

# 宇宙システムと途上国支援

## Satellite Systems and Supporting Developing Nations

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# Introduction

- Toshihiro Obata
- 1997: Start Working at Mitsubishi Electric Corp.
- 2004: 1 year at Astrium Germany (now Airbus DS)
- Worked for around 12 kinds, 15 satellite,  
ex) ALOS-2, GOSAT, HTV and etc.  
Strategy for Technology Development,  
Proposal for new satellite projects
- 2016: Retired after 19 years in Mitsubishi Electric Corp.
- Now Working for Nakasuka-Funase Lab, Univ. of Tokyo.
  - Small SAR satellite project
  - Autonomy, satellite on-board
  - Systems engineering

# Supporting Developing Nations

- Affordability of Nano Satellites encourage Developing Nations having their own one and solving national and international issues by themselves
- having their own satellite contributes to education of science and enlightens their people

■ We are supporting the following areas:

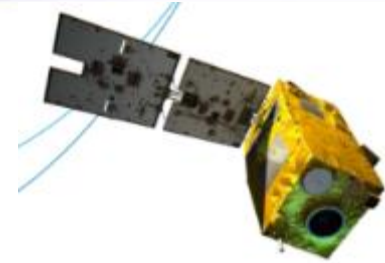
## 1. Remote Sensing

- Disaster monitoring, crop field management, monitoring illegal deforestation, forest fire and etc.

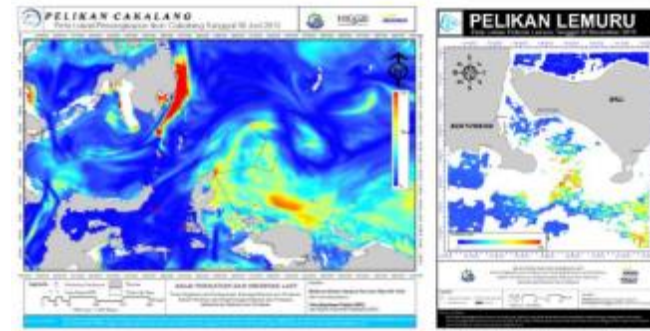
## 2. Store & Forward (Low speed machine to machine communication)

- Good enough mission for cubesats and suitable for capability building
- Constellation proposed for water quality and water level management

## 3. Support for education of space systems and space applications



VNREDSat-1 contributing International Disaster Monitoring ©VNSC





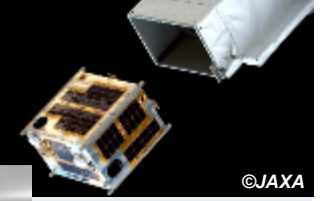

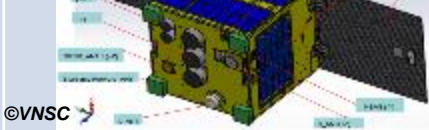
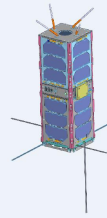
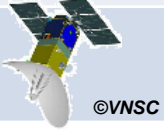
Fishing Area at Indonesia ©Lapan

Drought Estimation at Philippines

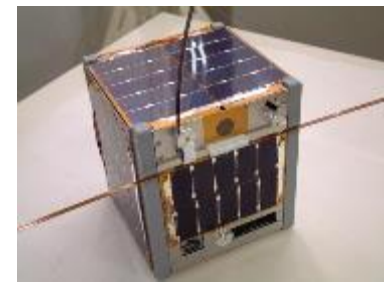


# Example of Collaborations and Capability Building

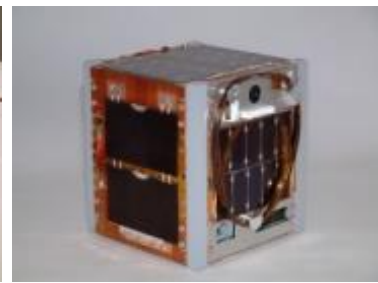
- Many Countries collaborate with Japanese government, agencies, universities and industries and building capabilities

