SNIPE Mission:
Formation Flying Nano-Satellite for Small Scale Space Weather Research

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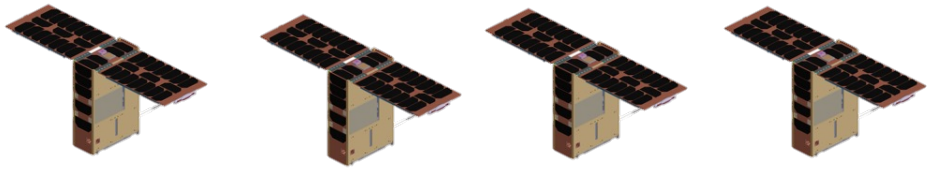
About SNIPE mission

- **New idea: Multi-satellite formation flying enables us to identify temporal and spatial variation of Space Plasmas.**

SNIPE (Small scale magNetospheric and Ionospheric Plasma Experiment)

- Constellation of four 6U CubeSats (~10 kg for each satellite)
- Formation Flying (Slow separation from 10 km to >100 km for 6 months)
- Scientific Instruments: **Langmuir Probe, Solid State Particle Detector, and Magnetometer**
- Design life Time: 1 year (Science operation time: 6 months)
- Orbit: ~550 km, Sun Synchronous
- Launched on 25 May 2023 at Naro Space Center, South Korea



SNIPE-A SNIPE-B SNIPE-C SNIPE-D

Five Bullets for Scientific Targets

- **Science Targets**

✓ Spatial scale and energy dispersion of electron microbursts

✓ Temporal and spatial variations of plasma trough during magnetic storms

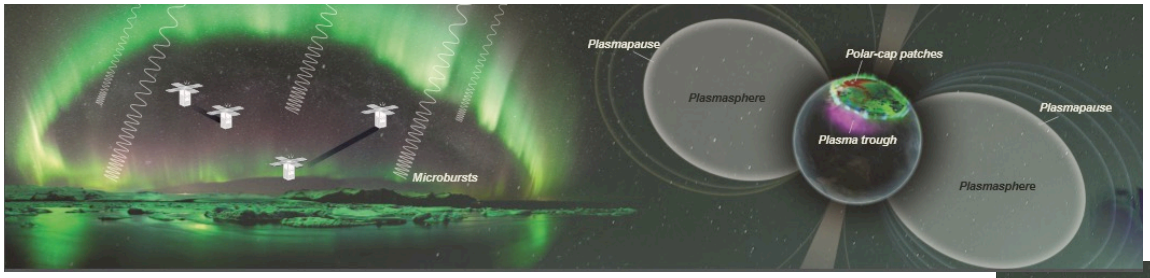
✓ Temporal and spatial variations of electron density and temperature in polar cap patches

