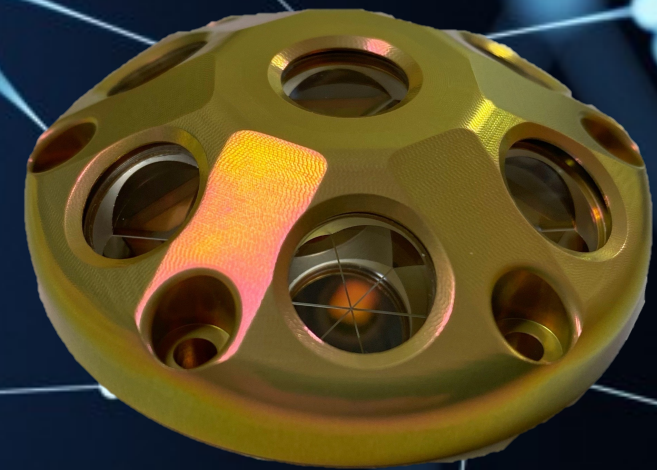


Applying SLR to a 1U CubeSAT with a Reflector Module mini-Mt.FUJI

The e-kagaku Association of Global Science and Education

Takanao Ishii



2023 Virtual International Laser Ranging Workshop

October 16-20, 2023

Outline

- About us
- Project Summary
- Mission
- SLR by mini-Mt.FUJI



About us, e-kagaku



Our Mission:

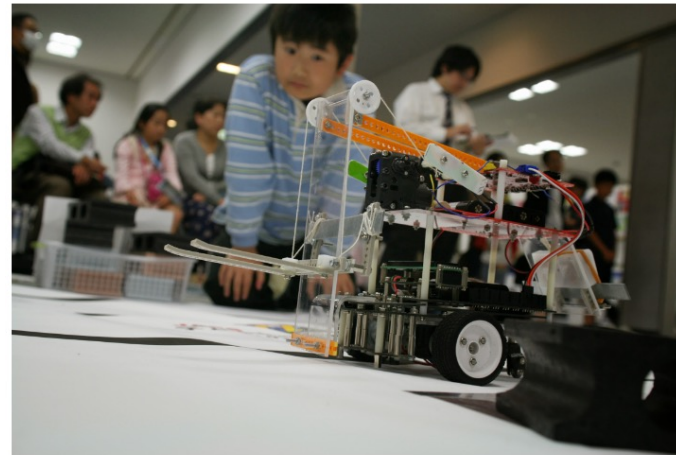
Create a society where all generations can learn science, ICT, and AI anytime and anywhere

Activities:

Organizing AI/data science and ICT classes

Hosting science contests (robot and drone contests, presentation contests, etc.)

Organizing project-based learning



Previous Project-Based Learning

Space Balloon project:

Create observation logger equipped with radiation, ultraviolet light, and temperature sensors, and a 4K camera.

Previous project members have presented their findings at JAXA symposiums, and MATLAB Expo.



Project Summary



Satellite: e-kagaku-1

Nickname: IWATO

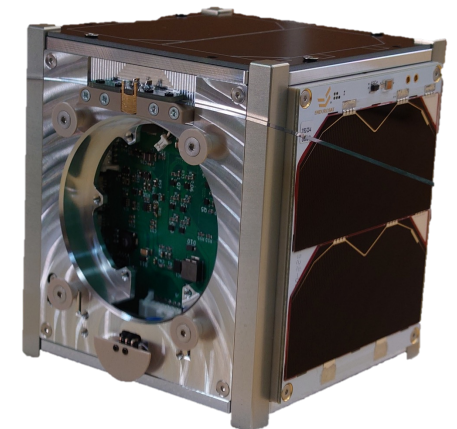
1U CubeSAT, planned to be deployed from KIBO module (an experimental module on ISS) in 2024

Objective:

Conducting orbit analysis by laser ranging, and publishing high-precision orbit information for the first time as a CubeSat

Members:

24 Junior High and High school students, 9 University students



Project Summary



Partnership: JAXA, Mitsui Bussan Aerospace, Kyushu Institute of Technology, Ishitoshi Machining Inc., external advisors

Mitsui Bussan Aerospace

- safety inspections
- launch opportunity coordination

Ishitoshi Machining Inc.

