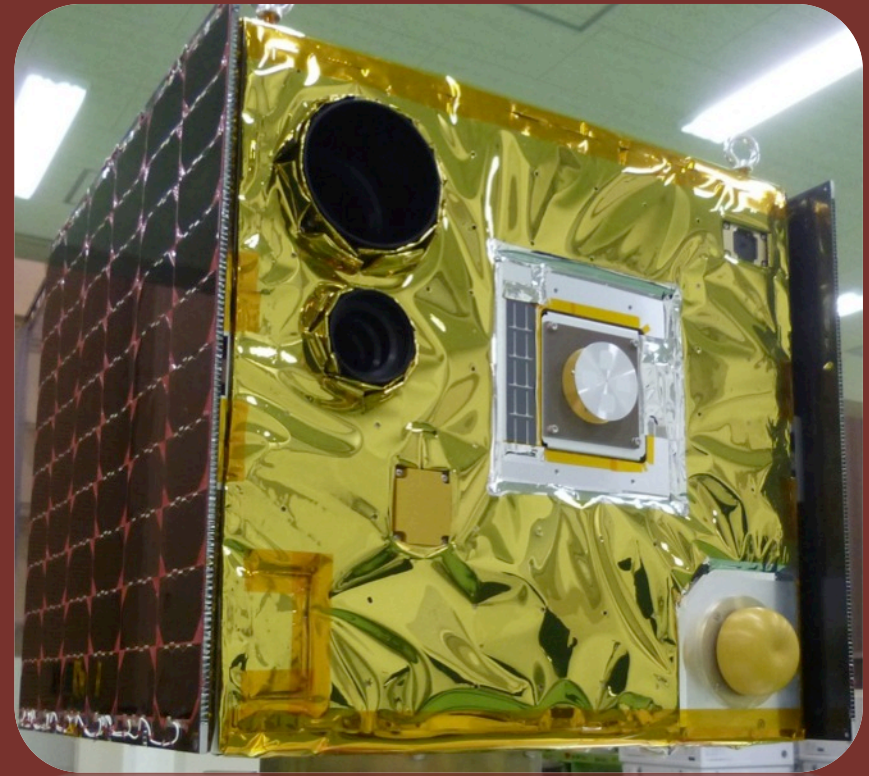# UNIFORM-1: First Micro-Satellite of Forest Fire Monitoring Constellation Project

Shusaku Yamaura

Graduate School of System Design and Management, Keio University

Presentation Outline

- Project Overview
- UNIFORM System Design
- Test and Initial

      Operation Result

- Summary

Background and Purpose

- **Small Satellites for Utilization**

<u>Actual utilization</u> of satellites leads to develop sustainable space industry. <u>Constellation</u> of small satellites enables us to steadily acquire useful data.

- **International Collaboration**

Even with small satellites, it is not easy for one single country or organization to build constellation of them. Therefore, <u>international collaboration</u> is important for us.

- **Engineer Training**

<u>Training</u> on satellite engineers is necessary on the way to achieve the goal, since there does not always exists enough number of skilled satellite engineers in Japan and other countries.

3

Introduction of UNIFORM Program

UNiversity **I**nternational **FOR**mation **M**ission: microsatellite R&D program funded by Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, started at November 2010.
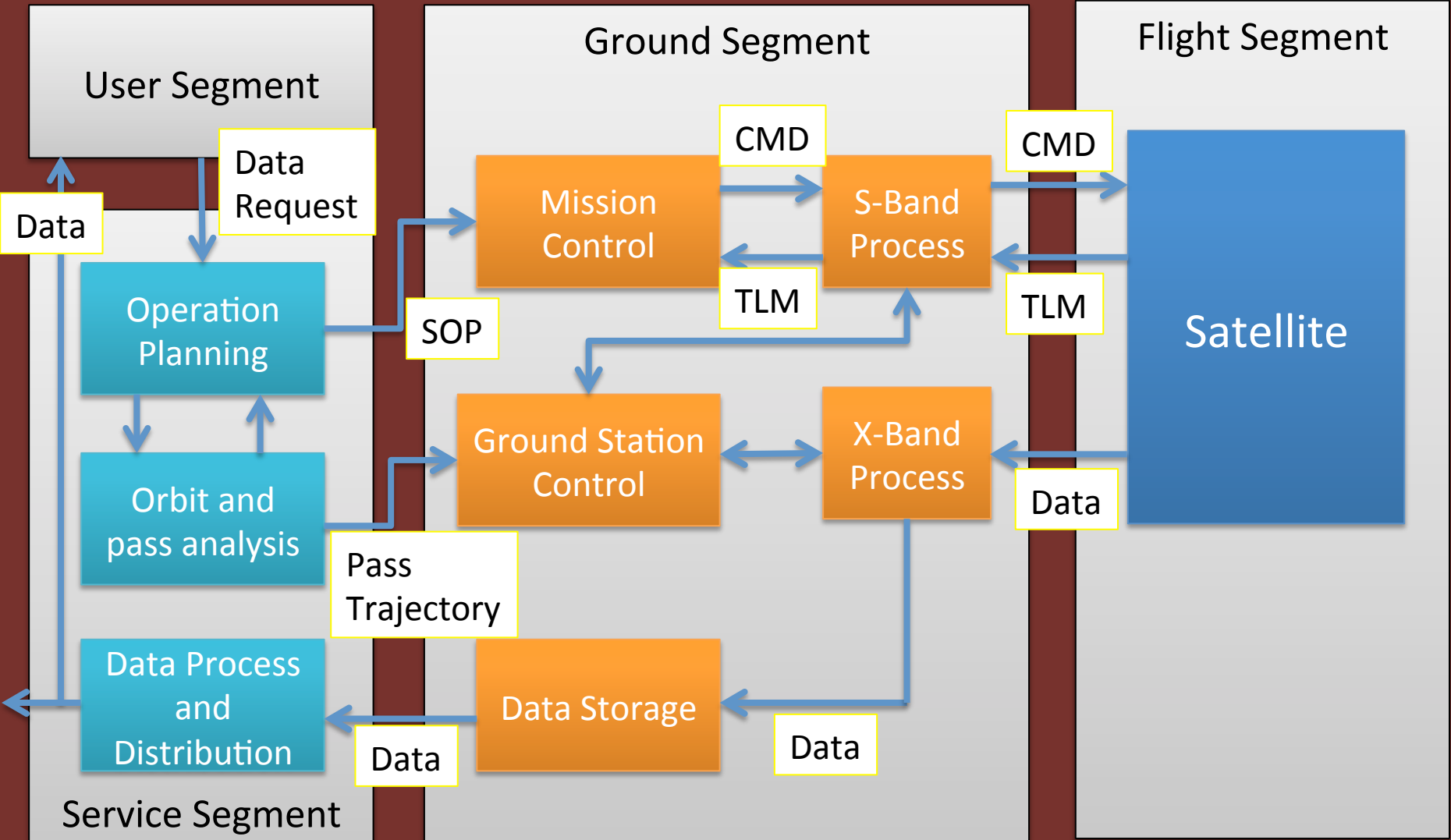
Scope of UNIFORM program

