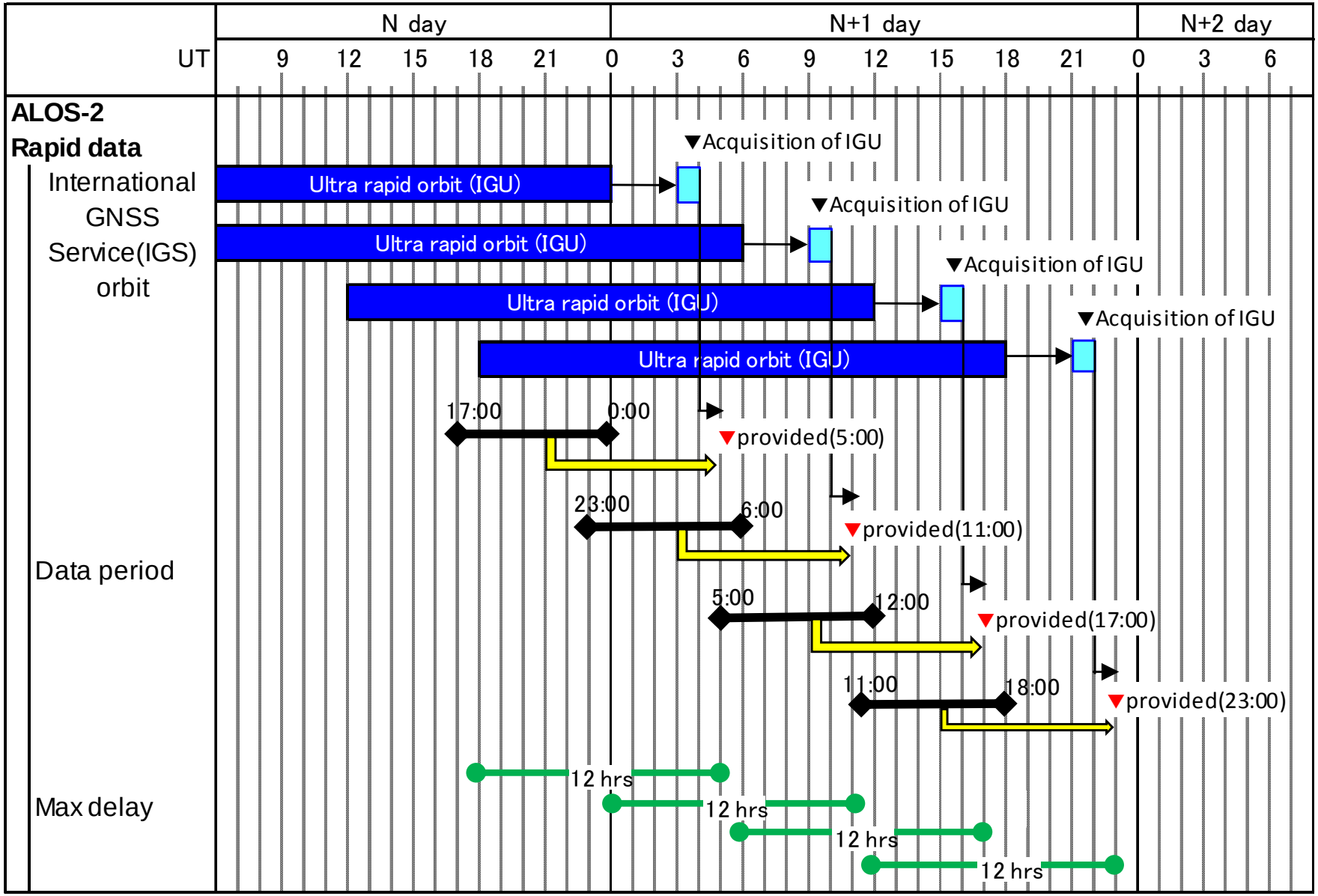
- **Distribution delay of Precision orbit data is improved, and Rapid data is added.**
  - **Precision data : Max 50 hrs delay (ALOS: Max 81 hrs delay)**
  - **Rapid data : Max 12 hrs delay (ALOS: not provided)**

