Current Status and Future Vision of Hodoyoshi Microsatellites – Systems for Quick and Affordable Space Utilizations

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Pre-”Hodoyoshi”

“University Satellites” Activities in Japan
Emerge of Nano/pico-Satellites in Japan

Success of CubeSat (1kg) by Univ. Tokyo and Titech (2003.6.30)
- University level budget (30K$)
- Development within 2 years
- Surviving in space for >10 years
- Ground operations, frequency acquisitions, launch opportunity search processed by ourselves

1~50kg (Micro/Nano-sat):
Starting from education but higher level satellites appears
Educational Significances of CanSat/Micro/Nano/Pico-Satellite Projects

- **Practical Training of Whole Cycle of Space Project**
  - Mission conceptualization, satellite design, fabrication, ground test, modification, launch and operation
  - Know what is important and what is not.

- **Importance for Engineering Education**
  - Synthesis (not Analysis) of an really working system
  - Feedbacks from the real world to evaluate design, test, etc.
  - Learning from failures (while project cost is small)

- **Education of Project Management**
  - Four Managements: “Time, human resource, cost and risk”
  - Team work, conflict resolution, discussion, documentation
  - International cooperation, negotiation, mutual understanding

- **Also contributions to other technology areas !**
Training step: CanSat 1999-now
# CubeSat “XI-IV (Sai Four)”

**Mission:** Pico-bus technology demonstration in space, Camera experiment  
**Developer:** University of Tokyo  
**Launch:** ROCKOT (June 30, 2003) in Multiple Payload Piggyback Launch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>10x10x10[cm] CubeSat</td>
</tr>
<tr>
<td>Weight</td>
<td>1 [kg]</td>
</tr>
<tr>
<td>Attitude control</td>
<td>Passive stabilization with permanent magnet and damper</td>
</tr>
<tr>
<td>OBC</td>
<td>PIC16F877 x 3</td>
</tr>
<tr>
<td>Communication</td>
<td>VHF/UHF (max 1200bps)</td>
</tr>
<tr>
<td></td>
<td>amateur frequency band</td>
</tr>
<tr>
<td>Power</td>
<td>Si solar cells for 1.1 W</td>
</tr>
<tr>
<td>Camera</td>
<td>640 x 480 CMOS</td>
</tr>
<tr>
<td>Mission life</td>
<td>more than 8 years</td>
</tr>
</tbody>
</table>

Captured Earth Images and Distribution to Mobile Phones
CubeSat “XI-V (Sai Five)”

Mission: CIGS solar cell demonstration, Advanced camera experiment
Developer: University of Tokyo
Launch: COSMOS (October 27, 2005) deployed from “SSETI-EXPRESS”

Size 10x10x10[cm] CubeSat
Weight 1 [kg]
Attitude control Passive stabilization with permanent magnet and damper
OBC PIC16F877 x 3
Communication VHF/UHF (max 1200bps) amateur frequency band
Power Si, GaAs, CIGS cells
Camera 640 x 480 CMOS
Mission life > 5 years

Deployed from SSETI-EXPRESS in space
Captured Earth Images
JAXA/NEDO CIGS Solar Cells
T-POD deployment System
SSETI-EXPRESS
# PRISM “Hitomi”

**Mission:** Earth Remote Sensing (20 m GSD, RGB) with Deployable Boom

**Developer:** University of Tokyo

**Launch:** H-IIA (Jan 23, 2009) Piggyback with GOSAT (CO₂ monitoring sat)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
<td>20x20x40[cm] in rocket</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>8.5 [kg]</td>
</tr>
<tr>
<td><strong>Attitude control</strong></td>
<td>3-axis stabilization with</td>
</tr>
<tr>
<td></td>
<td>Sun, Magnet sensor, MEMS gyro magnetic torquers</td>
</tr>
<tr>
<td><strong>OBC</strong></td>
<td>SH2, H8 x 2, PIC x 2</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
<td>VHF/UHF (max 9600bps)</td>
</tr>
<tr>
<td><strong>Mission life</strong></td>
<td>&gt; 2.5 years</td>
</tr>
</tbody>
</table>