- development and manufacturing of frame
- manufacturing of laser reflector mini-Mt. FUJI

JAXA

- joint research on demonstration of SLR using mini-Mt. FUJI

External advisors

- technical advice

e-kagaku Satellite Project

Development Team

Experiment Team

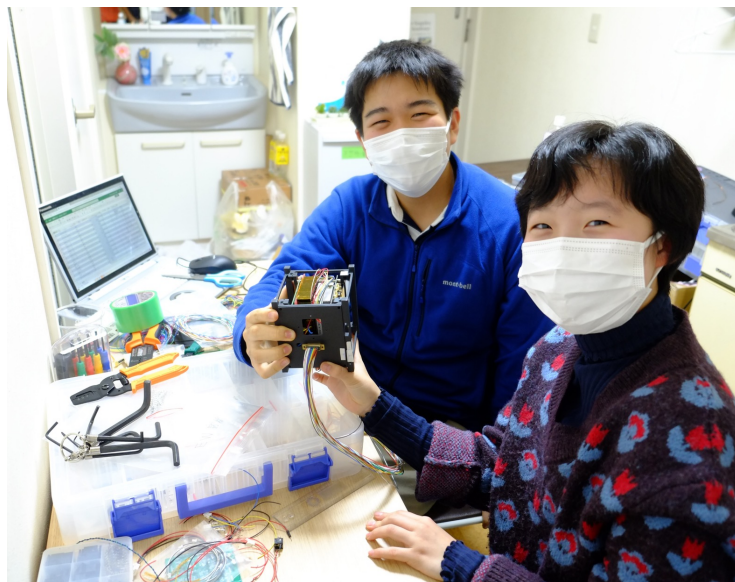
Project Summary

Education of junior-high and high school students

Development Camp Iwaki, Fukushima



Development Base Shinjuku, Toyko

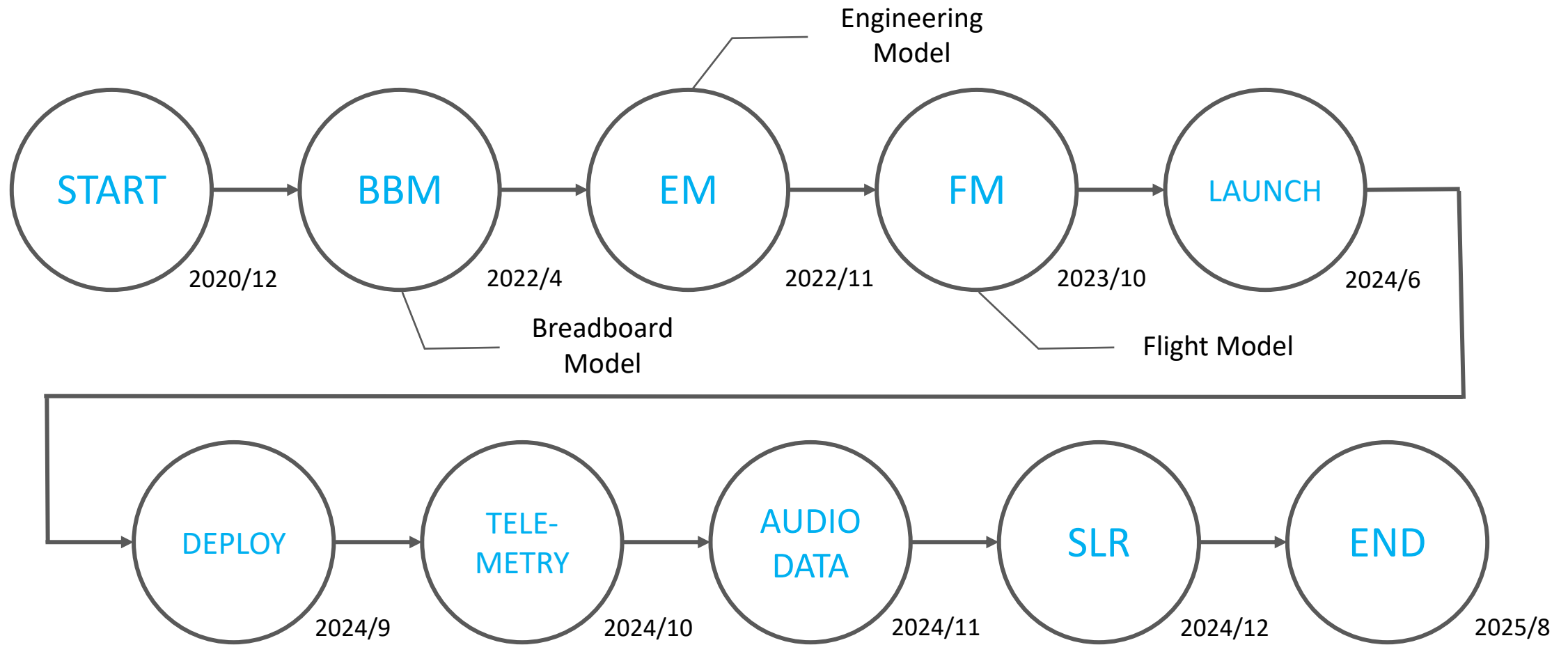


Remote Development Zoom



Members are from all over Japan

Schedule



Technological

Receiving downlink data such as housekeeping data (HK data), GPS data, and gyro sensor data

Receiving Audio Data
