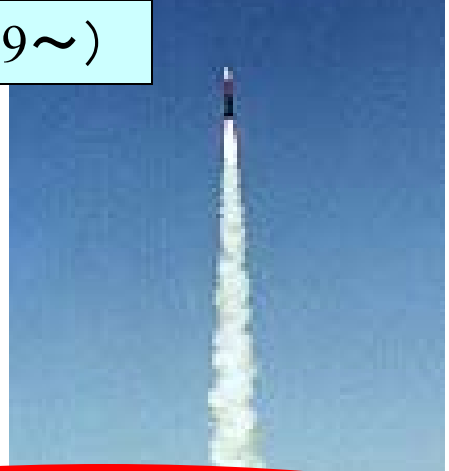
CanSat & Rocket Experiment(‘99～)



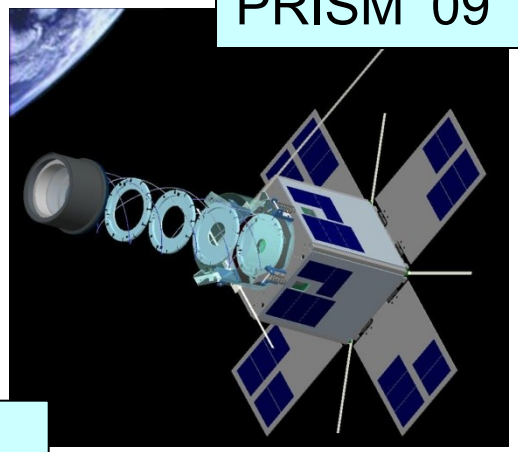
Hodoyoshi-1 2012

Opening Remarks at the 4th Nano-satellite Symposium

Shinichi Nakasuka
University of Tokyo

CubeSat 03,05

PRISM ‘09



Nano-JASMINE ‘13

Welcome Address

- Welcome to the Nano-satellite Symposium, co-hosted by:
  - United Nation Office for Outer Space Affairs
  - University of Tokyo, Japan

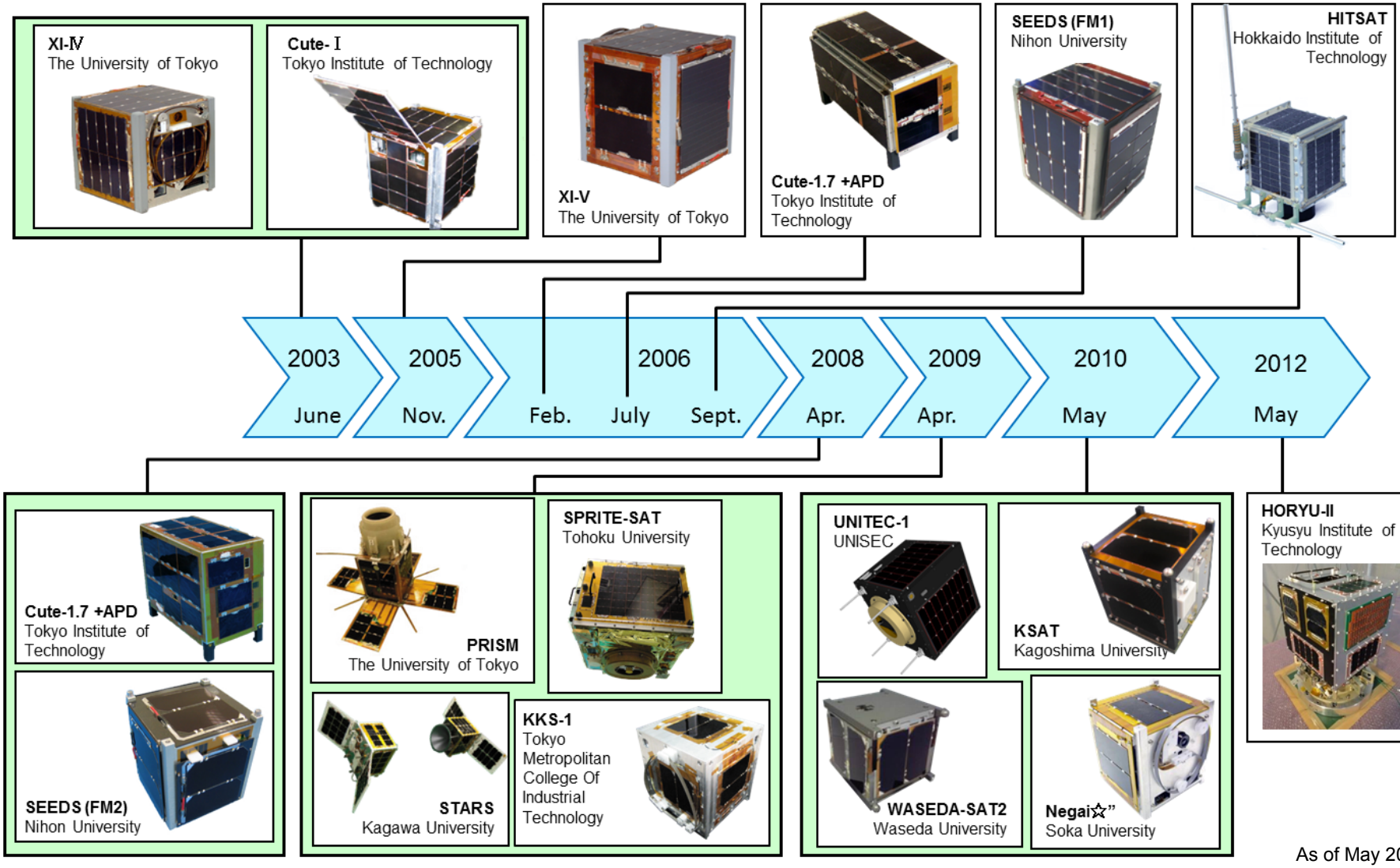
- Main symposium in "Hodoyoshi-Project," Japanese nation-wide project for creating new paradigm of space development and utilization by Micro/nano-satellites (already had symposiums 3 times since 2010)

