

Smart Remote-sensing using Micro-satellite Constellation

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Creative Research Institution (CRIS)

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Requirements and expectations to space development

- **every country** wants to monitor own country by themselves
- **time resolution** should be improved than existing satellites especially for disaster monitoring
- **minimize the total number** of satellites to avoid collision
 - international alliance
- satisfy **not only for disaster** monitoring but also watching climate change, agriculture, fisheries, mining, etc...



Breakthrough occurred in 2014 in utilization of very small satellites

Micro-satellite

Larger-satellite



3-5M USD

> A few 100M USD

Quick fabrication (One year)

Long period (>10years)

On-demand operation
based on User's purposes

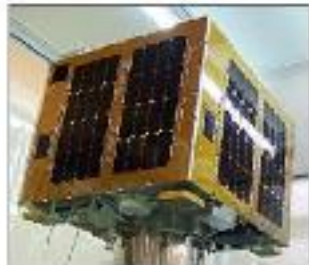
To carry heavy equipments

GiFT



Hokkaido Univ. and Tohoku Univ. have many experiences in developing micro-satellites and advanced sensors
with very small companies ... industry-academia collaboration

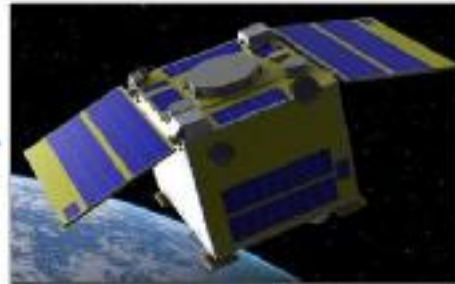
2ND



RISING-2

43.2-kg microsatellite
Launch in early 2014 (est.)

4TH



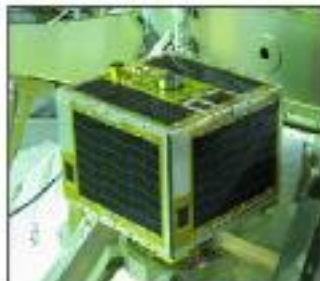
RISESAT

55-kg microsatellite
Launch in 2015 (plan)



International Space Station

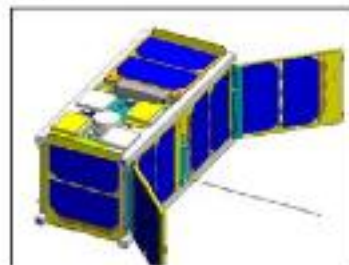
1ST



SPRITE-SAT

44.8-kg microsatellite
Launched in 2009

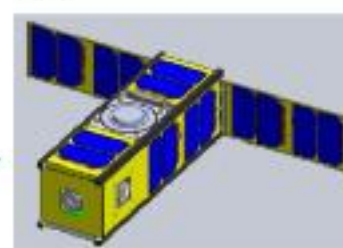
3RD



RAIKO

2.6-kg cubesat
Launched in 2012
10-month ops. finished

5TH



S-CUBE

4.0-kg cubesat
Launch in 2014 (plan)



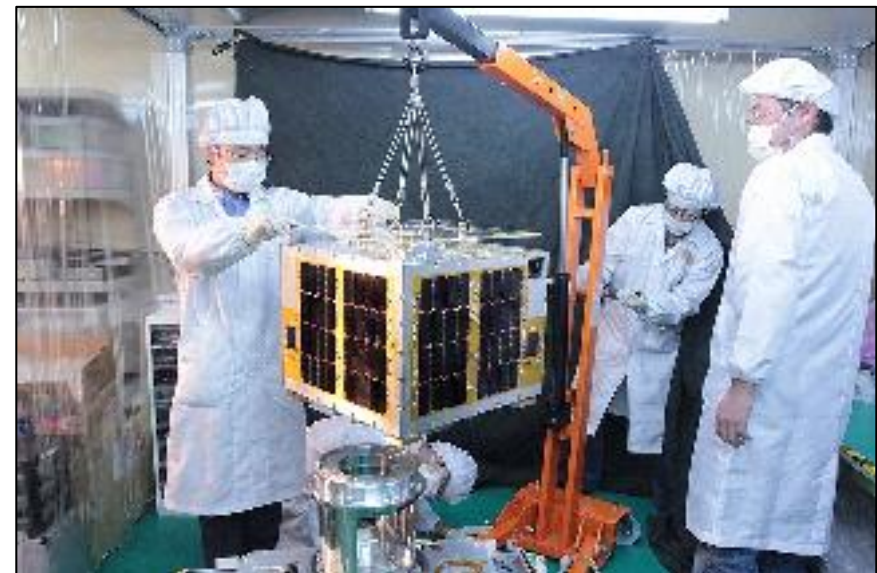
Venus Orbiter

RISING-2 satellite

survived the big earthquake on the table
of a building in Tohoku University



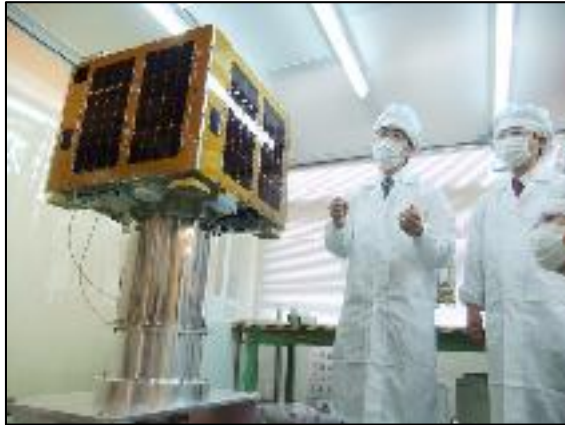
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RISING-2 (launched May 24, 2014)