✓ Measuring length of coherence for Ionospheric bubbles/blobs

✓ Large amplitude disturbance of field aligned currents

Additional Science

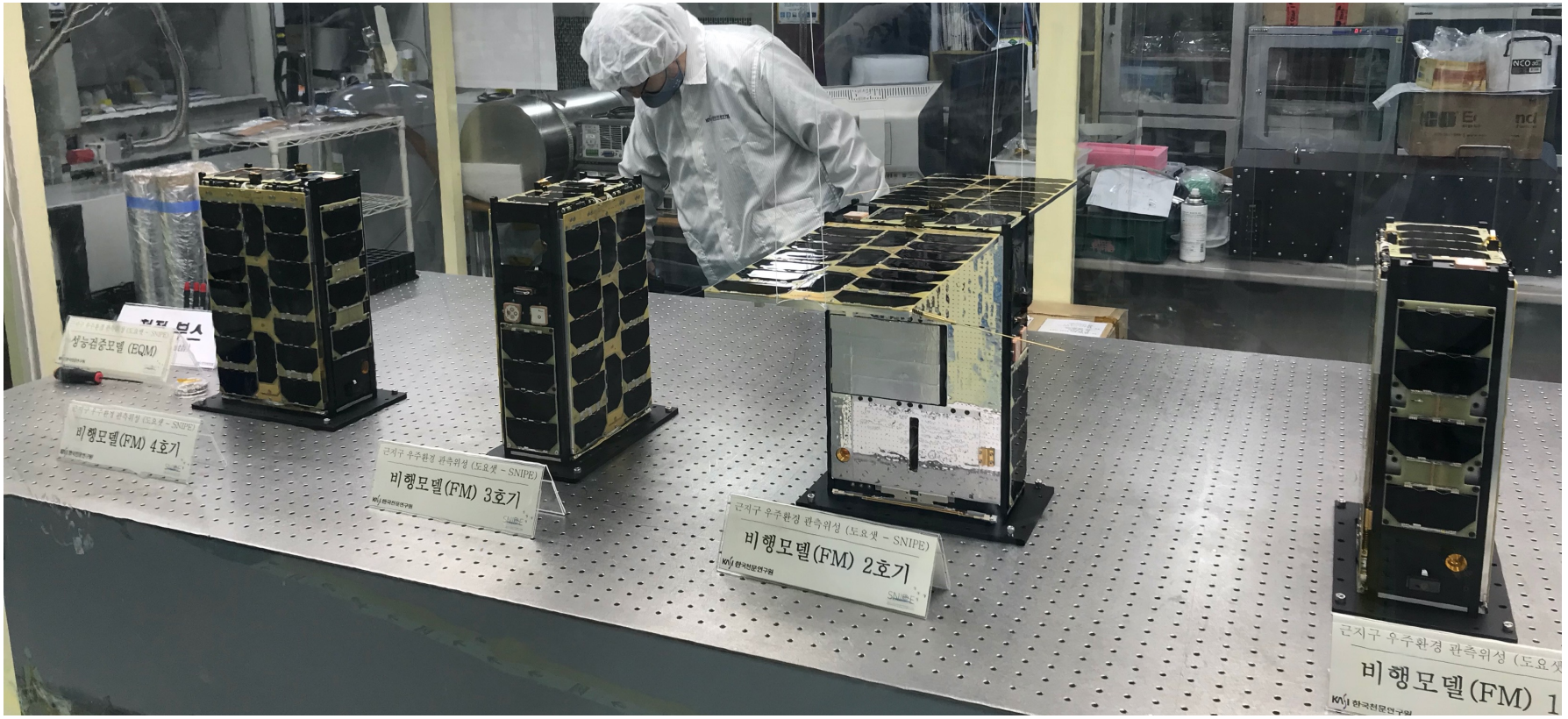
✓ EMIC waves at the top of ionosphere



SNIPE Bus System

Subsystem	Specification
ADCS	Three-axis attitude control by reaction wheels → Field aligned attitude control during microburst observation Accurate GPS system for position and velocity determination Attitude information from Sun Sensor, Star Tracker, Magnetometer, and Mems-Gyro Attitude Control Accuracy : < ±1 deg (Attitude Pointing Knowledge Accuracy: 0.05 deg)
CDHS	Onboard Computer: Dual Core Microcontroller (OS: Linux, Platform Software: cFS) Communication between OBC and payloads with CAN BUS protocol Onboard Flash Memory: 16GB (Micro SD Card) Program Memory: 16MB
EPS	Deployable solar panel (44 W) High capacity Li-Polymer batteries (40Wh)
COMS	UHF Up/Downlink: 437.5 MHz (9.6 kbps) S-band Up/Downlink: 2240.84 MHz (1 Mbps (TBD)) IRIDIUM Communication (Short Burst Data Service)
Propulsion	High performance micro-thruster (Vacco Cold Gas Thruster) Del-V : ~50 m/s, Thrust: 100 mN
Formation Flying	Along and Cross Track Formation Minimum Distance between satellites: 10 km

SNIPE Flight Model

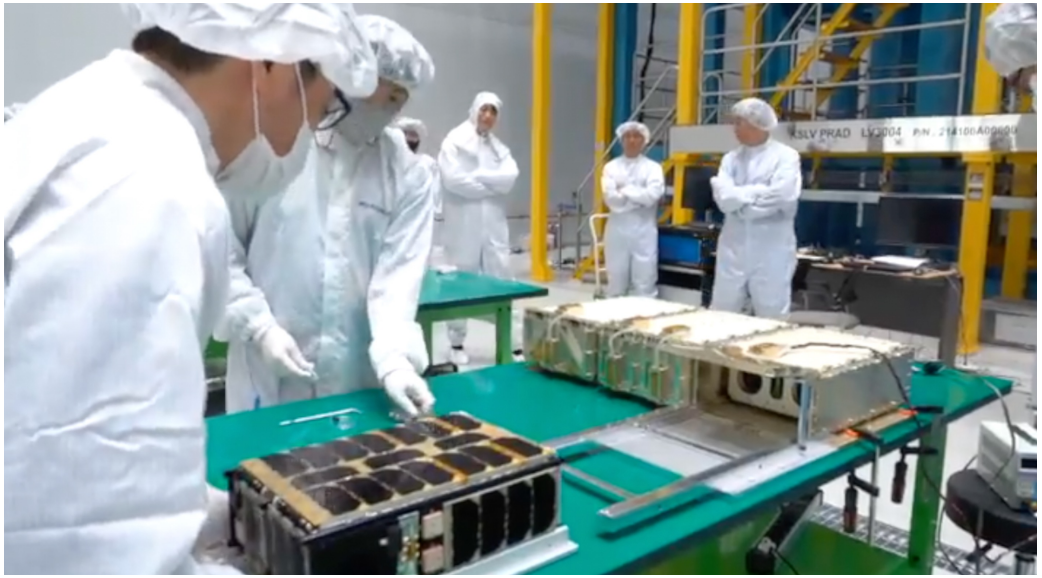


We completed the integration of the SNIPE FM in end of 2021.
After that, We DO Test, Test and Test, however it was not enough.

The night before leaving to the launch site

SNIPE team members (2nd May 2023)

At the Naro Space Center

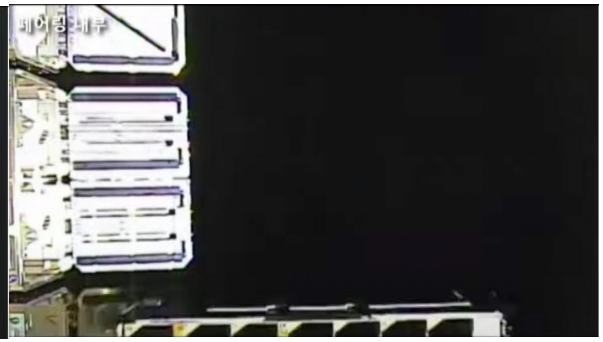


Launch and separation (5/25)