(Large Capacity Data)

Demonstrating SLR
using mini-Mt. FUJI

Educational

Fostering space engineers of next generation

Involving a wide range of age groups in project based learning

Establishing learning methods for satellite systems

Receiving downlink data

Downlink data

- HK data is broadcasted periodically
- Mission data is downlinked when the satellite receives certain commands

HK data

- Temperature
- Current, Voltage
- Remaining battery capacity

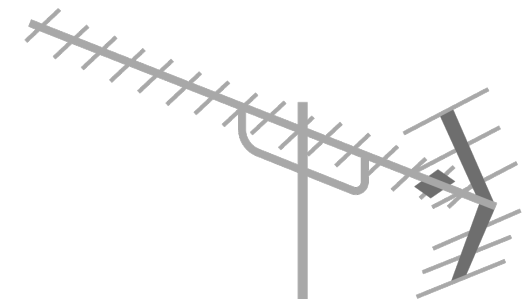
Mission data

- GPS data
- gyro sensor data



Uplink modulation type
• AFSK

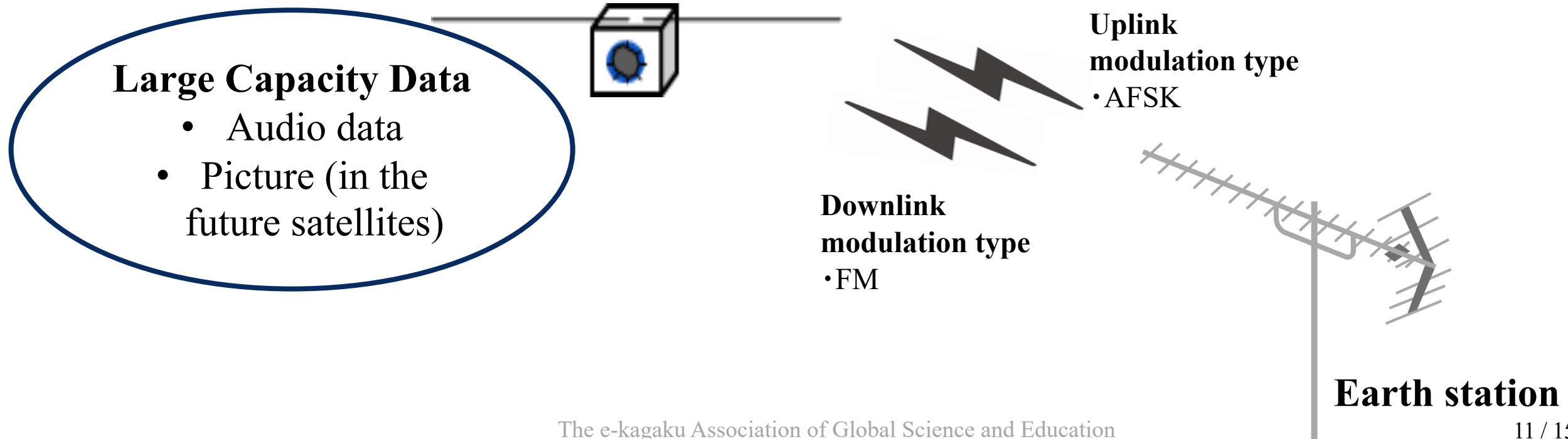
Downlink modulation type
• CW
• AFSK
• GMSK