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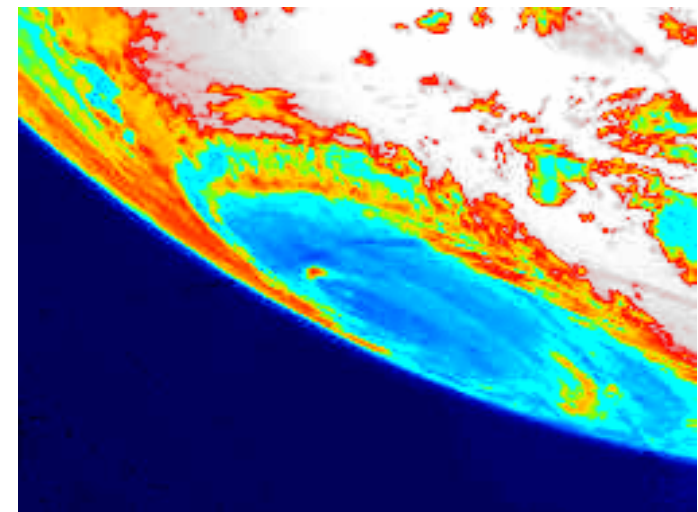
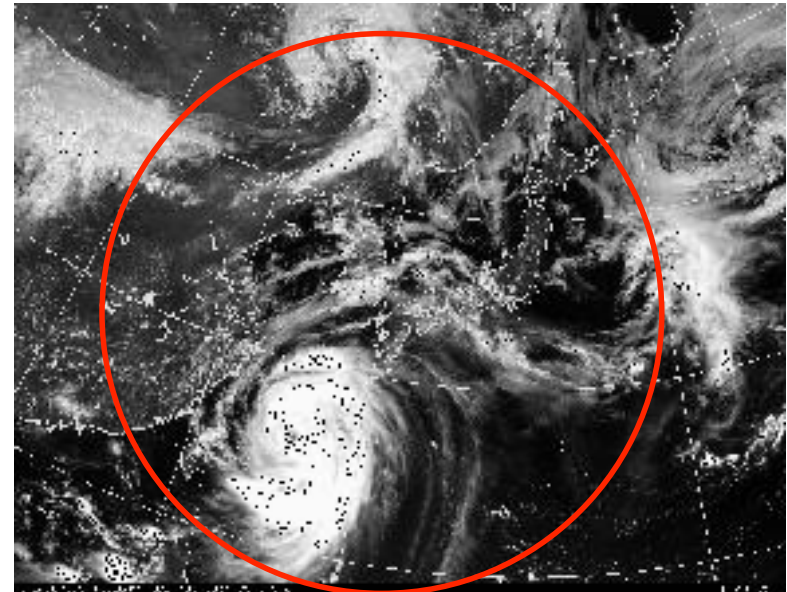
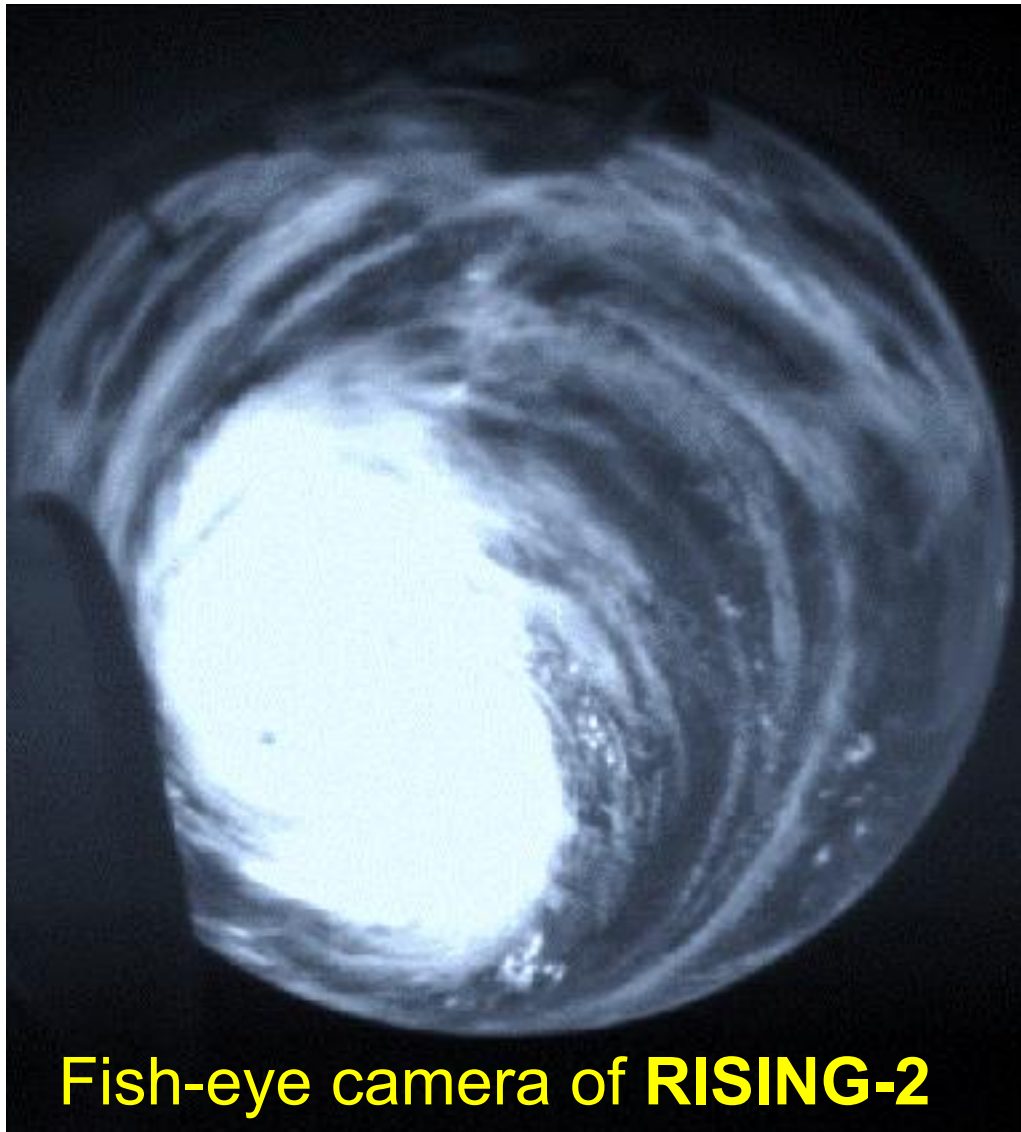


Operation at lab. (or at home)



(C) JAXA

Typhoon 2014-#8 Nogree





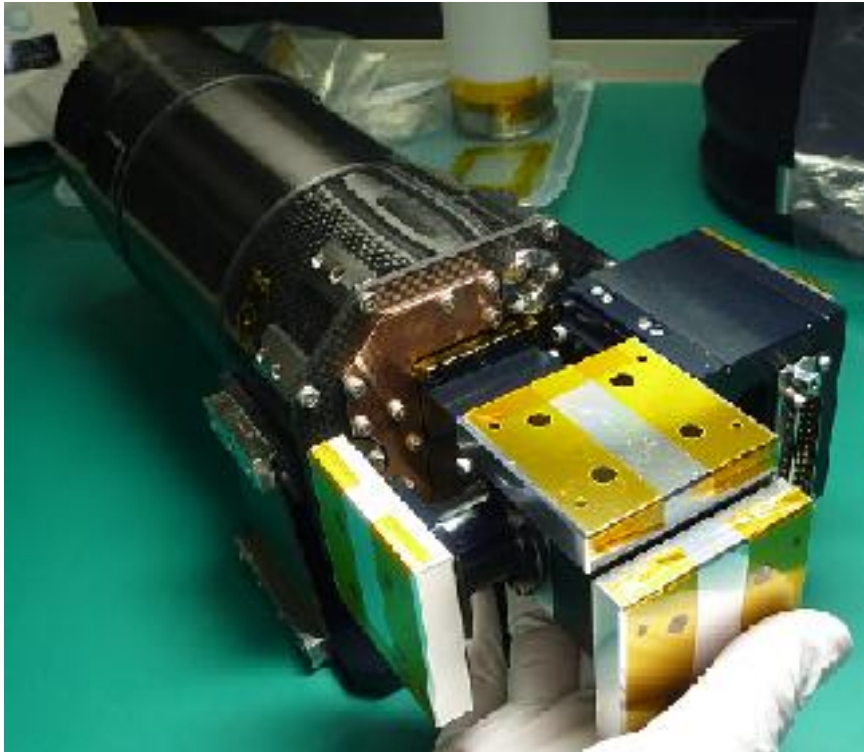
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5m resolution color image
one of the best with 50 kg-class satellite

High Precision Telescope with Liquid Tunable Filter (HPT with LCTF)

the world first super multicolor LCTF imager in space



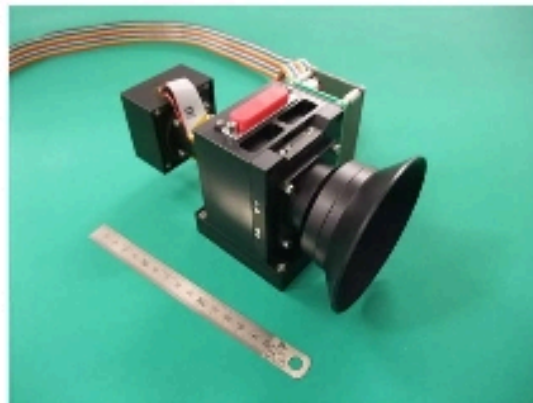
- 1-m focal length, 10-cm dia. (F10), Case grain telescope
 - **5-m resolution** (659 x 494 pixels)
 - 3-CCD (R,G,B) + Multi spectrum CCD
 - **Liquid Crystal Tunable Filter (LCTF)**
 - range: **650 - 1050nm**
 - **1-nm step selection (400 wavelengths)**
 - order of 10s-msec switching time
 - High sensitive (ISO8000)
 - 1/50,000s min. exposure time
 - light and strong stiffness CFRP structure
 - zero-expansion high stiffness ceramic mirror (ZPF)
- Size: W380xD161xH124mm
 - Weight: < 3.0 kg

Liquid Crystal Tunable Filter camera



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Airborne Multicolor Imager (AMI)