**Captured images**

- Mexico Seashore
- US Desert
- Kita-Kyushu (Japan)
- Wide Angle Camera

![Satellite Image](image-url)
# Nano-JASMINE

**Mission:** Astrometry (Getting precise 3D map of stars and their movements)

**Developer:** University of Tokyo, National Astronomical Observatory of Japan, Shinshu University, Kyoto University

**Launch:** Cyclone-4 (planned within 2014-15) from Alcantara Launch Site

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>50 [cm-cubic]</td>
</tr>
<tr>
<td>Weight</td>
<td>33 [kg]</td>
</tr>
<tr>
<td>Attitude control</td>
<td>3-axis stabilization with Star, Sun, Magnet sensor, FOG, RW, Magnetic torquers</td>
</tr>
<tr>
<td>OBC</td>
<td>FPGA</td>
</tr>
<tr>
<td>Communication</td>
<td>S-band 100 [kbps]</td>
</tr>
<tr>
<td>Mission life</td>
<td>2 [year]</td>
</tr>
</tbody>
</table>

**Special features:**
- Attitude Stability: 0.8 arcsec for 8.8 sec
- Thermal Stability: < 0.1K (at -50 degree)
- Map Accuracy: Compatible with “Hipparcos” Satellite (‘89)
- Telescope: two CCDs with TDI
Satellites made by UNISEC Universities

As of May 2012
**WNISAT-1**

**Missions:** Iceberg observation in Arctic Ocean, Atmospheric Observation (CO₂)

**Developer:** AXELSPACE, Weather news Inc.

**Launch:** DNEPR (2012) (planned)

<table>
<thead>
<tr>
<th>Component</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>27x27x27[cm]</td>
</tr>
<tr>
<td>Weight</td>
<td>15 [kg]</td>
</tr>
<tr>
<td>Attitude control</td>
<td>3-axis stabilization with STT, SAS, Magnetometer, Gyros RW, magnetic torquers</td>
</tr>
<tr>
<td>OBC</td>
<td>FPGA</td>
</tr>
<tr>
<td>Communication</td>
<td>UHF (max 38.4 kbps)</td>
</tr>
<tr>
<td>Camera</td>
<td>Visible &amp; NIR, GSD 500m</td>
</tr>
<tr>
<td>Laser</td>
<td>CO₂ absorbed (1.55μm)</td>
</tr>
<tr>
<td>Mission life</td>
<td>2 years</td>
</tr>
</tbody>
</table>

**Components by AXELSPACE**

- Star Sensor (AxelStar)
- Coarse Sun Sensor (AxelSun)

More info available at our website!

Please visit: [http://www.axelspace.com](http://www.axelspace.com)
Outcomes of University Satellite Projects

• Significant educational effects have been proved!!
• Can be applied to even “really useful” missions;
  – Earth observation, Space sciences
  – Entertainment, contents creation, education…
• Possibility of “business use” by especially non-government customers
• For those objectives, we should improve in many directions;
  – Reliability (but without so much additional cost)
  – Component technologies in many areas
  – Development process (especially the ground tests)
  – Utilization techniques and user community generation
Governmental “First” Program
”Hodoyoshi-project” (2010-2014)

- Reliability concept for micro/nano/pico-satellites
  - “So-so and not expensive (Hodoyoshi)” reliability
    (compromise between cost (workload) vs. reliability)

- Component technology development
  - Should solve “size and power problem”

- Development process innovation
  - Software architecture
  - Ground test, etc.

