# Conceptual Study of Satellite System Design for Japanese Future Altimetry Mission

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## Introduction

The Japan Aerospace Exploration Agency (JAXA) has started a conceptual study of an altimetry mission for marine environment monitoring, fishery, etc. Conceptual study team in JAXA is considering to name the mission COMPIRA (Coastal and Ocean measurement Mission with Precise and Innovative Radar Altimeter) and its main sensor SHIOSAI (SAR Height Imaging Oceanic Sensor with Advanced Interferometry). The sensor is a Cross-Track Interferometric Synthetic Aperture Rader (CT-InSAR) which enables much wider observable area than an existing nadir-looking radar altimeter.

This paper aims at reporting the present state of our conceptual study of the COMPIRA satellite system design, especially concerning (1) the way how candidates of orbit were selected, (2) results of electrical power analysis for some candidates of orbit, and (3) data transmission analysis.

## Requirements Considered in Orbit Selection

【Requirement 1】 Compensation of the influences of oceanic tidal constituents in terms of the aliasing period/frequency in altimetry.

a) Maximum aliasing period among tidal constituents(Tamax)≦0.5year
b) Minimum separation period between two arbitrary tidal constituents(Td)≦3years
c) Tidal constituents to be taken into consideration : the eight major tides and eight dominant tides near Japanese coast.

【Requirement 2】 Temporal and spatial coverage of observation

a) More frequent observation of the sea around Japan:
   i) Once per 3-5 days as an period to suppress the errors in ocean 4D data assimilation
   ii) Orbital inclination to be as small as possible to cover the sea around Japan with more dense ground tracks, covering the region from Sakhalin to the North Pacific
b) Spatial coverage ratio per observation repetition cycle to be about 90% in the sea around Japan.

## Current Nominal Orbit

Table 1. Orbital Parameters of Current Nominal Orbit.

| Observation Repetition Cycle $T_{obs}$ [day] | Cycle of Orbital Plane relative to the Earth: $T_E$[day] | Cycle of Orbital Plane relative to the Sun: $T_S$[day] | Sub-Recurrent Parameters (Revolutions per day) N+L/M | Orbital Altitude h[km] | Orbital Inclination i[deg] |
|---|---|---|---|---|---|
| 9.9 | 0.99 | 74.2 | 14 - 3 /10 | 937.5 | 51.2 |

N：Revolutions per day(Integer), L：the Number of ground tracks shifted per day, M：Recurrent Period.

【 For Requirement 1】

1) Dominant tidal constituents in the sea around Japan were selected based on tidal stations data;
Q1, O1, P1, K1, N2, M2, S2, K2, Mm, MSf, Mf, Mu2, Nu2, L2, M4, MS4.

2) Necessary time for the compensation tidal influences are shown in the table below. All of them are acceptable.

- Maximum aliasing period among tidal constituents taken into consideration (Tamax).
- Minimum Separation Period of two arbitrary tidal constituents (Td).
- Aliasing Period of each tidal constituents (Ta).

Table 2. Necessary Time for Compensation of Tidal Influences.

| Observation Repetition Cycle | Maximun Aliasing Period | Minimum Separation | Aliasing Period of Each Tide(Ta)[day] | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 8 dominant tidal constituents | | | | | | | | 8 dominant tidal constituents in the sea around Japan | | | | | | | | |
| | | | | | | | | | | | Tidal constituents causing residual errors in long-term variations | | | Tidal constituents with shorter tidal period than the recurrent time. (They must be removed with aliased cycle) | | | | | |
| Tobs [day] | Tamax [day] | Td [year] | Q1: | O1: | P1: | K1: | N2: | M2: | S2: | K2: | Mm: | MSf: | Mf: | Mu2: | Nu2: | L2: | M4: | MS4: |
| 9.8671 | 149.6 | 2.27 | 53 | 57 | 62 | 93 | 34 | 150 | 37 | 47 | 28 | 30 | 36 | 25 | 40 | 23 | 75 | 49 |

【 For Requirement 2】

a) Spatial coverage ratio of 98% at the latitude of 35deg and 85% at the equator are achieved.
b) Regarding temporal coverage, almost 70% of area are observed 2 times per recurrent period(10days), which will enable us to improve the ocean 4D data assimilation.