	Country	Japanese Partner	Launch	
PicoDragon	Vietnam (Vietnam National Satellite Center)	JAXA, IHI, Univ. of Tokyo	2013	 <p>©VNSC</p>
Turksat-4	Turkey (Turksat)	JAXA, MELCO	2014,15	 <p>©MELCO</p> <p>Capability Building Included</p>
Diwata-1	Philippines (Department of Science and Tech., Philippine Univ)	Tohoku Univ. Hokkaido Univ.	2016	 <p>©JAXA</p>
UBAKUSAT	Turkey (Istanbul Technical University)	JSF, Kyushu Institute of Technology	2017	 <p>©DIRECTORATE GENERAL OF AERONAUTICS AND SPACE TECHNOLOGIES, Turkey</p>
Micro Dragon	Vietnam (Vietnam National Satellite Center)	Univ. of Tokyo Keio Univ. etc.	2018	 <p>©VNSC</p>
UNISEC- Global	Many (14 authorized, 34 prepared)	UNISEC	Under discussion	<p>Store &amp; Forward or other collaborative missions</p> 
Lotus-1/2	Vietnam (Vietnam National Satellite Center)	METI	Planned	 <p>©VNSC</p>

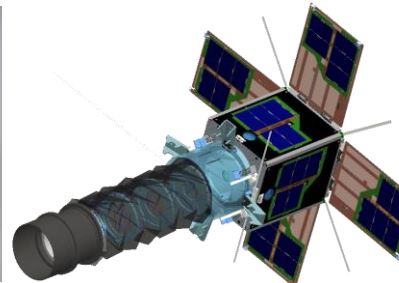
# Univ. of Tokyo Small Sats (9 Developed, 8 Launched)



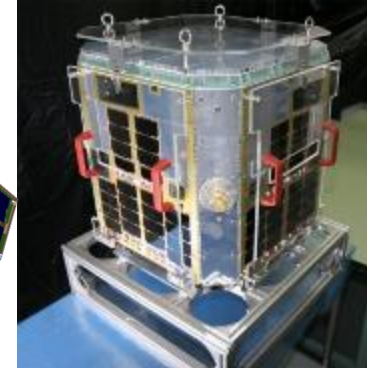
World 1<sup>st</sup> 1kg Sat  
XI-IV(2003)



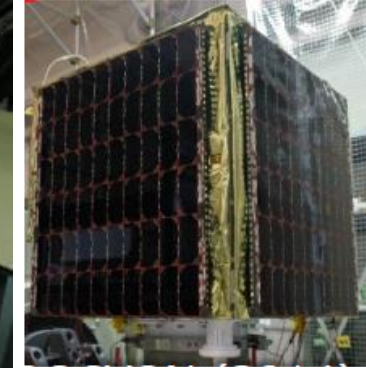
Tech Demo  
XI-V(2005)



8kg for 30m GSD  
PRISM(2009)



State of the Art  
Space Science  
Nano-JASMINE  
(Waiting for launch)



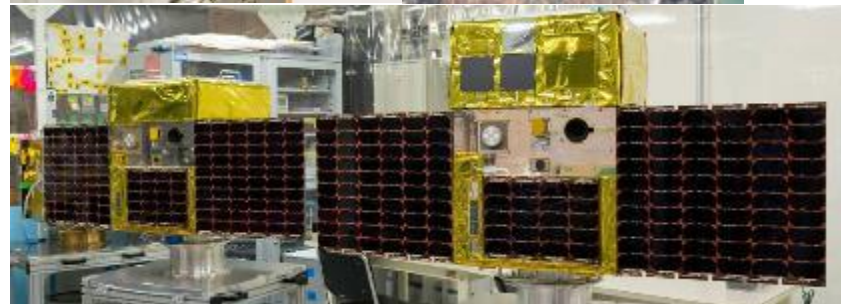
World 1<sup>st</sup> Deep  
Space Small Sat  
PROCYON(2014)