1. Build multiple microsatellites for practical use (Not a science mission)
2. Create international community to collaborate
3. Capacity building

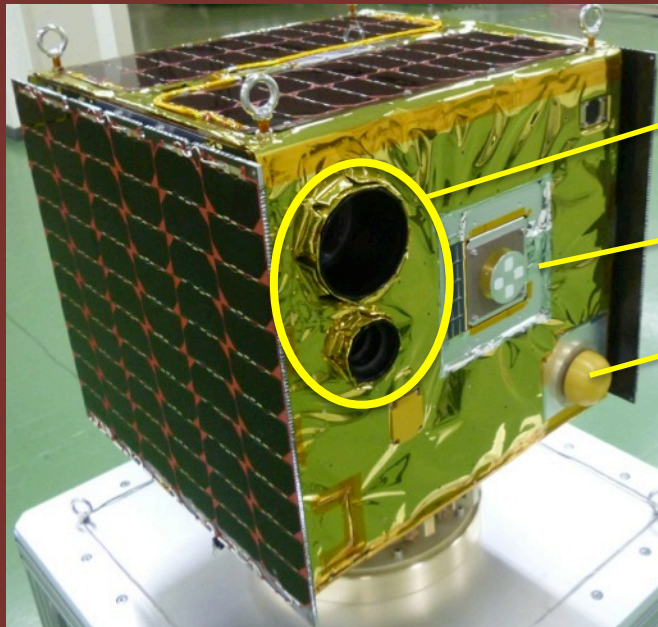# Forest Fire Monitoring: As the First Step

UNIFORM-1 System Architecture

User Segment

Ground Segment

Flight Segment

Data Request

Data

Operation Planning

SOP

Orbit and pass analysis

Pass Trajectory

Data Process and Distribution

Data

Service Segment

CMD

CMD

Mission Control

S-Band Process

TLM

TLM

Ground Station Control

X-Band Process

Data

Satellite

Data Storage

Data

Data

6

Overview of UNIFORM-1 Satellite

BOL, VIS

S-band Ant.

X-band Ant.

Sun Sensor

Star Tracker

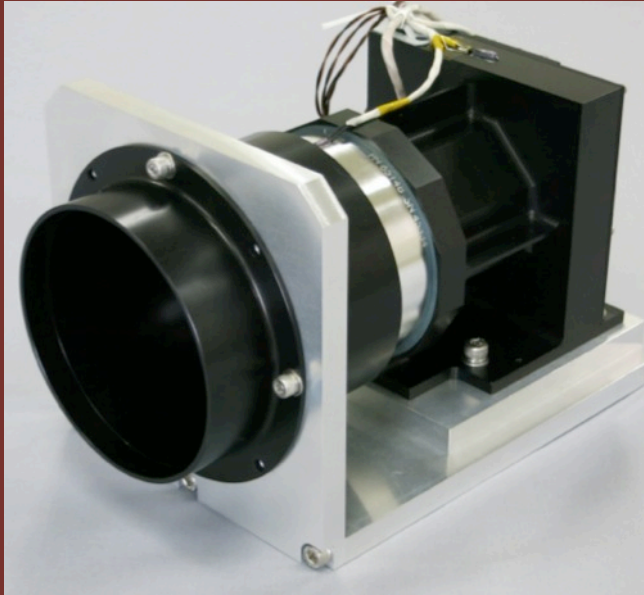|	
Launch	By H-IIA on Mat 24th as a secondary payload
Orbit	628km alt., SSO Local Time: 12:00
Size, Mass	50kg, 50 x 50 x 50 cm
Mission Payload	Microbolometer Visible Light Camera
OBC	SOI-SOC CPU RS422, ADC
Communication	S-band: Telemetry & Command X-Band: Mission (10Mbps)
Power	SAP: 140W (Max.) Li-Ion Battery: 23-33V, 6.2Ah
ADCS	GPS-R, Sun sensors, Star tracker, FOG, Magnetometer, Magnetic Torquers, Reaction wheels

System Diagram

Mission

BOL | VIS

Communication

SHU

XTX — X-ANT

EPS

HRM 1
HRM 2

HEATER
HEATER
HEATER
HEATER
HEATER

SAP

BPDU

LIBM

PCU

SW1
SW2
SW3

MTQ-1
MTQ-2
MTQ-3

GAS

NSAS-1
NSAS-2
NSAS-3

FOG

GPSR

STT

G-HYB — G-ANT1 / G-ANT1

RW1 | RW2
RW3 | RW4

ADCS AOBC

C&DH MOBC

WDB

STRX — S-HYB — S-ANT-1 / S-ANT-2

AD590
AD590
AD590
AD590
AD590
AD590
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AD590
AD590
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AD590