Spacecraft	NORAD ID
SNIPE_A	56749
SNIPE_B	56745
SNIPE_D	56744

Nuri
Launch

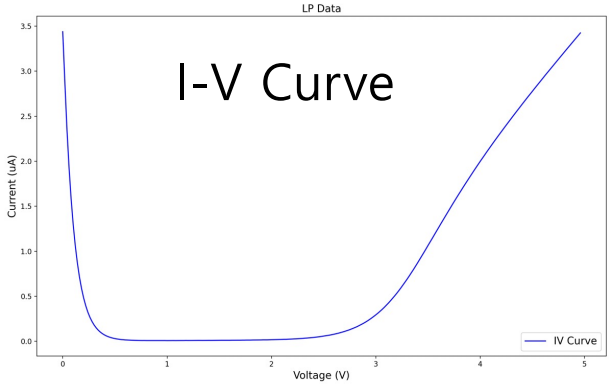
SNIPE_B
Separation

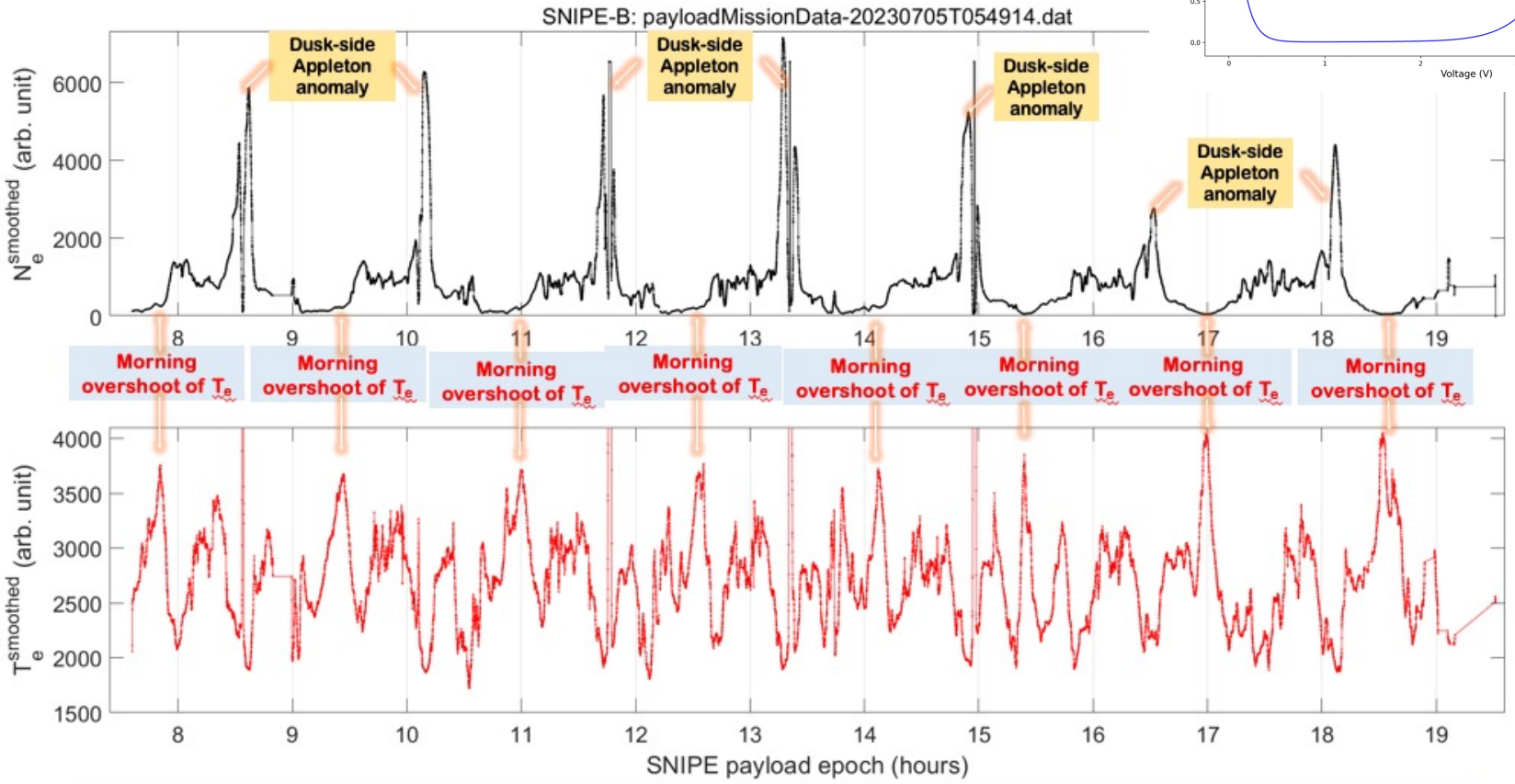


SNIPE_D
Separation

SNIPE_C was not separated from launch vehicle.