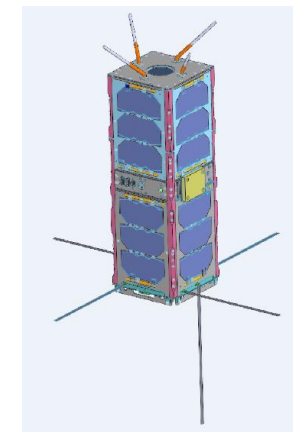
6mGSD  
(Chiba JPN)



Wide  
(Sri Lanka)



60kg class 6mGSD (2years for development)  
Hodoyoshi-1 Hodoyoshi 3/4(launched in 2014)



**S&F satellite TRICOM-1 (Jan 2017)**

**Sri Lanka**  
**(LCAM 240m GSD)**





***Greek (false color)  
(MCAM 40m GSD)***



**Chiba**  
**(6m GSD)**



# Dubai (6.7mGSD)





アカロア (ニュージーランド)

AXELSPACE提供

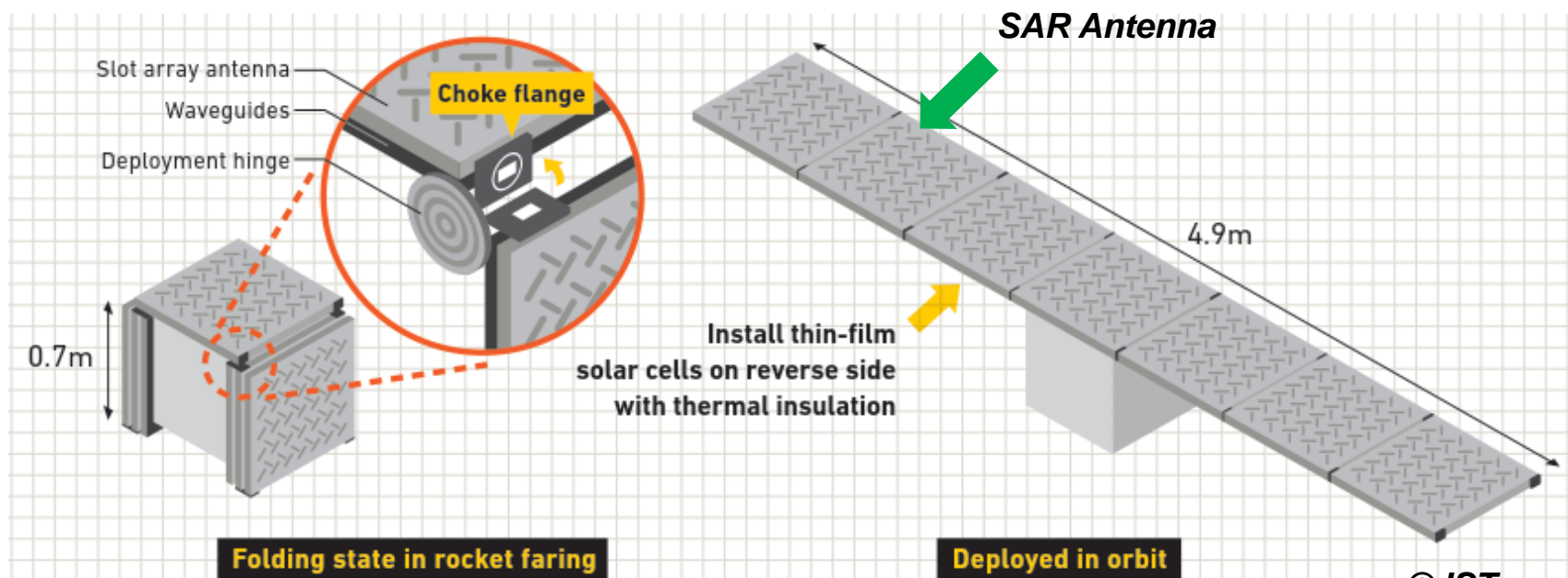
# AxelGlobe by Axelspace

- 50 small satellite constellation for earth observation
- 3 satellite will be launched in 2017
- Inviting partners  
all over the world  
who build satellites  
within AxelGlobe  
scheme
- Building 1 satellite  
allow them to  
access capability of  
50 satellites