- Main Theme: "Paradigm Shift – Changing Architecture, Technologies and Players"
- Presentations/discussions on technologies including satellite architecture, advanced components, ground tests and standardization, legal matters, education and utilizations primarily for/using micro/nano-satellites
- Community building and friendship enhancement is another important theme

Introduction of Micro/Nano/Pico-satellites in Japan and “Hodoyoshi-Project”

New Space Development and Utilization Paradigm by Nano-satellites Introducing Japan-oriented “Reasonable Reliable Systems (Hodoyoshi) Engineering” (2010-2014)

Satellites Developed by Japanese Universities (June.2003～May.2012)



As of May 2012

Significances of Micro/Nano/Pico-Satellite Projects

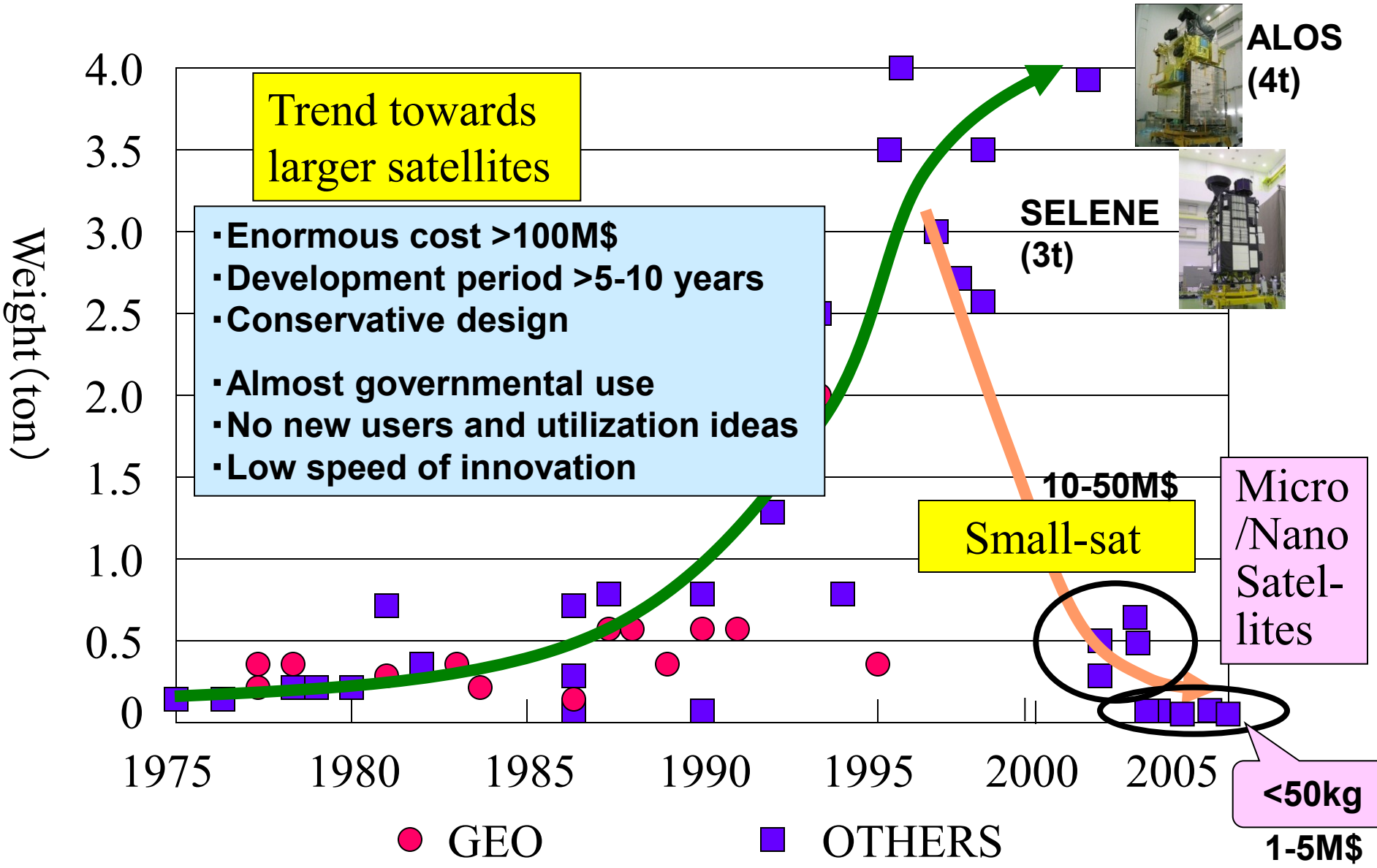
- ***Initial phase contributions: Education***
  - Practical Training of Whole Cycle of Space Project
  - Feedbacks from the real world to evaluate design, test, etc.
  - Learning from failures (while project cost is small)
  - Training for project management
  - International cooperation, negotiation, mutual understanding
    - ***Also contribute to other technology areas !***

- ***Create a new paradigm of space development and utilizations with low cost and quick development***
  - Will introduce new players(individual, company, local government, research institute, etc.) seeking for their own use
  - Will create novel ways of space utilizations
  - Will lead to participations of more nations