AD590
AD590
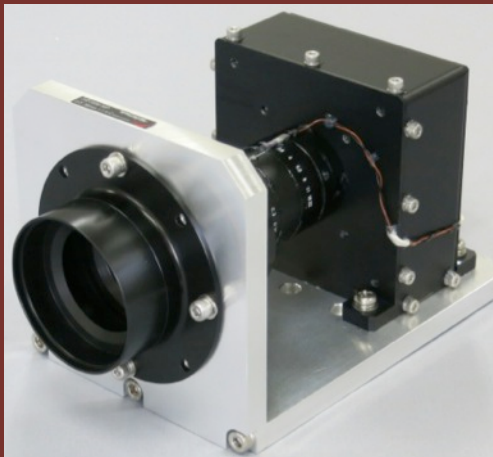AD590
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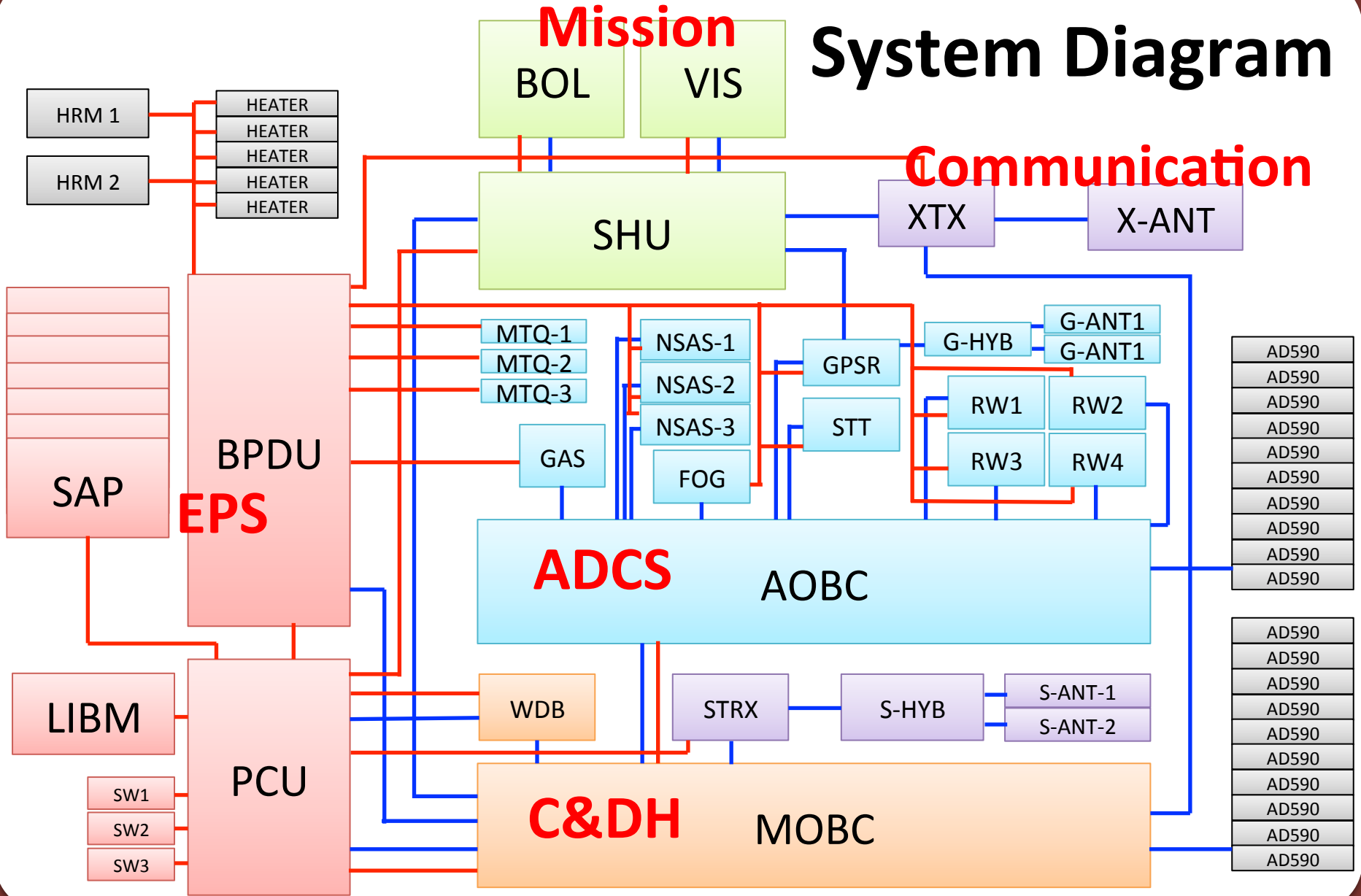
Mission Subsystem

Microbolometer (Uncooled TIR Sensor)
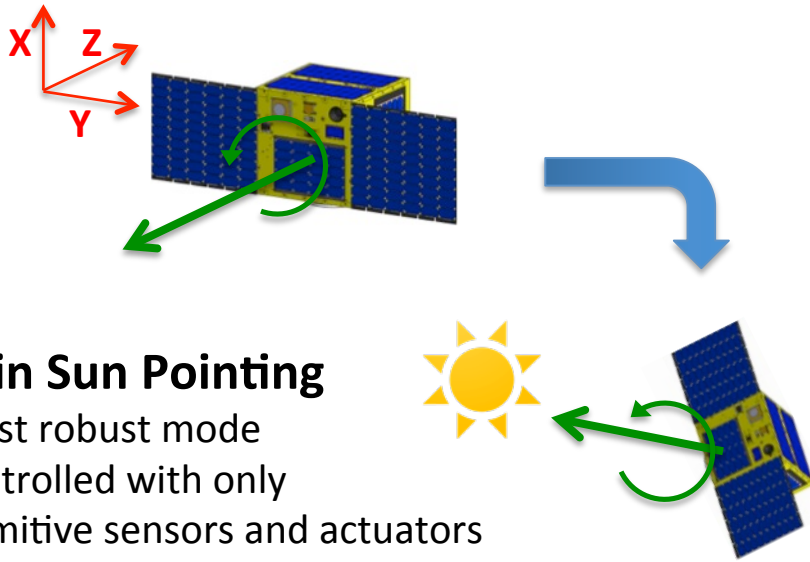For detecting heat anomaly spot on ground.

Wave Length	8 - 14 [um]
Accuracy	+/- 3 [K]
NETD	0.12 [K]@300K, f/1
Resolution	0.0143 [deg/pixel] (157 [m/pixel]@628km)
FOV	9.2 x 6.9 [deg] (100 x 75 [km])
Size & Weight	100 x 100 x 123 [mm], 800[g]

Visible Light Camera (Black & White CMOS)
For helping localization of taken image.

Wave Length	400 - 1000 [nm]
Resolution	0.0079 [deg/pixel] (86 [m/pixel]@628km)
FOV	10.6 x 8.1 [deg] (110 x 88 [km])
Size & Weight	90 x 90 x 90 [mm], 580[g]

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Attitude Determination and Control Subsystem

Spin Sun Pointing

Most robust mode
controlled with only
primitive sensors and actuators

Coarse Sun Pointing

3-axis control with
RWs to point to the Sun

NSAS, MAG and FOG for attitude determination

Coarse Earth Pointing

3-axis control with
RWs to point to the Earth

NSAS, MAG and FOG for attitude determination

Fine Earth Pointing

3-axis control with
RWs to point to the Earth

STT and FOG for attitude determination

System Integration & Test

System Integration

Start with placing and connecting some "base" components. Place and connect rest of components one by one.

