Nano-Satellite Development at Seoul National University, South Korea
SNUSAT-Series (SNUSAT-1/1b, -2, -3)

2017.08.

NEPAL

In-Seuck Jeung

Seoul National University, Korea
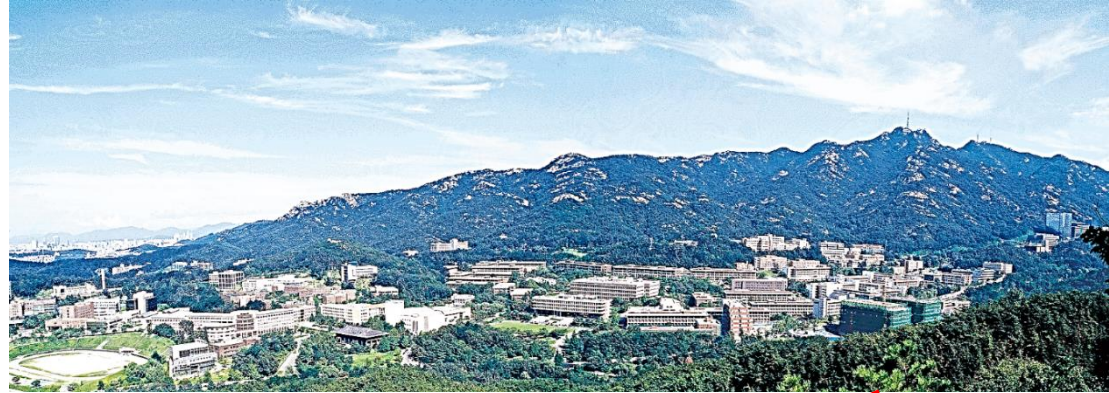
Presentation

- SNU-APCL Introduction
- CanSat Experiences
- SNUSAT-1 / 1b consortium for QB50 Program
- SNUSAT-2 supported by KARI
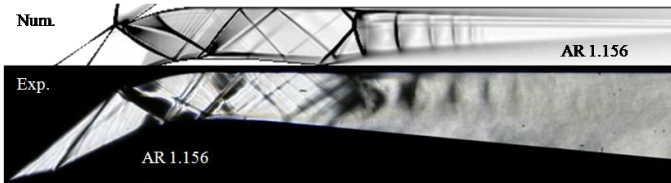- SNUSAT-3 (NEX·Sat) collaborated with KASI

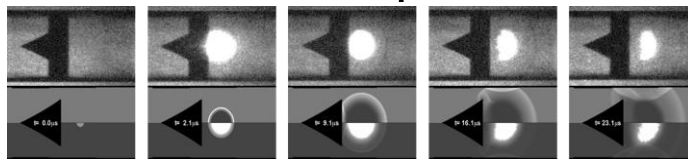# Seoul National University, Korea
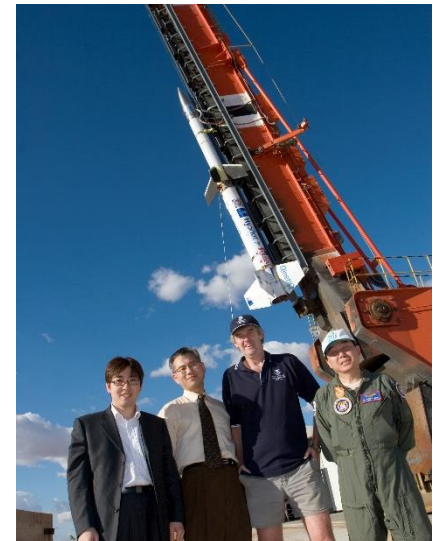
Researches in APCL at SNU

Supersonic Intake

CubeSat

SCRamjet Engine

Laser Propulsion

Ram Accelerator
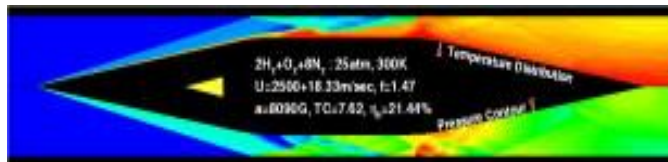
Hydrogen Explosion
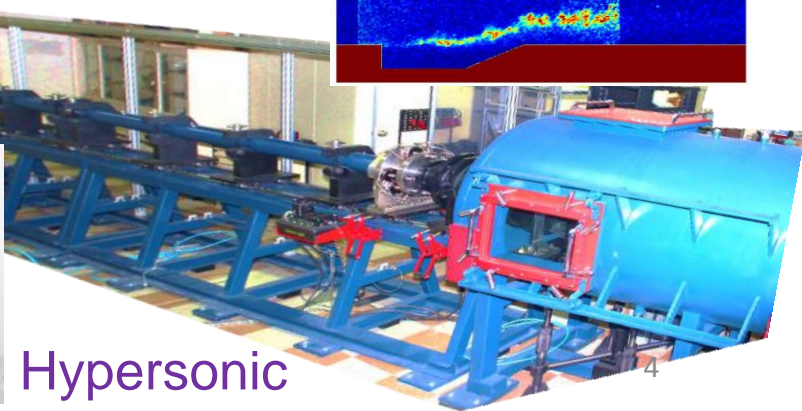
Hypersonic

SNU CanSat Team

- ARLISS and CanSat Competition Activities

2006

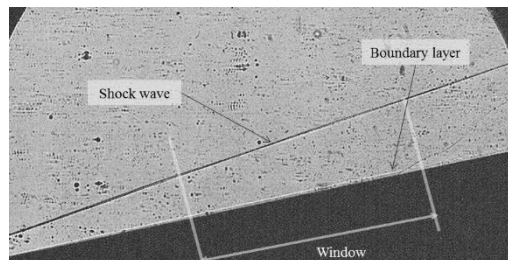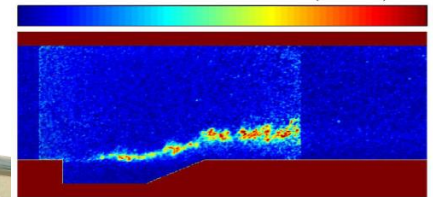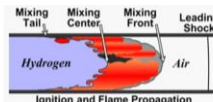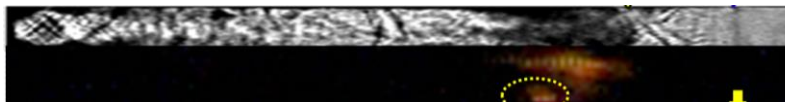2008

2010

2014

2007

2009

2012
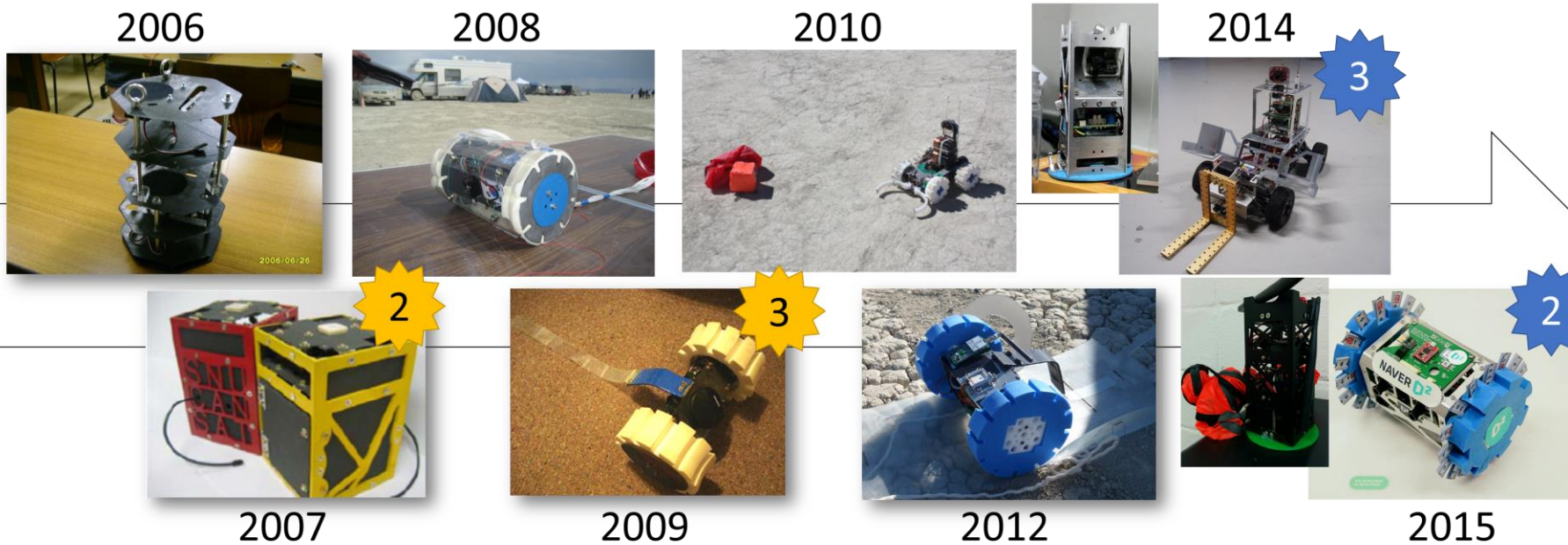
2015

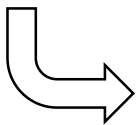: Come back competition   : Mission competition

