SNIPE mission for Space Weather Research

CubeSat Developers Workshop 2017

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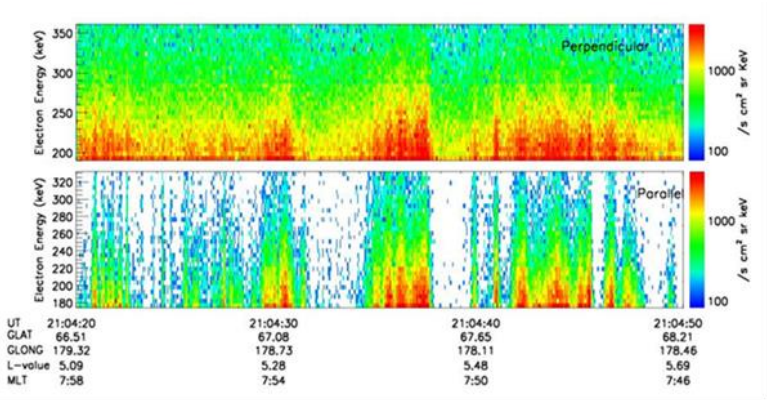
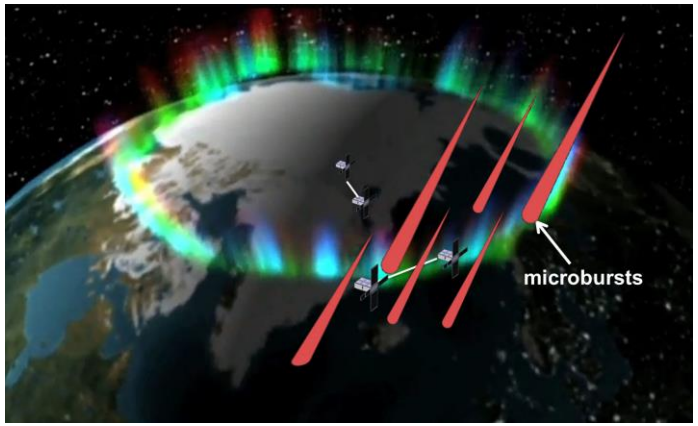
New Challenge with Nanosatellites



Korean scientific satellite, STSAT-1 (2003) Observation



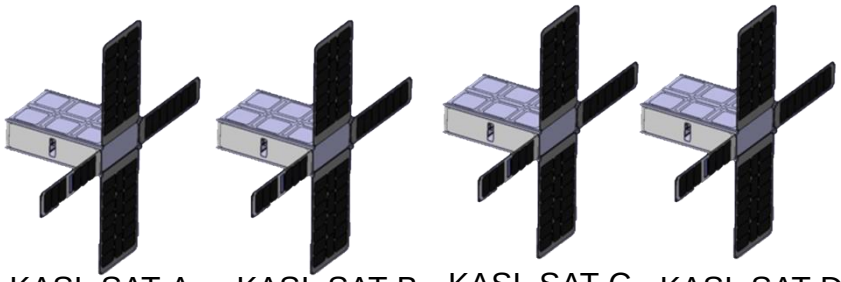
Small Scale Electron Precipitation

- In observing small-scale plasma structures, single satellite inherently suffers from space-time ambiguity.
- **New idea**: multi-satellite formation flying enable us to identify temporal and spatial variation
- **How**: KASI will launch SNIPE mission that consists of four nanosatellites in 2020.