Heat Cycle Test

Check if all functions work under cold/hot environment

EMC Test

Check if no components create noise to prevent other components form working properly, with RF aerial communication in radio anechoic chamber.

Thermal Vacuum Test

Calibrate thermal model, check BOL lens temperature control performance and check if all functions work under thermal vacuum environment

Separation Shock Test

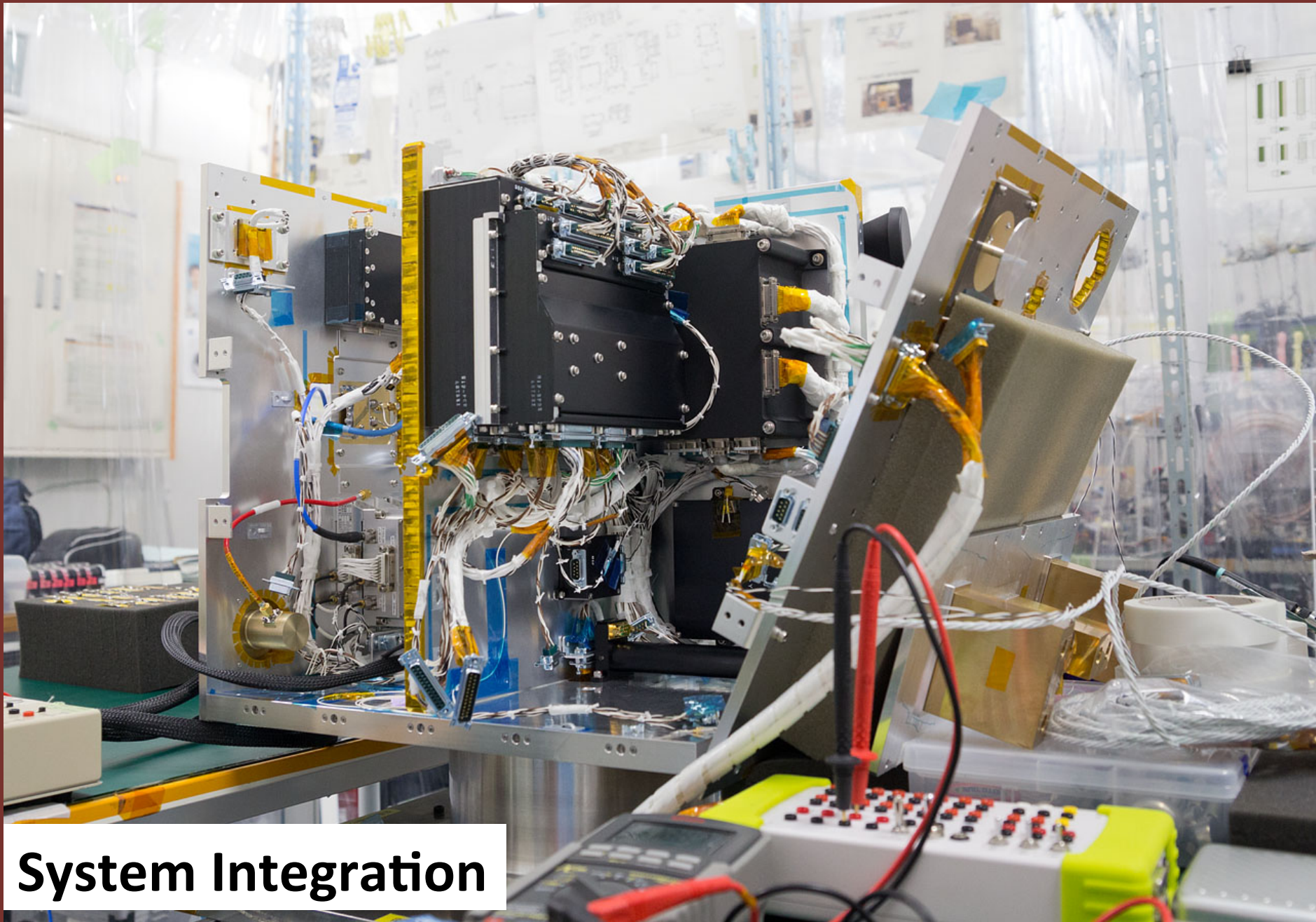Check if no mechanical damage found after the test

Vibration Test

Check if natural frequency is higher than required value, no mechanical damage found, no chattering on separation switch and SAP wings do not open

Software Test

Application layer is tested as a whole system after environment test, while data handling layer is tested before. ADCS application is developed and tested indeptly.