CubeSat Research Center

- 2005: Started as SNU CanSat team
  - Hands-on engineering training
  - Participate CanSat and ARLISS competitions
- 2011: Expanded to CubeSat activities
- 2015: Found CubeSat Research Center
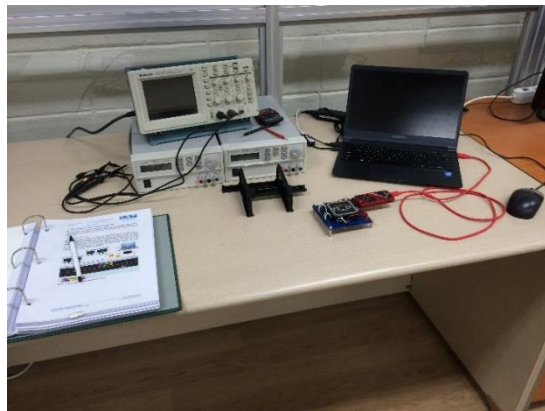
Undergraduate Yr. 1~2

Undergraduate Yr. 2~4
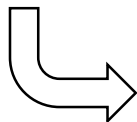
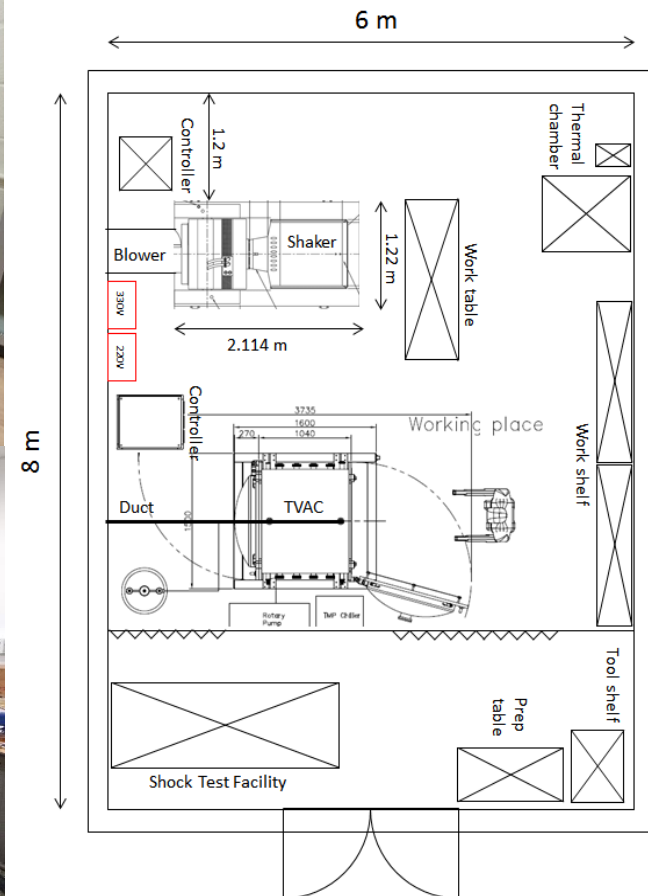Undergraduate and graduate

CubeSat Research Center

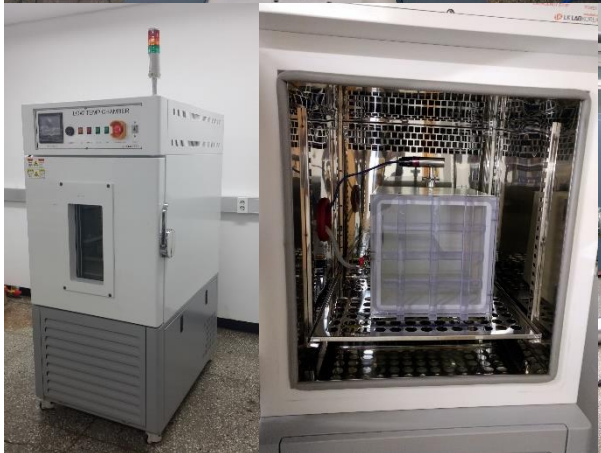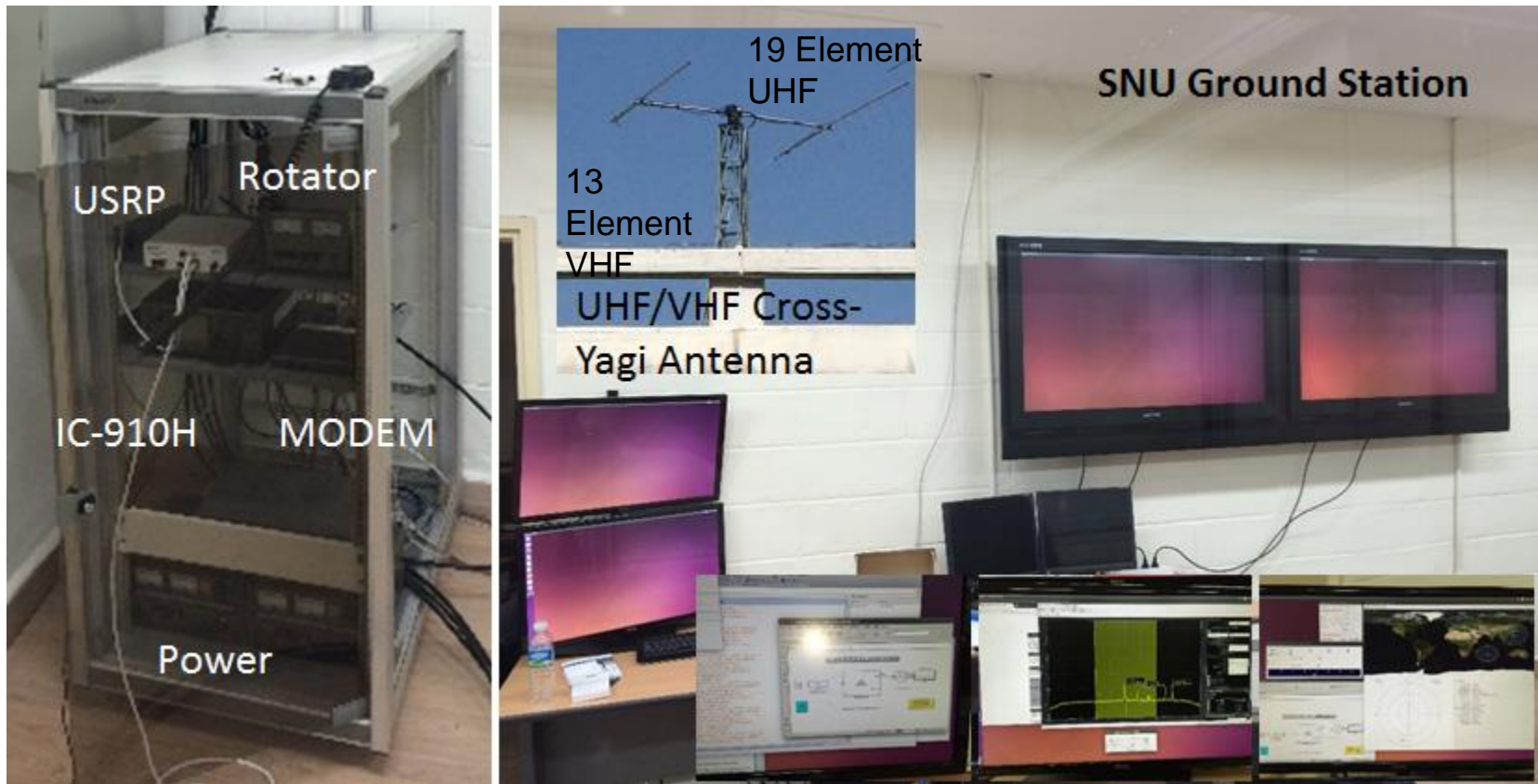- In-house facility: Clean room (Class 100,000)

CubeSat Research Center

- In-house facility: Environmental testing facilities
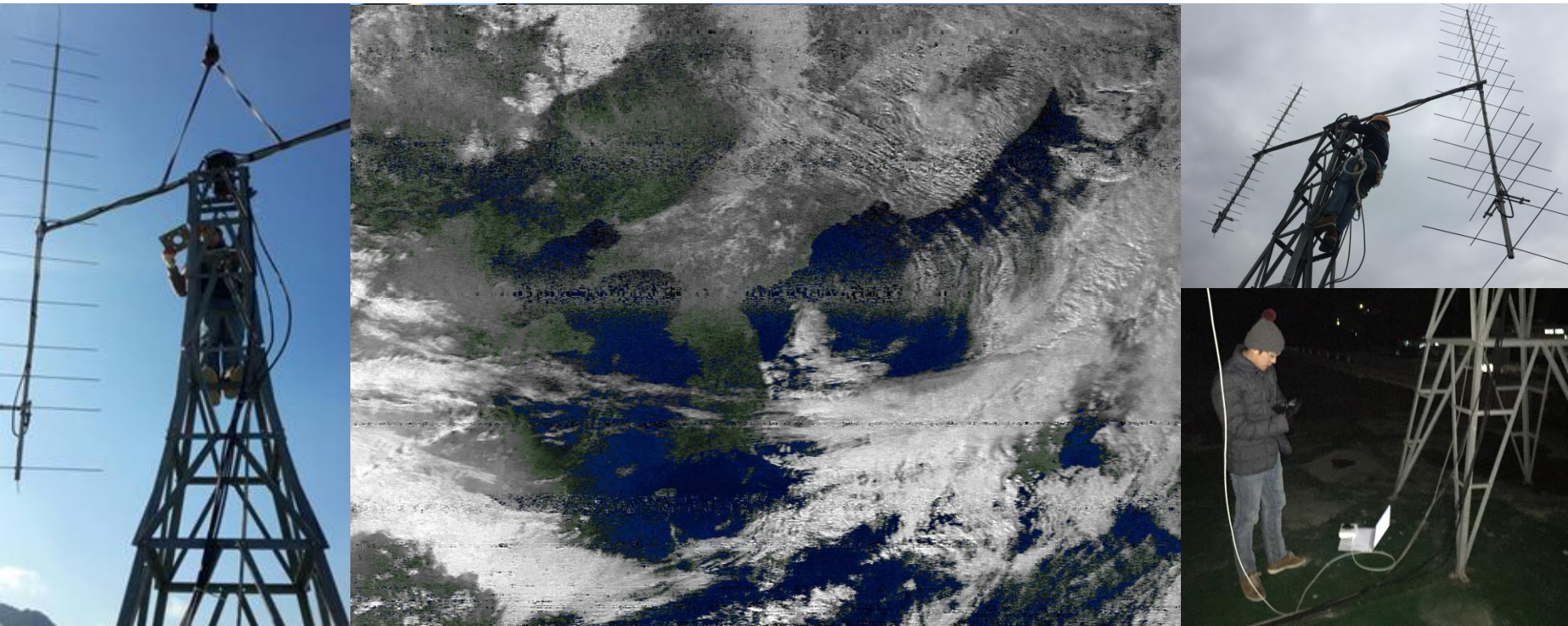
CubeSat Research Center