	ALOS	ALOS-2	
Type	Precision Data	Precision Data	Rapid Data (added)
Distribution time	09:00 (UT)	20:00 (UT)	① 05:00 (UT) ② 11:00 (UT) ③ 17:00 (UT) ④ 23:00 (UT)
Data period	N-3day 0:00 to N -2 day 0:00 (UT)	N-2 day 17:00 (UT) to N-1 day 18:00 (UT) *divided into four data	12 hours – 5 hours before Ex) ① N-1 day 17:00 (UT) to N day 00:00 (UT) *overlapped 1 hour

Precision data distribution

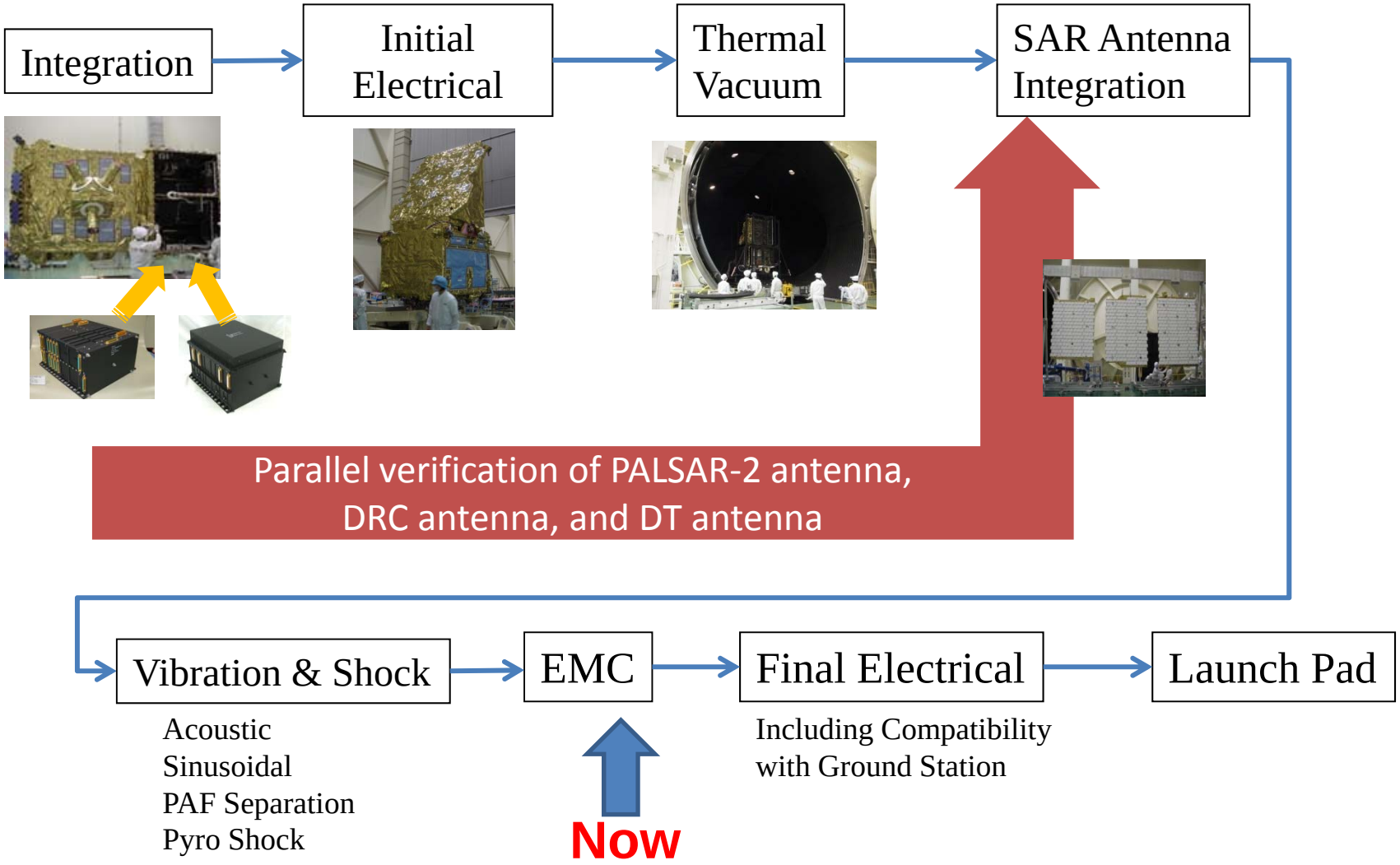


Rapid data distribution



3. System Test Status

System verification sequence

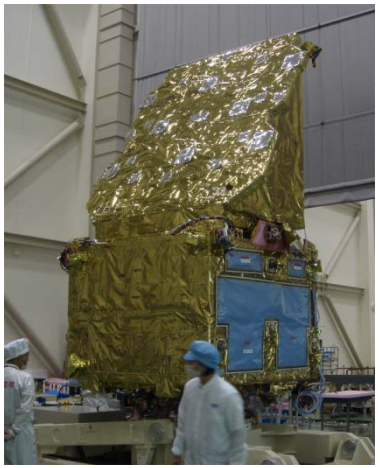


Initial electrical and functional test

- **(Jan. 2012 – Sep. 2012)**

Purpose

- Electrical connection; System -Components
- Electrical function of all sub-system