Mission Summary

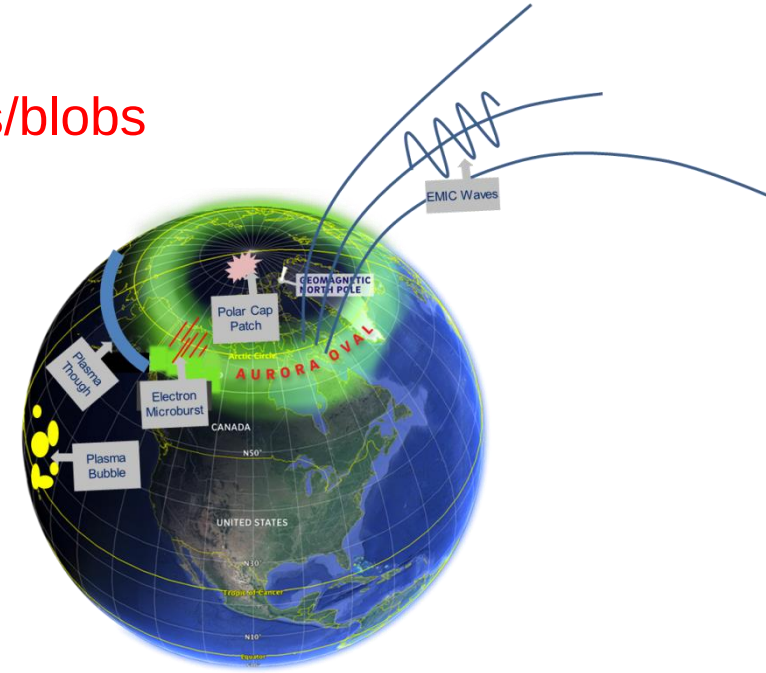
SNIPE (Small scale magNetosphere and Ionosphere Plasma Experiment)

- Mission: Identifying temporal and spatial variation of small scale plasma structures in Ionosphere and Magnetosphere
- Constellation of Four 6U-Nanosats (~10 kg for each satellite)
- Formation Flying (Slow separation from 10 km to 100 km for 6 months)
- Mission Life Time: 1 year (Science Operation (Success Criteria) Time : 6 months)
- Orbit: ~500 km – 600 km, Polar Orbit (Sun Synchronous (TBC))
- Launch in 2020