Table 3. Temporal and Spatial Coverage of Observation.

| <with the SAR swath of 70km x 2> | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 4 Observations | 3 Observations | 2 Observations | 1 Observation | No observation | Frequency of observations | Ratio of observable area |
| Latitude | 0 deg. | | | 37.9% | 47.3% | 14.8% | 1.44 | 85.2% |
| | 25 deg. | | | 53.6% | 39.2% | 7.2% | 1.58 | 92.8% |
| | 35 deg. | 0.1% | 6.4% | 70.2% | 21.6% | 1.7% | 1.85 | 98.3% |

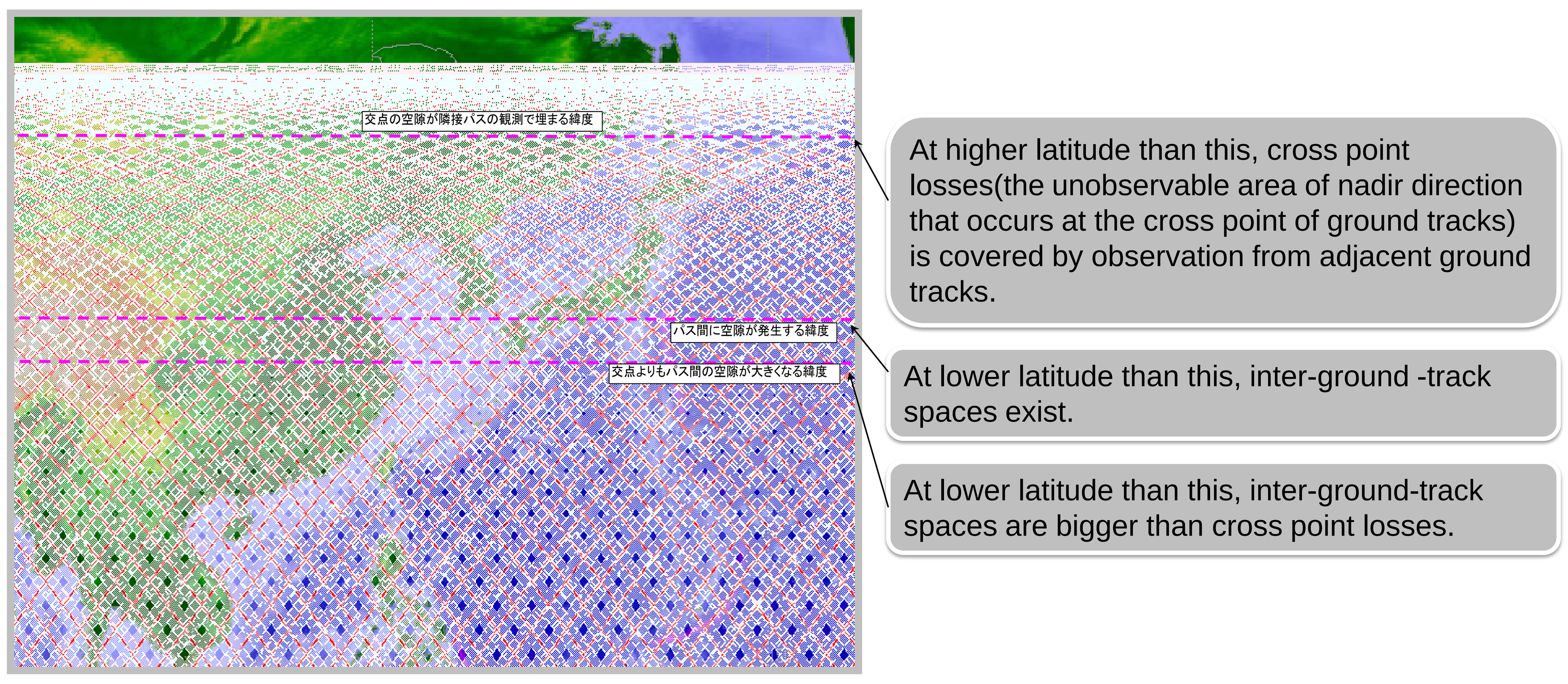


Figure 1. Spatial Coverage of Observation.

## Electrical Power Analysis

Assumptions

* ±X direction: direction of orbital velocity
* ±Y direction: perpendicular to orbital plane

- Orbit :Current Nominal Orbit (see Table 1)
- Power Consumption of spacecraft including the payload: 2.5 kW

Necessary Power Source and Energy Storage

- With solar array paddles on ± Y planes*
  - Solar array paddles: about 20 $m^2$ × 2
  - Battery: about 200 Ah
- With solar array paddles on ± X planes*
  - Solar array paddles: about 20 $m^2$ × 2
  - Battery: about 290 Ah

In terms of battery size, the case of solar array paddles on ± Yplanes has an advantage. On the other hand, in the case of solar array paddles on ± X planes, rotation rate of solar array paddles can be very slower than orbit rate required in case of ±Y paddles. This enables less disturbances. In order to decide satellite configuration, we need more comprehensive trade-off including field-of-view, RF interference and rocket interface issue etc.