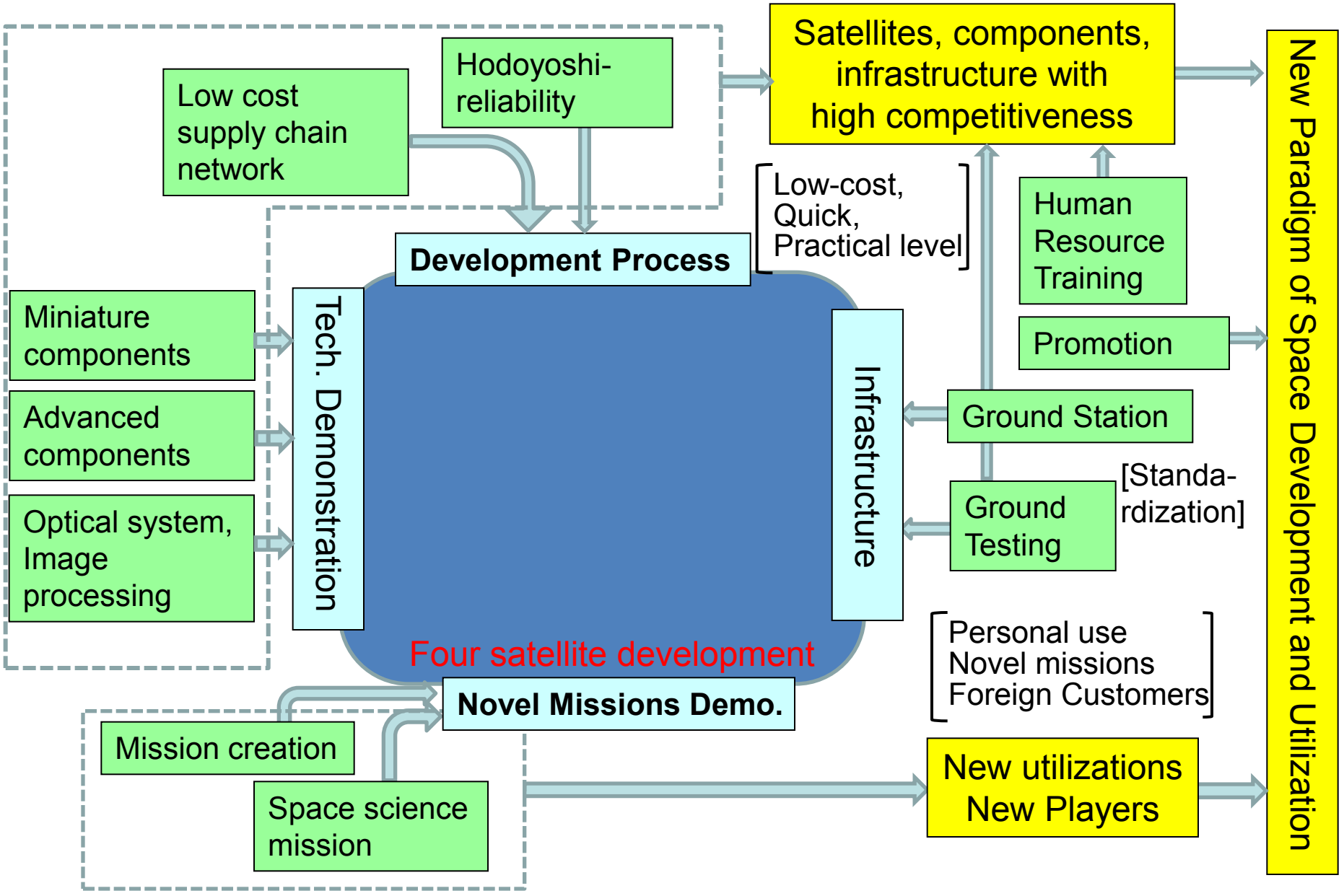
Governmental "First" Program
"Hodoyoshi-project" (2010-2014)

- 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.*
- Novel applications and user communities
  - *Non-government users as individuals, companies, local government, research institute can seek for their interest*

Motivation: Problem of Mid-large Satellites

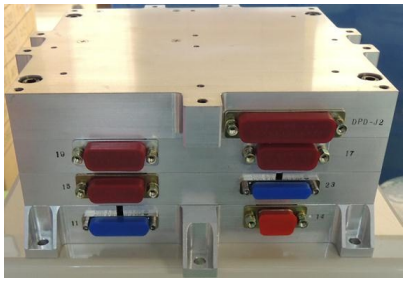


Overall R&D Structure of Hodoyoshi-PJ



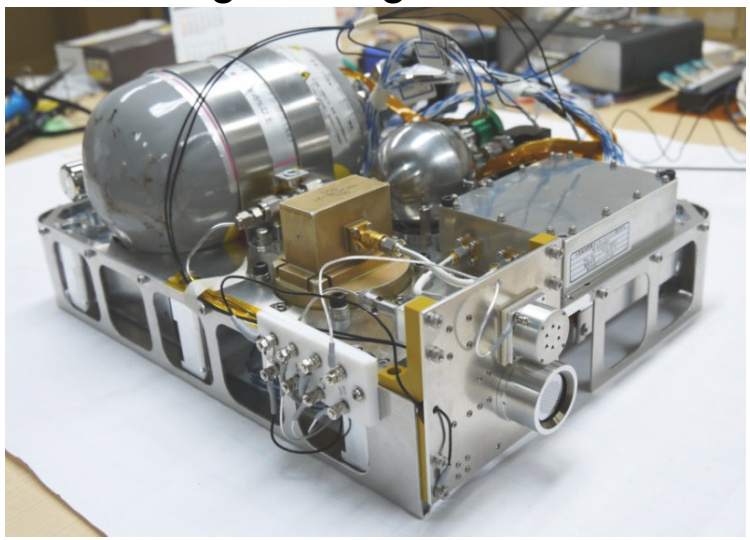
Components under development (example)

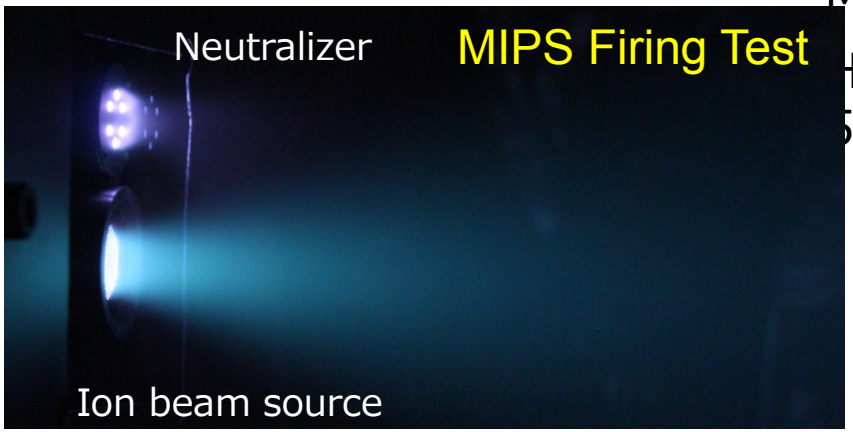
- Radiation-hardened SOI-SoC onboard computer
- Software architecture (SDK, HILS, etc.)
- Optical camera with 2.5 - 200m GSD
- Li-Ion battery and power control unit
- Low-shock lock/release & deployable mechanism
- High speed and versatile data handling unit
- High speed, low power RF transmitter (>100Mbps)
- 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)