AC adapter

AC power supply

Windows-based PC

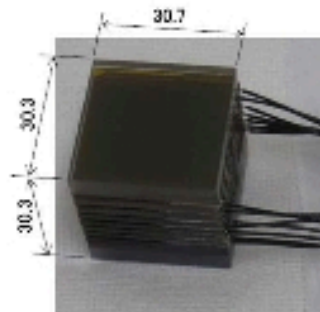
USB cable

Multispectral Camera

- Wide FOV lens
- High-sensitive CCD
- Liquid Crystal Tunable Filter (LCTF) for Visible
- 190 x 100 x 100 mm
- 1.3 kg

Camera controller

- 100-240 V AC input
- USB 2.0 interface
- 300 x 200 x 60 mm
- 2.0 kg



LCTF

Specifications

Wavelength range	420 - 700 nm
Band width (FWHM)	8 - 25 nm
Response time	< 0.3 sec
Frame rate	> 1 frame /sec
Number of pixels	659 x 494
Field of view	92 degree



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Aircraft (UAV) campaign with AMI in Java (2012/10/29-31)

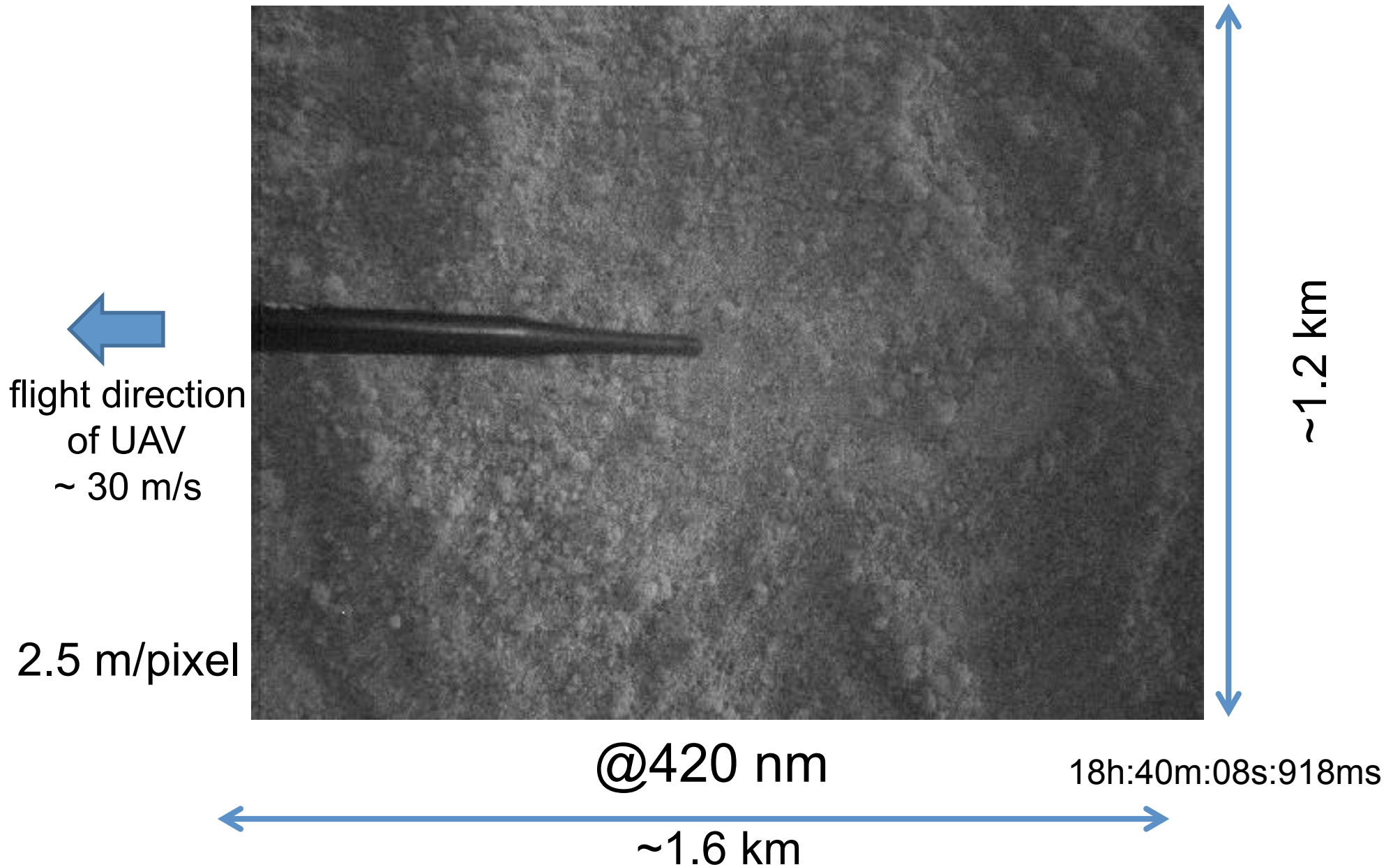


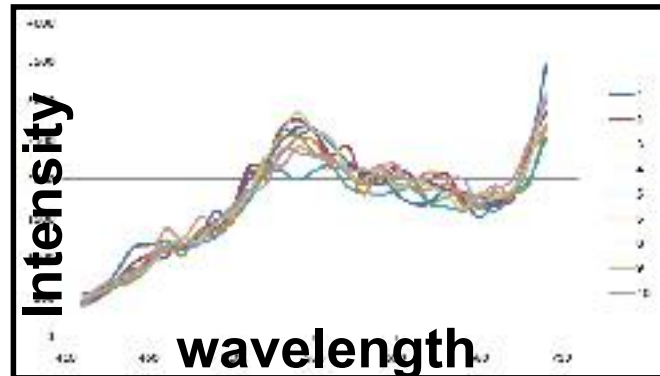
UAV developed and owned by **BPPT**

10/31 ~18:40
forest in the target area



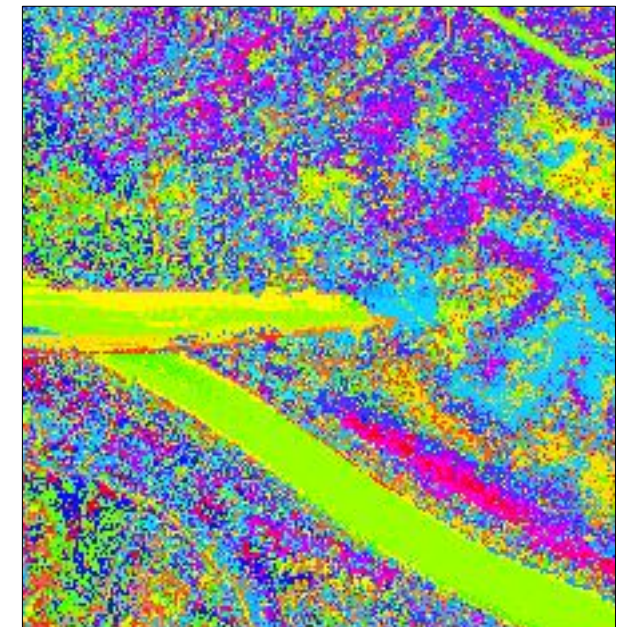
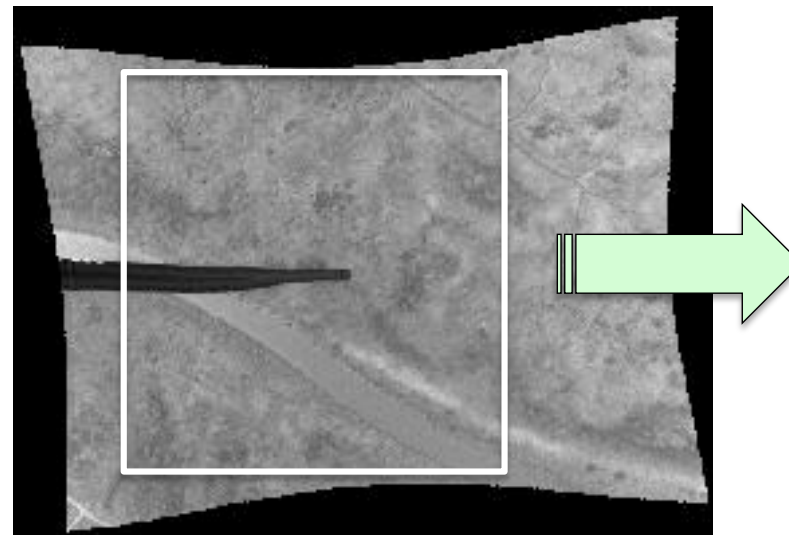
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from 30 wavelengths