- In-house facility: UHF/VHF ground station facility

CubeSat Research Center

- Ground station antenna calibration & testing

Acknowledgement

- Youdan Kim
- Chan Gook Park
- Hyoun Jin Kim
- Sungwan Kim
- Ji Hyun Park
- Vishnu Anand
- Sangyoon Lee
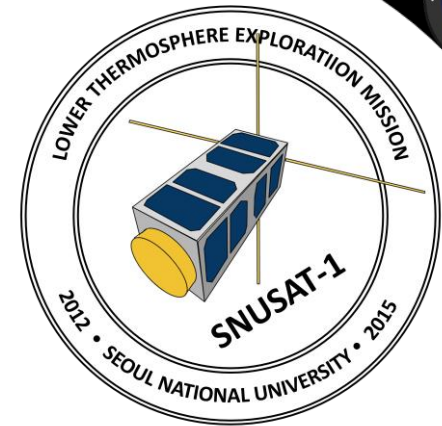
SNUSAT-1/1b: Overview

- 2U CubeSat

- Kick-off: November 5, 2012

- Mission:
  - QB50 Science (FIPEX: Oxygen Measurement)
  - FDIR Tech-Demo
  - CMOS Sensor space validation

- ADCS: 3-Axis Stabilization

- Funding: NRF (EC-FP Cooperation)

- Time Schedule

SRR   PDR   AITRR   Launch

2012.11.5   2013.6.28   2014.10.15   2016.10

2013.2.26   2014.1.2   2016.4.15

SDR   CDR   FRR
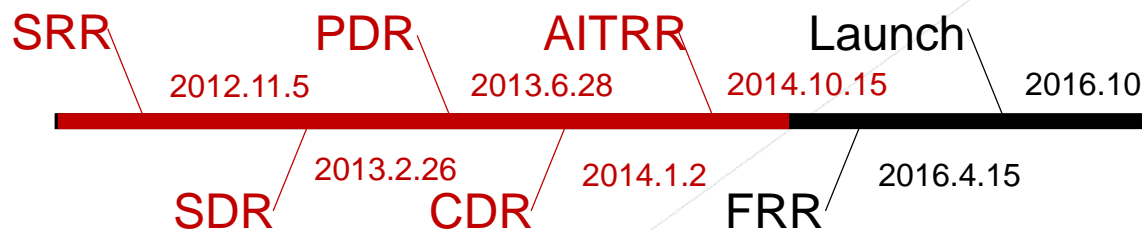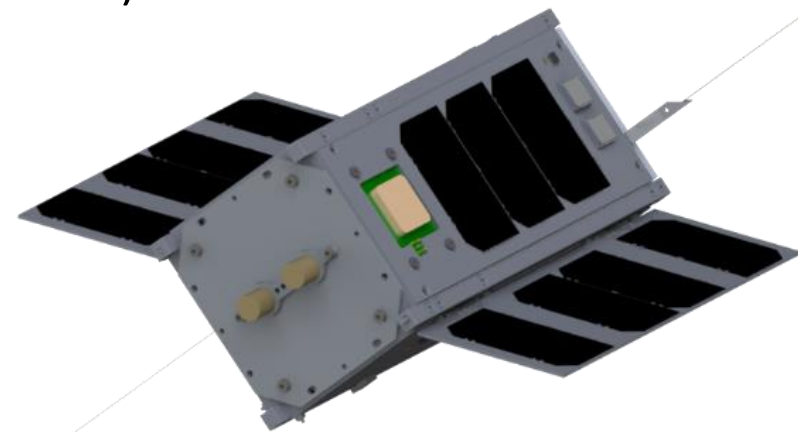
SNUSAT-1/1b: Configuration

UHF/VHF antenna

FIPEX

6 Axis IMU

4 Axis RW

GPS

EPS

TT&C

GPS antenna

FIPEX

OBC
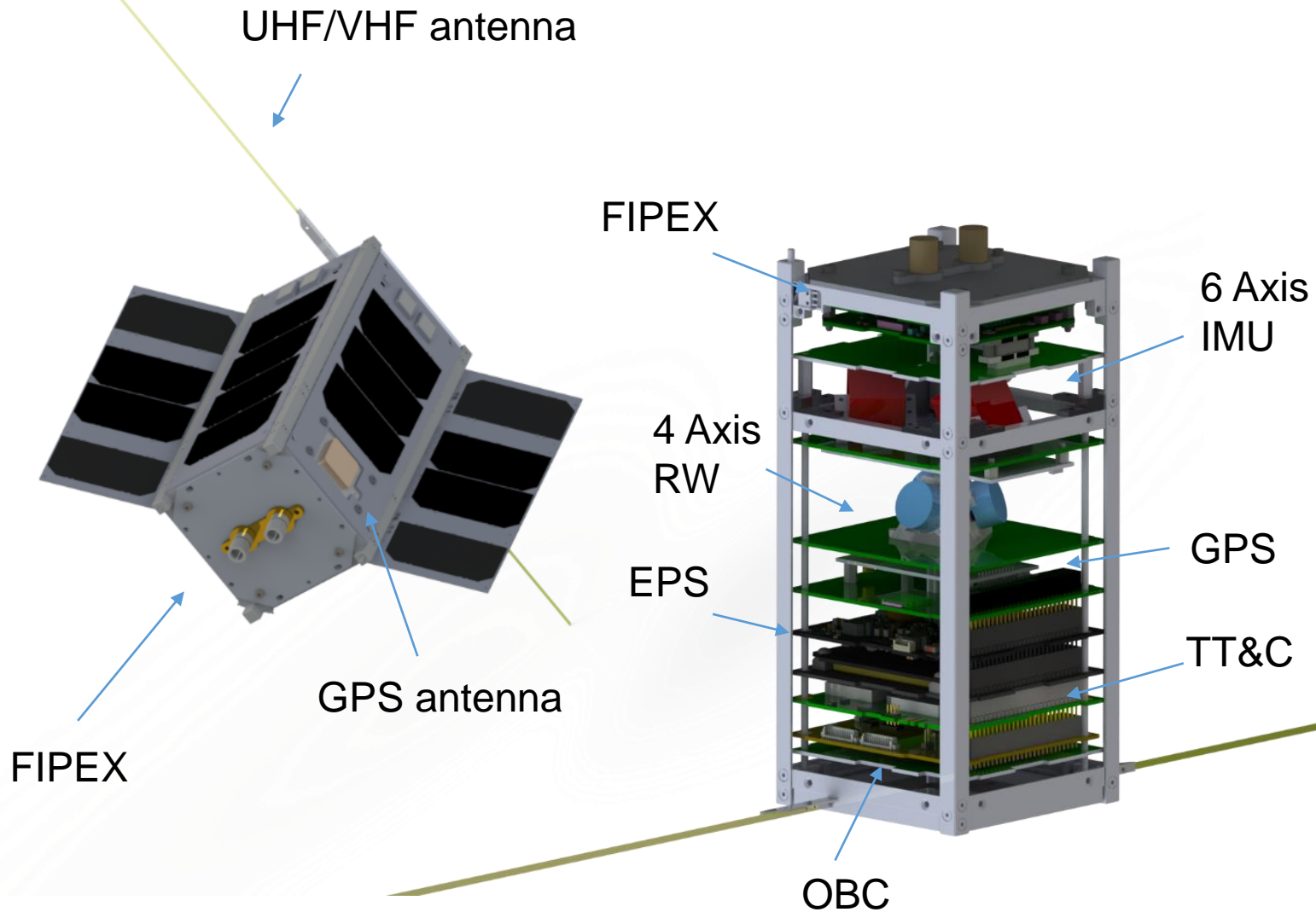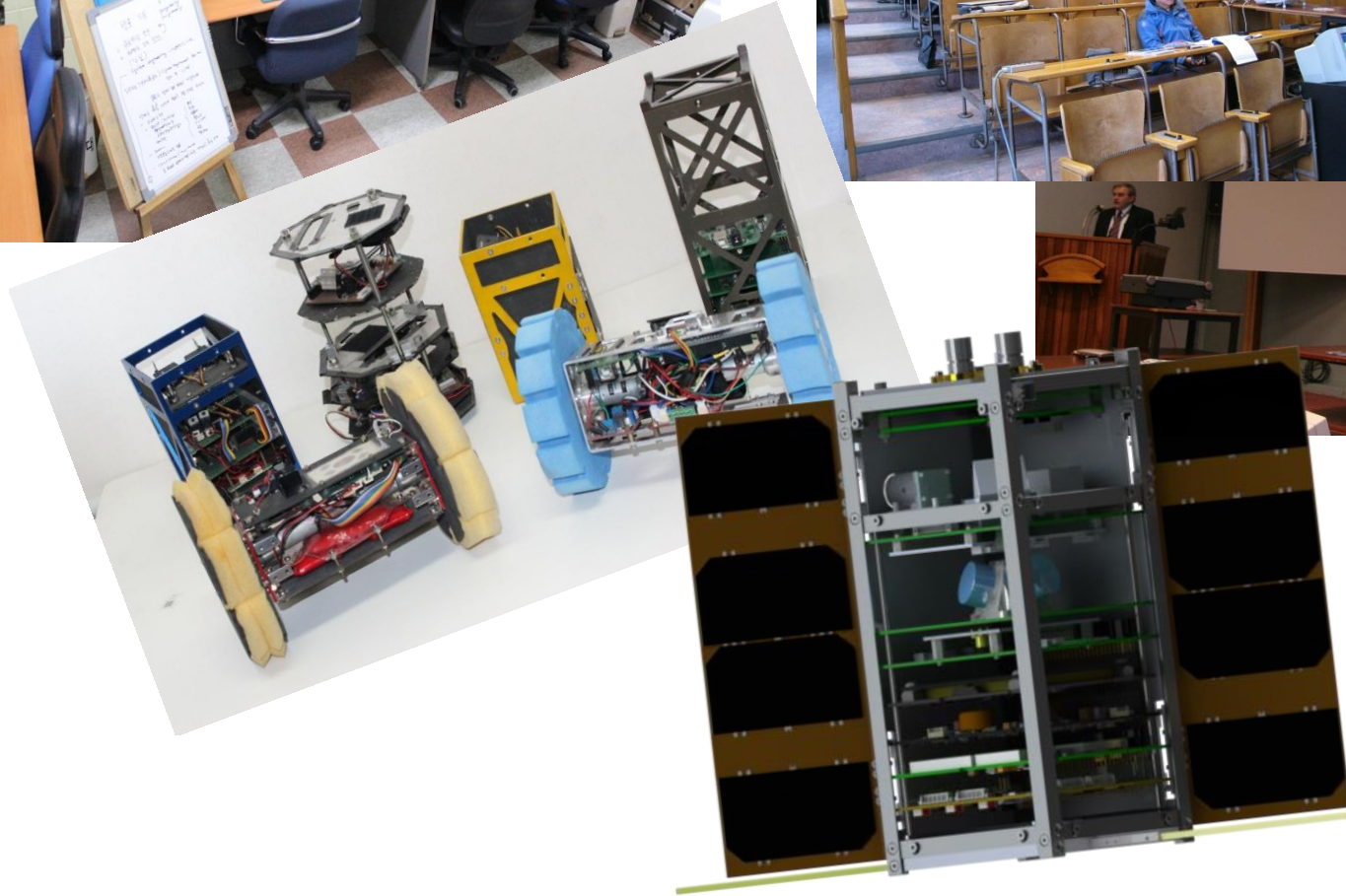
SNUSAT-1/1b: Overview