- Create novel applications and use communities
  - Non-government users as individuals, companies, local government, research institute can seek for their interest
Overall R&D Structure of Hodoyoshi-PJ

- **Satellites, components, infrastructure with high competitiveness**
- **Low-cost, Quick, Practical level**
- **Human Resource Training**
- **Promotion**
- **Ground Station**
- **Ground Testing**
- **[Standardization]**
- **Personal use**
- **Novel missions**
- **Foreign Customers**
- **New utilizations**
- **New Players**

**Development Process**

- **Hodoyoshi-reliability**
- **Miniature components**
- **Advanced components**
- **Optical system, Image processing**
- **Low cost supply chain network**

**Four satellite development**

**Novel Missions Demo.**

**New Paradigm of Space Development and Utilization**

- **Space science mission**
- **Mission creation**

- **Personal use**
- **Novel missions**
- **Foreign Customers**
- **New utilizations**
- **New Players**
Motivation: Problem of Mid-large Satellites

- Enormous cost >100M$
- Development period >5-10 years
- Conservative design
- Almost governmental use
- No new users and utilization ideas
- Low speed of innovation

Trend towards larger satellites

Small-sat

Micro/Nano Satellites

<50kg

1-5M$
**HODOYOSHI-1**

**Mission:** Earth Remote Sensing (6.7m GSD, 4 bands: RGB & NIR)

**Developer:** AXELSPACE, University of Tokyo, NESTRA

**Launch:** DNEPR in 2012

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Details</th>
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<tbody>
<tr>
<td>Size</td>
<td>50 [cm-cubic]</td>
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<tr>
<td>Weight</td>
<td>50 [kg]</td>
</tr>
<tr>
<td>OBC</td>
<td>FPGA</td>
</tr>
<tr>
<td>Communication</td>
<td>UHF, X (max 20 Mbps)</td>
</tr>
<tr>
<td>Mission life</td>
<td>2 [year]</td>
</tr>
<tr>
<td>Attitude control</td>
<td>3-axis stabilization with STT, SAS, Magnetometer, Gyros, RW, Magnetic torquers</td>
</tr>
<tr>
<td></td>
<td>- stability 0.1 deg/sec</td>
</tr>
<tr>
<td></td>
<td>- pointing accuracy 5 arcmin</td>
</tr>
<tr>
<td></td>
<td>- determination 10 arcsec</td>
</tr>
<tr>
<td>Optical sensor</td>
<td>15kg, 6.7m GSD (500km alt.)</td>
</tr>
<tr>
<td></td>
<td>- Focal length 740mm (F# 7)</td>
</tr>
<tr>
<td></td>
<td>- IFOV 24.3 x 16.2 km (500km alt.)</td>
</tr>
<tr>
<td></td>
<td>- Bands(SNR) B(103), G(119), R(84), NIR(63)</td>
</tr>
<tr>
<td></td>
<td>- Onboard storage 8GB (~100 compressed images)</td>
</tr>
</tbody>
</table>

*Optical Camera (6.7m@500km) developed by Genesia Corporation*
Hodoyoshi-1 completed in early 2013

DNEPR Rocket (at Ukraine)

6.7m GSPO
Refraction Optics
# HODOYOSHI-2 (RISESAT)

## International Space Science Missions

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TriTel – 3D Dosimeter</td>
<td>(Hungary)</td>
</tr>
<tr>
<td>Meteor counter - DOTCam</td>
<td>(Taiwan/NCKU)</td>
</tr>
<tr>
<td>TIMEPIX – Particle counter</td>
<td>(Czech)</td>
</tr>
<tr>
<td>SDTM – MEMS Magnetometer</td>
<td>(Sweden)</td>
</tr>
<tr>
<td>Ocean Observation Camera - OOC</td>
<td>(Tohoku University)</td>
</tr>
</tbody>
</table>

### Camera Instruments

- High Precision Telescope- HPT (Taiwan/Vietnam)
- TIMEPIX – Particle counter
- Ocean Observation Camera - OOC
- Sensor Instruments