Miniature Ion-Propulsion System（MIPS）

MIPS Engineering Model





KEY TECHNOLOGIES

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

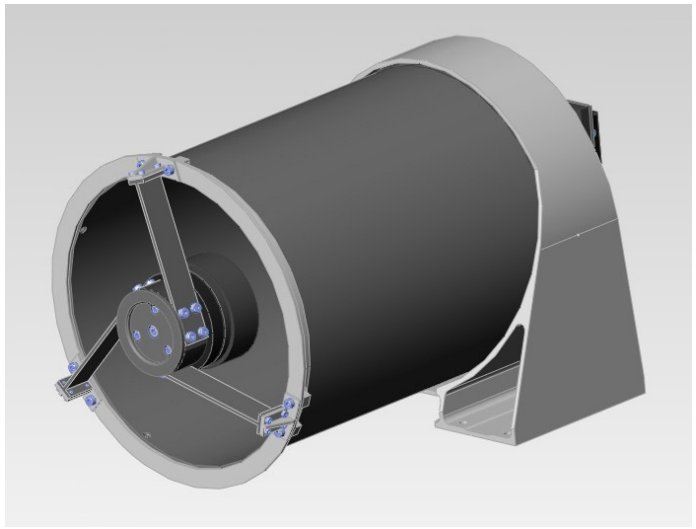
REMARKS

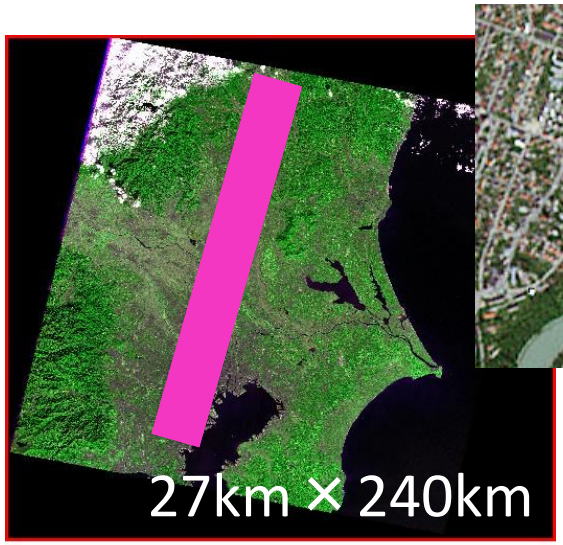
- World first Ion-thruster system for micro-satellites
- Modular type propulsion system

MIPS specifications	
Weight	6 kg (incl.1kg Xe)
Size	39×28×16cm
Power consumption	20-30 W (TBD)
Thruster	260 μN
ISP	1170 s
Total impulses	12 kNs
Total ΔV	240 m/s (50kg S/C)

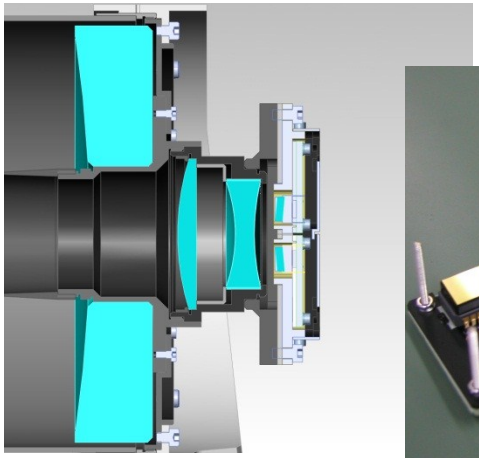
High Resolution Camera

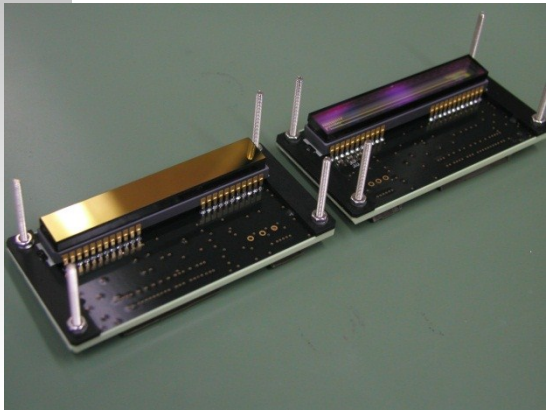
- Aperture: 15cm, weight: 3.5kg GSD: 5m suitable for micro-sat
- 4 bands: R,G,B, NIR
- Scalable design extension for 2.5m GSD advanced camera





5m GSD



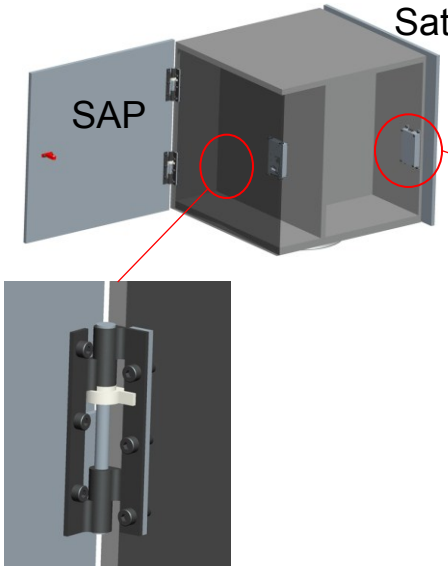


Item	Specification
GSD	5～7m
Swath	20～28km
Style	Push-bloom
Focal length	1000mm
F-value	6.7