SNUSAT-1/1b: Overview

- ❑ **NanoRacks: Launching to ISS**
- ✓ Inclination 51.65 degree, altitude ~400 km
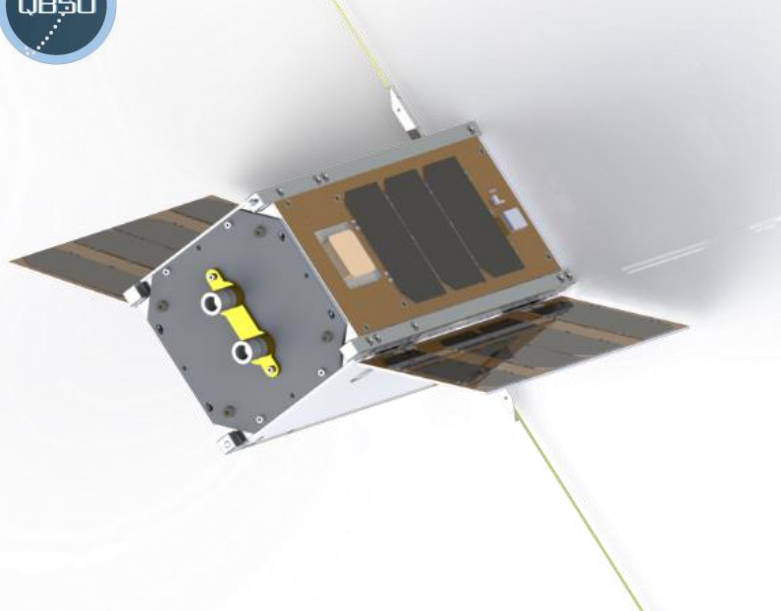- ✓ 2017 2QT Launch (26 May 2017)
- ❑ **Orbit Deployer**
- ✓ 2U-Sat (40 Module) 3U-Sat (10 Module)
- ❑ **SNUSAT-1/1b**
- ✓ 2U-Sat Configuration
- ✓ QB50 Common Mission
- ✓ SNU Mission

SNUSAT-1/1b: Primary Mission

QB50, Seventh Framework Programme, Space Division

Lower thermosphere exploration and reentry research

✓ Existing high elliptical orbit's short time is covered

✓ Availability of wide range (380km~90km) exploration using 50 CubeSats

✓ Temporal and spatial exploration

✓ Reentry research as orbit decays

✓ SNU: Development of 2U CubeSat

✓ VKI: Provision of SU and Launch
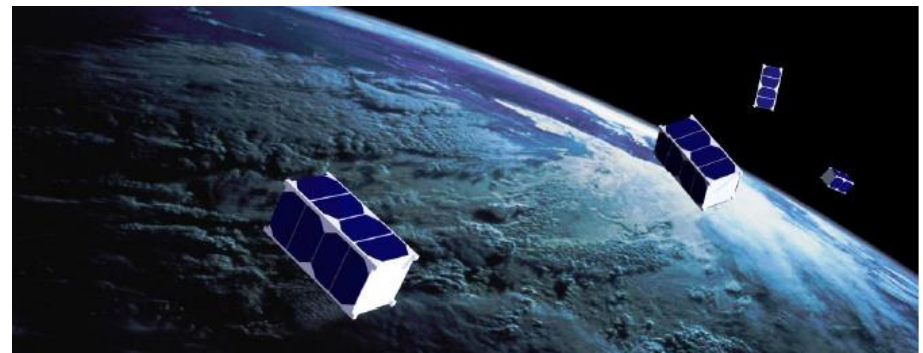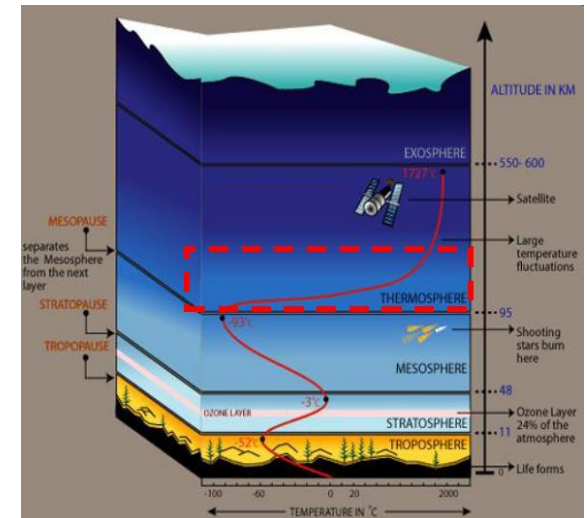
Langmuir Probe: Electron temperature/density

FIPEX Sensor: Atomic/molecular oxygen

INMS: Ion/Neutral Mass Spectrometer

LEO Advantages

✓ Lifetime < 25 years

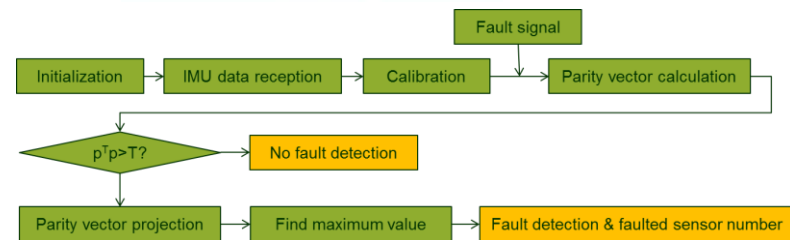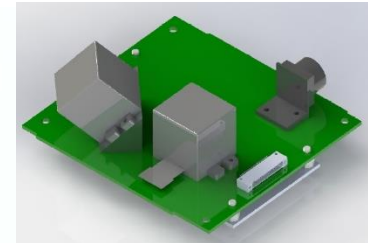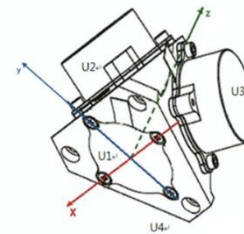✓ Bellow Van Allen belt

✓ Higher data rates

SNUSAT-1/1b: Secondary Mission

FDIR Algorithm Validation

Sensor/Actuator FDIR space operation validation

- ✓ Technical demonstration for future applications
- ✓ Sensor FDIR using RIMU
- ✓ Actuator FDIR using four-axis reaction wheels
- ✓ Validation phase – Nominal phase