## Data Transmission Analysis

Assumptions

* DRTS: Data Relay Test Satellite
* EOC:Earth Observation Center (Ground Station)

- Data rate / Band-width: 643 Mbps / 80 MHz
- Data transmission rate: 800 Mbps (to EOC* and next-DRTS*)

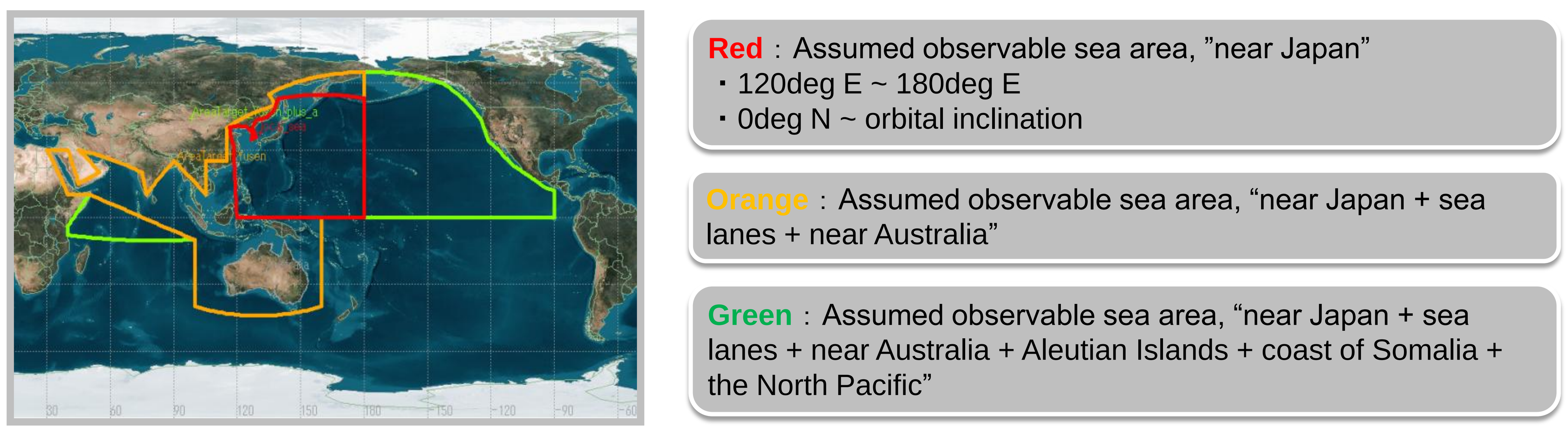


Figure 2. Observable Ocean Area.

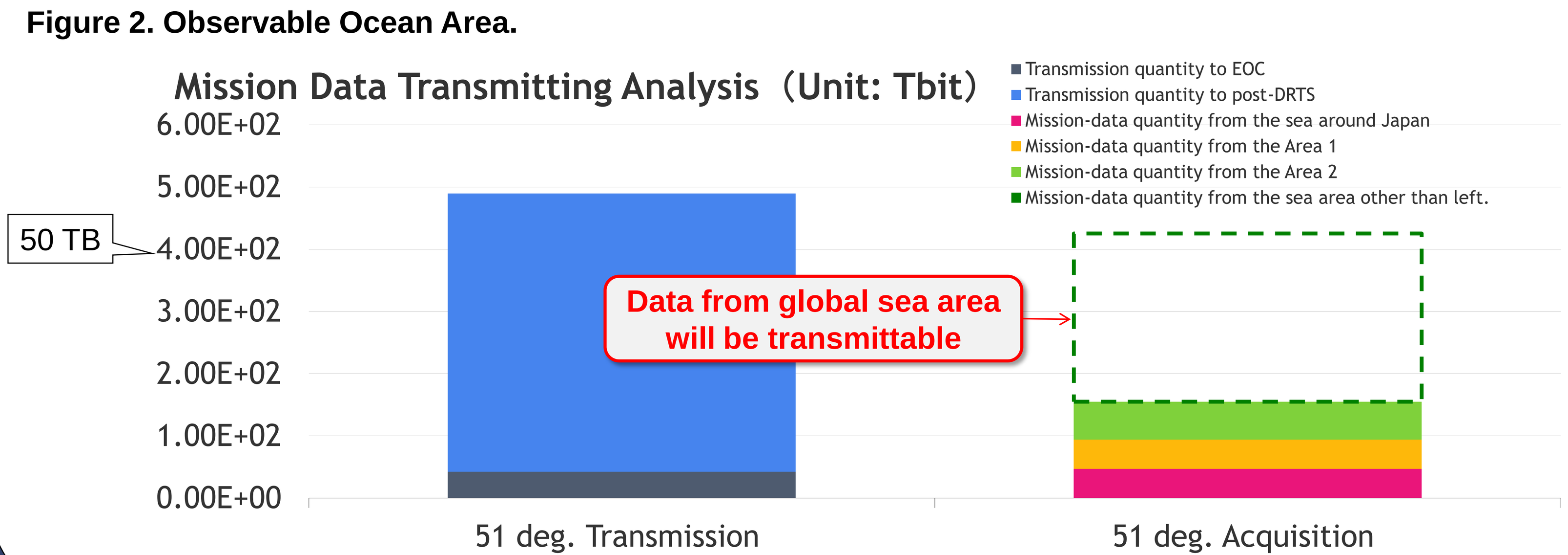


Figure 3. Results of Mission Data Transmitting Analysis.