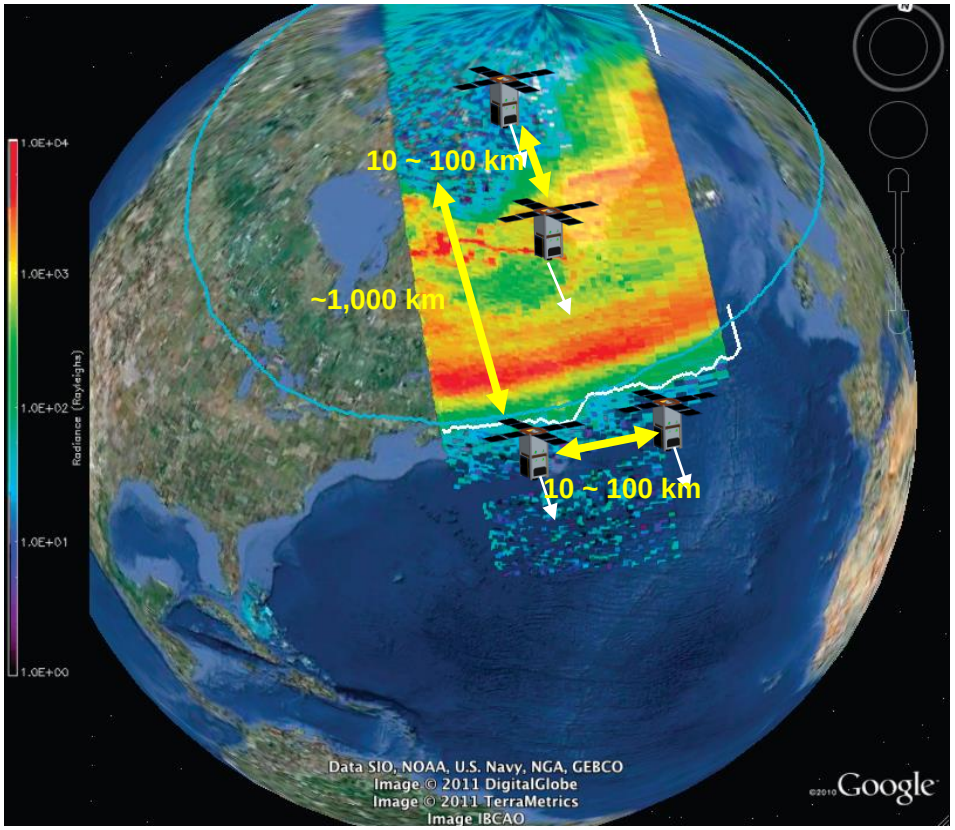


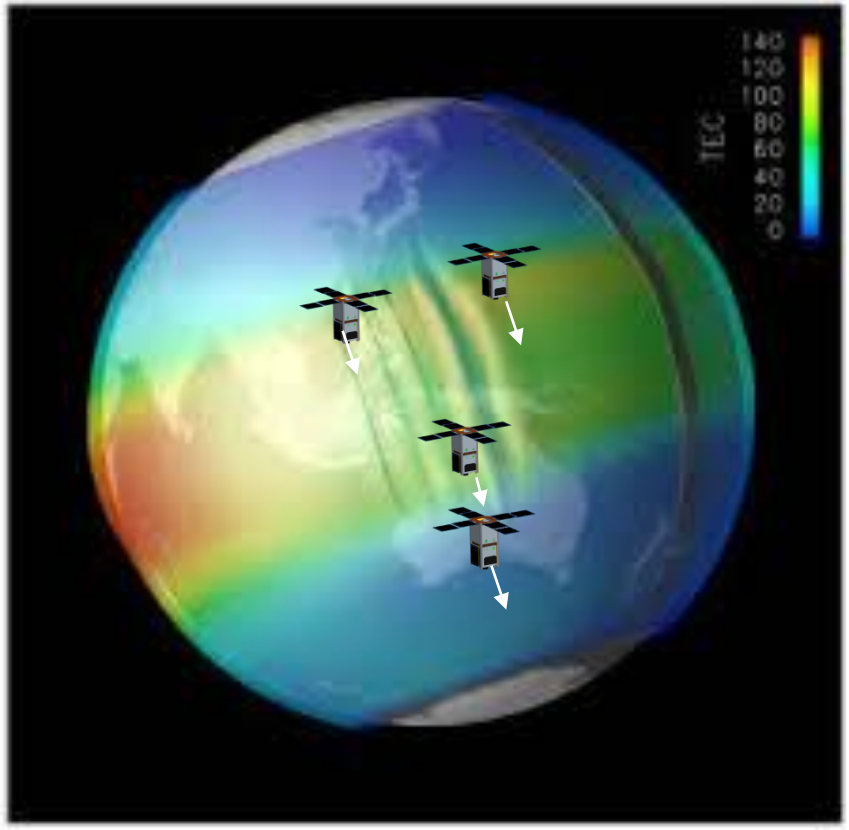
Scientific Objectives

- 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 bubbles/blobs
- EMIC waves at the top of ionosphere