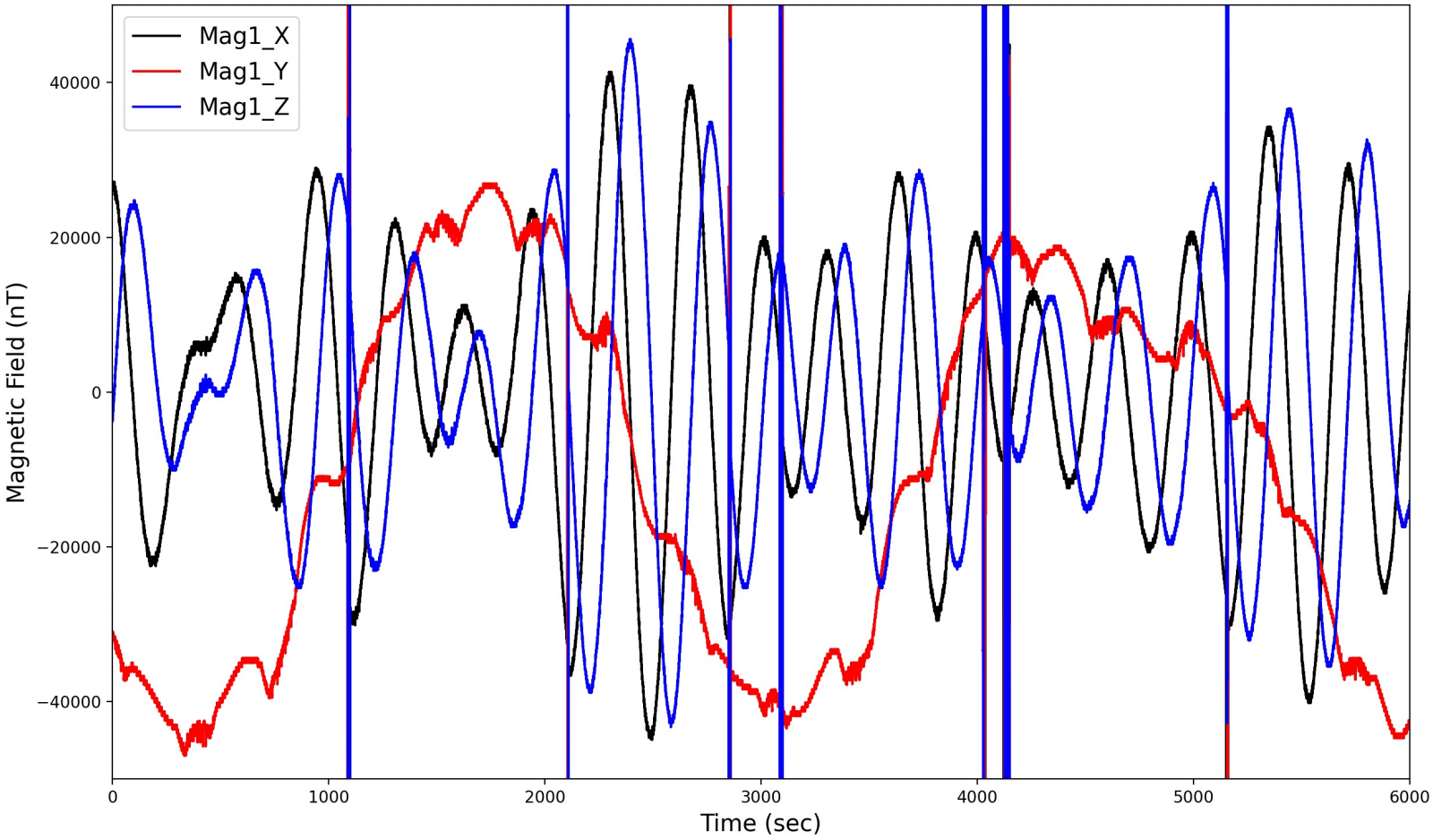
LP data downloaded on 05 July 2023 (SNIPE-B)





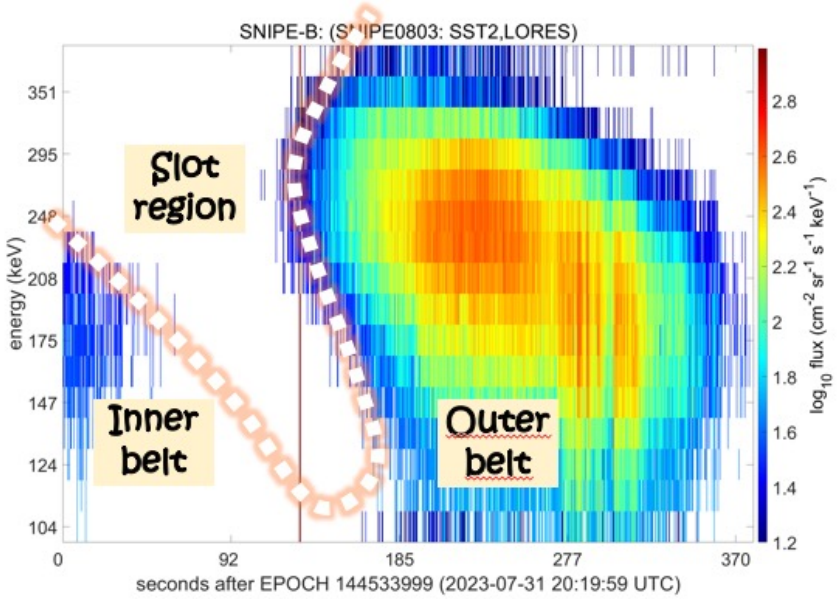
SNIPE-B/LP successfully observed the typical EIA and morning overshoot.