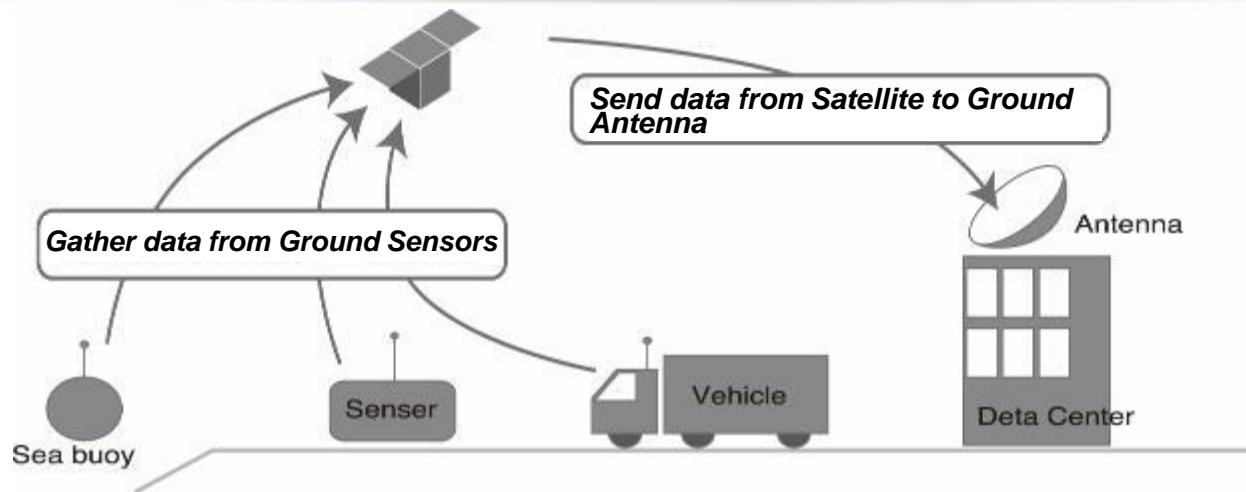


# SAR development for Small Satellite

- Synthetic Aperture Radar, 1m class Resolution, on the 100kg class satellite
- On-demand mission:
  - The data is provided to users < half a day, under all weather, even nighttime.
  - The satellite is launched after a request within a few hours to an adequate orbit that enables on-demand observation.
- Funded by Japanese government within ImPACT program.