System Integration

System Integration	Start with placing and connecting some "base" components. Place and connect rest of components one by one.
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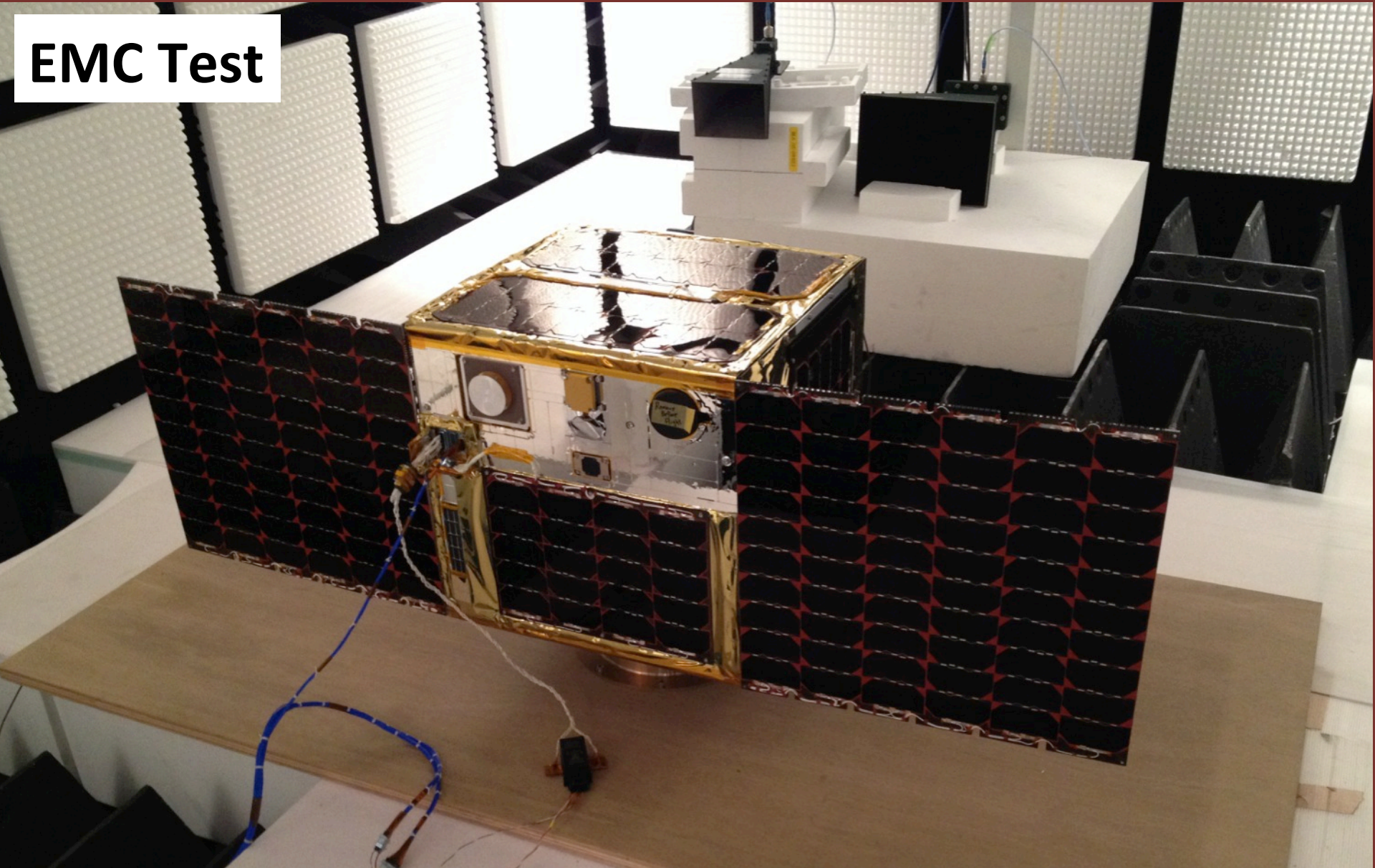|	
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EMC Test