900 m



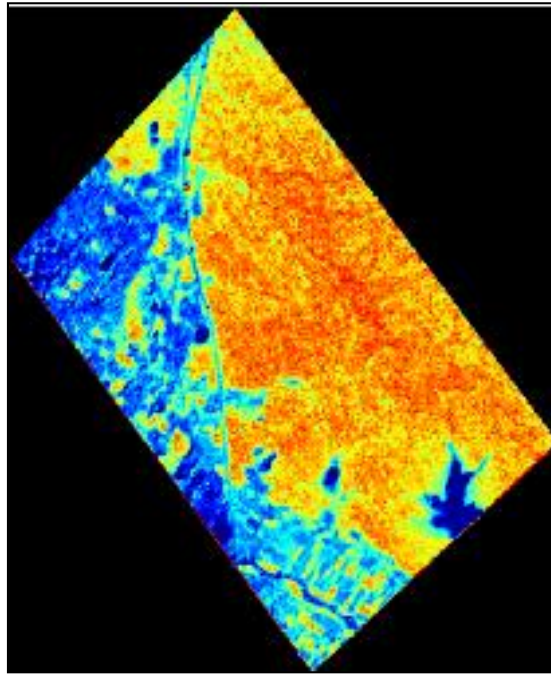
classification of species or monitoring condition for each tree...

”disaster” and ”usual environment”

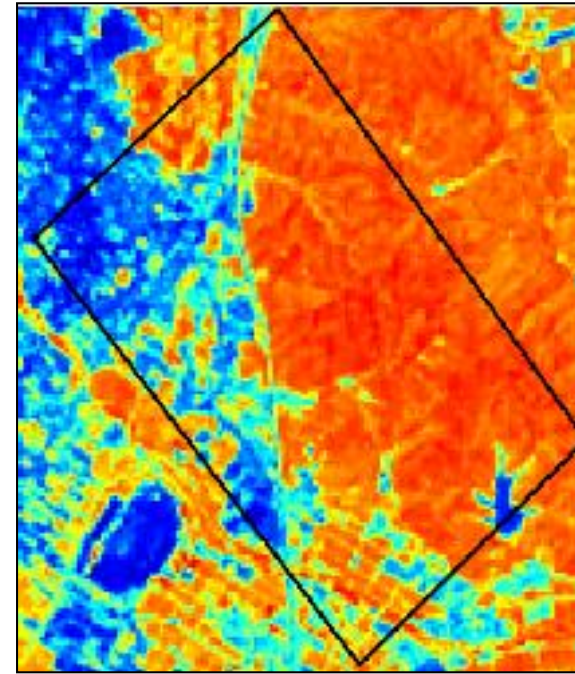


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NDVI (vegetation index) = **forest and crops**
based on precise spectral imaging



RISING-2 (2014/9/14)



Landsat-8 (2013/8/14)

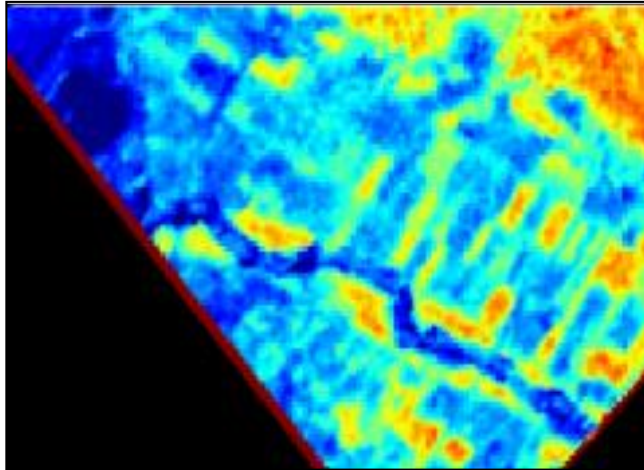


Hikone city

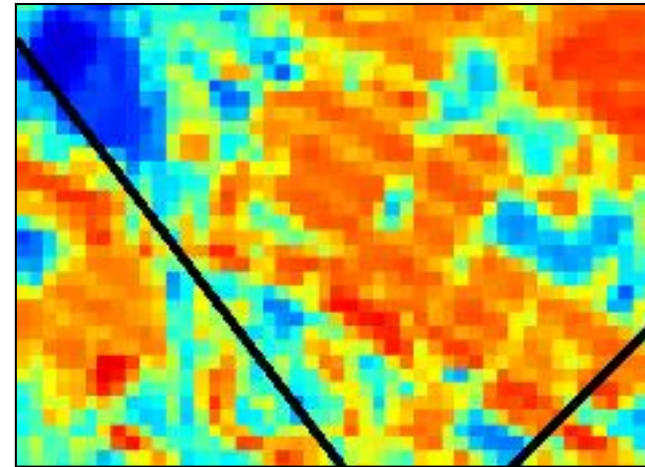
the detection of detail effects of disaster, such as
tsunami, sea water, volcano ... **pollution** caused by
disaster, on crops or environment.



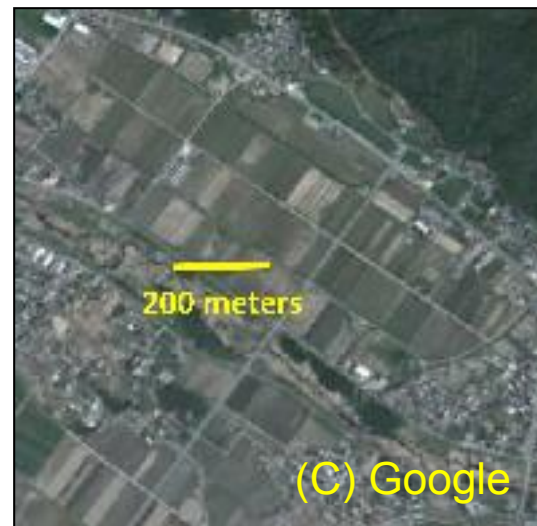
The world's best resolution of spectral imaging