- Total function and performance as system



The requirements of total function and performance of system was confirmed to be satisfied

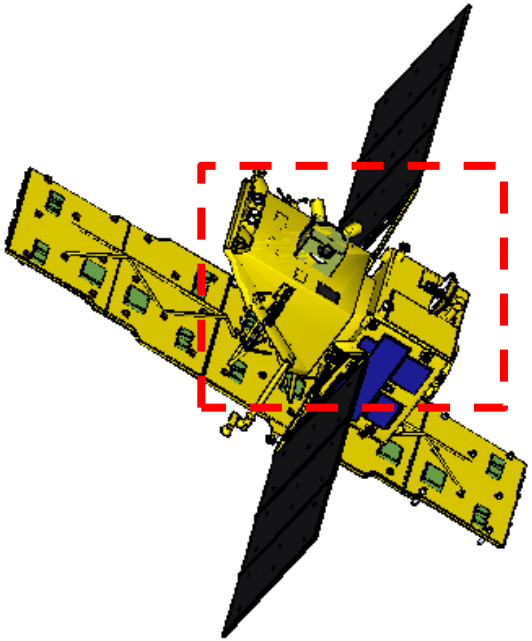
* After the PFT of PALSAR-2 subsystem, the PFM of Electric Unit (ELU) was installed inside the satellite system, and then its electrical function was also verified.

Thermal vacuum test

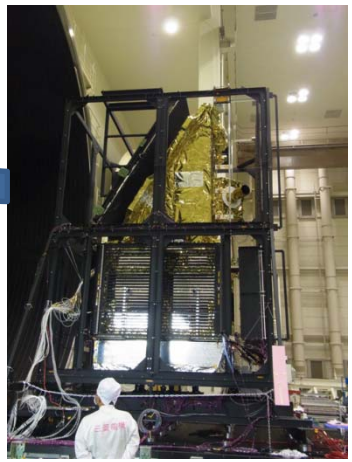
- **(Oct. 2012 – Nov. 2012)**

Purpose

- Verify the thermal design of satellite system
- Function and performance of thermal control device
- Electrical function and performance under vacuum



PALSAR-2 antenna, DRC antenna and Solar array paddle had been tested independently.