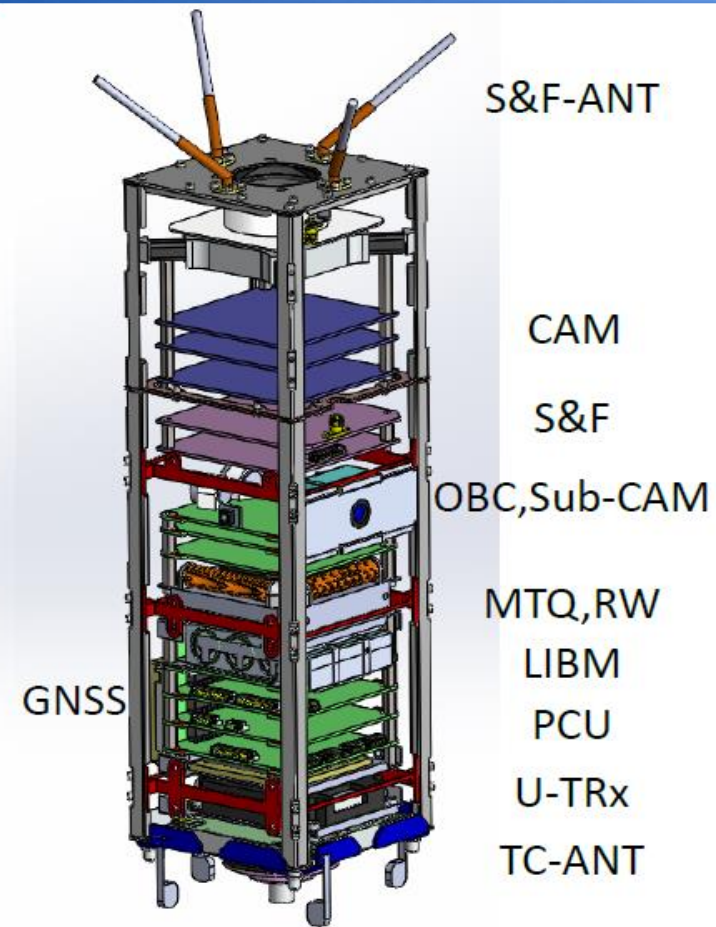
# Stored & Forward



- Ground or buoy sensors to measure, satellites to collect data that downlinked to ground stations at low bit rate
- UNISEC-Global is now proposing to build a constellation of cubesats for the mission. Each country/university can contribute with their own satellite and get frequent access of sensor data through the constellation
- Key is 'what to measure'
  - Water quality, water level, soil, environment(CO<sub>2</sub>, gas), car velocity(traffic jam), ship route(oceanic current), ground movement(earthquake)
  - Competitive where no mobile infrastructure, dangerous areas, etc.

# 3U CubeSat "TriCom-1"

- Store & Forward Test Satellite of University of Tokyo,  
(Launch in Jan 2017)
- Affordable : Cubesat
- No RF license is needed, globally
- Simple protocol
- Less power, good enough data rate (100bps)
- Suitable mission for capability building



**Receiver Module**



**Transmitter  
on the Ground**

# UNISEC-Global (University Consortium)

34 regions/countries are interested to start UNISEC (UNiversity Space Engineering Consortium) in their countries: **South Africa**, Angola, Namibia, **Egypt**, Ghana, Kenya, **Nigeria**, **Tunisia**, **Bangladesh**, Korea, Mongolia, Nepal, the Philippines, Singapore, Taiwan, Thailand, **Turkey**, Australia, Indonesia, Saudi Arabia, Canada, USA, Guatemala, **Mexico**, **Peru**, Brazil, **Bulgaria**, **Italy**, **Samara (Russia)**, Switzerland, **Germany**, Slovenia, **Lithuania** and **Japan**.



*13 Local Chapters and  
1 Association of Local  
Chapters have been  
acknowledged. (red part)*

# CanSat Leadership Training Program

Lectures on Space Engineering by CanSat organized by UNISEC

CLTP1 (Wakayama Univ. in Feb-March, 2011)

**12 from 10 countries**, namely Algeria, Australia, Egypt, Guatemala, Mexico, Nigeria, Peru, Sri Lanka, Turkey (3), Vietnam.

CLTP2 (Nihon Univ. in Nov-Dec, 2011)

**10 from 10 countries**, namely Indonesia, Malaysia, Nigeria, Vietnam, Ghana, Peru, Singapore, Mongolia, Thailand, Turkey.

CLTP3 (Tokyo Metropolitan Univ. in July-August, 2012)

**10 from 9 countries**, namely Egypt (2), Nigeria, Namibia, Turkey, Lithuania, Mongolia, Israel, Philippines, Brazil.

CLTP4 (Keio Univ. in July-August, 2013)

**9 from 6 countries**, namely Mexico(4), Angola, Mongolia, Philippines, Bangladesh, Japan.

CLTP5 (Hokkaido Univ. in Sept 8-19, 2014)

**7 from 5 countries**, namely Korea (2), Peru, Mongolia, Mexico (2), Egypt.

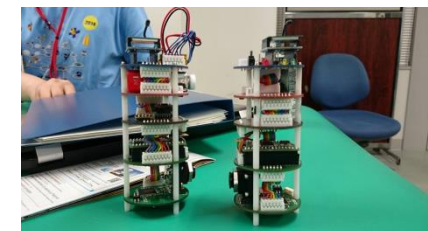
CLTP6 (Hokkaido Univ. in August 24-Sept 3, 2015)