Imaging Mission using COTS Imager

Imaging of Earth/Space/Earth+Space using COTS imager

- ✓ Educational impact
- ✓ Space qualification of COTS imager
- ✓ Future application for star gazing
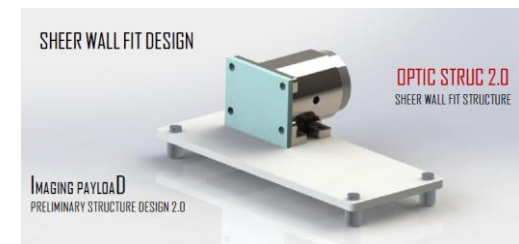
Effective Pixel Array : 656 (H) X 496 (V)
Pixel Size : 5.55um X 5.55 um
Max. Clock Frequency: 27MHz
Max. Frame Rate : 30fps @ 27MHz 60fps @Bayer Only 27MHz
Dark Signal : 25.2mV/s
Sensitivity 2.83 V/Lux.sec
Power Supply : 2.8V Core : 1.5V/1.8V IO: 1.8V~3.3V
Power Consumption : 67mW (Dynamic), 6.8uW (Standby)
Operating Temerature : -40~105 degC

# SNUSAT-1/1b: Participants

Major Consortium Institutes
- ✓ **Seoul National University (Korea)**
- ✓ KAIST (Korea)
- ✓ Von Karman Institute (Belgium)
- ✓ University of York (Canada)
- ✓ University of Leicester (UK)
- ✓ Adelaide University (Australia)
- ✓ Technical University of Dresden (Germany)
- ✓ Graz University of Technology (Austria)
- ✓ Beihang University (China)
- ✓ Ecole Polytechnique (France)
- ✓ Technical University of Delft (Netherlands)
- ✓ Istanbul Technical University (Turkey)
- ✓ University of Surrey (UK)
- ✓ University College London (UK)
- ✓ University of Rome "La Sapienza" (Italy)
- ✓ Peruvian Consortium (Peru)
- ✓ National Cheng Kung University (Taipei)
- ✓ Addis Ababa Institute of Technology (Ethiopia)
- ✓ Nanjing University of Science and Technology (China)

SNUSAT-1/1b: Project Cycle
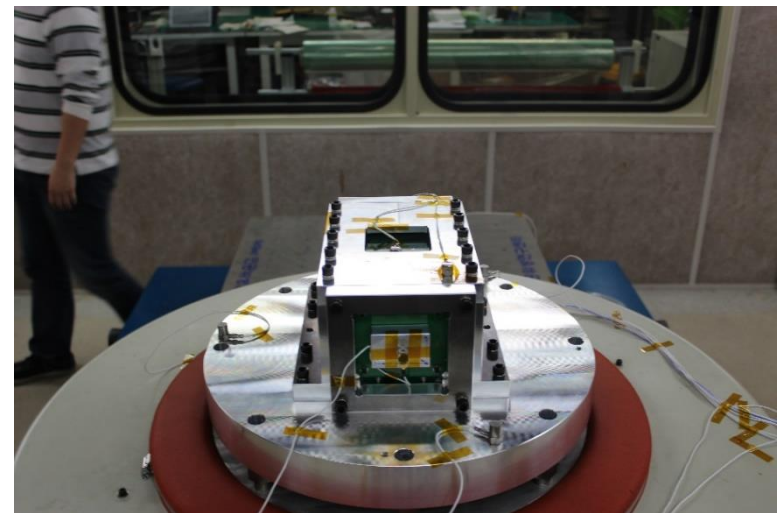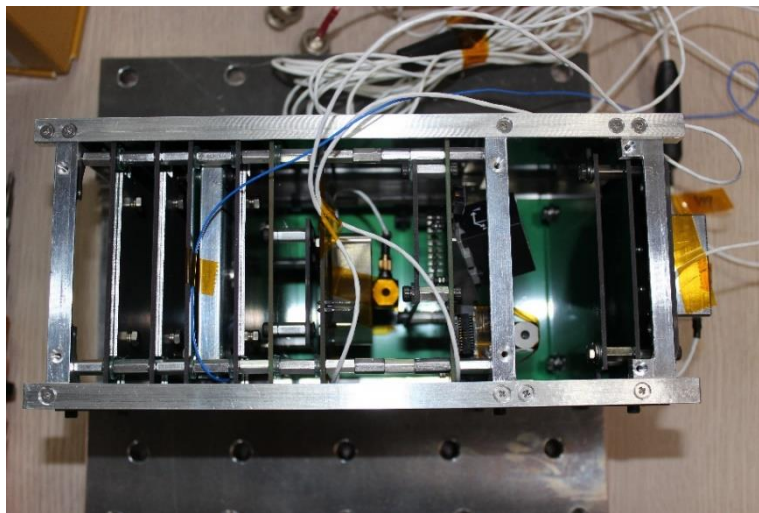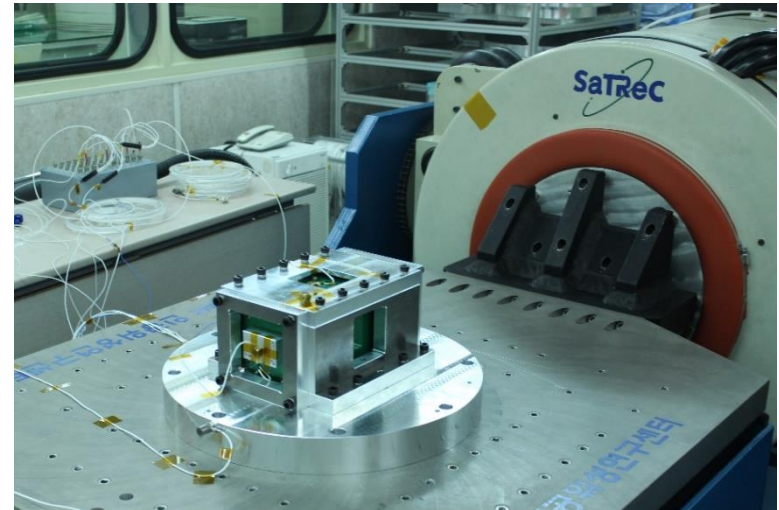
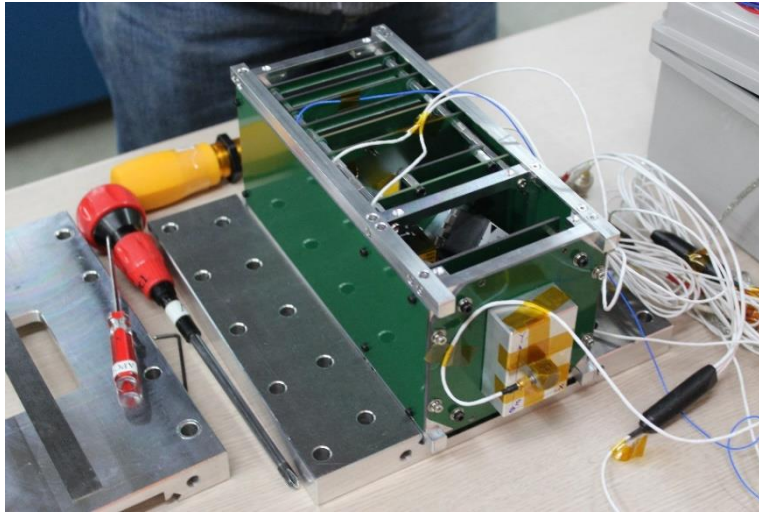Technical Aspect of the SNUSAT-1 Project Cycle
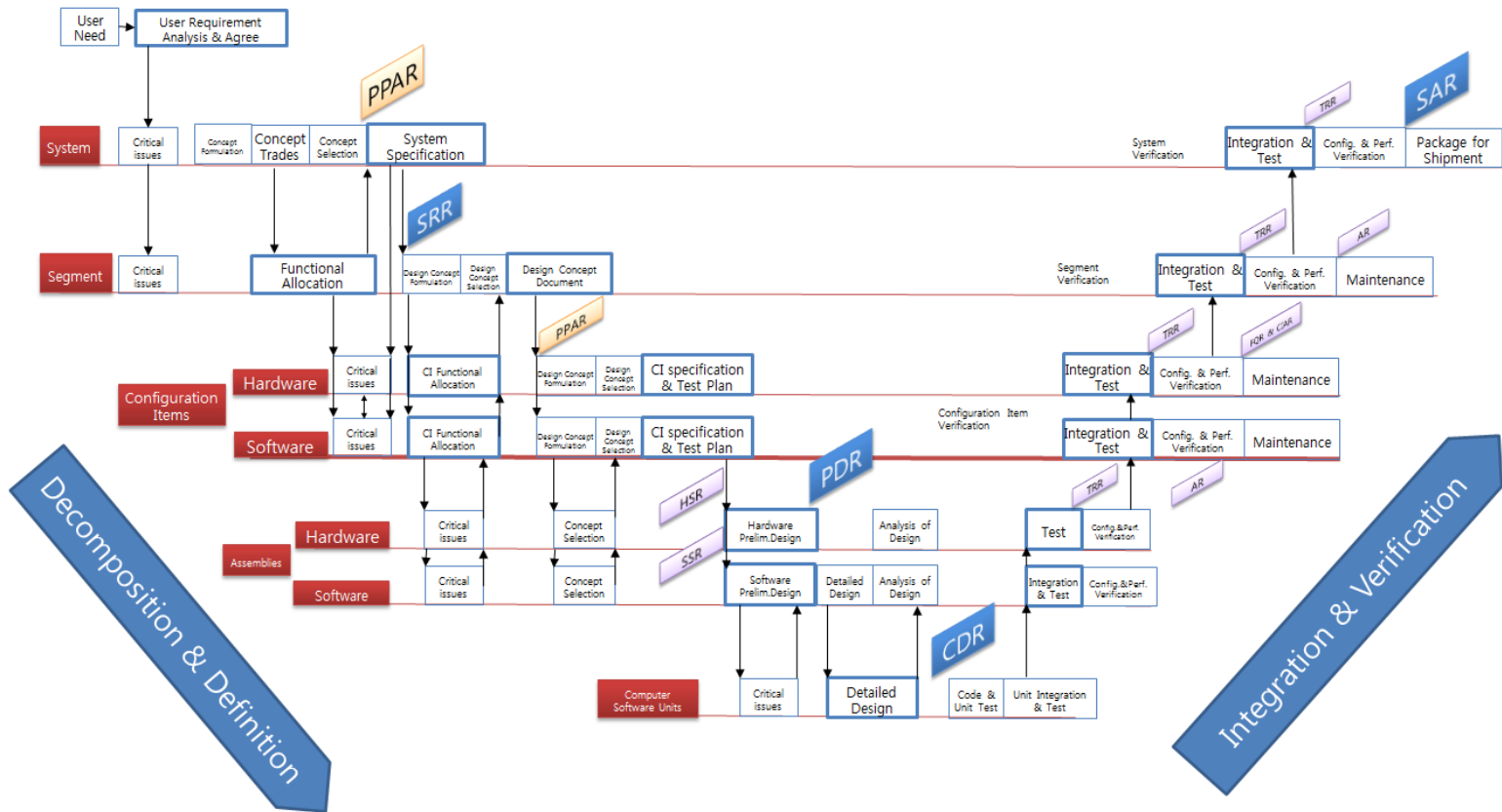
SNUSAT-1/1b: BBM Test
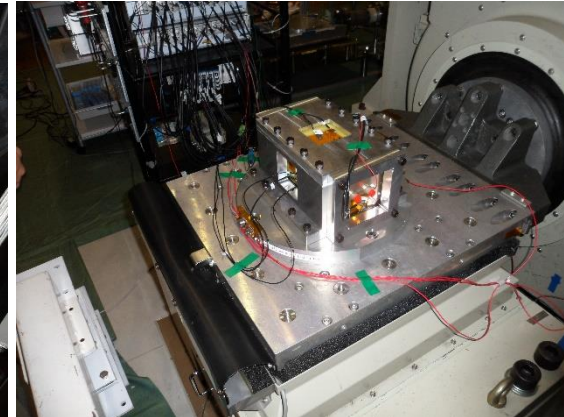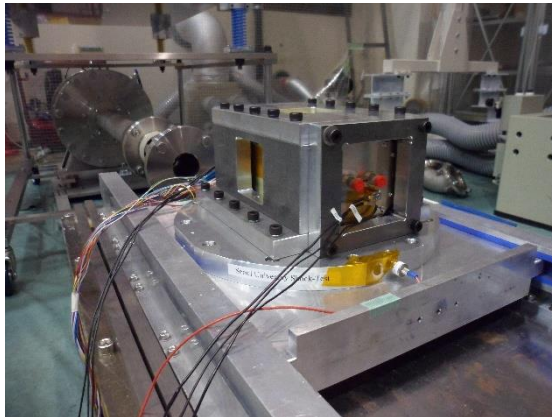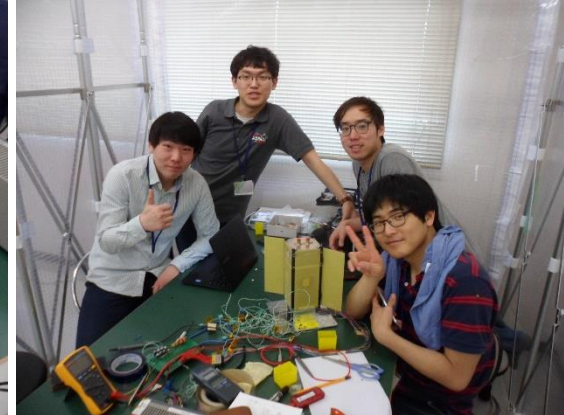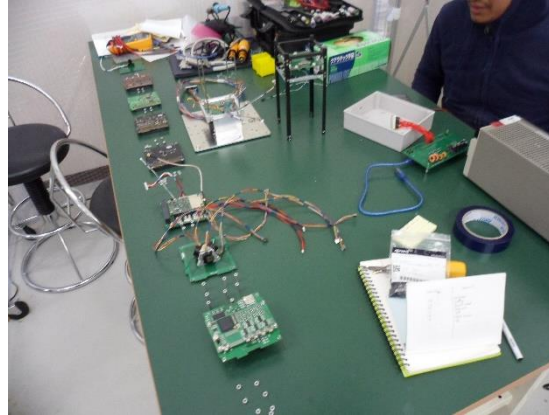
❑ On-hand space environment test experience
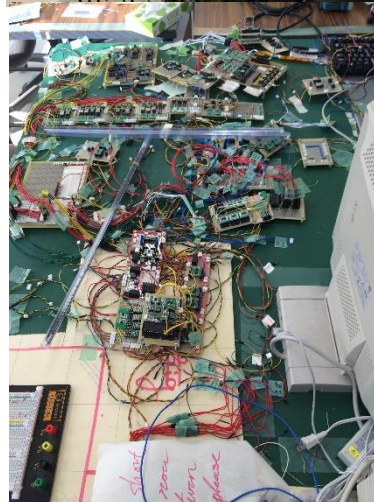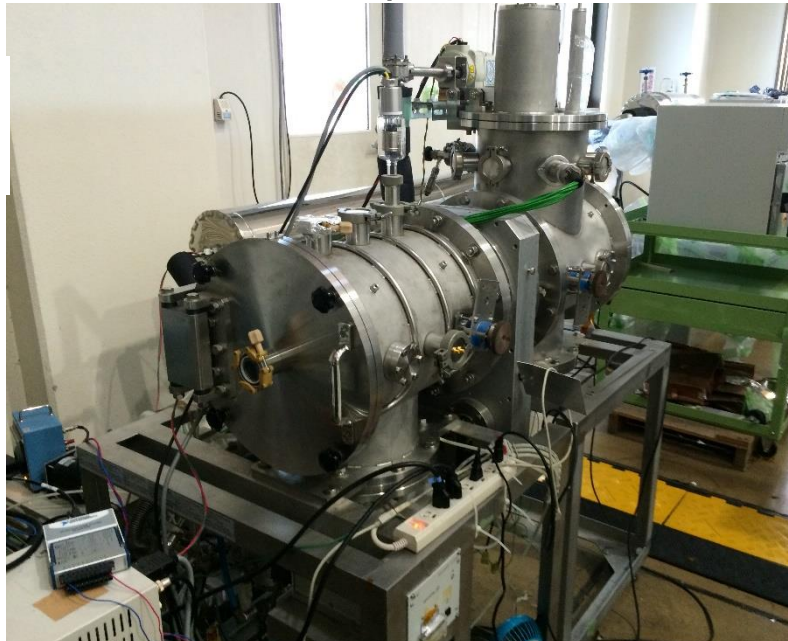
SNUSAT-1/1b: EM Test