### Technical Specifications

- **Size:** 50cm, 55kg
- **Comm:**
  - S-band: 38.4kbps
  - X-band: 2Mbps
- **Power:** 100W
- **ACS:** <0.1°
- **Rocket:**
  - H-IIA (TBD)
HODOYOSHI-3 & 4

<table>
<thead>
<tr>
<th></th>
<th>Hodoyoshi-3</th>
<th>Hodoyoshi-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>0.5 × 0.5 × H0.65m</td>
<td>0.5 × 0.6 × H0.7m</td>
</tr>
<tr>
<td>Weight</td>
<td>60kg</td>
<td>66kg</td>
</tr>
<tr>
<td>Orbit</td>
<td>SSO. 600km, LTAN 10am~11am</td>
<td></td>
</tr>
<tr>
<td>ACS</td>
<td>Earth pointing, 3 axis stabilization</td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>Power generation: max 100W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power consumption: average 50 W</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bus voltage: 28V, 5V</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Battery: 5.8AH Li-Ion</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>H/K and Command: S-band uplink: 4 kbps, downlink: 4/32/64 kbps</td>
<td>Mission data downlink: X-band 10Mbps (100Mbps to be tested on Hodoyoshi-4)</td>
</tr>
<tr>
<td>Orbit control</td>
<td>H₂O₂ propulsion</td>
<td>Ion-thruster (Isp: 1100s)</td>
</tr>
<tr>
<td>Missions</td>
<td>Mid-resolution optical camera</td>
<td>High-resolution optical camera</td>
</tr>
<tr>
<td></td>
<td>GSD: 40m &amp; 200m</td>
<td>GSD: 5m</td>
</tr>
<tr>
<td></td>
<td>Store &amp; Forward</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hosted payloads (10cm cube x 2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hetero-constellation experiment</td>
<td></td>
</tr>
</tbody>
</table>

Rocket: DNEPR launch in early 2014
Component/software technologies Development
Components under development (example)

- Radiation-hardened SOI-SoC onboard computer
- Software architecture (SDK, HILS, etc.)
- Optical camera with 2.5 - 200m GSD
- Li-Ion battery and power control unit
- Low-shock lock/release & deployable mechanism
- High speed and versatile data handling unit
- High speed, low power RF transmitter (>100Mbps)
- Electric propulsion system (Ion thruster)
- Attitude control system for micro/nano-satellite
  - Fiber optical gyro, Reaction wheel, CMG, etc.
- Debris mitigation device (deployable membrane)
- Optical communication system (with NICT)
Software: “Hodoyoshi SDK”
- Hardware in the Loop and Verification System -

- Software verification is essential to achieve software reliability.
- We developed hardware in a loop OBC software verification system.
- In the verification system, the performance and interface of the peripheral equipment is simulated by the PC simulator, and closed-loop simulation using a real OBC can be realized.
Framework and Driver Library in Hodoyoshi SDK

• Framework Software System

• Driver Library
Deployable Structure

Simple and reliable devices for deployable structure

- Simple and reliable hold-release mechanism
- Latchable hinge
- Will be verified in space by “HODOYOSHI” #3 and #4 satellite

Satellite main structure

Latchable hinge

HRM (wire-cut type)

Latch mechanism

Theoretical estimation of performance of deployable structure

- Estimation of shape accuracy after deployment (for high-precision deployable structure)
- Estimation of smooth deployment

Constraint condition for each joint (position and attitude)

\[ f_{mn} = [x_i + R_i \cdot (y_{mi} + T_{mi} \cdot z_m)] \]

\[ - [x_j + R_j \cdot (y_{nj} + T_{nj} \cdot z_n)] = 0 \]

\[ g_{mn} = R_i \cdot T_{mi} \cdot Q_m - R_j \cdot T_{nj} \cdot Q_n = 0 \]

Relation between deviation of design parameter \( u \) and state vector \( \xi \)

\[ H \cdot \delta u + L \cdot \delta \xi = 0 \]