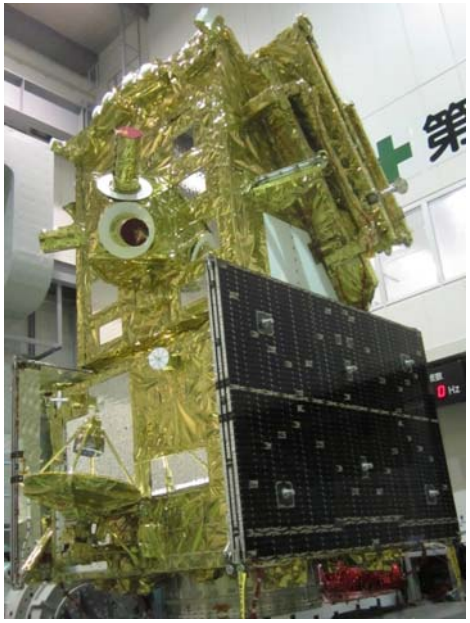
Vibration and Shock test

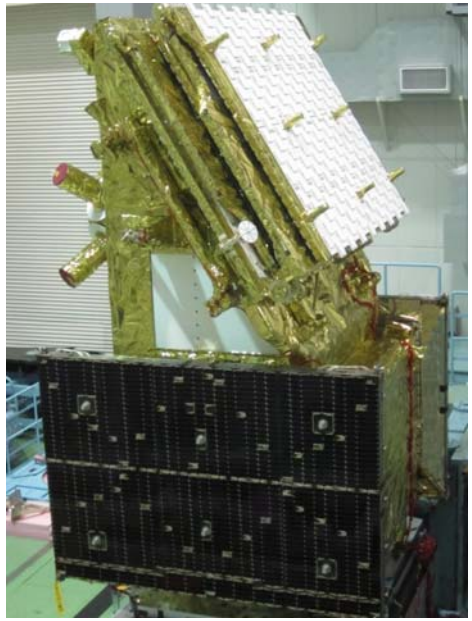
- **(Sep. 2013 – Nov. 2013)**

Purpose

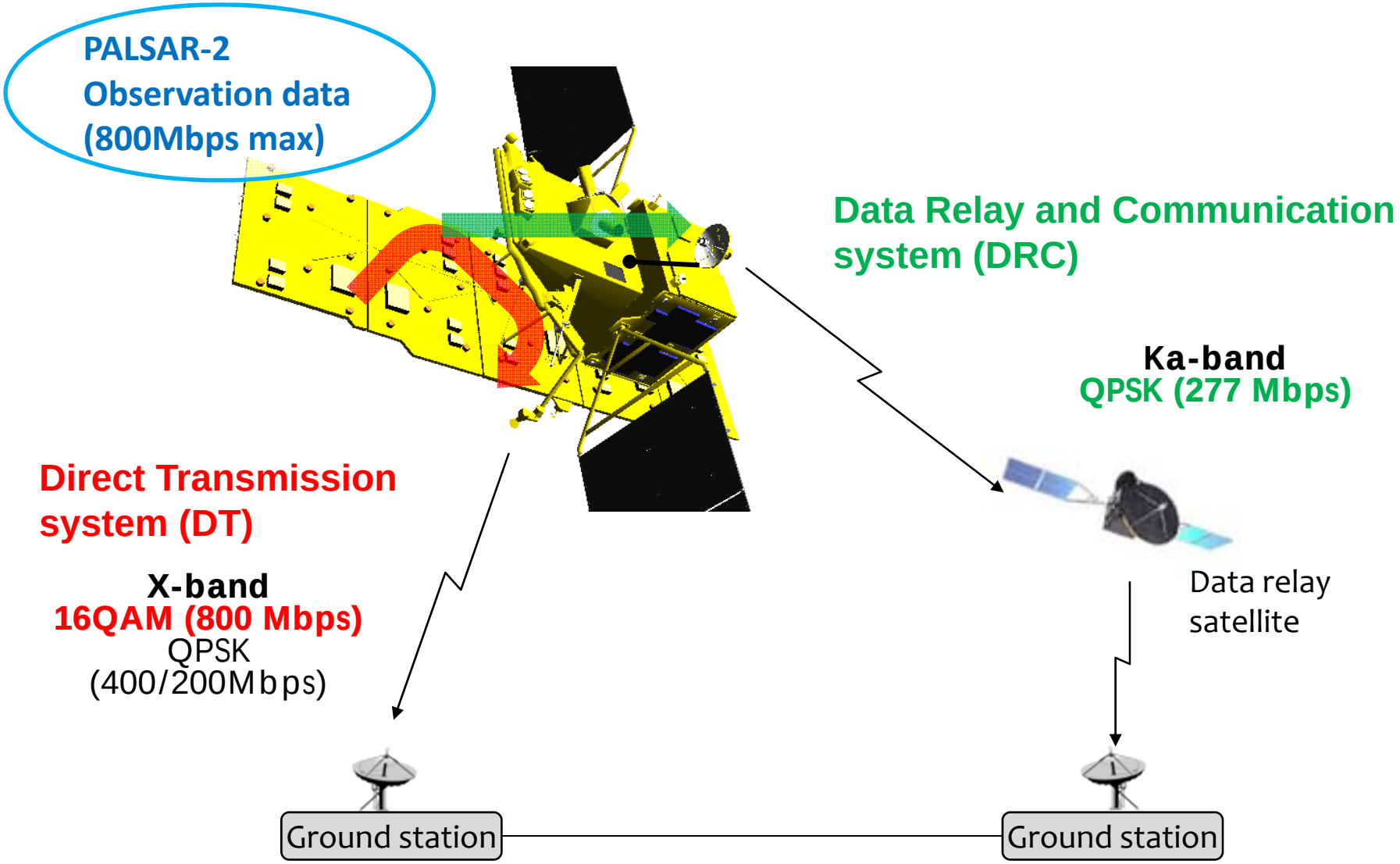
- Verify the structure design of satellite system
- Function and performance of pyro-technic devices and deployment mechanisms
- Electrical function and performance after the vib