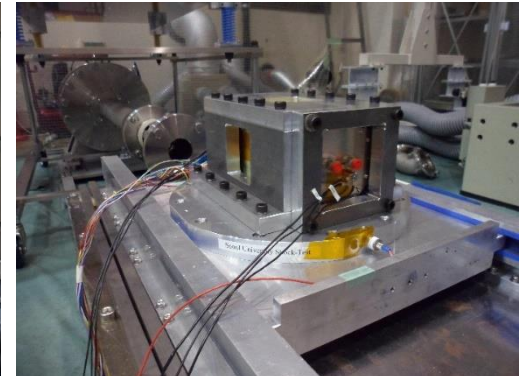❑ On-hand space environment test experience
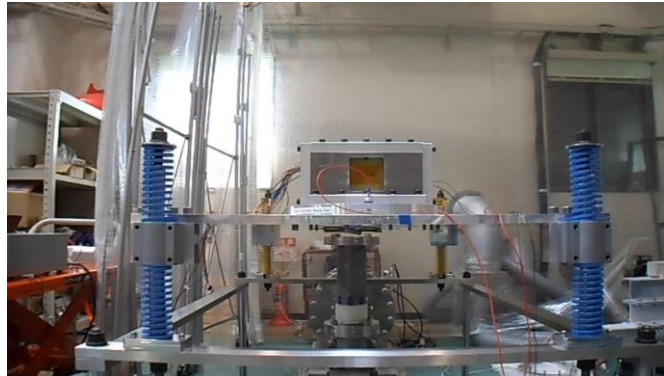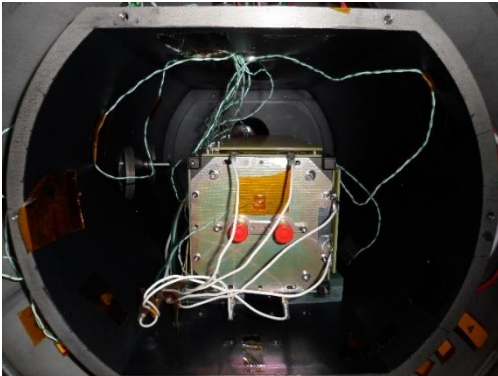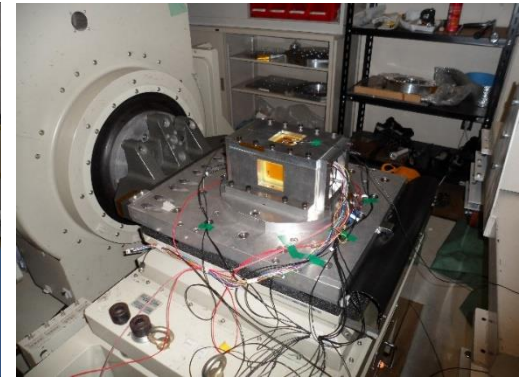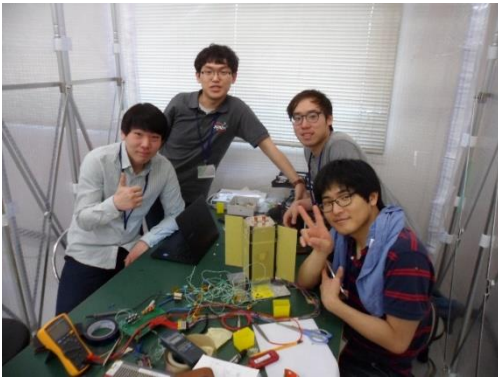
SNUSAT-1/1b: EM Test