Estimation of performance
CMG and Advanced Ground Test Methods

1. Design and Development of Integrated Simulator to Verify Attitude Determination and Control System for Advanced Small Satellites

2. Design and Development of small CMG for Large Torque Generation and High-rate Attitude Maneuver

3. Integrated and Environment Tests of Attitude Determination and Control System
Satellite Optical System

Athermal Apochromatic Optics
- Robust to temperature changes
- Swath 27.8km - GSD 6.7m
- 4 bands (RGB+NIR), S/N > 100

For Hodoyoshi-1
\[ \beta_{lens} = \alpha_{metal} = \alpha_{glass} + \left( \frac{dn}{dT} \right)/(n-1) \]

Selecting appropriate optical material and its combination can reduce optical distortion made by Thermal expansion of support structure

Optical Receptor
- CCD with Precise Optical Filter
- Push Bloom type
- NIR-band for Super resolution

Optical Filter and Line CCD
- NIR Filter
- RGB CCD
- Mono CCD

Visible Image
NIR Image
4 band CCD Detector System

Onboard Hodoyoshi-1 to be launched in early 2014
Advanced Optics & Image Data Processing

Image Data Processing

- Modeling of satellite and telescope
  - Elevation model using parallax
  - Distortion correction for attitude jitter

Adaptive Optics

- Correction of distortion in optical system
- Optimization using multi actuator control
  - Deformable mirror and its pattern

- Deformable mirror and its pattern

- Elevation model and attitude jitter

- Resolution enhancement

Advanced solutions for future optical observation
Propulsion system: Hodoyoshi-1 and 3

- Hodoyoshi-3 will employ non-toxic $\text{H}_2\text{O}_2$ propulsion system which is also used in Hodoyoshi-1
- This propulsion system is capable of 2,400 Nsec of total impulse, that can achieve 180 km perigee descent maneuver from 600 km circular orbit for 50 kg satellite

<table>
<thead>
<tr>
<th>Item</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Propellant</td>
<td>$\text{H}_2\text{O}_2$</td>
</tr>
<tr>
<td>Thrust</td>
<td>500mN</td>
</tr>
<tr>
<td>Specific thrust</td>
<td>80 sec</td>
</tr>
<tr>
<td>Propellant weight</td>
<td>2.5kg</td>
</tr>
</tbody>
</table>
Miniature Ion-Propulsion System (MIPS)

**KEY TECHNOLOGIES**
- Low power (1 W) plasma generation by microwave
- High efficiency Ion beam through miniature grid
- Optimization of neutralizer

**REMARKS**
- World first Ion-thruster system for micro-satellites
- Modular type propulsion system
- High orbit transfer capability (>400km for 50kg)

**MIPS specifications**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>8 kg (incl. 1 kg Xe)</td>
</tr>
<tr>
<td>Size</td>
<td>39×28×16 cm</td>
</tr>
<tr>
<td>Power consumption</td>
<td>30 W (TBD)</td>
</tr>
<tr>
<td>Thruster</td>
<td>300 μN</td>
</tr>
<tr>
<td>ISP</td>
<td>1200 s</td>
</tr>
<tr>
<td>Total impulses</td>
<td>12 kNs</td>
</tr>
<tr>
<td>Total ΔV</td>
<td>240 m/s (50kg S/C)</td>
</tr>
</tbody>
</table>

Onboard Hodoyoshi-4 (2014 launch)

**Neutralizer**

MIPS Firing Test

**Ion beam source**
Ground station system for Micro-satellite operation

1) Ground station using active phased array antenna system

- Antenna element development for omni-directional active phased array antenna
- Integrated printed board of pre-amp, phase shifter, mixer, and adder

2) Ground station with parabola antenna

- UHF, S, C, X antenna
- Kyushu univ. (2.4m), Taiiki-cho (3.8m), ISAS, Tokai Univ (2.4m), and Fukui-tech (10m)
- Networking and intelligent ground operation
Ground Testing