Magnetometer data

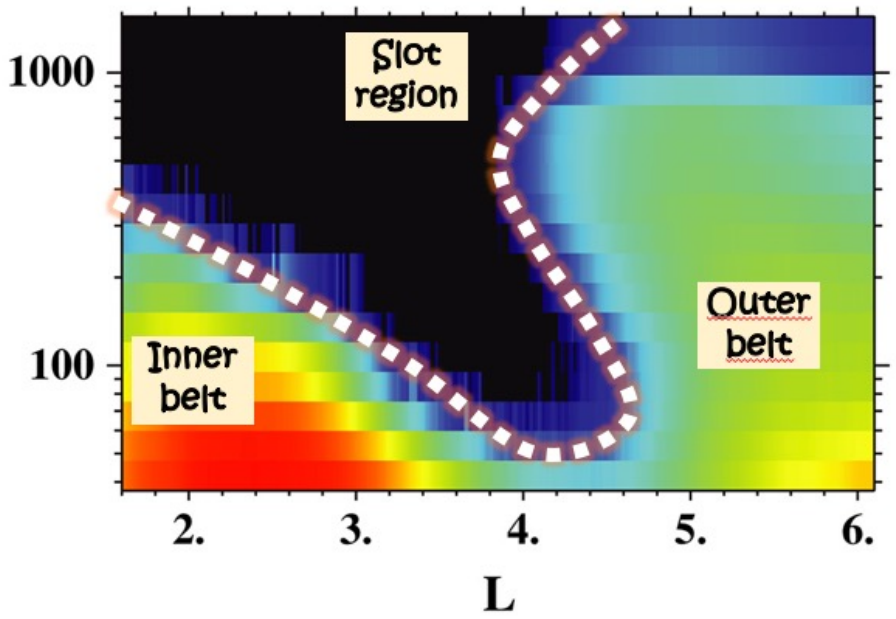


SST data

SNIPE-B on July 31, 2023

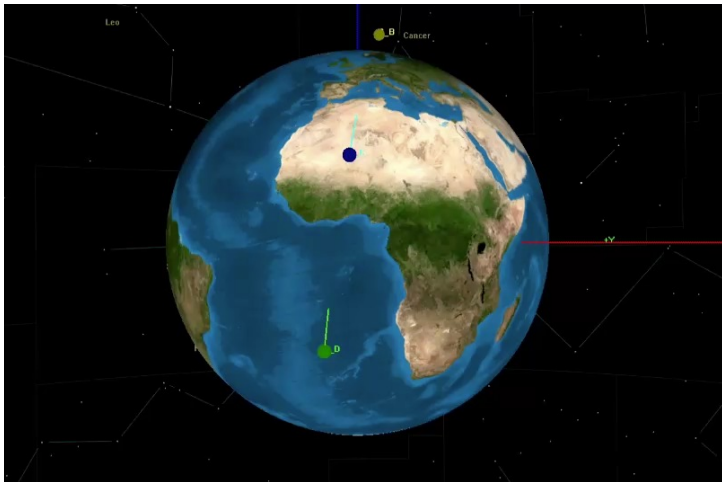


Van Allen Probes in March 2013 (Reeves et al., JGR 2015)



SNIPE-B/SST successfully observed the typical S-shape morphology of the slot region.