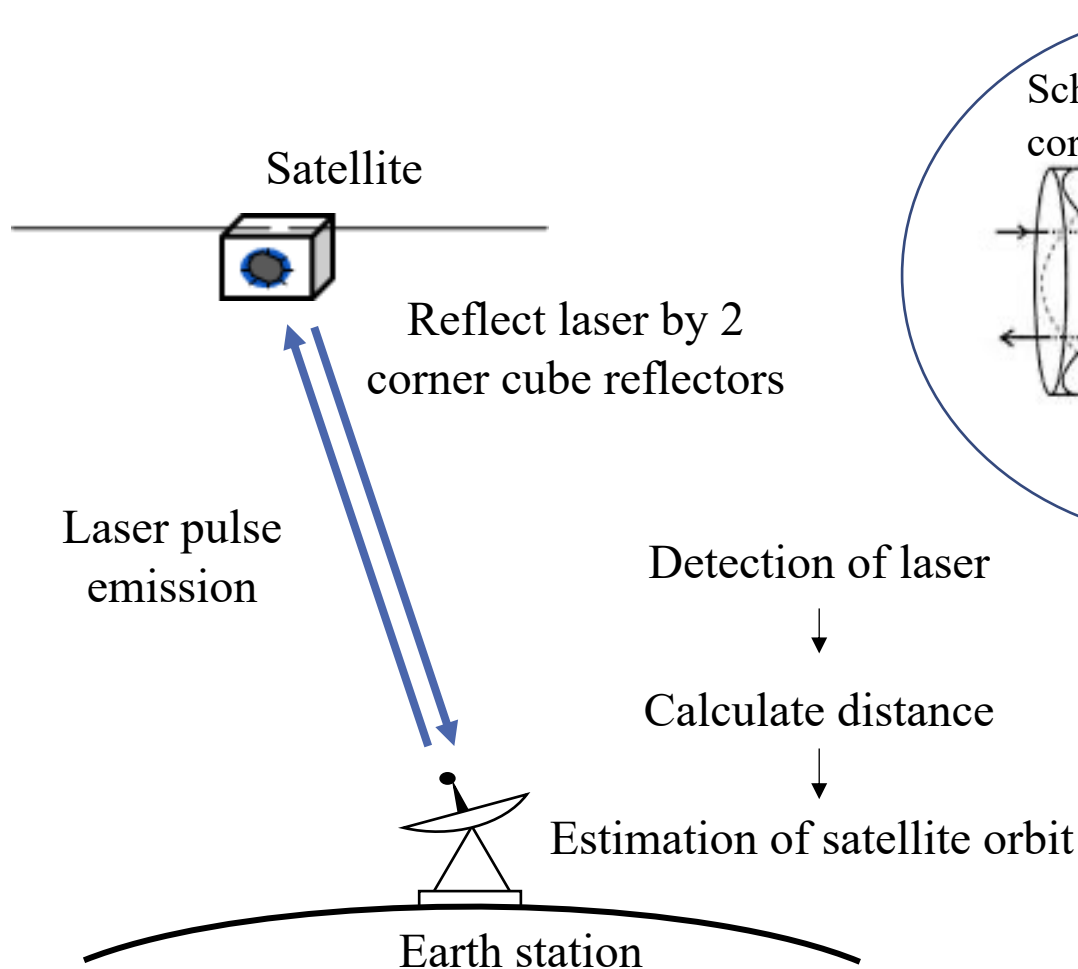
Earth station

Downlink of large capacity data

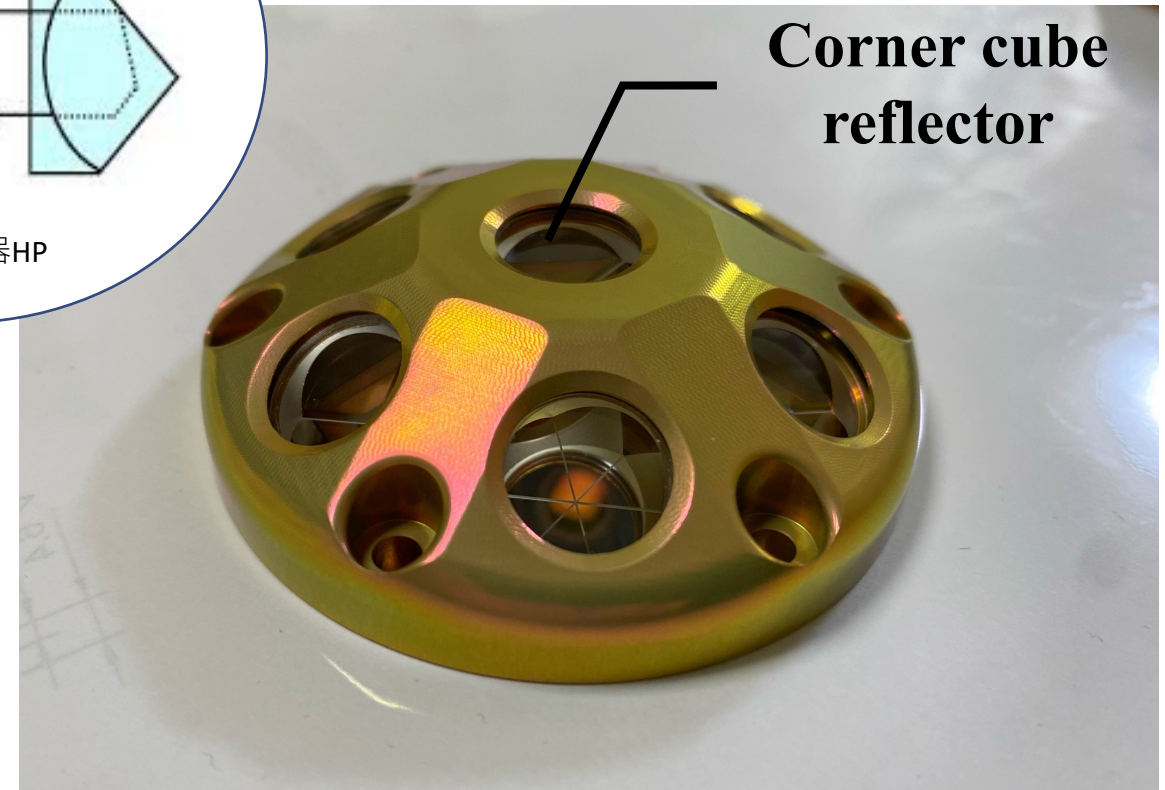
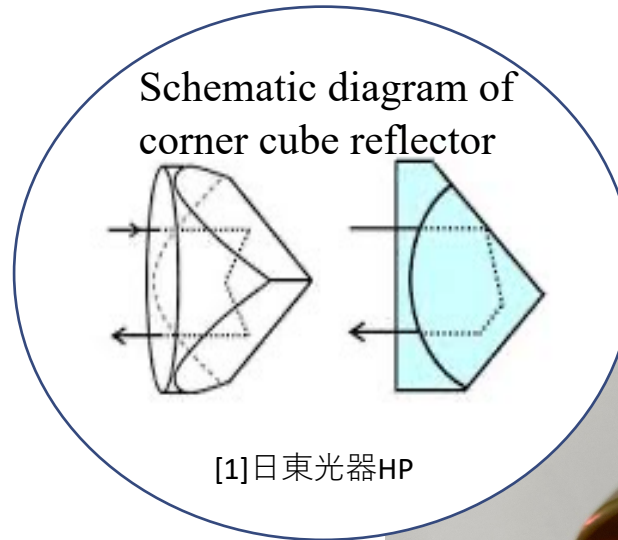
- Verify if large capacity data can be downlinked stably.
- Downlink audio data by FM, when ordered from the Earth station.
- If it succeeds, this technology can be applied to the downlink of a picture taken by a camera on a satellite in the succeeding satellites.



Satellite Laser Ranging, SLR



Schematic diagram for SLR mission



mini-Mt.FUJI

Satellite Laser Ranging, SLR

Purpose of the SLR mission