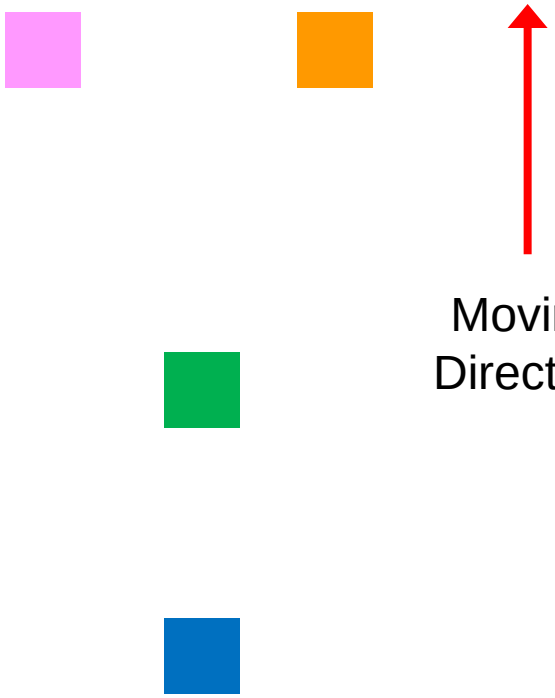
Observation by Formation Flying



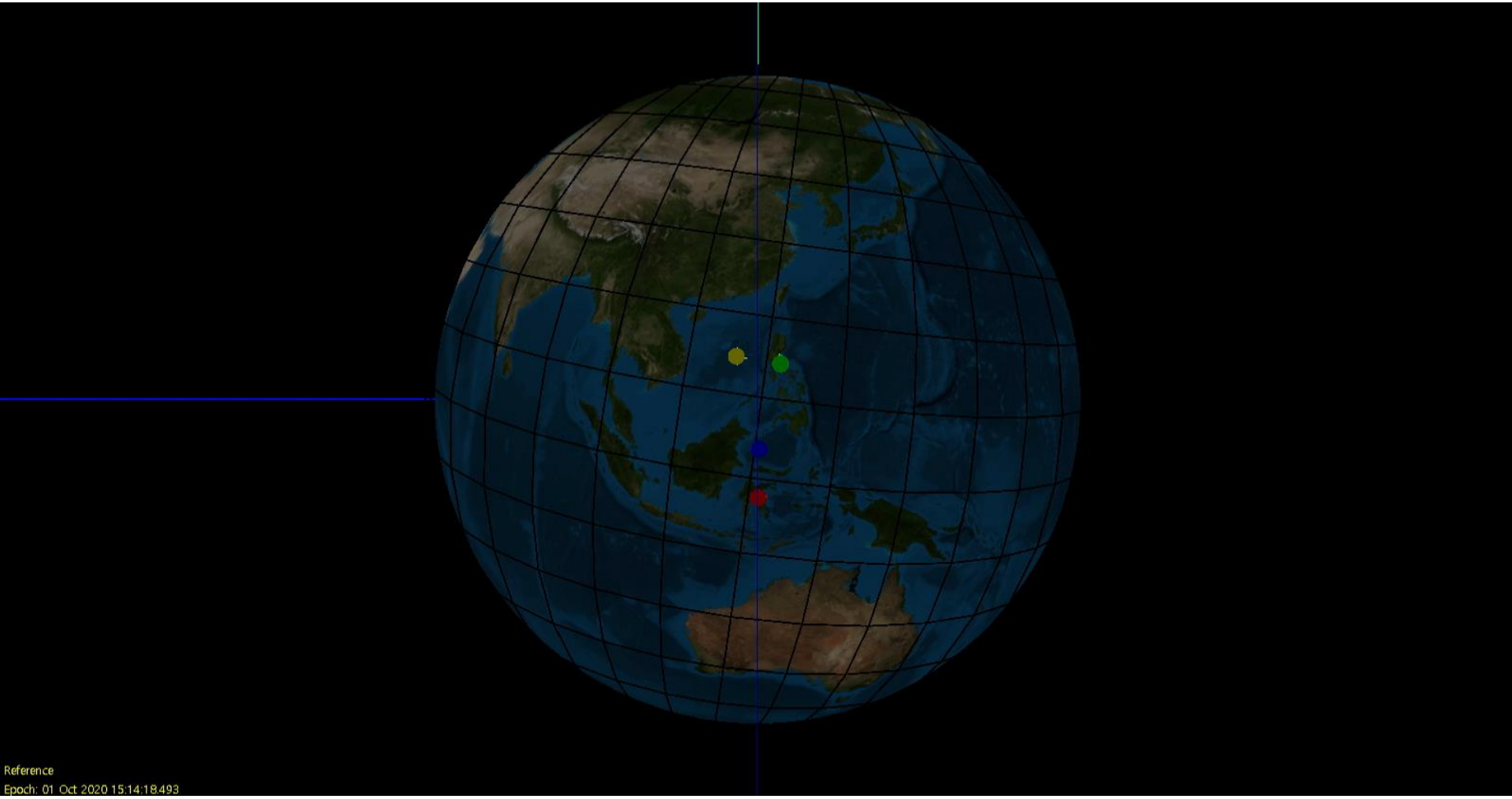


- Observation of auroral region and equatorial ionospheric instabilities with the same formation.
- Parallel formation identifies spatial variation, while serial pair identifies temporal variation.