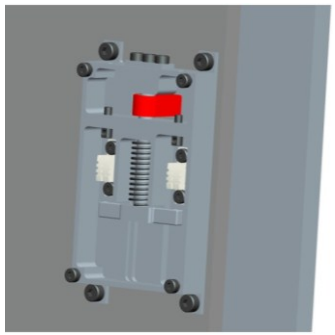
Deployable Structure

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

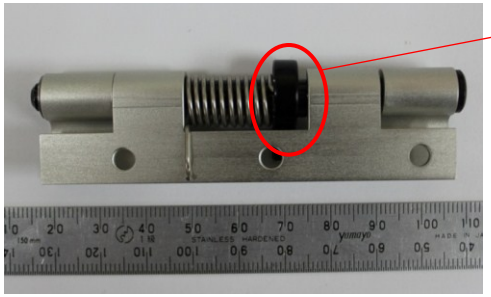


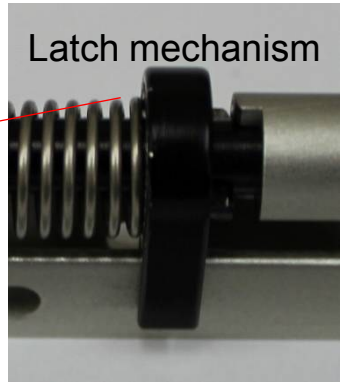
Satellite main structure



HRM (wire-cut type)

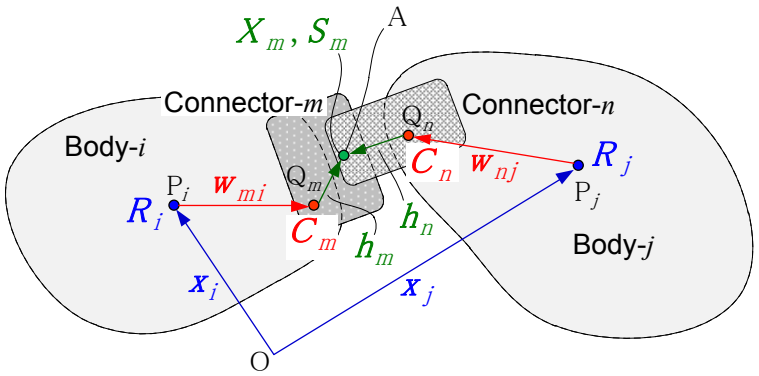
Latchable hinge





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)

$$f_{mn}(x_m, R_m, y_m, T_m, z_m, \cdots, x_n, R_n, y_n, T_n, z_n, \cdots) = 0$$

$$g_{mn}(R_m, T_m, Q_m, R_n, T_n, Q_n, \cdots) = 0$$

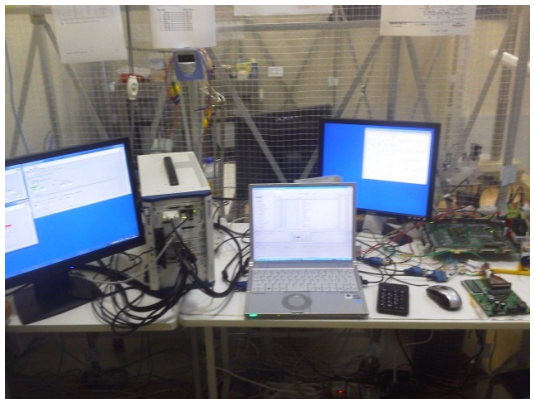
➡ Relation between deviation of design parameter **u** and state vector ξ

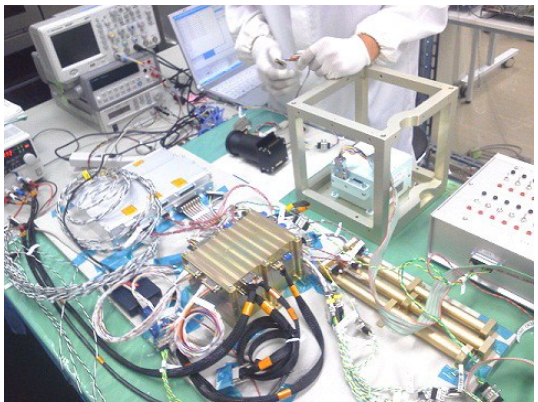
$$H(u, L, \cdots) = 0$$

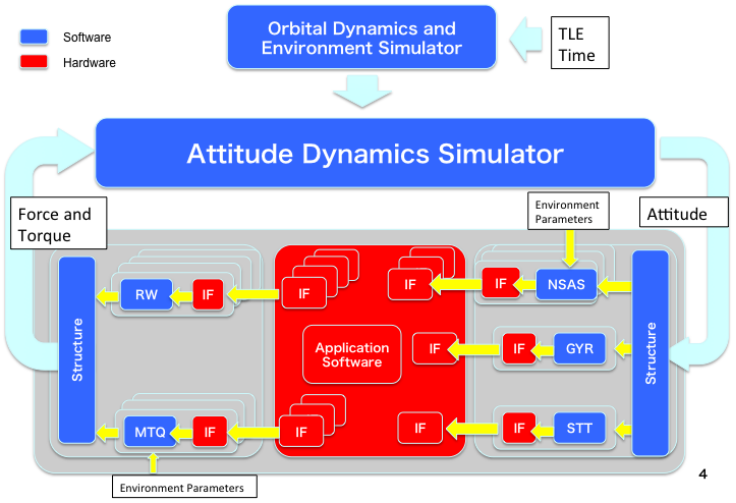
➡ Estimation of performance

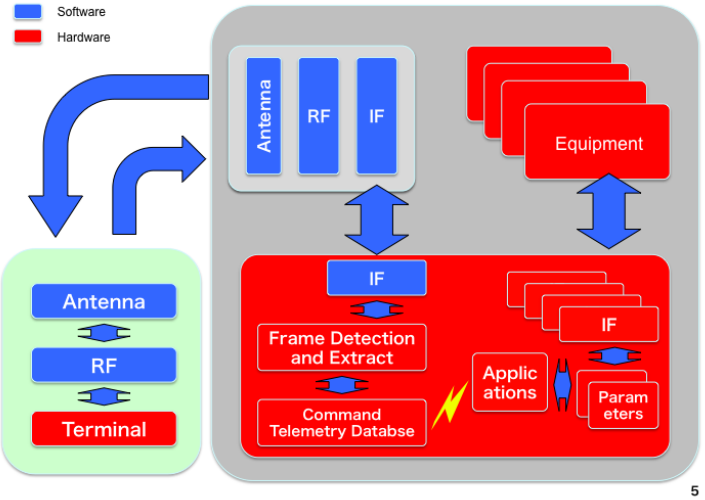
Software: Hardware in the Loop and Verification System

- 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.