SNIPE formation flying



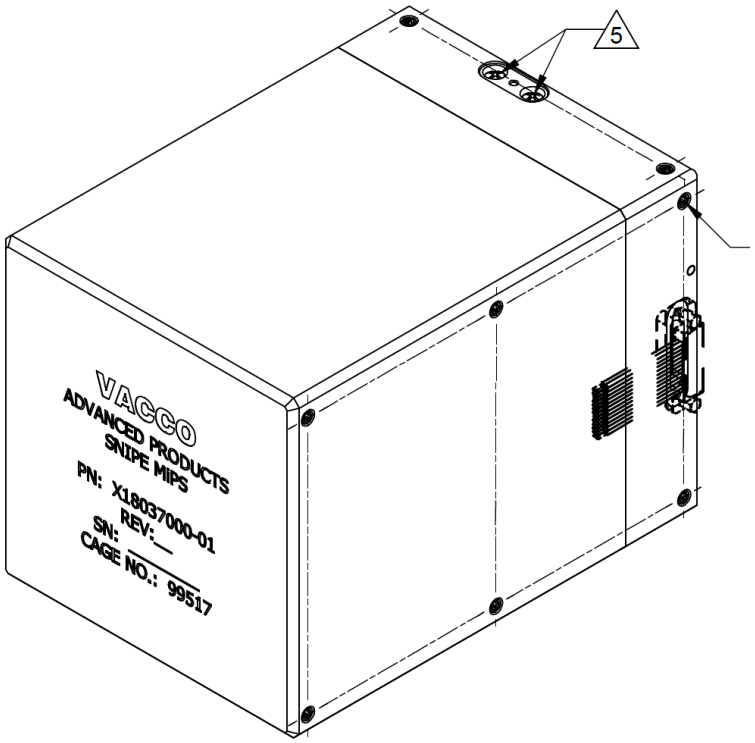
- Along track formation

Observe temporal variation of plasma structures

- Cross track formation

Observe spatial variation of plasma structures

Cold Gas Thruster



PROPELLANT: R-236fa

OPERATING TEMP: 10° TO 55°C

ELECTRICAL INTERFACE: RS422

PEAK POWER: 12 WATTS MAX

PROPELLANT VOLUME: 988 CC

PROPELLANT MASS: 1,235 grams

DRY MASS: 1,209 grams

THRUSTERS: 4 RCS

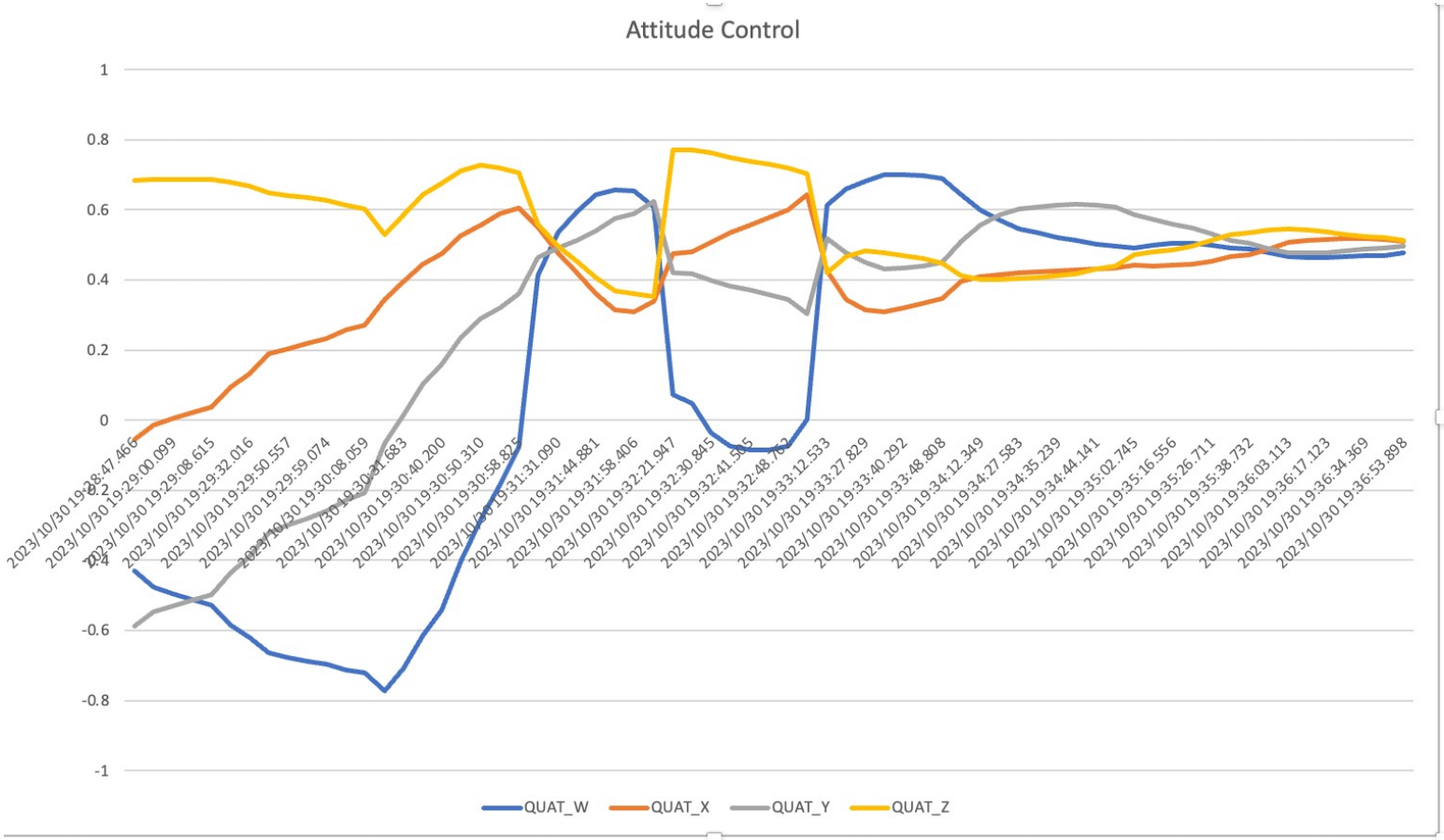
THRUST: 25 mN for each thrust

ISP: 40 SEC

TOTAL IMPULSE: 478 N-sec

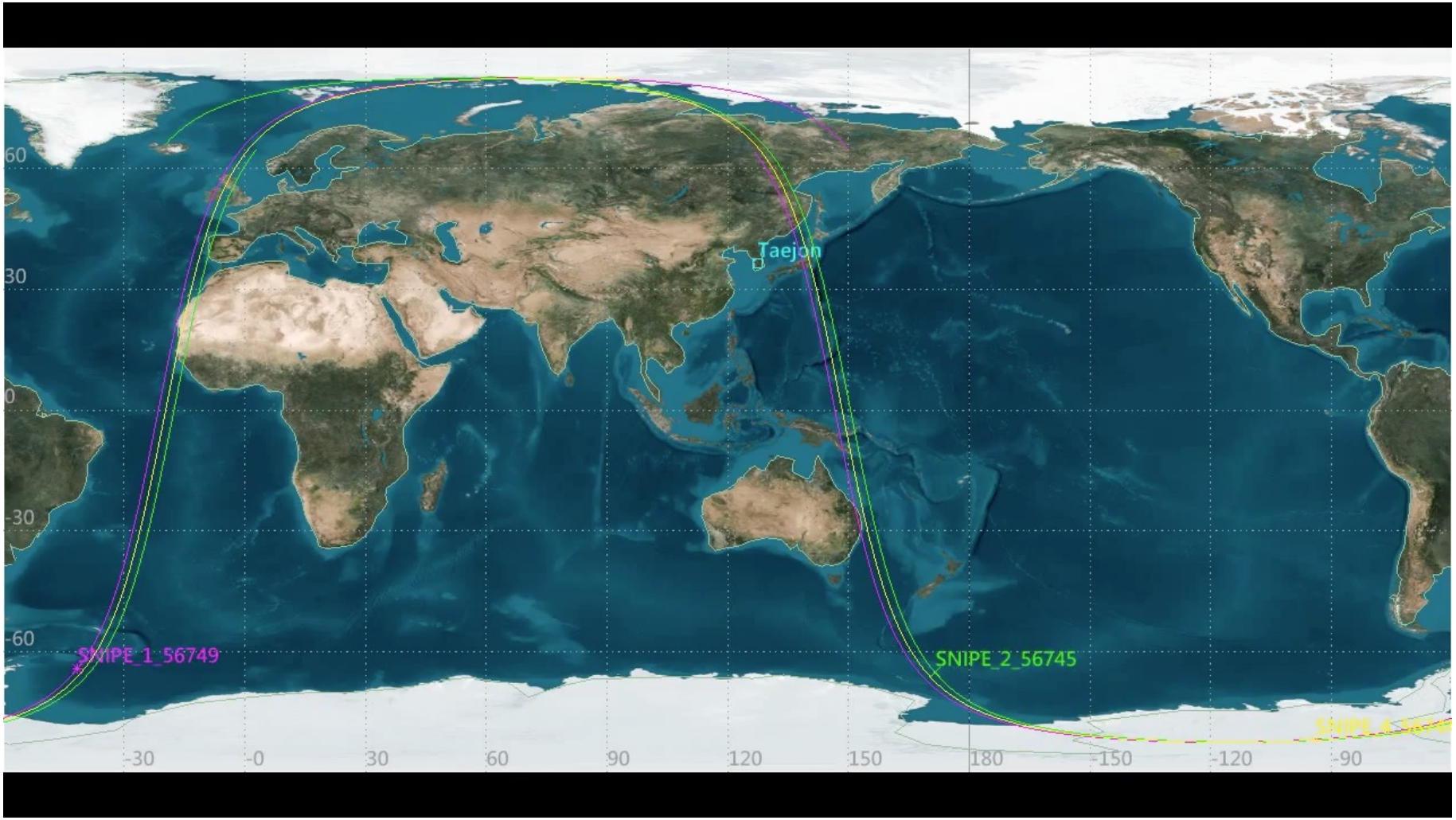
We can gain the velocity of ~50 m/sec totally.

