International Scientific Micro-satellite RISESAT based on Space Plug and Play Avionics
Small satellite development at SRL

#1: SPRITE-SAT (RISING-1)
- Launch: Jan. 2009 (H-IIA)
- Demonstration of
  - Image acquisitions by mission camera
  - Coarse attitude control
  - Deployment of the boom

#2: RISING-2
- FM ready. Launch in 2013 (H-IIA)
  - Mission
    - Multi-spectrum observation with a Liquid Crystal Tunable Filter (650-1000nm)
    - High resolution stereo observation of cumulonimbus clouds
    - Detection of terrestrial luminous events in upper atmosphere

#3: RAIKO
- Launch: July 2012
  (Deployment from the ISS: Sep. 2012)
- Mission
  - Technology demonstrations (Communication URX, S, Ku, Image acquisition, De-orbit)

#4: RISESAT (2013~)
- International Scientific Missions
RISESAT Project Background

Hodoyoshi Program (Professor Nakasuka, The University of Tokyo)
- Development of multiple 50kg class micro-satellites
- Launch is planned in the Japanese fiscal year of 2013
- One of the satellites is an international scientific micro-satellite (RISESAT) (Tohoku University is responsible for the project management)

RISESAT: Rapid International Scientific Experiment Satellite
Mission Objectives
- Demonstrate international scientific missions by inviting instruments from abroad
- Investigation on advanced bus system technologies for future scientific micro-satellites
- Development of a reliable, robust and cost effective micro-satellite bus system

Expected effects
- Realization of mechanism of rapid demonstration of scientific missions in the future
- Improvement of microsatellite technologies which enables future challenging scientific missions
- Commercial spin-off of providing cost-effective microsatellite bus systems

>> Apply technological heritages of SRL
RISING-2 High-Precision Telescope

- Earth observation
  - New development of a 5-m resolution cassegrain mirror telescope system
  - Liquid Crystal Tunable Filter (650-1000 nm) for Multi-spectrum observation

- Scientific objectives
  - high resolution stereo images of cumulonimbus clouds

➢ Expected achievements
  ➢ reveal the mechanism of cumulonimbus and guerrilla heavy rains
  ➢ quick observation of, e.g. worldwide disasters
RISESAT Payload Instruments

**Camera Instruments**
- High Precision Telescope - HPT (Taiwan (NCU))
- Ocean Observation Camera - OOC (Hokkaido University)
- TLE detection camera - DOTCam (Taiwan (NCKU))

**Sensor Instruments**
- TriTel – 3D Dosimeter (Hungary)
- TIMEPIX – Particle counter (Czech)
- MEMS Magnetometer (Sweden)

**Technology Demonstration**
Laser Communication Transmitter (NICT, Japan)
Mission Objectives

Scientific Missions

S1. Astronomical Observation with HPT (NCU)
   • Successor of PRISING-2’ HPT
   • LCTF(s) will be installed

S2. Earth Observation with HPT (NCU)
S3. TLE Detection with DOTCam (NCKU)
   • Detect Meteor/ Lightning/ TLE at the night side

S4. Ocean Observation with OOC (TBC)
   • Three to four filters for ocean observation with wide FOV.

S5. Radiation Environment Monitoring with 3 axis Dosimeter (KFKI)
   • Silicon detector with 4π coverage
   • Mapping of radiation environment
   • Dual observation with another TriTel on ISS.

S6. Micro Magnetic Field Sensor (ASTC)
   • Originally scientific mission planned. → Re-arranged as engineering mission.

S8. Store&Forward
   • Global environment monitoring with distributed sensors.
   • International partner wanted.

Engineering Missions

E1. High performance three axes attitude control
   • Enable accurate scientific observation
   • Sensors and Actuators partly newly designed/developed.
   • Achieve robustness and high reliability

E2. New Development of Panel Deployment Mechanism
   • Tohoku University’ original development.
   • Improve power generation performance for higher scientific observation/experiment capability

E3. New Development of Thin Film Deployment Mechanism
   • De-orbit after mission completion

E4. Micro-monitoring camera
   • Visual intuitive operation

E5. X-band high-speed downlink

E6. Redundant and robust main computer
   • Higher reliability and strategic new technology demonstration

E7. Store&Forward demonstration
   • Receive upcoming information from distributed sensor network
   • Application in global monitoring expected

E8. Advanced optical communication
   • Collaborative research topic between NICT and Tohoku University.
   • Downlink of real scientific data
# RISESAT System Specifications