Concentration of Nano-satellite environment tests

Test Center at Kyushu Institute of Technology

HORYU2  FITSAT  QSAT-EOS  STARS-II  UNIFORM

Outreach
(15 tests of components manufactured by small business)

Development of new test method

Rupture & Leak test  Single-event test

Telescope for nanosatellite

International Standardization

Rupture & Leak test  Single-event test

International standardization workshop
Hodoyoshi reliability (Reasonably reliable systems engineering)

Enlarge problem framework and search for total optimum solution with new DOF

Ultra high reliability requires enormous cost

Cost or workload

Increased requirement yields additional cost

Reliability or performance

Find out optimum setting of requirement on reliability and performance

Current Space Develop.

1) Factors really affecting satellite reliability

- Reliability = designed reliability \times probability that the system behaves as designed

- "Context number" has been introduced to roughly indicate the “complexity of the system” which degrade the second part

- If Context number is large or propagated to other subsystem, then the combinatorial explosion of context number degrades system reliability tremendously

2) Design Strategy to reduce Context Number or cut the propagation of Context Number

- Re-setting
- Athermal design
- Solar cells on all surfaces
- Under Voltage Control
- Thermal design with minimum node
- On-orbit tuning/reconfiguration

Design strategy example

Athermal-Apochromatic design

3) Efficient development process (Process approach)

- Optimum distribution of workload
- Interface re-consideration with outside vendors
- Program level continual Improvement off reliability
Creation of Missions

more to be discussed

in the 2\textsuperscript{nd} day’s panel discussion
Suitable Missions for Micro/nano-satellites

- Low-cost and small size realize satellite constellation
  - More frequent (ex. semi-daily) observation of the same areas
- Formation flight
  - Many scientific applications such as interferometer, multi-site observation, stereo vision
- “Personal Satellite” “My Satellite”
  - Novel ways of utilization including entertainment, education, contents, etc
  - Just like “PC and internet” innovation which has changed the world
Monitoring Agriculture/Fishing/Forest

- Every day growth of crops, plants, etc.
  - To decide when to harvest wheat
  - To check health status of plants and trees
- Prediction of amount of crops
- Obtaining fields/forest management data
  - To detect not-used rice fields
  - To check usage of fields
  - To estimate tree types and volume of forest
- Search for fishing fields (by temperature, etc)
- Collection of water surface information
  - Detection of red tide
MOU for joint utilization of Hodoyoshi satellites was exchanged in October 2010 between Ukrainian organizations under SSAU and University of Tokyo.

Taking the advantage of simple, low cost, short lead-time of the micro satellites, the University of Tokyo is building a satellite constellation including Hodoyoshi-1,2,3,4 that can quickly respond to national catastrophes for the monitoring of disasters and an aftermath response.

First meeting of joint Japan-Ukraine committee for the cooperation to advance aftermath response to accidents at nuclear power stations was held in Tokyo, July 26th 2012 by Ministry of Foreign Affairs, and the joint satellite observation program was discussed and welcomed.

Ministry of Education and Science (MEXT) started to support to this program.

Ukrainian Chernobyl monitoring specialists were invited to the University of Tokyo in February 2013.
Hodoyoshi-3 & 4: Store & Forward

- UHF receiver onboard Hodoyohi-3 & 4 can collect data from ground Sensor Network (fixed points or mobile)

**S&F mission outline**

1. Fixed or mobile sensors on the earth get ground information and transmit them to Hodoyoshi-3&4 when they fly over the area
2. Hodoyoshi 3&4 receive and store the information, and forward (transmit) it to Ground Stations when it flies over them

*Example*

![Diagram](image)
Concept on Global Network for Water Level Monitoring with nano/micro satellites

Global network for water level monitoring

Water level monitoring sensor system which will be developed with low cost

Water level monitoring sensor systems installed in many places in the world send data to satellites