RISING-2
5 m/pixel



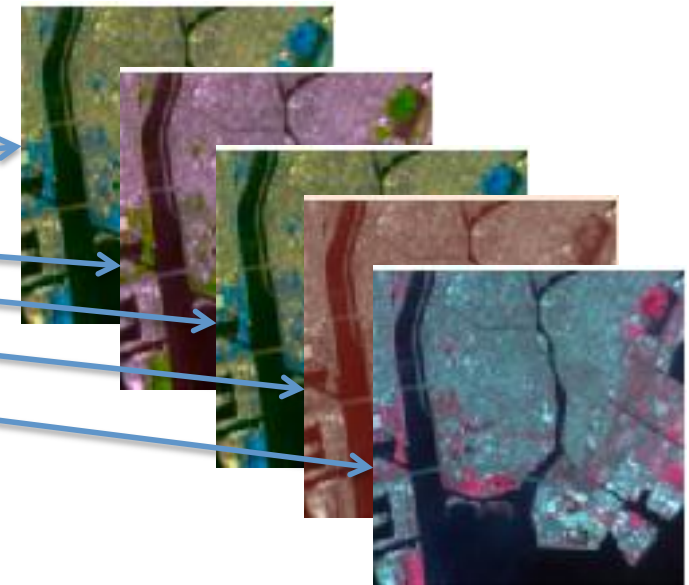
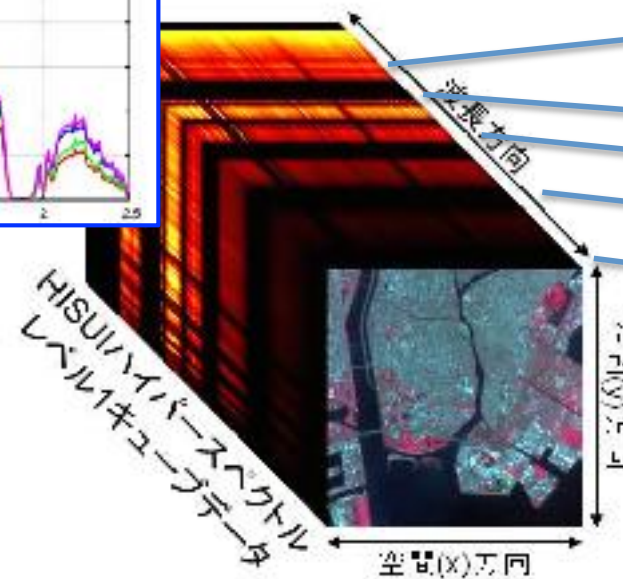
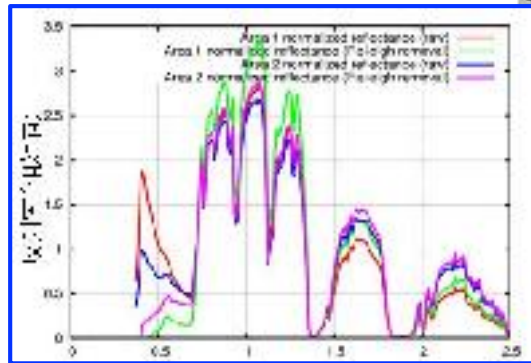
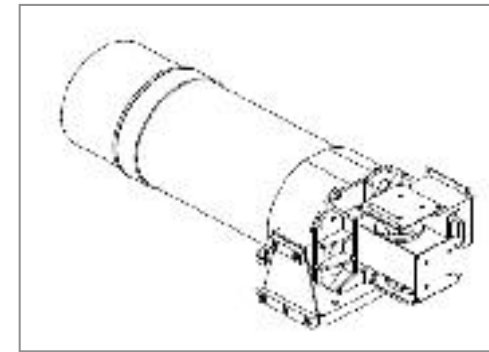
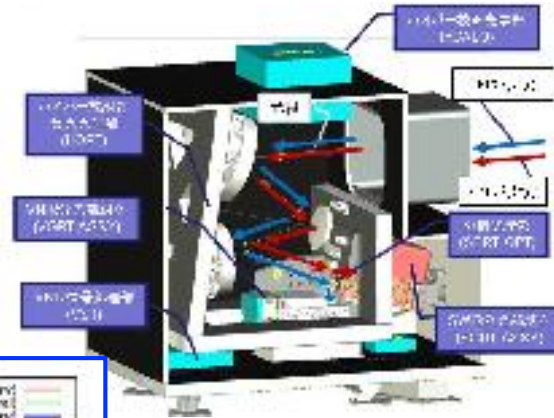
LANDSAT-8
30 m/pixel