As more and more debris surrounds the Earth, SSA(Space Situational Awareness) has become an international issue.

Conventional method

Radar, optical observation
Precision: ~10 m



Alternative method

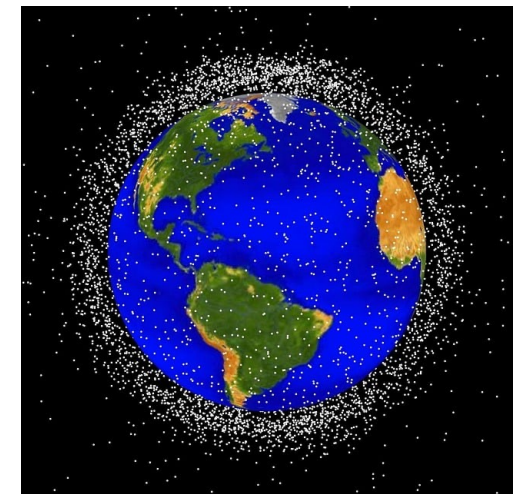
Mount reflectors on satellites so that it can be tracked by SLR, even after the end of operation.
Precision: < 1 cm

Problem of conventional reflectors:

Expensive, takes space, increase weight of satellites

➔ JAXA developed a modularized unit of corner cube reflectors called “Mt.FUJI”. Small, light, and inexpensive.