❑ On-hand space environment test experience

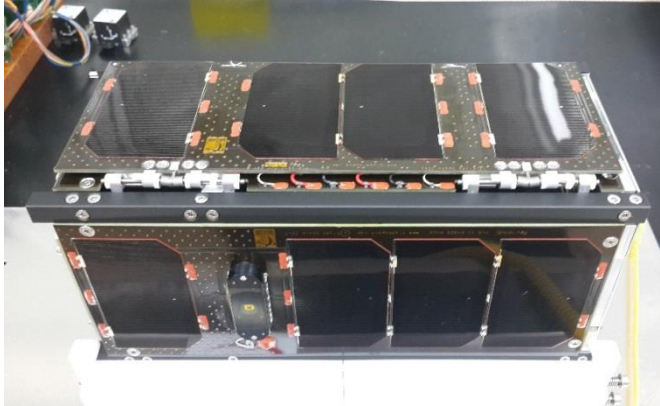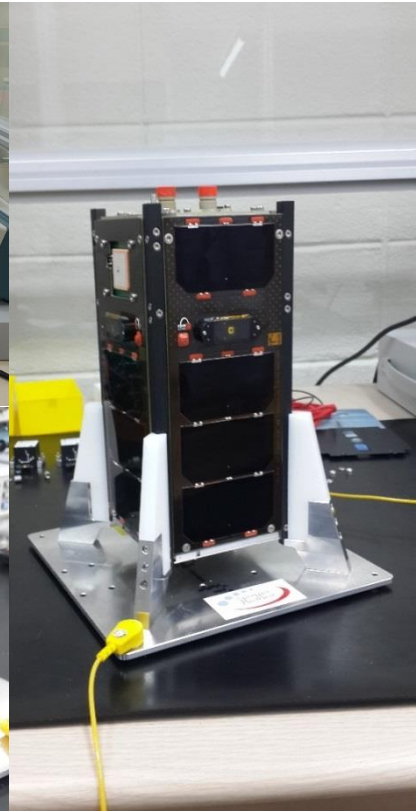# SNUSAT-1/1b: EM Test

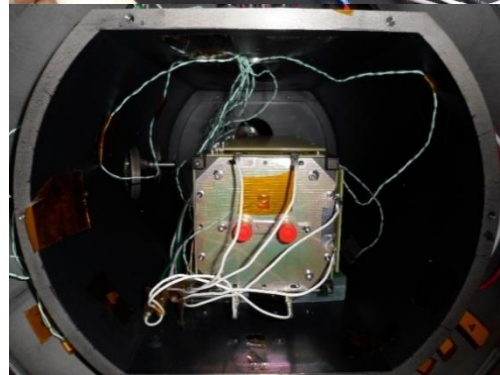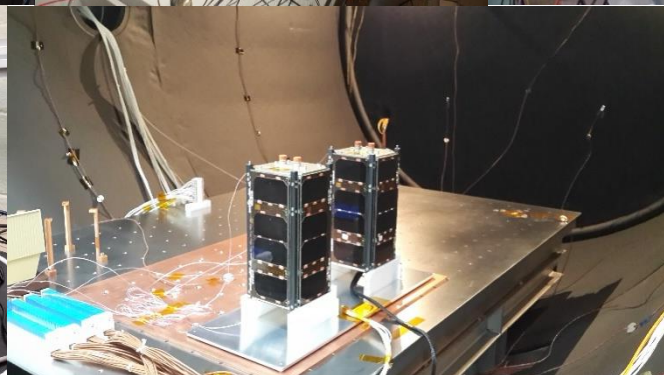❑ On-hand space environment test experience

SNUSAT-1/1b: FM Assembly
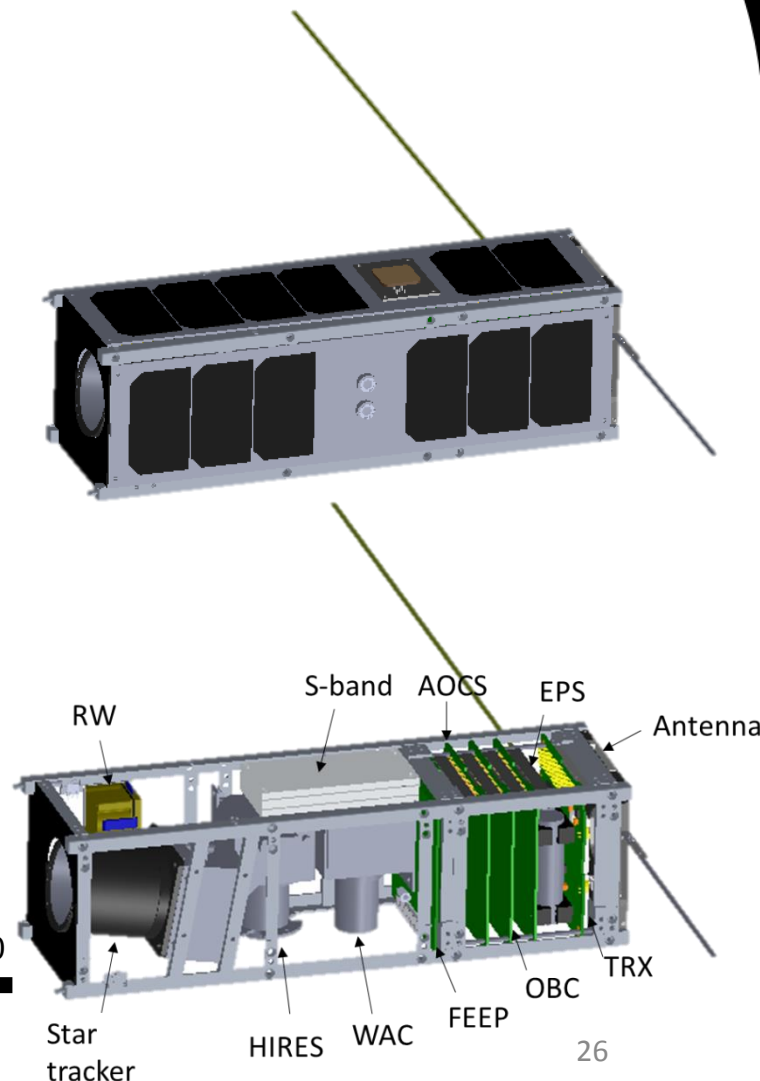
❑ FM Assembly @ SNU

SNUSAT-1/1b: FM Test

❑ On-hand space environment test experience

SNUSAT-2: Overview

- 3U CubeSat

- Kick-off: October 16, 2015

- Mission:
  - Early Point of Interest Scanning
  - Self active debris removal
  - Star tracker/Earth sensor development

- ADCS: 3-Axis Stabilization

- Funding: KARI

- Time Schedule

SRR 2015.10.16

PDR 2016.2.15

AITRR 2016.12.16

Launch 2017.10

SDR 2015.11.20

CDR 2016.5.13

FRR 2017.7.10

RW — S-band — AOCS — EPS — Antenna

Star tracker — HIRES — WAC — FEEP — OBC — TRX
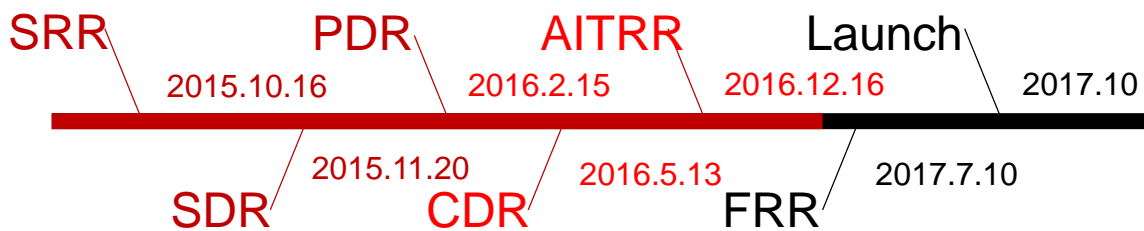
SNUSAT-2: Overview