Hyperspectral sensor

LCTF camera



< 10 wavelengths, 5m/pixel

185 wavelengths, 30 m/pixel

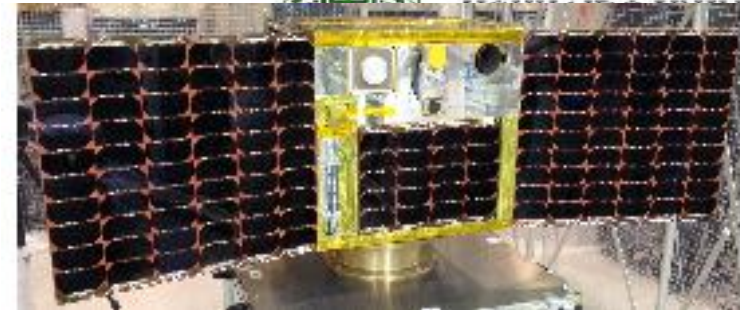


UNIFORM-1 satellite

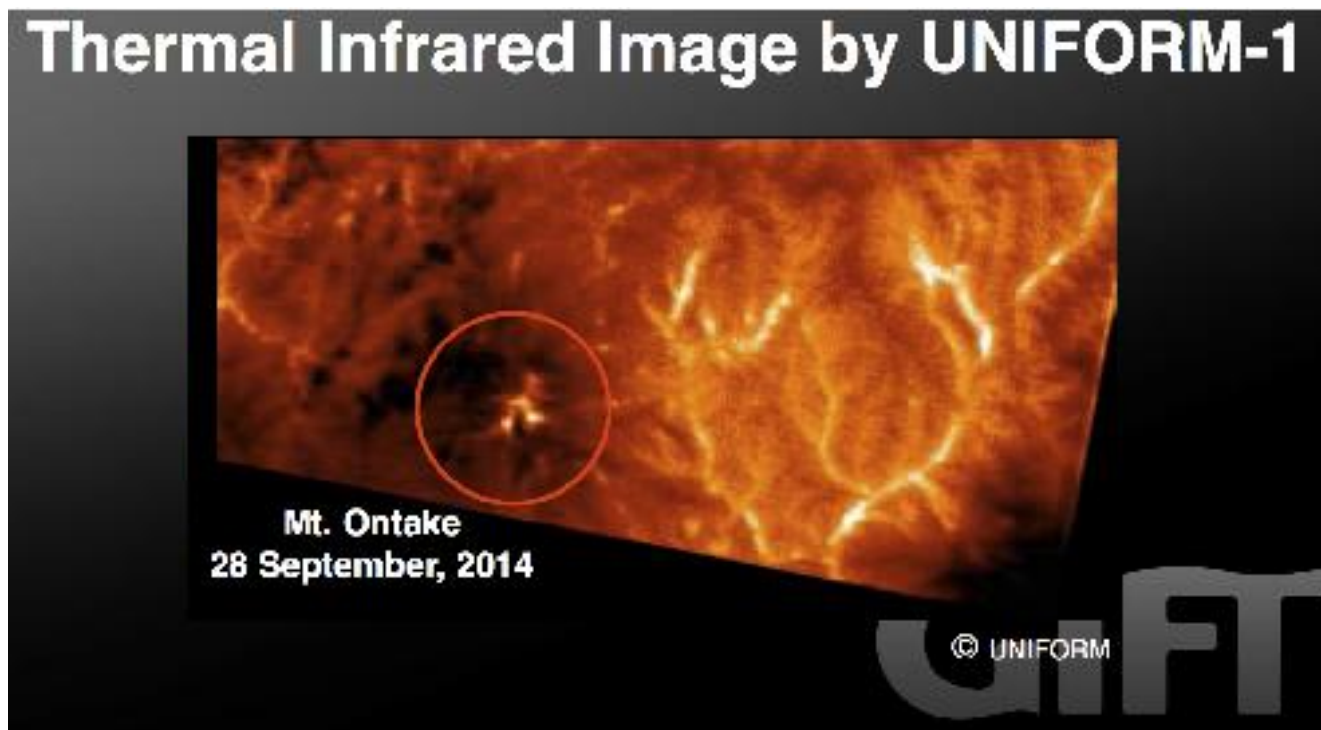
by University Union in Japan

launched in May, 2014

HU is in charge of sensor and data analysis



dedicated to forest fire detection + monitoring of volcano

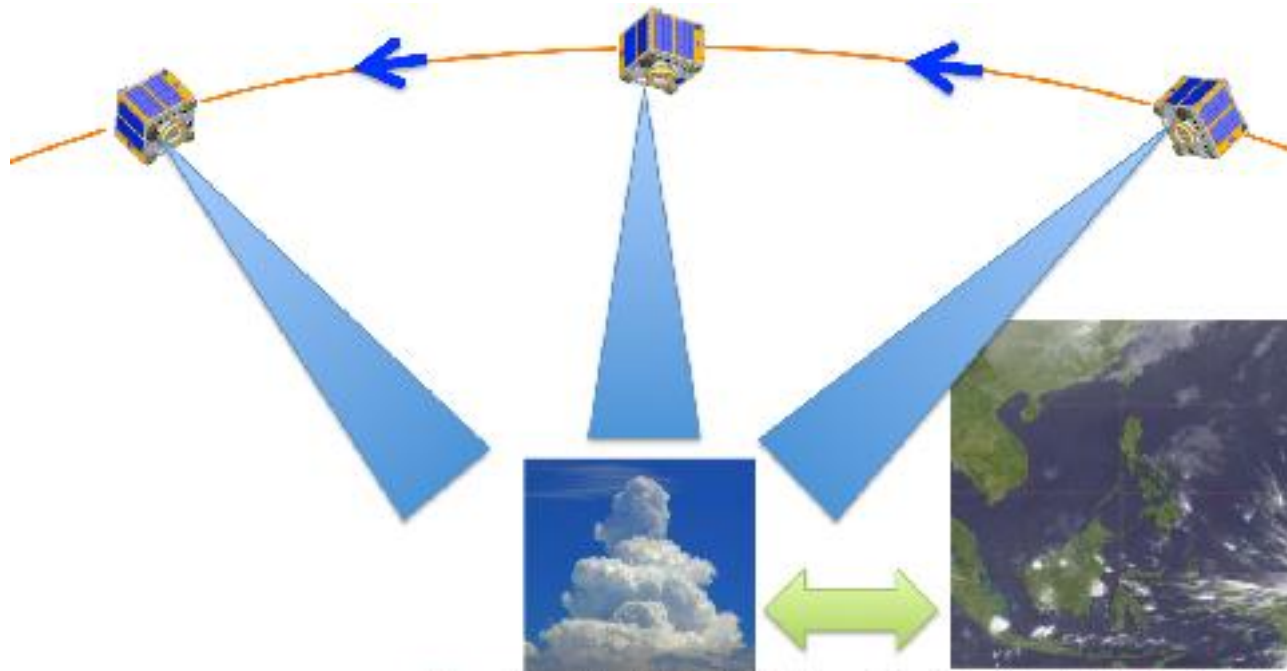


the earliest satellite report at infrared wavelength

Target Pointing by precise attitude control

... most of big satellites make pushbroom scan
by orbital motion... **1 time / 16 days**

- Flexible on-demand operation
covering from nadir to horizon (>5000 km in diameter)
enables **frequent visiting (2 times / day in daytime)**
- 3-D reconstruction



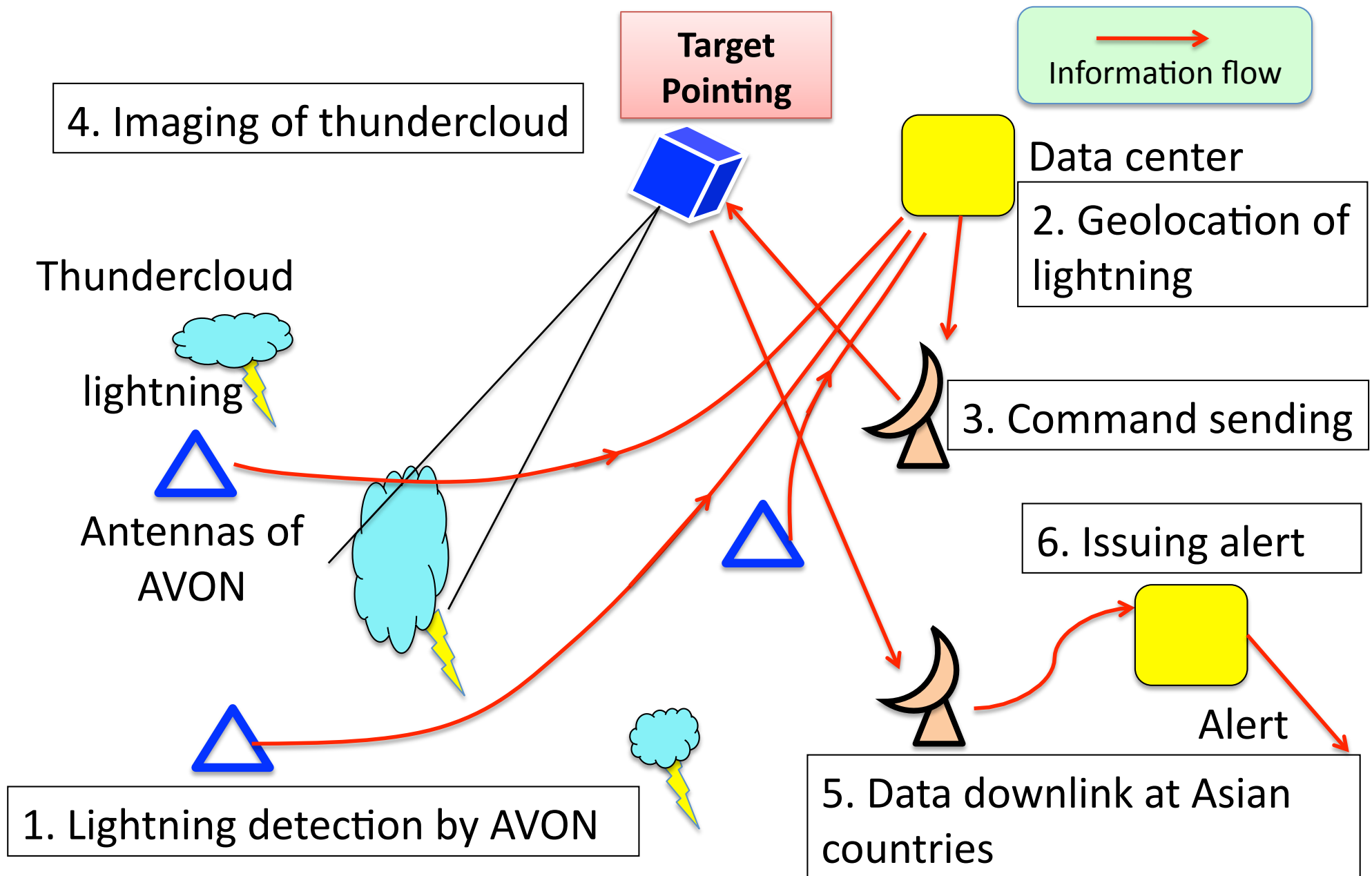
10m resolution by micro-sat.

0.5-1km res. by meteorological sat.



~50 satellites realize continuous monitoring

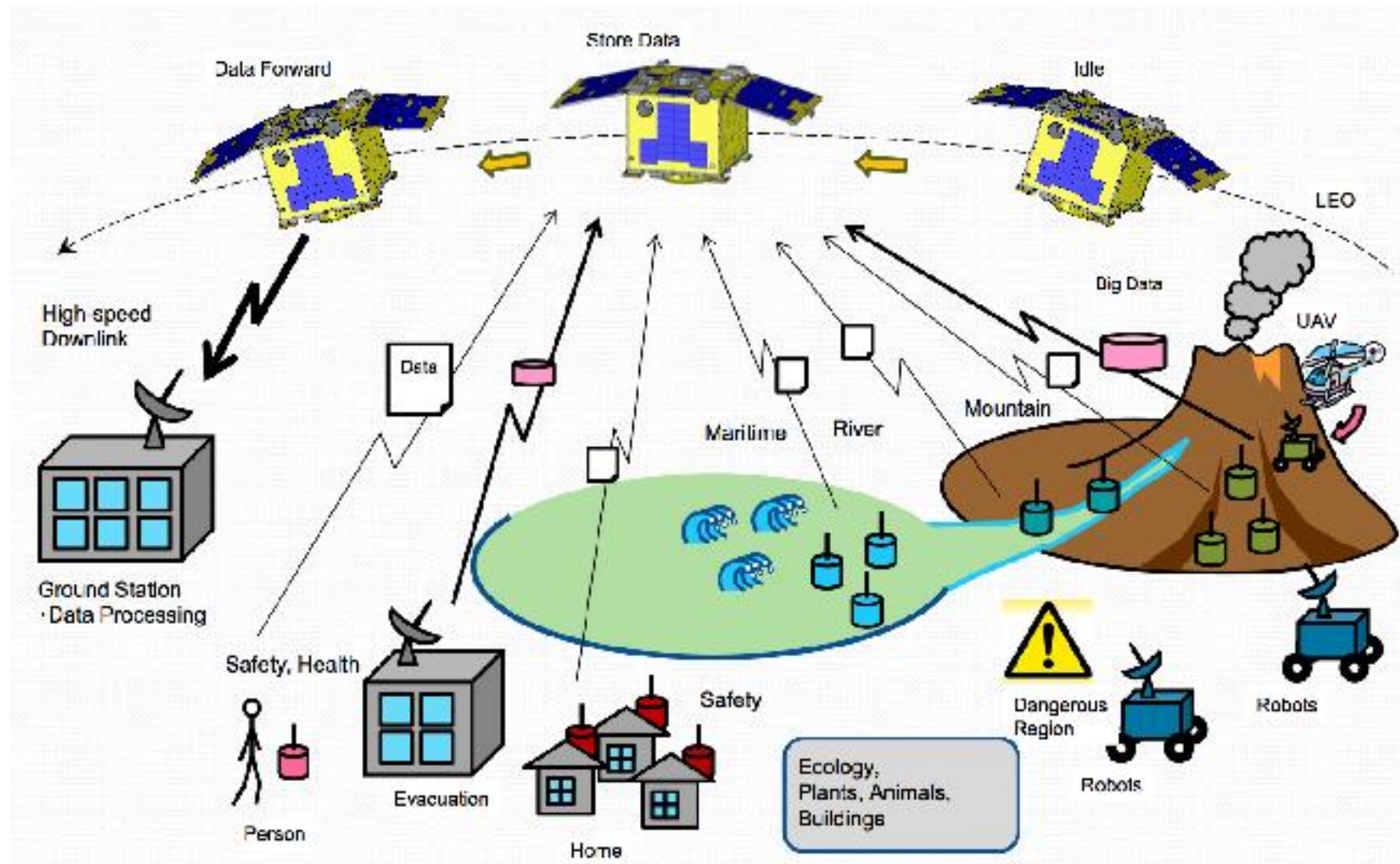
“On-demand operation” of micro-satellites for disaster alert