T-shape Formation (I)



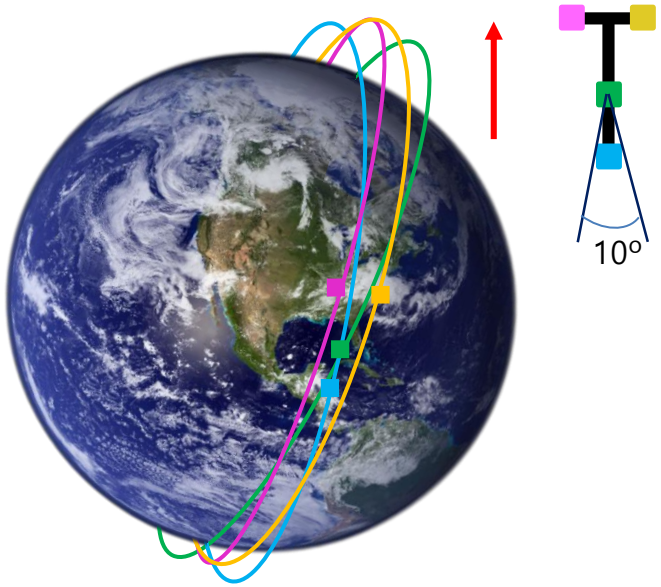
T-shape Formation (II)



Propulsion System Requirements

	$\Delta v_{1cycle} = \Delta v_1 + \Delta v_2$	Number of orbit maneuver for 1 year	$\Delta v_{total} = \Delta v_{1cycle} \times n$
Sat a in form 1	$5.36 \times 10^{-2}\ m/s$	543	$29.10\ m/s$
Sat b in form 1	$5.67 \times 10^{-2}\ m/s$	543	$30.79\ m/s$
Sat c in form 2	$8.99 \times 10^{-2}\ m/s$	236	$21.22\ m/s$
Sat d in form 2	$11.87 \times 10^{-2}\ m/s$	226	$26.83\ m/s$

- Disturbances
  - Gravitational model (JGM3: 70 by 70)
  - Air drag (JacchiaRoberts)
  - SRP, 3rd bodies(Luna, Sun), Relativistic correction
- Make “T” shape formation on equator
- The formation accuracy of 10 º
- Operate thruster to keep formation 1-2 times a day



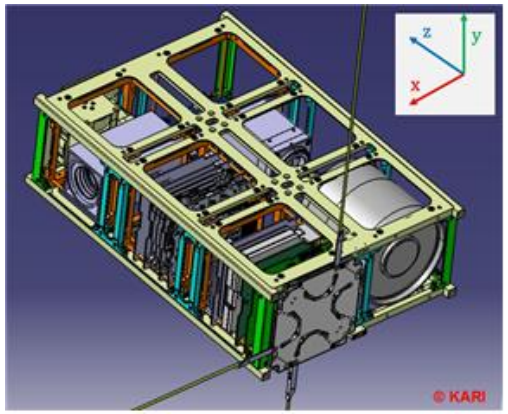
Instruments

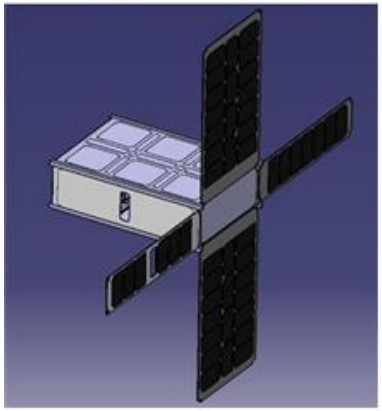
Unit	Instruments	Specification
1U for 4 satellites (KASI)	SST (Solid State Telescope)	Energy Range: 50- 400 keV Energy channel: 16 ch Two sensors : Parallel and Perpendicular to the geomagnetic field Sampling rate: 100 Hz
	Mag (Flux Gate Magnetometer)	Range: -40,000 – 40,000 nT Resolution: 0.1 nT Sampling rate: 10 Hz
	LP (Langmuir Probe)	Electron density: 10^3 - 2×10^6 / cm^3 Electron Temperature: 10^3 - 10^4 ° K Time resolution : 10 sec (full I-V Curve) 1 sec (Ne, Te) 0.1 sec (Fixed Voltage)
1U for 2 satellites (Japan*)	Search Coil	Frequency Range: 10 Hz – 10 kHz
	Electro-Static Analyzer	Energy Range: 10 eV – 10 keV

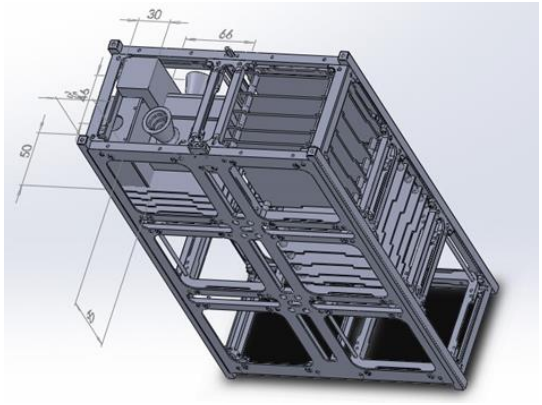
*Japan team submitted the proposal to JAXA and now is under review.