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size and weight</strong></td>
<td></td>
</tr>
<tr>
<td>size</td>
<td>Smaller than W 500 x D 500 x H 500 mm</td>
</tr>
<tr>
<td>weight</td>
<td>Max. 60, Typ. less than 55 kg</td>
</tr>
<tr>
<td></td>
<td>Payload: ~12 kg</td>
</tr>
<tr>
<td><strong>Orbit</strong></td>
<td></td>
</tr>
<tr>
<td>type</td>
<td>Sun Synchronous Orbit</td>
</tr>
<tr>
<td>local time</td>
<td>9:00–15:00 (Default LTN 11:00)</td>
</tr>
<tr>
<td>altitude</td>
<td>between 500 – 900 km</td>
</tr>
<tr>
<td>inclination</td>
<td>approx. 98 deg</td>
</tr>
<tr>
<td><strong>Attitude determination and control</strong></td>
<td></td>
</tr>
<tr>
<td>method</td>
<td>3-axis stabilization</td>
</tr>
<tr>
<td>pointing accuracy</td>
<td>&lt; 0.1° (3σ) (Reqs.), &lt; 0.04° (3σ) (Objectives)</td>
</tr>
<tr>
<td>pointing stability</td>
<td>6”/s for 200ms</td>
</tr>
<tr>
<td>sensors</td>
<td>star sensor (2), FOG (3-axes),</td>
</tr>
<tr>
<td></td>
<td>magnetometer (3-axes), GPS receiver (1),</td>
</tr>
<tr>
<td></td>
<td>course and accurate sun sensors(4π)</td>
</tr>
<tr>
<td>actuator</td>
<td>reaction wheels (4)</td>
</tr>
<tr>
<td></td>
<td>magnetic torquers (3-axes)</td>
</tr>
<tr>
<td><strong>Power supply</strong></td>
<td></td>
</tr>
<tr>
<td>solar cells</td>
<td>GaAs multijunction cell</td>
</tr>
<tr>
<td></td>
<td>10 series x 5 parallel x 3 panels</td>
</tr>
<tr>
<td></td>
<td>(Deployable panels and one body panel)</td>
</tr>
<tr>
<td>battery unit</td>
<td>10 series x 1 parallel + 10 series x 2 parallel</td>
</tr>
<tr>
<td>max. power generation</td>
<td>&gt; 100 W</td>
</tr>
<tr>
<td>max. power consumption</td>
<td>&gt; 50 W</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td></td>
</tr>
<tr>
<td>command uplink</td>
<td>UHF, 2400bps at Sendai station, Japan</td>
</tr>
<tr>
<td>HK downlink</td>
<td>S-Band, 0.1W, 38400bps – max. 500Kbps</td>
</tr>
<tr>
<td></td>
<td>main: Sendai station, Japan</td>
</tr>
<tr>
<td></td>
<td>sub: Fukui Univ. of Tech. station, Japan</td>
</tr>
<tr>
<td></td>
<td>sub: Kiruna station, Sweden</td>
</tr>
<tr>
<td>Mission Data downlink</td>
<td>X-band, max. 2.4Mbps</td>
</tr>
<tr>
<td></td>
<td>main: Fukui Univ. of Tech. station, Japan</td>
</tr>
<tr>
<td></td>
<td>sub: Sendai station, Japan</td>
</tr>
</tbody>
</table>

Launch configuration

After panel deployment
System Architecture

Telemetry, Tracking & Command
- UHF antenna hybrid
- UHF receiver
- S-band transmitter
- De-orbit Mechanism
- Battery unit
- X-band transmitter

Command & Data Handling
- Telecommand, telemetry, and recovery
- Power control unit
- Solar cells
- Data Decoder
- Satellite central unit
- Processor unit (nominal)
- Processor unit (redundant)
- Command and telemetry router

Orbit determination
- GPS receiver
- Magnetic Torquers (3-axes)
- Geomagnetic Sensor (3-axes)
- Coarse sun sensors

Payload
- Micro monitor camera
- Laser Link Terminal VSOTA

Fine Attitude Control System
- Attitude Control Unit
- Reaction wheels (4)
- Star Trackers (2)
- Gyroscope (3-axes)
- Sun earth sensors (4)

Power Supply System
- High-speed Downlink
- Power Supply System
- Main Bus Com. Line
- Scientific Data Line
- Power Line
- Other General Lines
- Main computing unit
- Antifuse FPGA
Mechanical Configuration

Launcher Interface

Payload Segment
RISESAT Engineering Model

Bus System Side

Payload Side

SHU Integration
Conclusions

- On the basis of technological heritages obtained by microsatellites RISING-1/2, and Cubesat RAIKO, RISESAT aims to demonstrate application of SPA to international collaborative scientific missions.

- RISESAT provides clear standardized interface to payload instruments for easy integration, tests, and operation.

- RISESAT bus system has a potential to serve as a flexible high-performance bus system for future international scientific missions.
Thank you for your attention.

International students are very welcome!