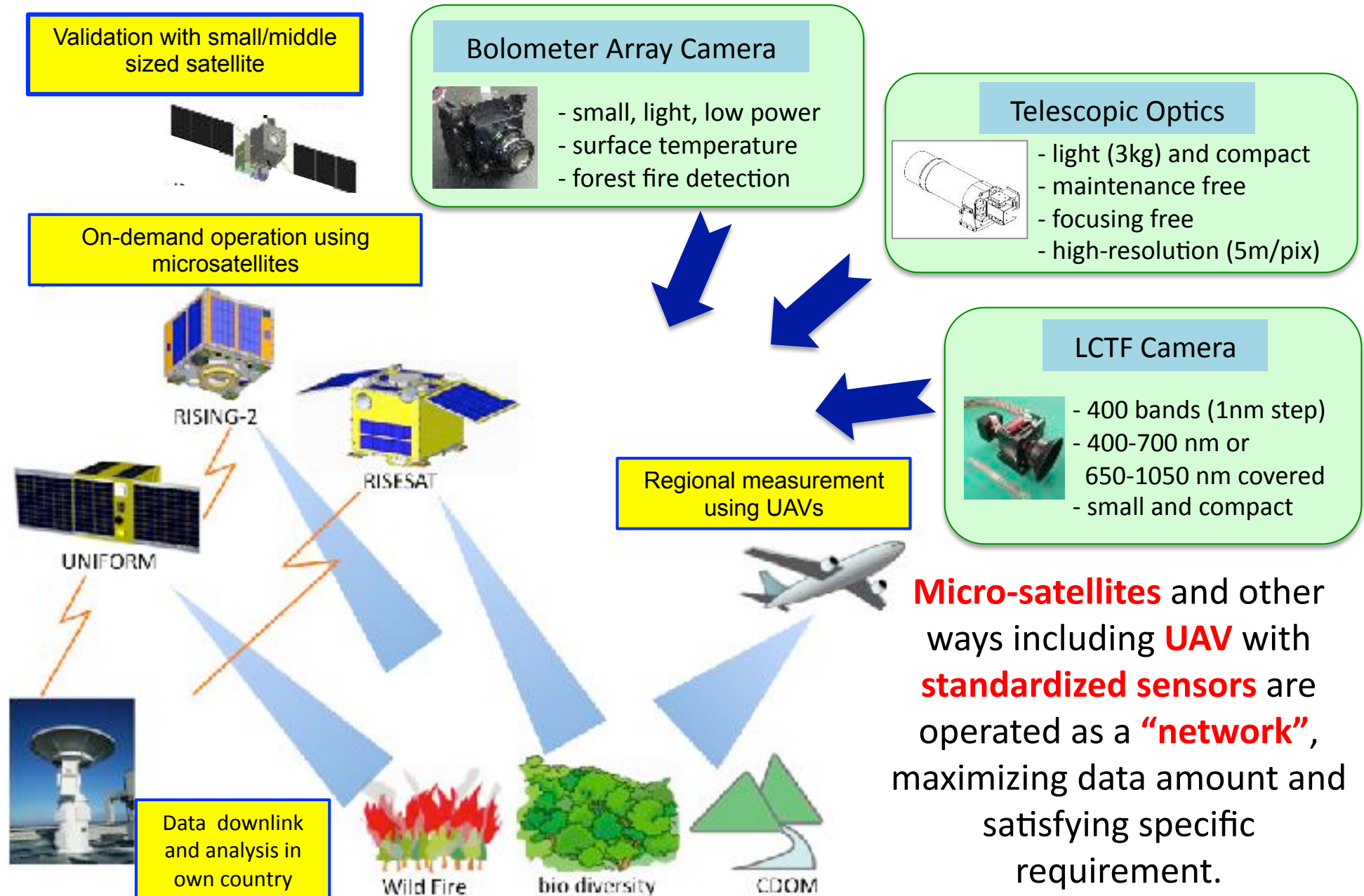


Store-and-Forward technology (developed by [Tohoku Univ.](#))

to collect ground-based information at un-accessible locations



Start-up of “the world first” *Smart Remote Sensing* using satellites, UAVs and ground measurements



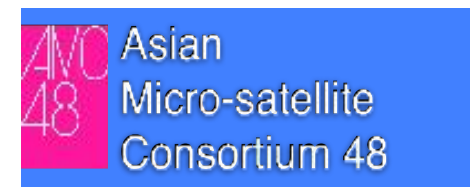
Micro-satellites and other ways including **UAV** with **standardized sensors** are operated as a “**network**”, maximizing data amount and satisfying specific requirement.

Asian Micro-satellite Consortium

sharing technologies, data and application methods

establishing **standardization** of sensors and BUS operating system

collaboration in making **ground validation**



being contacted universities, space agency, and government in Asian countries.