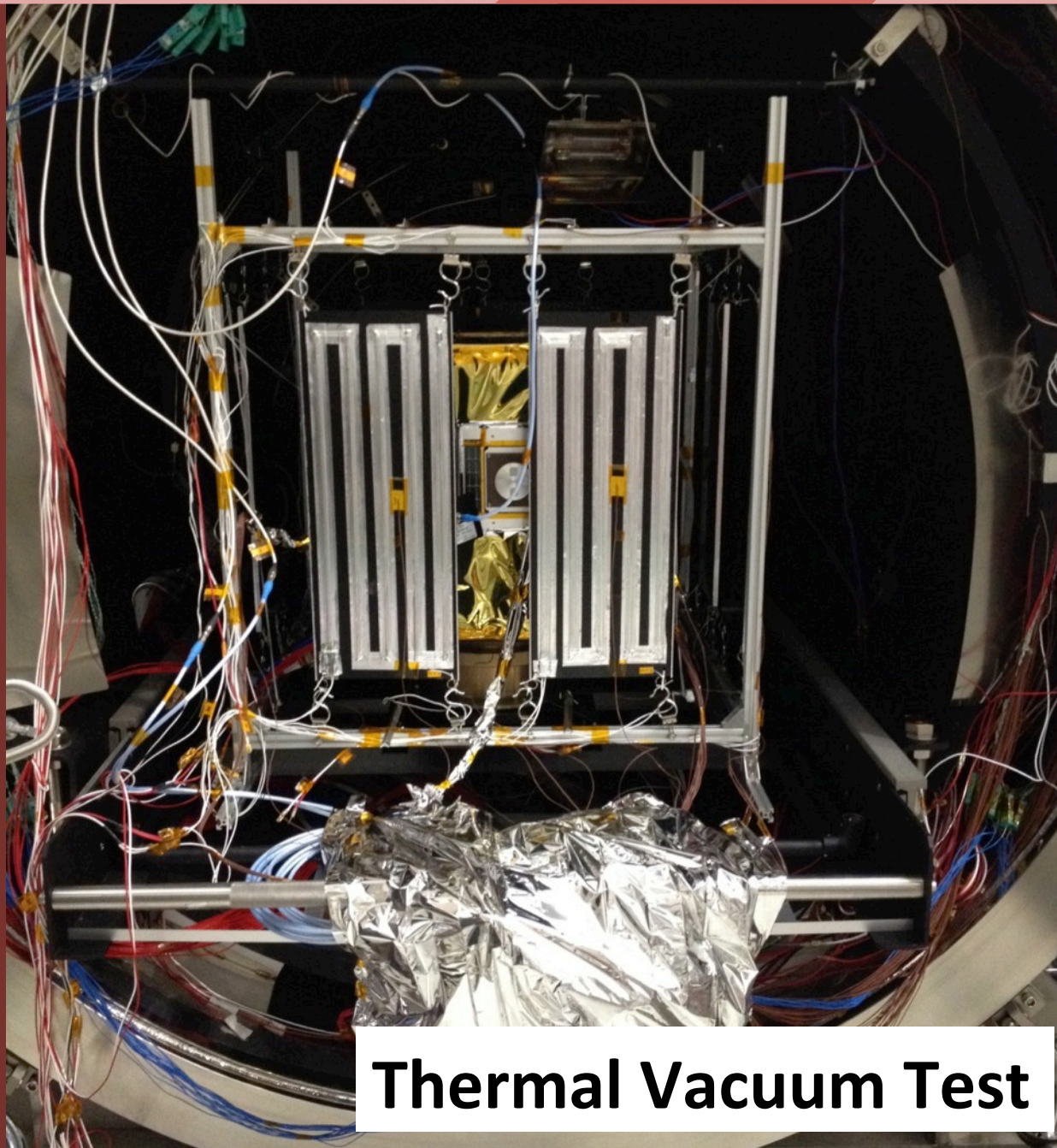|	
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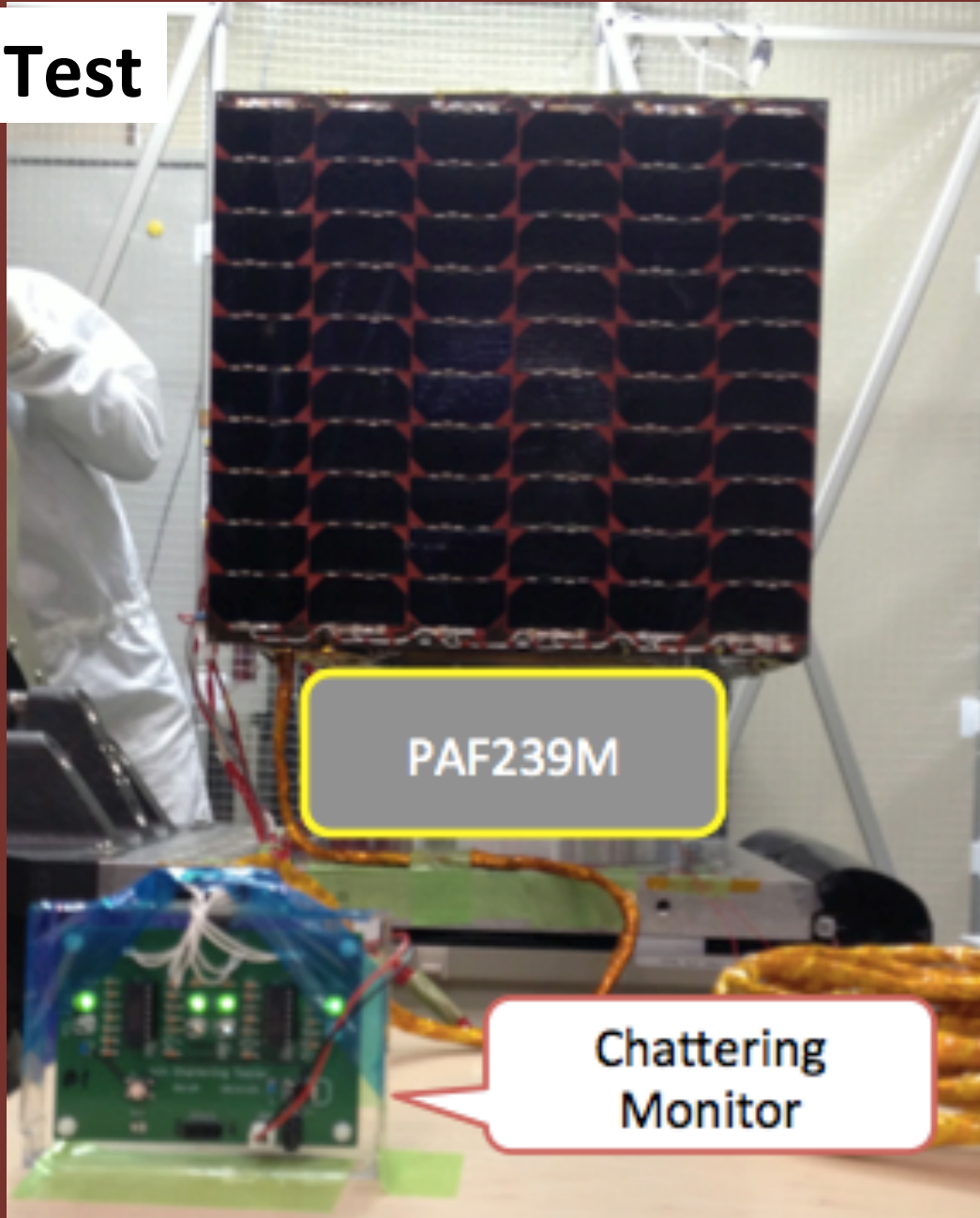|	
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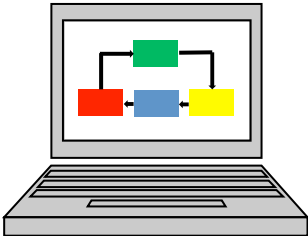|	
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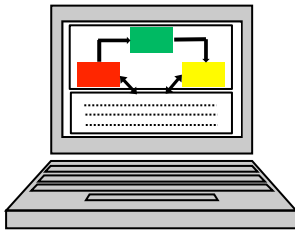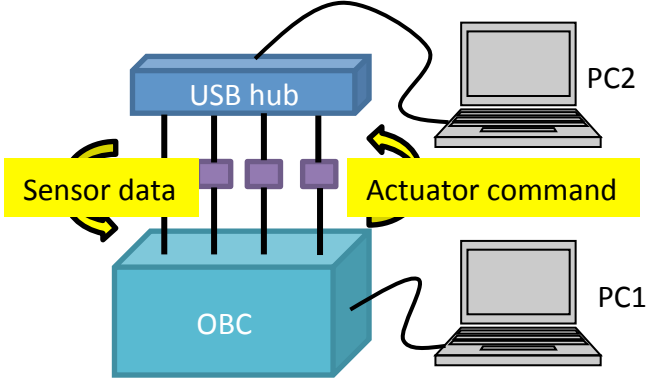|	
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ADCS Software Verification

|	① MILS (*Model* In-the-Loop Simulation)	② SILS (*Software* In-the-Loop Simulation)	③ HILS (*Hardware* In-the-Loop Simulation)
Test configuration			
Things to test	Control Logic, mode transition	C code	C code on OBC, Sensor/actuator drivers
Tools	MATLAB/ Simulink	MATLAB/Simulink	MATLAB/Simulink, LabVIEW

① MILS: The GNC algorithm made of MATLAB/Simulink in the AOBC is simulated.

② SILS: Actual software written in C in the AOBC is simulated.

③ HILS: Actual software on actual OBC is simulated.