Engineering Test for formation flying

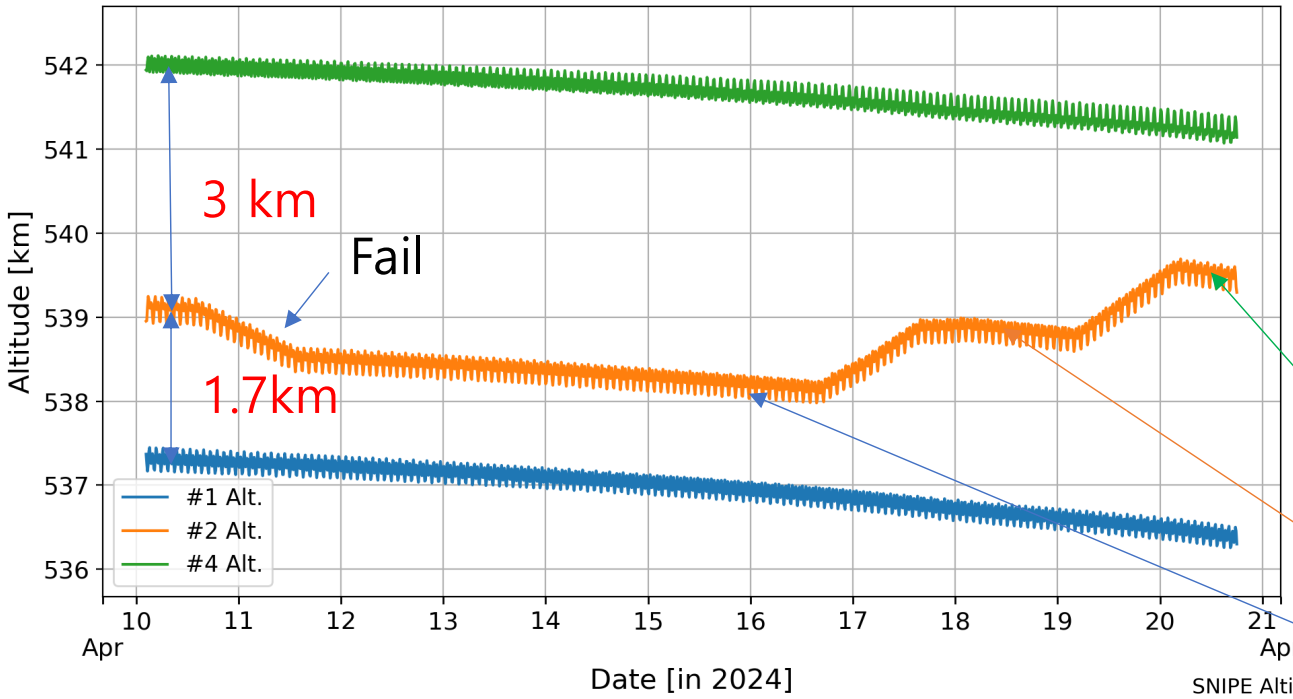


- Attitude control with three axis reaction wheels.
- Commanded to orient to quaternion (0.5, 0.5, 0.5, 0.5).
- We are ready to do formation flying operation.