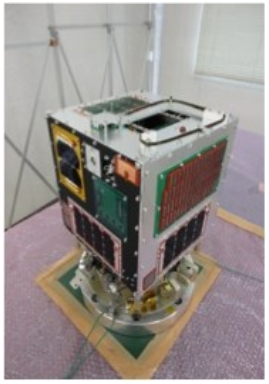




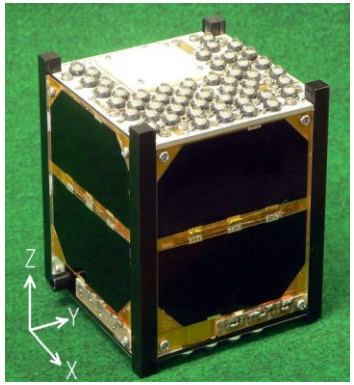
Ground Testing

Test Center at Kyushu Institute of Technology

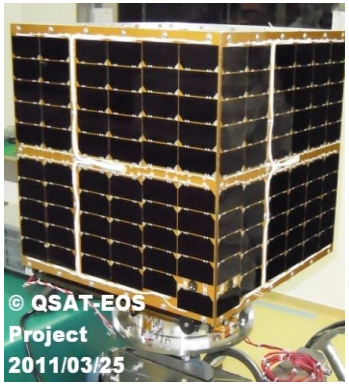
Concentration of Nano-satellite environment tests



HORYU2



FITSAT



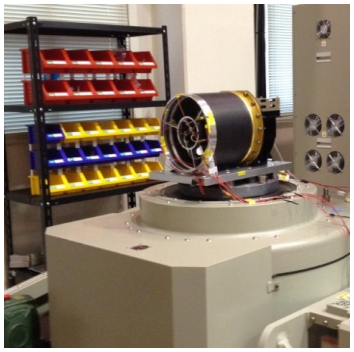
QSAT-EOS

STARS-II

UNIFORM

Outreach

（15 tests of components manufactured by small business)



Telescope for nanosatellite

Development of new test method

Rupture & Leak test

Single-event test

International Standardization

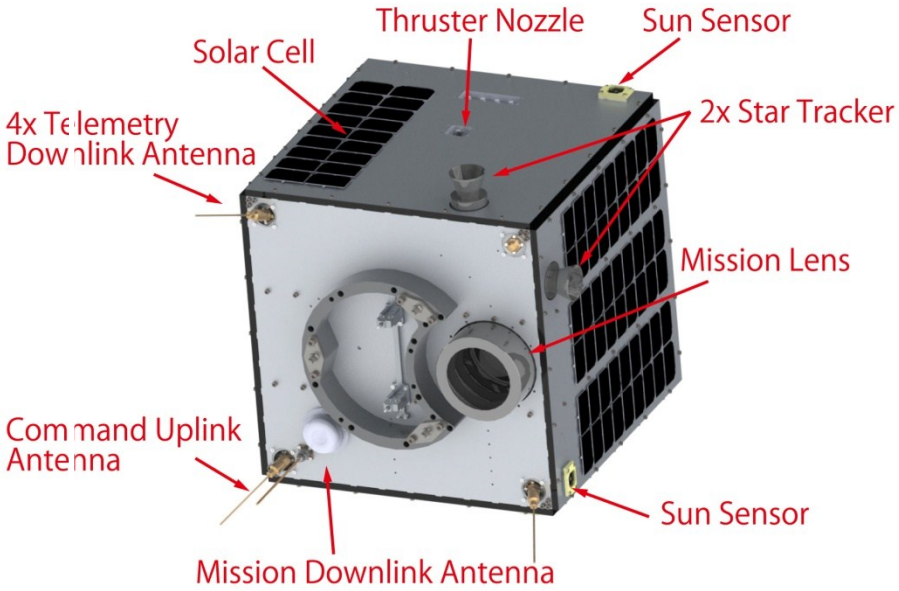
（Spin-out of test standardization project)

International standardization workshop

HODOYOSHI-1

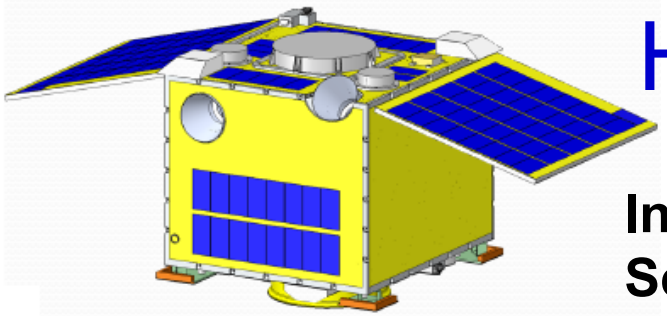
Mission: Earth Remote Sensing (6.7m GSD, 4 bands: RGB & NIR)
Developer: AXELSPACE, University of Tokyo, NESTRA
Launch: DNEPR in 2012

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



Optical Camera (6.7m@500km)
developed by Genesia Corporation

HODOYOSHI-2（RISESAT)