**8 from 8 countries**, namely Bangladesh, Egypt, Mexico, New Zealand, Angola, Turkey, Tunisia, Austria

CLTP7 (Hokkaido Univ. in Sept 21-Oct 1, 2016)

**8 from 7 countries**, namely Egypt, Peru, Mongolia, Nepal, Myanmar, Serbia, Dominica Republic

**64 participants  
from 32 countries**





# Mission Idea Contest (MIC) for Micro/nano satellite utilization

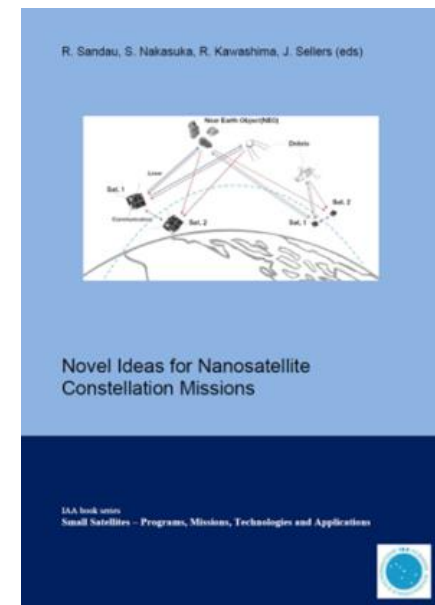


The 3rd  
**Mission Idea Contest**  
for Micro/Nano-satellite Utilization



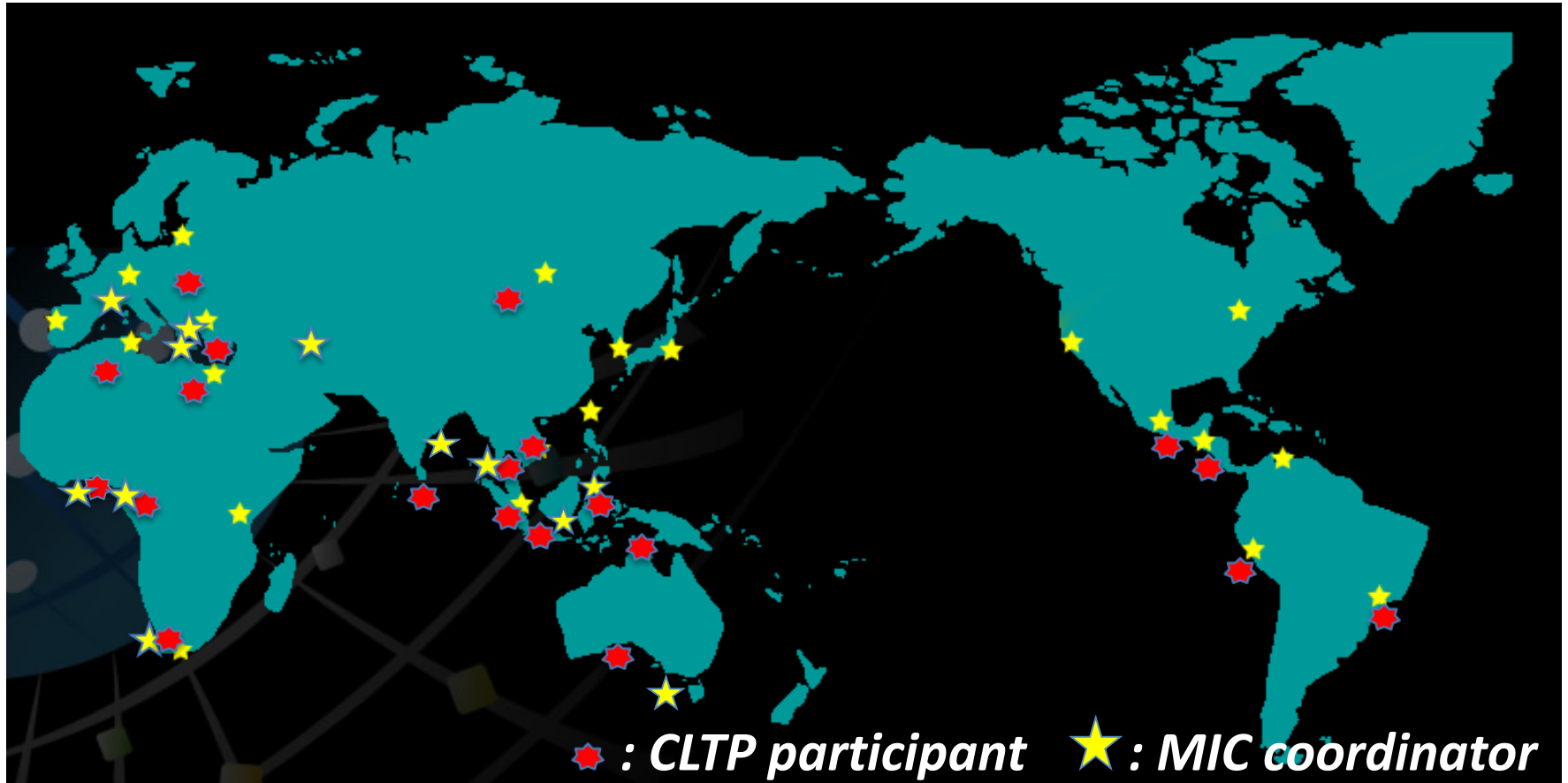
Pre-4th  
Mission Idea Contest  
Workshop