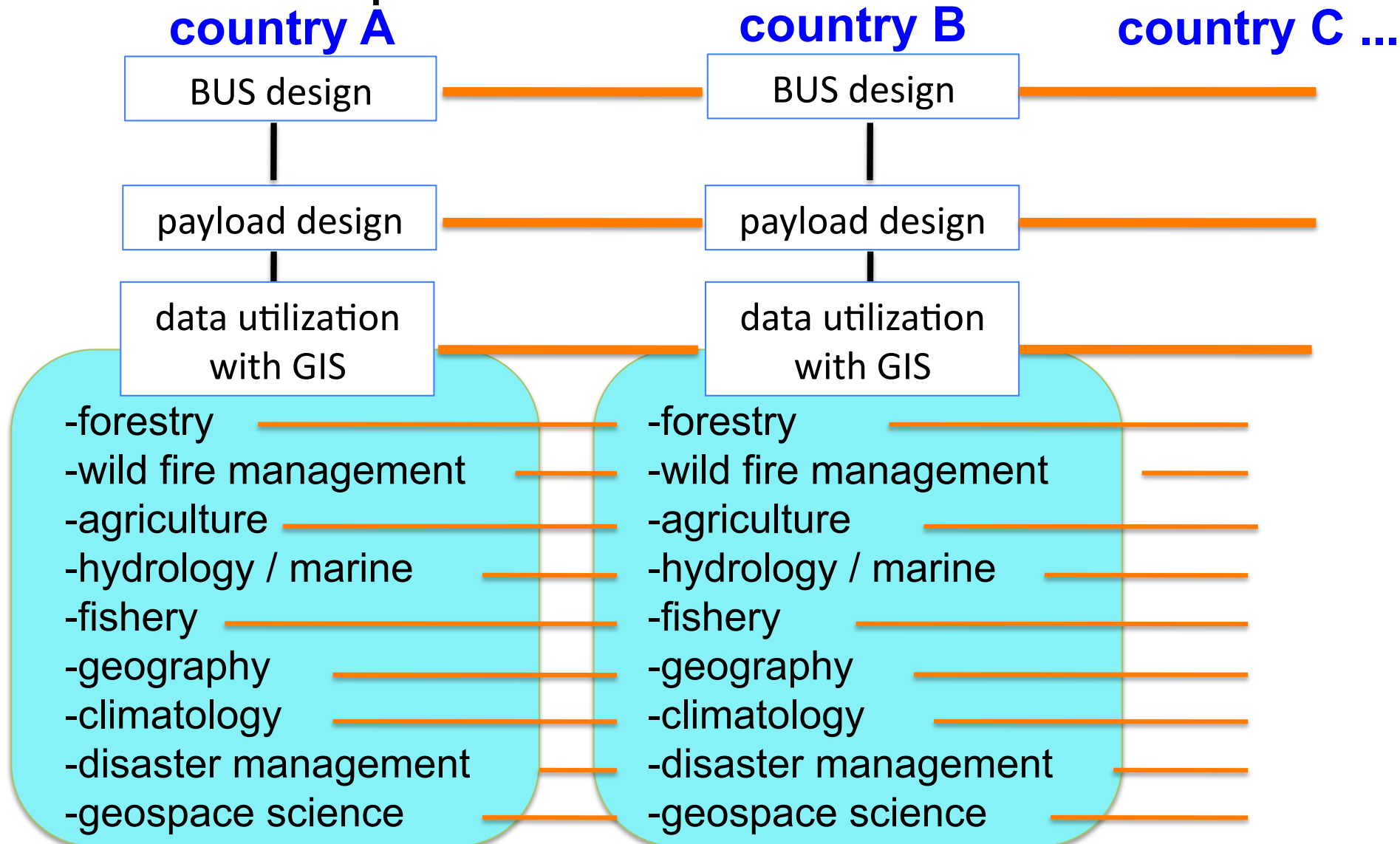
***To be started **with ~10 countries** officially soon.
(now under the final correction of MOU)***

Asian Micro-satellite Consortium

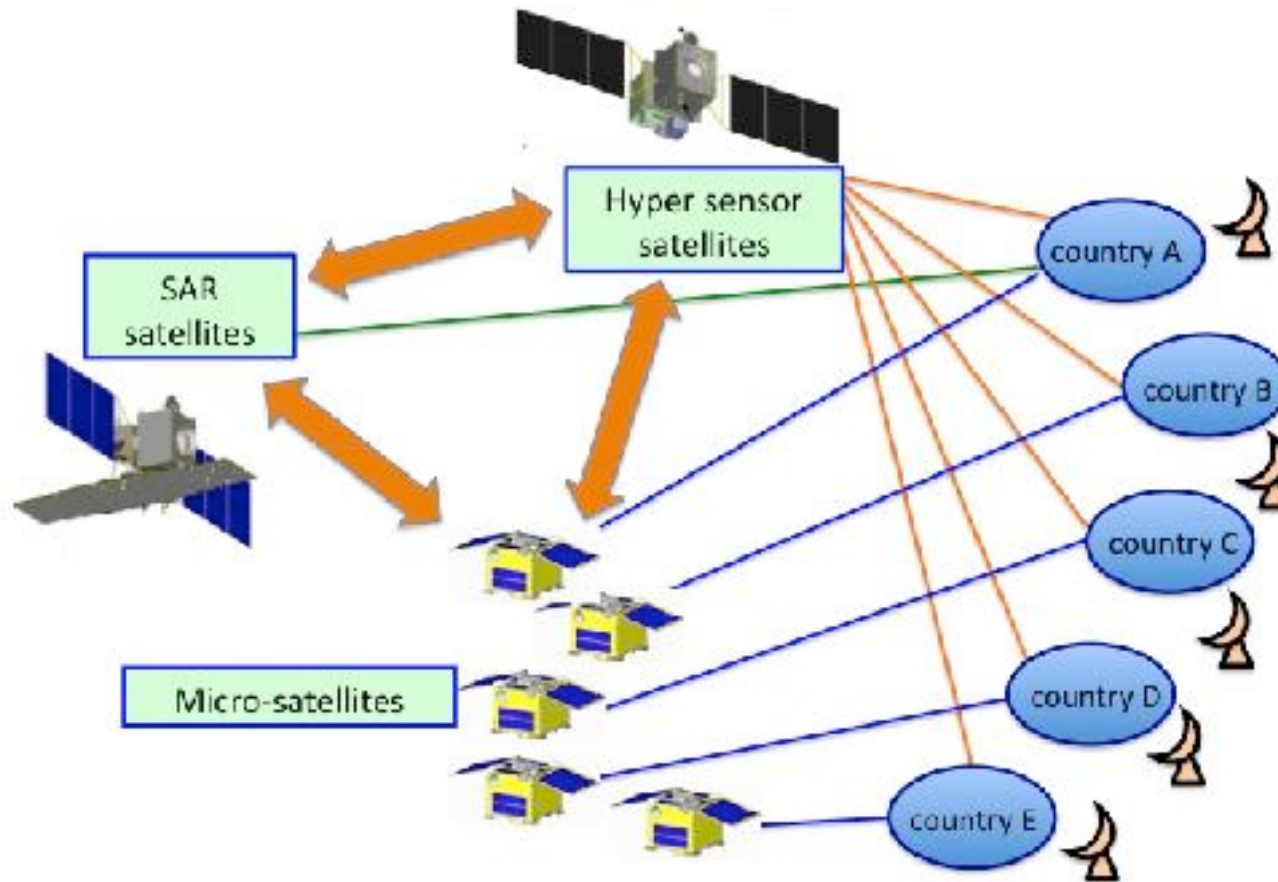


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- to maximize the efficiency of space use
- to realize the super-constellation



Space Remote-sensing Alliance ***promoted by Asian Micro-satellite Consortium***



Philippines

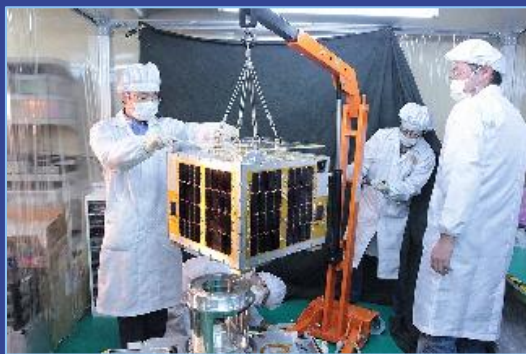


Myanmar



representatives from 6 countries

Micro-satellite constellation will provide unprecedented information.



Micro-satellite

50kg

3-5M USD

Quick fabrication (One year)

On-demand operation
based on User's purposes

Larger-satellite

300kg - 6000kg

> A few 100M USD

Long period (>10years)

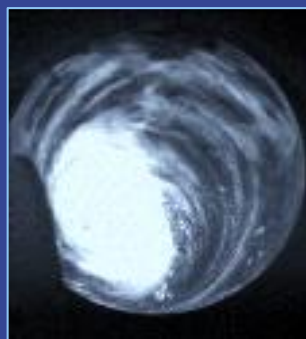
To carry heavy equipments

High performance

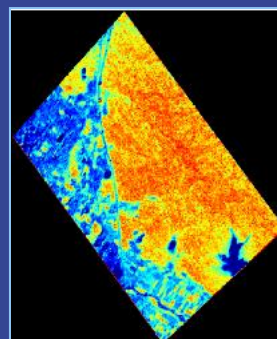
- Real time report with high spatial resolution
- Detail information on natural condition and damages



5m resolution image



Typhoon



Vegetation Index



Asian
Micro-satellite
Consortium 48