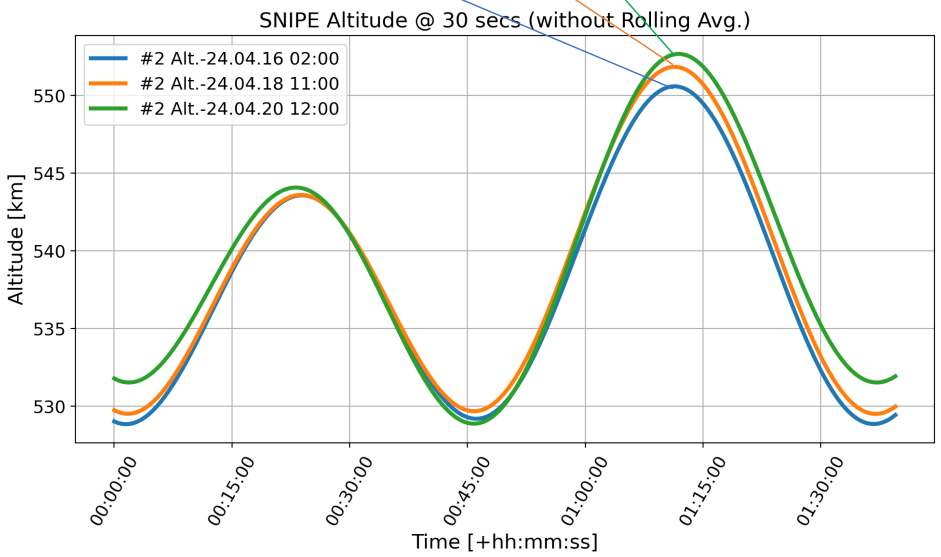
SNIPE Orbits



Orbit Maneuver



- By air drag, the altitude of the satellites is decreasing. About 1.7 km / Month
- We thrust for 20 sec and gain 0.8 km altitude variation.
- Here, we consume about 10 g propellant.

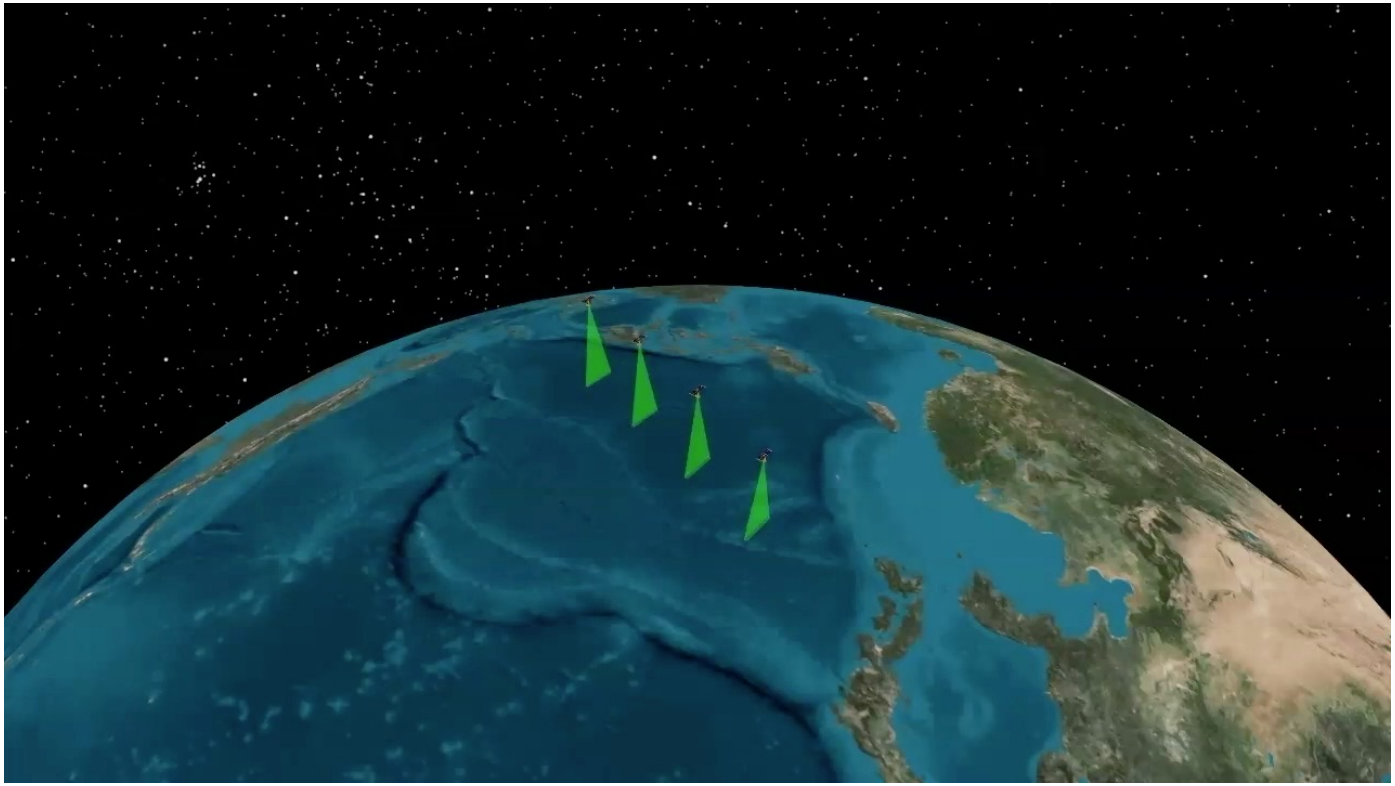


Summary of SNIPE status

- SNIPE_A has a power issue, not normally operating.
- The star trackers of SNIPE does not generate correct attitude data. We get the attitude information from magnetometers and sun sensors.
- Reaction wheel moment dumping is not effective, this limits the reaction wheel operation time.
- Now, we are trying to control the distance between SNIPE_B and SNIPE_D.

SNIPE Next

- Space SCANeR (Satellite Constellation Architecture for New Concept Surveillance and Reconnaissance) for Earth observation with wide filed of view.



- Payload: Off-Axis EO/IR Camera

→ for more information : 3:20 PM — Off-Axis Reflective Optics for EO/IR Camera Onboard CubeSat: Linear Astigmatism Free - Three Mirror System