All equipment including PALSAR-2 antenna is installed as the flight configuration.

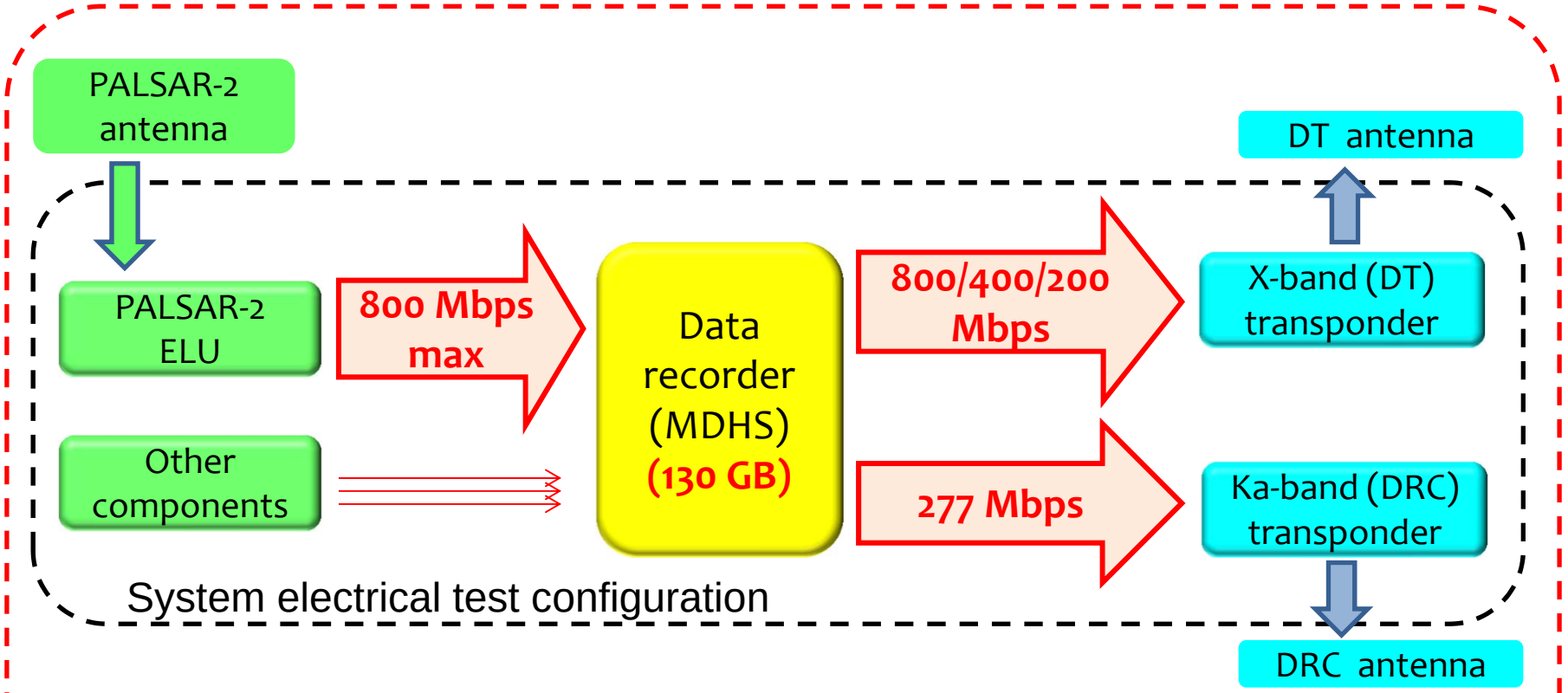




Mission data handling system



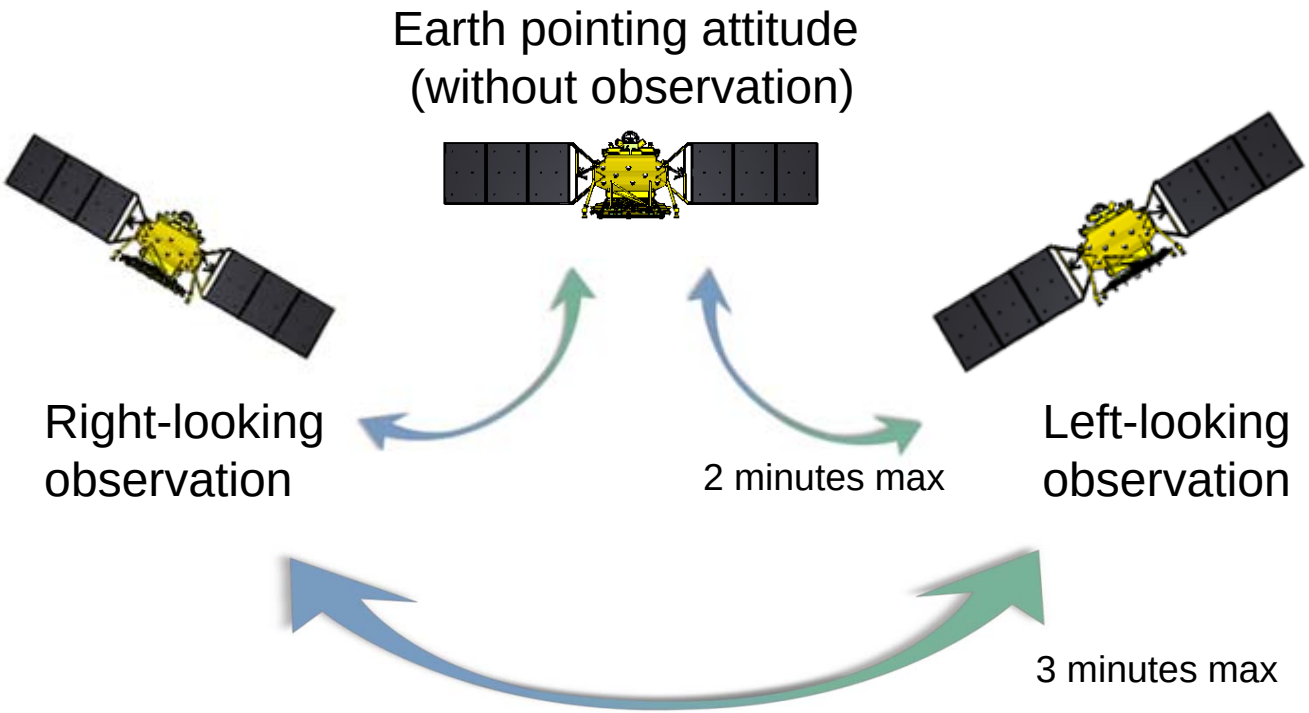
Mission data handling system



EMC test configuration

- Total performance of satellite including Mission data handling was verified based on the typical operational scenario.

Agile attitude pointing using high torque wheels



- One Reaction Wheel (RW) is aligned roll axis, and other four RWs are mutually skewed.
- RW was developed by the JAXA, more than 0.9Nm output torque and 40 Nms momentum (at 3200rpm)

Conclusion

- ALOS-2 will succeed ALOS's mission with enhanced capabilities.
- To achieve higher coherence of interferometry,
  - Autonomous accurate orbit maneuvering (within 500-m orbital tube)
  - Precise orbit determination (including enhanced GPS receivers with endurance against L-band SAR signal)
- For a quick response to disasters and for a flexible observation planning
  - Agile right- and left-looking function by satellite body rolling
  - Large-size data record and a high-speed data downlink system have been installed.
- ALOS-2 System test is on-going. It will be launched by the H-IIA Launch Vehicle.