ADCS Simulator

HILS Configuration
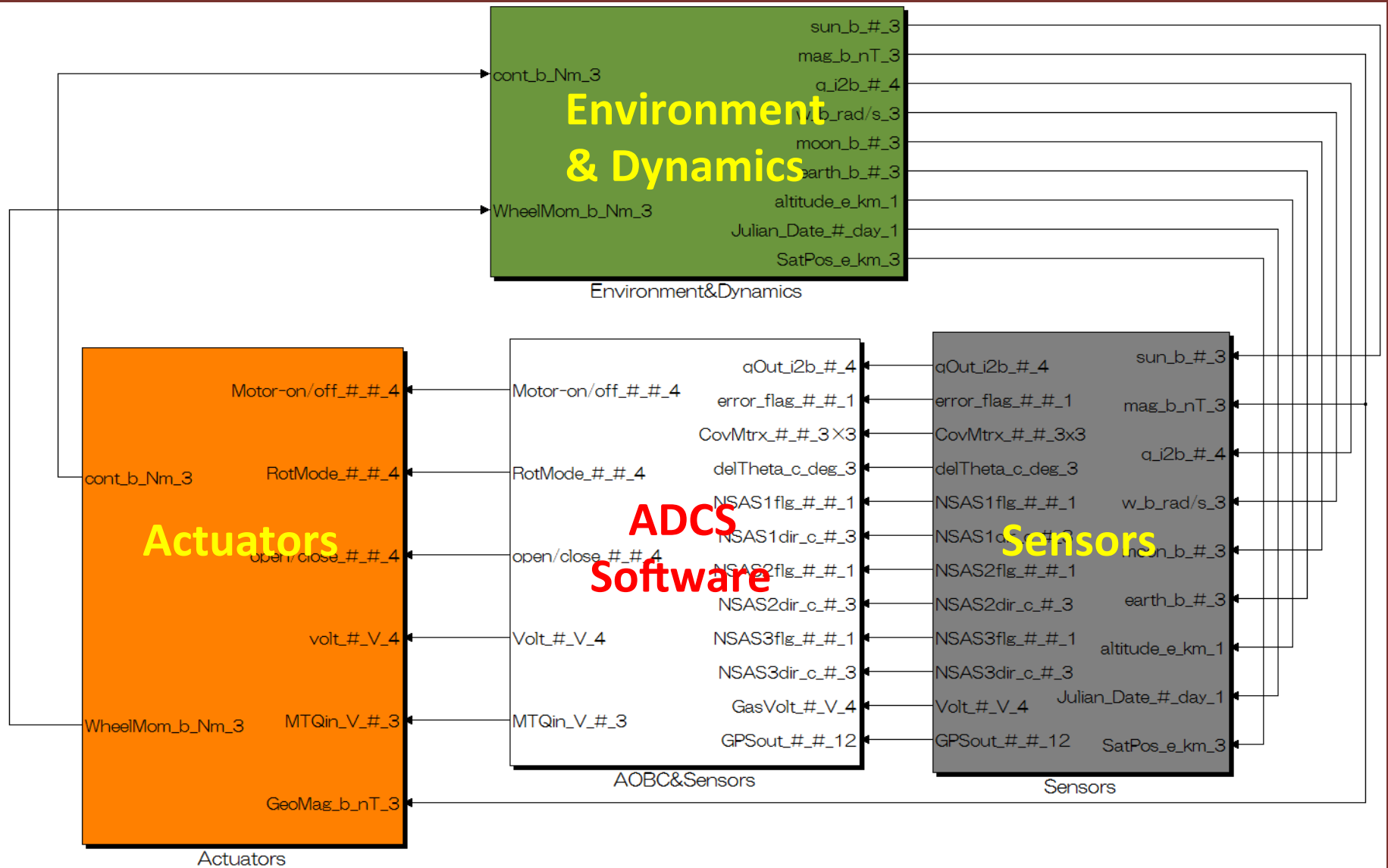
Initial Operation Result

UNIFORM-1 was launched at 12:05 (JST) May 24th. Initial operation has been conducted following order.

- [X+00h]: Launched at Tanegashima Island by H-IIA
- [X+02h]: First AOS, satellite initialization
- [X+48h]: SAP Deployment
- [X+71h]: Spin Sun Pointing Mode stabilized
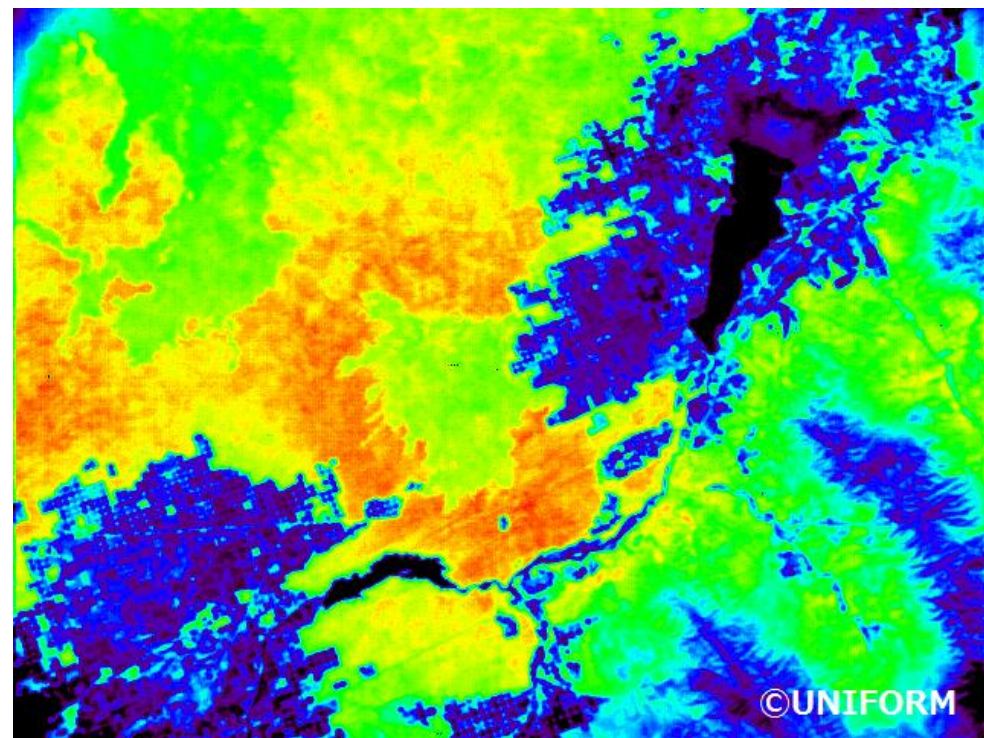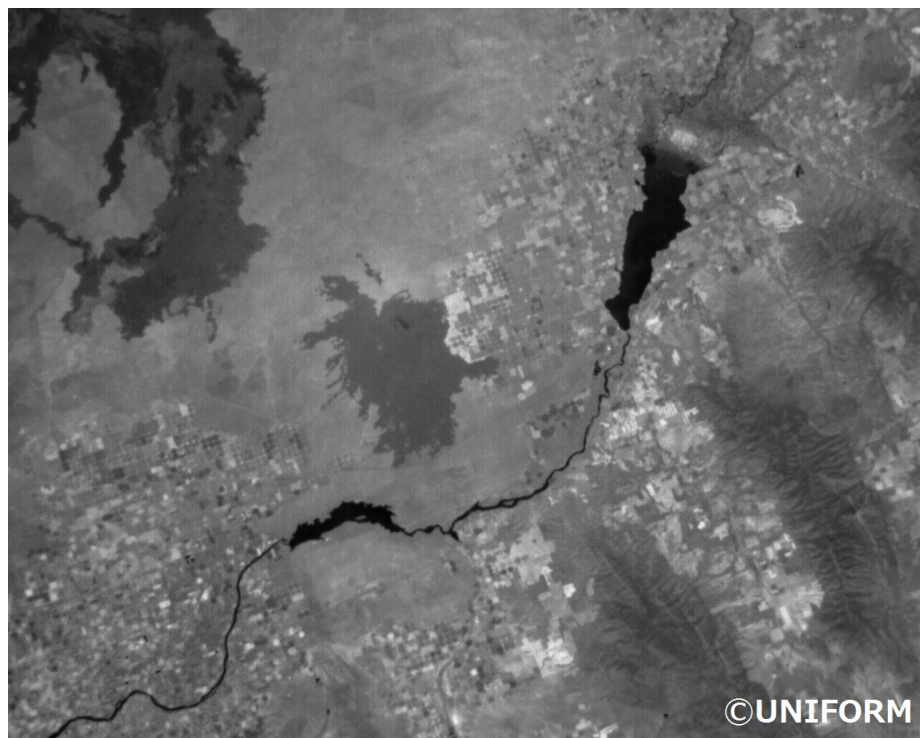- [X+97h]: First Light by BOL and downlinked