International Space Science Missions

Size:
50cm
55kg

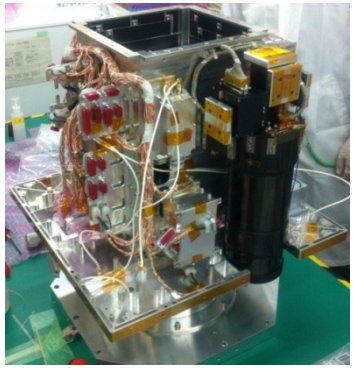
Comm:
S-band
38.4kbps
X-band
2Mbps

Power:
100W

ACS:
<0.1°

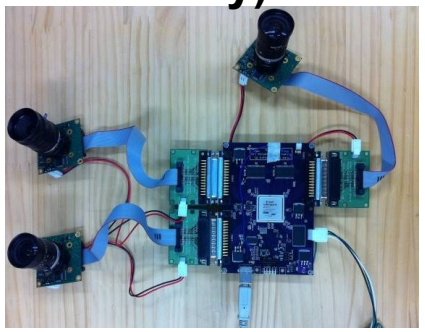
Rocket:
2013, CYC LONE-4

High Precision Telescope- HPT (Taiwan/Vietnam)



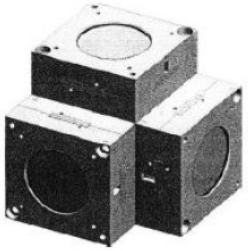
Meteor counter - DOTCam (Taiwan(NCKU))

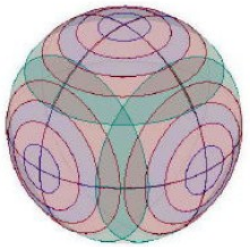
Ocean Observation Camera - OOC (Tohoku University)



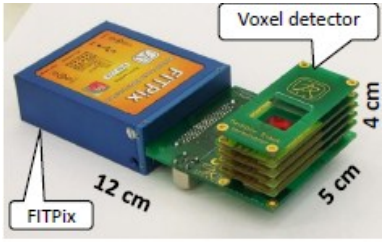
Camera Instruments

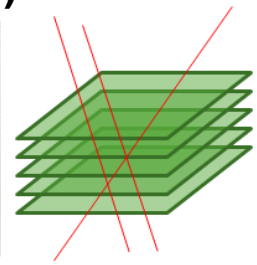
TriTel – 3D Dosimeter (Hungary)



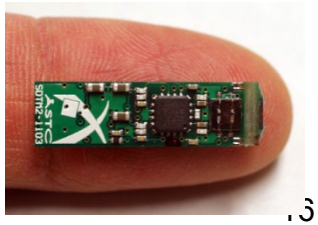


TIMEPIX – Particle counter (Czech)





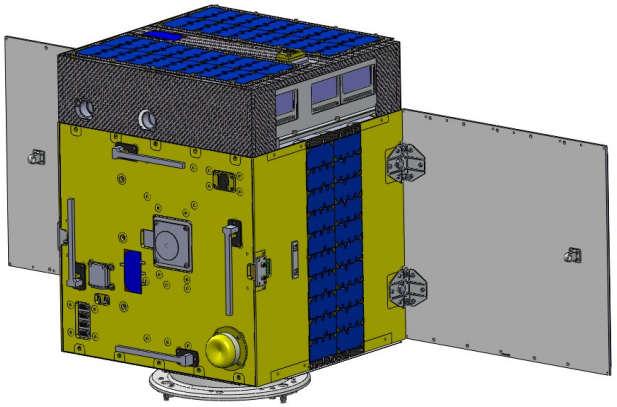
SDTM – MEMS Magnetometer (Sweden)



Sensor Instruments

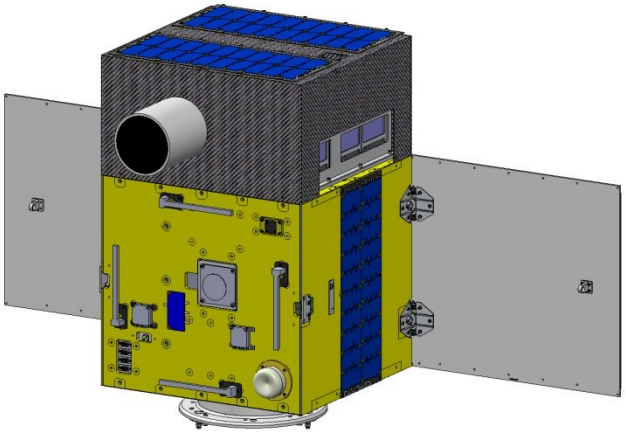
HODOYOSHI-3 & 4

Hodoyoshi-3



Based on a Standard bus

Hodoyoshi-4

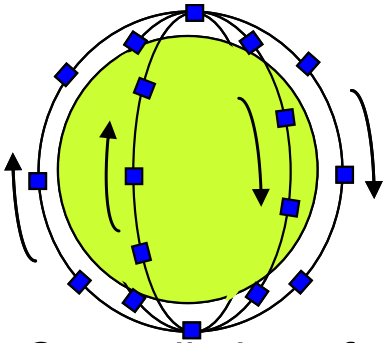


Rocket: DNEPR launch in 2013

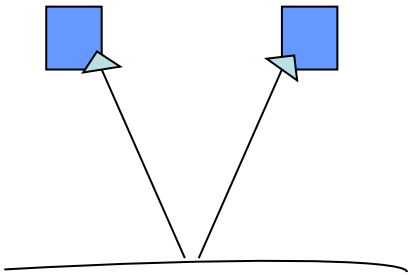
	Hodoyoshi-3	Hodoyoshi-4
Size	0.5×0.5×H0.65m	0.5×0.6×H0.7m
Weight	60kg	66kg
Orbit	SSO. 600km, LTAN 10am～11am	
ACS	Earth pointing, 3 axis stabilization	
Power	Power generation: max 100W Power consumption: average 50 W Bus voltage: 28V, 5V Battery: 5.8AH Li-Ion	
Commu-nication	H/K and Command: S-band uplink:4 kbps, downlink:4/32/64 kbps Mission data downlink: X-band 10Mbps (100Mbps to be tested on Hodoyoshi-4)	
Orbit control	H_2O_2 propulsion	Ion-thruster (Isp: 1100s)
Missions	Mid-resolution optical camera GSD: 40m & 200m	High-resolution optical camera GSD:5m
	Store & Forward Hosted payloads (10cm cube x 2) Hetero-constellation experiment	