Spacecraft Platform

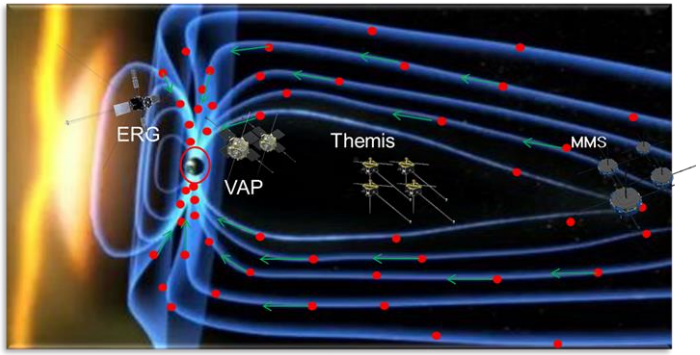
ADCS	Three-axis attitude control by reaction wheels Field align attitude control during microburst observation Accurate GPS system for position and velocity determination
CDHS	Time Sync between OBC and payloads Reliable communication between OBC and payloads with CAN BUS protocol
EPS	High efficiency solar cells High capacity Li-ion batteries
COMS	High speed S-band for science data downlink UHF command uplink Telemetry downlink: VHF
Propulsion	High performance micro-thruster







Science Operation



- Science operation at the conjugate points with large missions, Themis, MMS, VAP, ERG, GOES etc.
- Multipoint observation with other low earth orbit satellites like ICON, POES, DMSP, SWARM, many Cubesats etc.
- Cooperation with ground observation like EISCAT, Intermag etc.

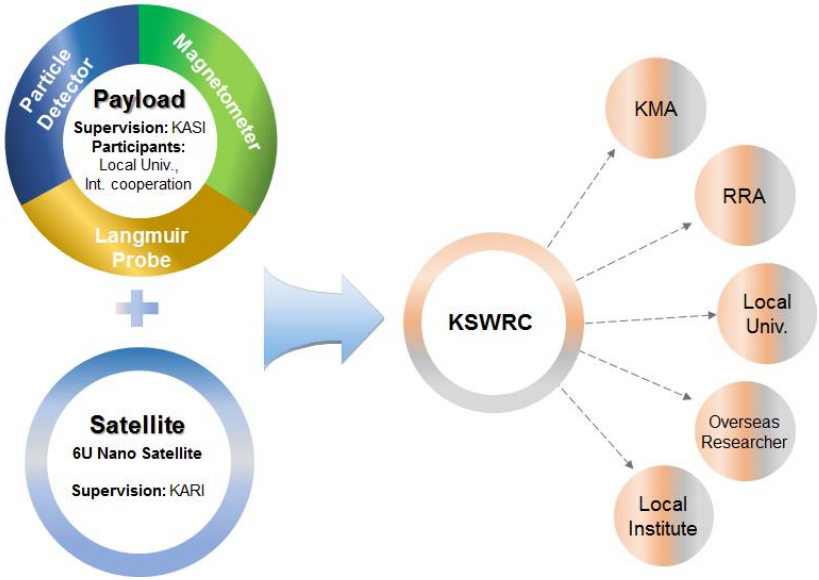
Cooperation

- **Korea Astronomy and Space Science Institute (KASI)**
  - Payload development
  - Mission management and operation
  - Cooperate with local universities and overseas cooperation institution (e.g., NASA, Japan)
  - Data processing and distribution via project of Korea Space Weather Research Center (KSWRC)

- **Korea Aerospace Research Institute (KARI)**
  - Development of nanosatellite bus system

- **Yonsei University**
  - Development formation flying algorithm

- **Japan** (Kyoto University, JAXA ISAS, Nagoya University, Kanazawa University)
  - Development of Science Instruments



THANK YOU