System outline of small standard bus and ASNARO spacecraft

August 11th, 2009
NEC Corporation, USEF, NEDO
Toshiaki Ogawa, Kenichi Saito, Keita Miyazaki, and Osamu Ito
Outline

1. Introduction
2. ASNARO spacecraft system outline
3. Standard bus system
4. Optical Mission
5. Conclusions
1. Introduction
NEC Space heritage (1/3)

NEC 1st and recent satellites

OHSUMI
Japan’s 1st sat.
Launched : 1970
Mass : 24kg

DAICHI (ALOS)
Earth Observation
Launched : 2006
Mass : 4000kg

KAGUYA
(SELENE)
Luna Observation
Launched : 2007
Mass : 2900kg

KIZUNA (WINDS)
Communication
Launched : 2008
Mass : 2700kg
(On-Orbit)

Courtesy JAXA
NEC Space heritage (2/3)

NEC Small Satellites

HAYABUSA (MUSES-C)
Observation of Asteroid ITOKAWA
Launched: 2003
Mass: 510kg

TSUBASA (MDS-1)
Engineering Test
Launched: 2002
Mass: 480kg

KIRARI (OICETS)
Optical Communication
Launched: 2005
Mass: 570kg

Planet-C
Venus Observation
Launched: 2010 (Planned)
Mass: 500kg

(C)Akihiro.Ikeshita
Courtesy JAXA
NEC Space heritage (3/3)

NEC Optical Sensors

- MESSR (MOS-1)
  - Resolution: 50m
  - Launched: 1987

- ASTER/VNIR (Terra)
  - Resolution: 15m
  - Launched: 1999

- PRISM (ALOS)
  - Resolution: 2.5m
  - Launched: 2006

- Hyper Spectral Sensor
  - Resolution: 30m
  - Under developing

NASA/courtesy of nasaimages.org

Empowered by Innovation
Background

ASNARO: Advanced Satellite with New system ARchitecture for Observation

What’s this?

- Small Satellite for Optical Earth Observation with high resolution optical sensor from LEO by precise 3-axes pointing control.

Characteristics of ASNARO

- High Performance
  - High Resolution
  - High Agility
  - High Data Rate Transmission
- Adopt Standard Bus concept
  - Lower Cost
  - Lighter Weight
  - Faster Delivery

*developed by NEC Co. and Institute for Unmanned Space Experiment Free Flyer (USEF) under the contract with New Energy and Industrial Technology Development Organization (NEDO).*
2. ASNARO spacecraft system outline
**ASNARO spacecraft system outline**

**On-orbit Configuration**

- **GPS Antenna**
- **S-band Antenna**
- **X-band Antenna**
- **Baffle**
- **Imager**
- **Camera**
- **Star Tracker**
- **Bus**
- **Solar Array Panel**
- **Payload**
- **Payload Equipment**
- **Thruster**

---

<table>
<thead>
<tr>
<th>Performances and Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mission</strong></td>
</tr>
<tr>
<td>- <strong>Optical Sensor</strong></td>
</tr>
<tr>
<td>Pan/Multi</td>
</tr>
<tr>
<td>GSD: &lt; 0.5m/2m (Pan/Multi, from 504km)</td>
</tr>
<tr>
<td>Swath: 10km</td>
</tr>
<tr>
<td>- <strong>Data Transmission</strong></td>
</tr>
<tr>
<td>X-Band: 16QAM, App. 800Mbps</td>
</tr>
<tr>
<td><strong>Attitude Control</strong></td>
</tr>
<tr>
<td>3-axes attitude control</td>
</tr>
<tr>
<td><strong>Coverage</strong></td>
</tr>
<tr>
<td>±45deg/±45deg (Cross/Along track)</td>
</tr>
<tr>
<td><strong>Agility</strong></td>
</tr>
<tr>
<td>45deg/45sec. (Average 1deg/sec)</td>
</tr>
<tr>
<td><strong>Launch</strong></td>
</tr>
<tr>
<td>JFY2011 (Expected)</td>
</tr>
<tr>
<td>JAXA New Solid (Assumed)</td>
</tr>
<tr>
<td>(Compatible with H-IIA, Dnepr, etc)</td>
</tr>
<tr>
<td><strong>Orbit</strong></td>
</tr>
<tr>
<td>Sun Synchronous Polar Orbit (504km)</td>
</tr>
<tr>
<td>Inclination: 97.4deg</td>
</tr>
<tr>
<td>Local Time of Descending Node: AM11:00</td>
</tr>
<tr>
<td><strong>Design Life</strong></td>
</tr>
<tr>
<td>3 years</td>
</tr>
<tr>
<td>&gt; 3 years</td>
</tr>
<tr>
<td><strong>Expected Operation</strong></td>
</tr>
<tr>
<td>Spacecraft Mass</td>
</tr>
<tr>
<td>Bus 250kg (Without Propellant)</td>
</tr>
<tr>
<td>Mission 150kg</td>
</tr>
<tr>
<td>Propellant 50kg</td>
</tr>
<tr>
<td>&lt;Total&gt; 450kg</td>
</tr>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>App. 2.5m X 3.5m X 3.2m (on orbit)</td>
</tr>
<tr>
<td><strong>Electrical Power</strong></td>
</tr>
<tr>
<td>SAP Power: App. 1300W (at EOL)</td>
</tr>
<tr>
<td>(For Mission: 400W)</td>
</tr>
</tbody>
</table>
Observation Mode