End users who need to monitor water level in the world

Collect and store data of water level

Satellites send collected data to ground station

Ground Station

Automatic analysis and distribution of data of water level

Internet

UNISEC - University Space Engineering Consortium
“Rental Space”: Hosted Payload (3 & 4)

- The “Hosted Payload” consists of 3 modules of 10cm cubic size (small cameras can capture inside)
- To provide the “orbiting laboratory” opportunity for enterprises and public
  - Space demonstration of new products
  - Space environment utilization (micro-gravity)
  - Space sciences, etc.
International Contributions
1) CanSat Leader Training Program (CLTP)

CLTP was established in 2011 to contribute to capacity building in space technology and to improve teaching methods in space engineering education.

- A one month course gives training through whole cycle of CanSat development including sub-orbital launch experiments
- Participants are expected to teach their students CanSat program in their countries
- Aiming at international CanSat education network

http://www.cltp.info
CLTP Participants

**CLTP1 (Wakayama Univ. in Feb-March, 2011)**
12 participants from 10 countries, namely Algeria, Australia, Egypt, Guatemala, Mexico, Nigeria, Peru, Sri Lanka, Turkey, Vietnam.

**CLTP2 (Nihon Univ. in Nov-Dec, 2011)**
10 participants from 10 countries, namely Indonesia, Malaysia, Nigeria, Vietnam, Ghana, Peru, Singapore, Mongolia, Thailand, Turkey.

**CLTP3 (Tokyo Metropolitan Univ. in July-August, 2012)**
10 participants from 9 countries, namely Egypt, Nigeria, Namibia, Turkey, Lithuania, Mongolia, Israel, Philippines, Brazil.

**CLTP4 (Keio Univ. in July-August, 2013)**
9 participants from 6 countries, namely Mexico, Angola, Philippines, Bangladesh, Mongolia, Japan.

**CLTP5(Planned) (Hokkaido Univ. in Aug.-Sept., 2014)**
2) Mission Idea Contest (MIC) for Micro/nano-satellite Utilization

- **Objective:** Encourage innovative exploitation of micro/nano-satellites to provide useful capabilities, services or data.
- **Requirement:** Propose innovative Mission Idea and Satellite Design

- Regional coordinators: 33 regions
- 1\textsuperscript{st}: 62 proposals from 24 countries (2011)
- 2\textsuperscript{nd}: 74 proposals from 29 countries (2012)
- 3\textsuperscript{rd}: Pre-event: Nov. 23, 2013  Final: 2014

[http://www.spacemic.net](http://www.spacemic.net)
Global network through Mission Idea Contest and CanSat Leader Training Program (MIC:33, CLTP: 21 countries) 38 countries in total

- CLTP participant
- MIC coordinator
Images of Microsatellites Development
Vibration Test and Thermal Vacuum test of Hodoyoshi-3 EM
Images of Microsatellites Development
Uniform, Hodoyoshi-3, -4 FM Integration underway
Current Development Status

- **Hodoyoshi-1**: Completed
  - Launch in Feb 2014 by DNEPR
- **Hodoyoshi-2**: FM Phase
  - Launch by H-IIA (TBD)
- **Hodoyoshi-3 & 4**: FM Phase
  - Launch in March/April 2014 by DNEPR

Hodoyoshi-3&4 Table Sat

EM Integration  EM Vibration test  EM Thermal Vacuum Test
Next Phase of Hodoyoshi PJ

• **Practical application phase**

• Usage of Hodoyoshi-bus:
  – Vietnam ODA capacity building project: teaching more than 30 persons in 4 years by 5 Japanese universities
  – “PROCYON”: deep space microsatellite by UT
  – Space science missions by JAXA (TBD)
  – Collaborations with private companies

• Missions realized by Hodoyoshi satellites
  – Measurement network using S&F
  – Fukushima environment monitoring mission
  – Rental space and image business
  – Disaster monitoring and other governmental missions