First Light Taken by Bolometer Camera

Taken at May 28th 11:52 (Local Time)

N
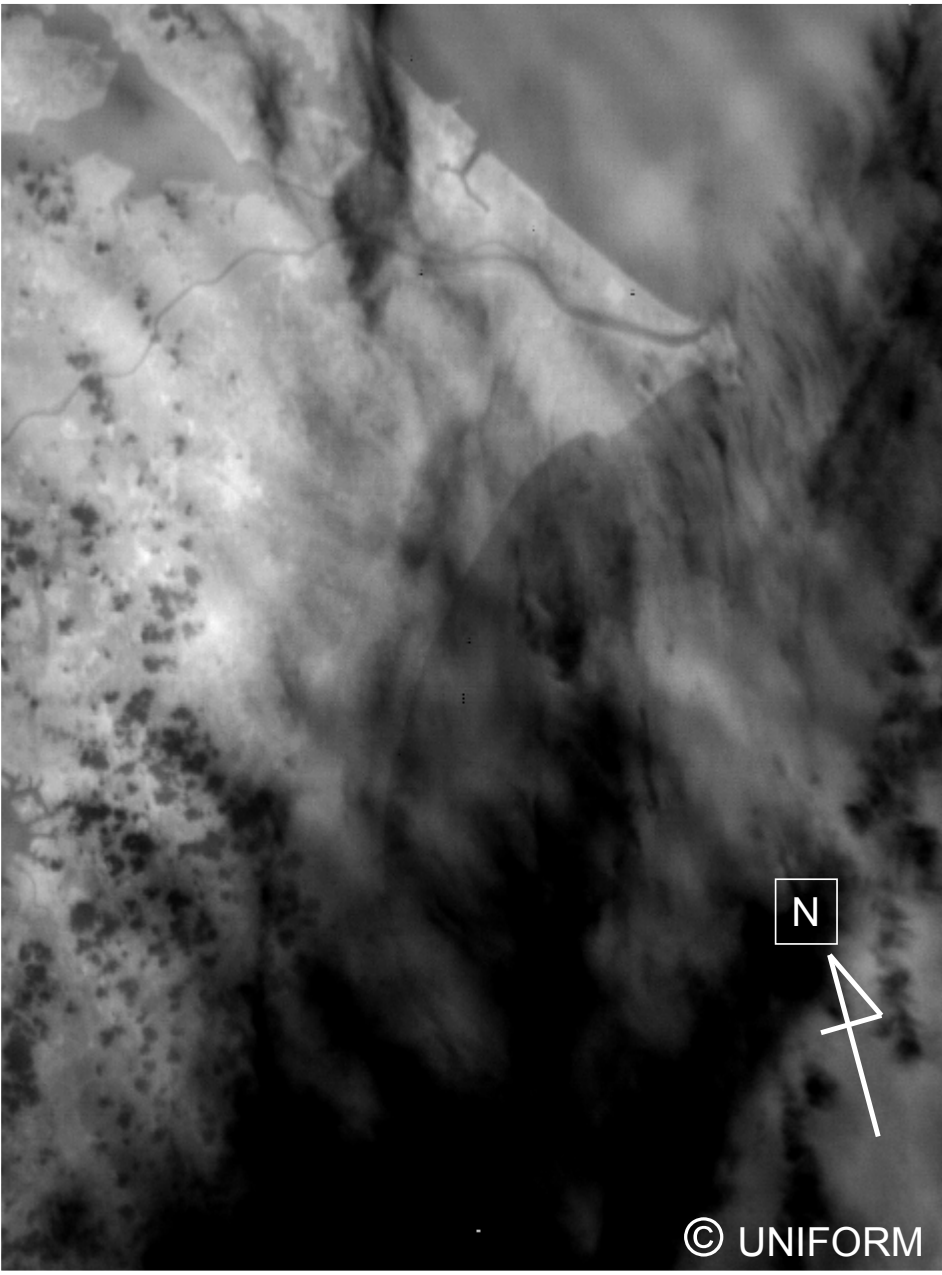
© UNIFORM

© Google

Up-Left: Image of VIS
Up-Right: Image of BOL

Taken at 2:02PM (local time)

State of Idaho, U.S.
around American falls reservoir
area of desert farming

<- From Google Earth

Future Plan

- UNIFORM-1 satellite operation
  - Finalize all checkout soon, and start acquiring forest fire information constantly.

- UNIFORM program and successor program
  - Currently, researchers from Kazakhstan and Brazil are expecting to build UNIFORM-2 and 3 together this year.
  - We also have started working for microsatellite development training program for Engineers from Vietnam.
  - We are still seeking more people and countries to collaborate with us.

Summary

- Our broad goal is to realize sustainable small satellite industry by internationally collaborating to construct small satellite constellation for practical use.

- First forest fire monitoring satellite UNIFORM-1 was developed and went through all the acceptance test.

- UNIFORM-1 has been launched and now we are trying to constantly provide forest fire data.

- Still seeking other countries to work with.

Thank you for listening.