(a) Snap Shot mode

(b) Wide View mode

(c) 3D mode

(d) Strip Map mode

Observation Mode

a. Snap Shot mode acquire the nominal 10 x 10 km area’s image. This mode is basic observation mode.

b. Wide View mode acquire wide area’s images which are consisted of a few sets of neighboring snap shot images.

c. 3D mode acquire the stereo image of the observing area. In this mode, the observations are performed two different orbital positions to obtain 3 dimensional information of the concerned area.

d. Strip Map mode acquire zonal image which is up to 850 km of continuous image by 10 km width. The maximum observable time is continuous 120 seconds.
3. Standard bus system
Standard bus Concept

- **Standardized payload interface**
  - Mechanical interface
  - Thermal interface
  - Electrical interface
  - RF interface

- **Minimized interface lines between payload and bus**
  - SpaceWire
  - Timing Signals
  - Power lines
  - Temperature control lines.

- **Compatible with various rockets**
  - JAXA new solid rocket
  - H-IIA
  - DNEPR
  - …

- **Various options for user requirements**
  - Solar array power
  - Solar array type (fixed or rotate)
  - Number of STT (1 or 2)
  - Number of Payload Heater/EED lines
  - Single bus or partial redundant bus
Applications

Under Developing

Optical Sensor

Scientific Telescope (JAXA/ISAS)

Planned

SAR Sensor

Hyper Spectral Sensor

Infrared Sensor
SpaceWire

SpaceWire network technology

What’s this?
- One of the protocol for network in spacecraft, established by ECSS (promoted by JAXA/ISAS in Japan).

Advantage of SpaceWire
- Standardized physical interface and network protocol.
- Communicate in high speed.
- Plug and Play
- The system configuration and the performance are flexible.
- The number of the harness can be decreased.
**Small On-board Computer**

- Versatile Computer
- Desk top PC size & light weight
- New 64bit space MPU (HR5000) developed by JAXA
- Applying Network technology
  - Flexible configuration corresponding to mission requirement

Conventional design

- 16bit MPU
- Memory
- Auxiliary circuit
  - Function A
  - Function B
  - Function C

New architecture

- HR5000 (64bit)
- Memory & Auxiliary circuit
- router
  - Function A
  - Function B
  - Function C
SpaceWire Router

- A6 size footprint & light weight
- 14 ports or 28 ports (14 ports x 2 in one unit)
- Applying Network technology
  → Plug & play architecture can be applied

14 ports Router (Development model)

Conventional design

New architecture

Bus controller
UNIT A
UNIT B
UNIT C

Network Host Computer

SpW router
UNIT A
UNIT B
UNIT C
SpaceWire -Flexibility of mission-

Optical sensor mission

DH Computer

Router

Mission Computer

Payload I/F Unit

Optical Sensor

Mission change

SAR sensor mission

DH Computer

Router

Mission Computer

Payload I/F Unit

SAR Sensor

SpaceWire

exclusive line
SpaceWire - High-reliability of bus system -

Single Bus Configuration

DH Computer
  ↓
Router
  ↓
EPS
  ↓
TMTC Processor
  ↓
RF

High-reliability

DH Computer
  ↓
DH Computer
  ↓
Router
  ↓
TMTC Processor
  ↓
RF
  ↓
TMTC Processor
  ↓
RF

redundancy

TMTC : Telemetry and command

SpaceWire exclusive line
4. Optical mission
# Optical Payload Specifications

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation Method</td>
<td>Push-Bloom Scan</td>
</tr>
<tr>
<td>Observation Bands</td>
<td>Panchromatic Band</td>
</tr>
<tr>
<td></td>
<td>Multi-spectral : 6 Bands</td>
</tr>
<tr>
<td>Grand Sample Distance (GSD)</td>
<td>Panchromatic: &lt; 0.5m</td>
</tr>
<tr>
<td></td>
<td>Multi-spectral: &lt; 2.0m</td>
</tr>
<tr>
<td>Swath Width</td>
<td>&gt; 10km</td>
</tr>
</tbody>
</table>
OPS View

- Optical Tube
- Heater Plate
- Secondary Mirror (SM)
- Prime Mirror (PM)
- Tertiary Mirror (TM)
- FPA
- Optical Bench
Silicon Carbide Mirror

New Technology SiC (NTSIC) Material
~ Developed by NTSpace / Toshiba

- General Features of SiC
  - Comparing with glass material,
    - Excellent specific stiffness (stiffness / density)
      - 4 times larger than glass
    - Low thermal distortion
    - Excellent thermal conductivity

- Advantages of NTSIC
  - 2 times higher strength than usual SiC
  - Suitable for visible optics
    - NT-SiC surface has no pores.
    - Usable without surface coating

ASNARO Flight Mirror
5. Conclusions
Conclusions

• ASNARO system is expected to be a pioneer of next-generation.
  – By using our new small standard bus, ASNARO is developed at lighter weight, lower cost and fast delivery.
  – By adopting SpaceWire technology, it is possible to reduce not only the design works, but also the satellite integration and test activities.

• ASNARO is expected to be launched in 2011 JFY. Now, manufacturing of ASNARO flight model has been already started.
Empowered by Innovation

Thank you for your attention !!

Toshiaki Ogawa
t-ogawa@dt.jp.nec.com