Even smaller unit called “mini-Mt.FUJI” was developed to apply SLR for nanosatellites such as CubeSATS



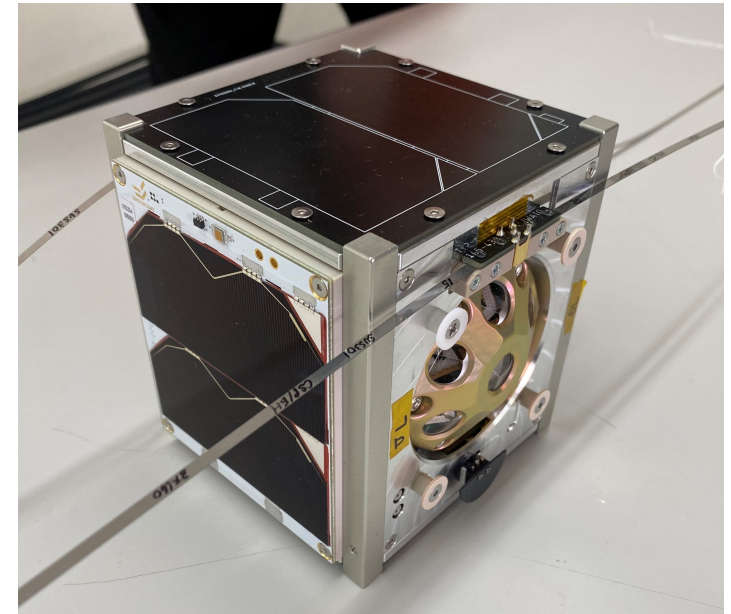
Satellite Laser Ranging, SLR

Specifications of mini-Mt.FUJI (CCR: Corner Cube Reflector)

	Mt.FUJI	mini-Mt.FUJI
Altitude of satellites	≤ 800 km	≤ 500 km
Diameter	112 mm	62.0 mm
Height	32 mm	17.5 mm
Mass	260 g	55 g
Size of CCR	1 inch	0.5 inch
Number of CCRs	7	7
Viewing angle	45 degrees	45 degrees
Materials	Body and pedestal: aluminum CCR: Synthetic quartz Shock absorber: PTFE, PEA	

Our satellite is the first to verify mini-Mt.FUJI!

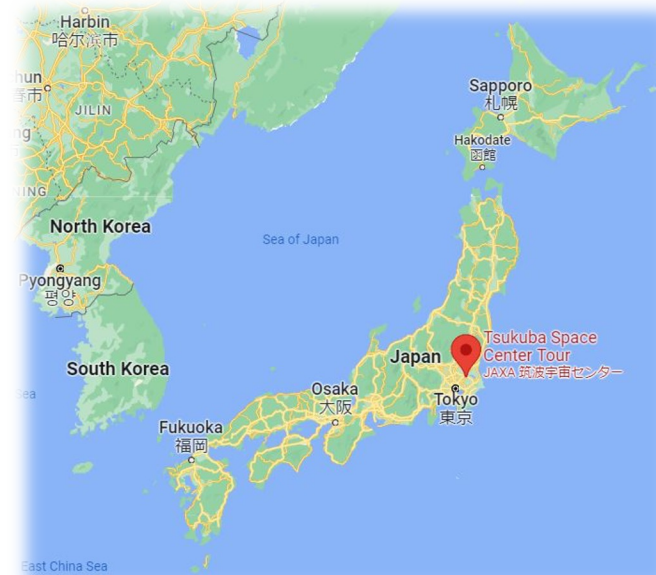
2 mini-Mt.FUJIs are mounted on e-kagaku-1, on $-X$ face and X face



Satellite Laser Ranging, SLR

Our main SLR station:
Tsukuba Satellite Laser Ranging Station (JAXA)

Optical Diameter	0.8m
Wavelength	532nm、1064nm
Repetition Rate	1kHz
Pulse Energy	260 μ J@532nm、 350 μ J@1064nm
Detector	SPAD (Single Photon Avalanche Diode)



In order to attain the higher precision of orbital estimate and verify the effectiveness of using mini-Mt. Fuji...

Collaboration from all over the world is crucial!