Missions Creation 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



Constellation of a hundred satellites



Stereo Vision

Arctic Ocean Glacier Observation satellite

International Contribution (1)
- CanSat Leader Training Program (CLTP) -

CLTP started 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

International Contribution (2)

- *Mission Idea Contest (MIC)* -

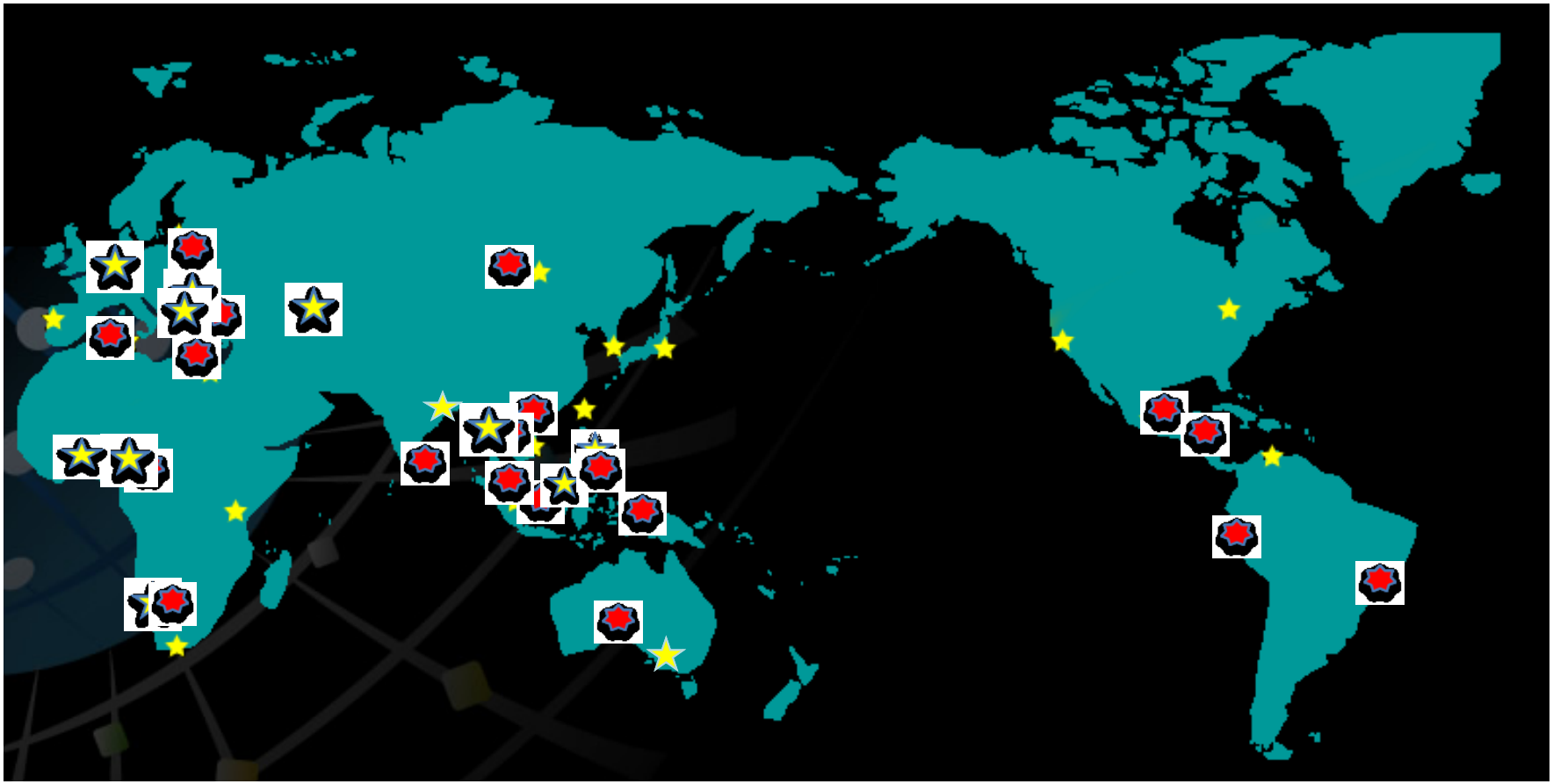
The 2nd Mission Idea Contest for Micro/Nano-satellite Utilization

- Objective: Encourage innovative exploitation of micro/nano-satellites to provide useful capabilities, services or data.

- Requirement:
  - category1: mission idea and satellite design
  - category 2: mission idea and business model using micro/nano satellite weighing less than 50kg.
- Regional coordinators: 33 regions
- 72 applications from 31 countries.
- **Oct 10, 2012 Final Presentation**

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

Micro/nano-satellites and future

- Large educational effect not only for space, but also for many technological areas
- New paradigm of space development and utilizations with low-cost and quick development
- More effort will be required in order for micro/nano-satellites to contribute more to the society, industry and human welfare
- Important international network using micro/nano-satellites for technologies, process, missions and educations

Structure of the Symposium

- 2nd Mission Idea Contest *(10th Wed)*
- Technical Sessions
  - *Satellite Architecture/technologies* *(11th AM)*
  - *Development Process* *(11th PM)*
  - *Space Utilizations/applications* *(12th AM)*
  - *Standardization and Regulatory Issues* *(12th PM)*
  - *Strategies for Capacity Building* *(12th PM)*
  - *Poster Session* *(10th and 11th FM)*
- UN Space Education Curriculum *(13th)*
- Panel Discussions
  - *How to keep good quality without too much cost* *(11th AM)*
  - *International Space Education* *(11th PM)*
  - *Space Debris* *(12th AM)*
- Social Events
  - *Reception (10th), UNISEC gathering(11th) and Gala Dinner (12th)*