- Mission and satellite design idea for less than 50kg micro/nano/pico-satellites
- Regional coordinators: 33
- History
  - MIC1 in Tokyo, March 14, 2011
  - MIC2 in Nagoya, Oct. 10, 2012
  - PreMIC3 in Tokyo, Nov. 23, 2013
  - MIC3 in Kitakyushu, Nov 19, 2014
  - PreMIC4 in Tokyo, July 3, 2015
  - MIC4 in Varna, Oct, 2016



# Global network through MIC and CLTP (MIC:33, CLTP: 21 nations) 38 countries in total

260 attendants from 47 nations in 5th Nano-sat Sympo 2013



- MicroDragon is developed with 36 Vietnam young engineers in four years
- Collaboration with Kazakfstan, Brazil, Ukraine, etc. is under discussion

# Educational Significances of Micro/Nano/Pico-Satellite and CanSat 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
- **The effects were found more than expected !!**
- **Also contribute to other technological areas !!**

# E-learning Course for Space Engineering

- E-learning course by Prof. Nakasuka triggers **international collaboration**



## TWO BODY PROBLEM: 2. DERIVATION OF ANGULAR MOMENTUM CONSERVATION LAW

If you make a cross product with  $\mathbf{r}$  from left, then

$$(4) \quad \mathbf{r} \times \ddot{\mathbf{r}} + \frac{\mu}{r^3} \mathbf{r} \times \mathbf{r} = \mathbf{r} \times \ddot{\mathbf{r}} = \mathbf{r} \times 0 = 0$$

$$(5) \quad \frac{d}{dt} (\mathbf{r} \times \dot{\mathbf{r}}) = \mathbf{r} \times \ddot{\mathbf{r}} + \dot{\mathbf{r}} \times \dot{\mathbf{r}} = \mathbf{r} \times \ddot{\mathbf{r}}$$

$$(6) \quad \frac{d}{dt} (\mathbf{r} \times \dot{\mathbf{r}}) = 0$$

$$(7) \quad \mathbf{r} \times \dot{\mathbf{r}} = \mathbf{r} \times \mathbf{v} = \text{constant} = \mathbf{c}$$



# Discussion

- Fund from Japanese gov. and international organization
  - ◆ JICA, Asian Development Bank, World Bank
  - ◆ To arrange necessary fund, **proposal from the development countries are needed first**, not from Japanese partner's side.
  - ◆ Fund may be **only for feasibility study or demonstration**.  
Acquiring funds for next phase like operation and make it **sustainable** is an issue.
  
- Human resources
  - ◆ Experienced peoples with international corporation are graduated from universities, however difficult to keep them for this activities
  - ◆ English and communication skills