- System block diagram
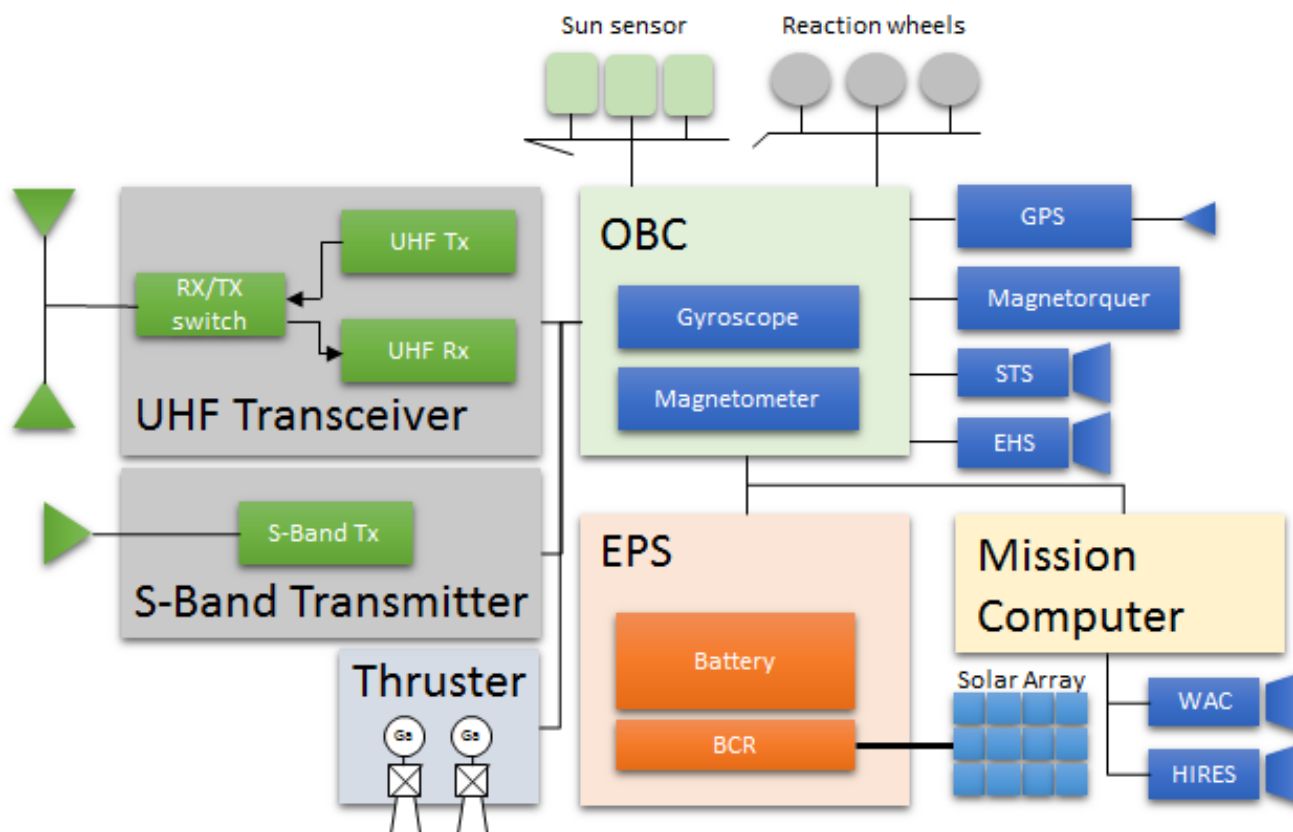
SNUSAT-2

- Mission
  - Autonomous Space Vision for Nano-Satellites
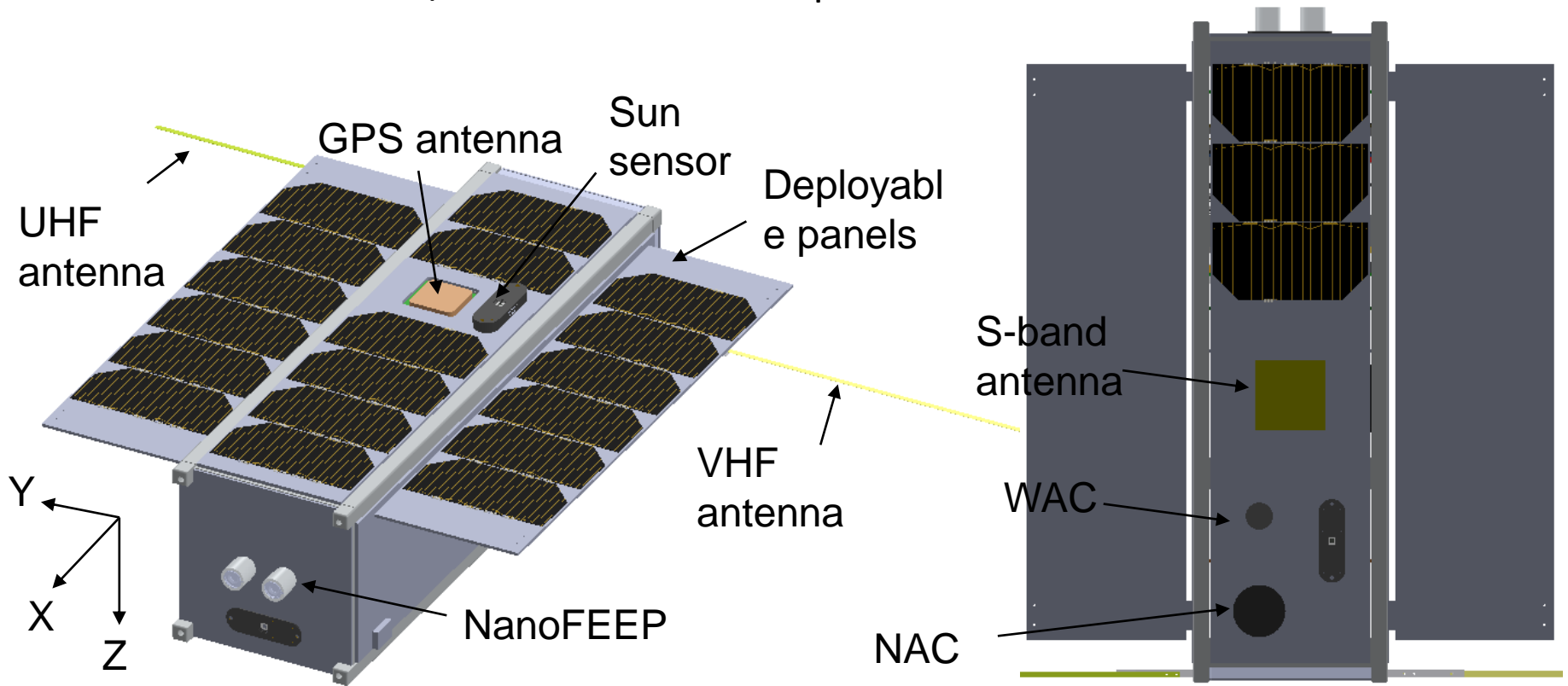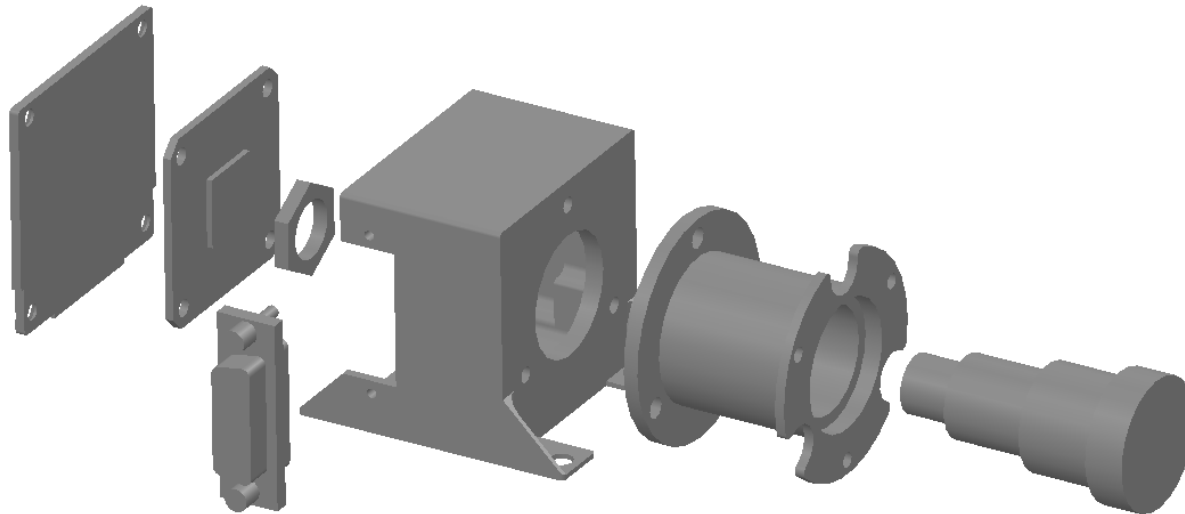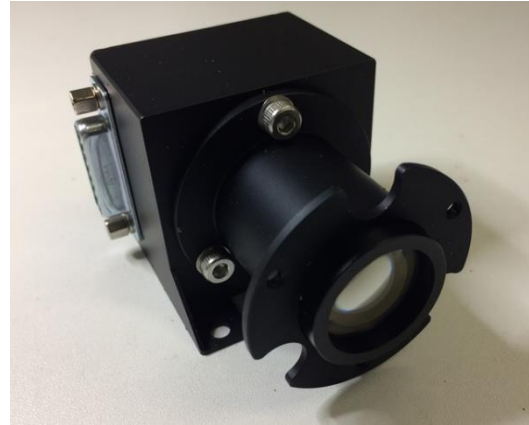 - Self active debris removal
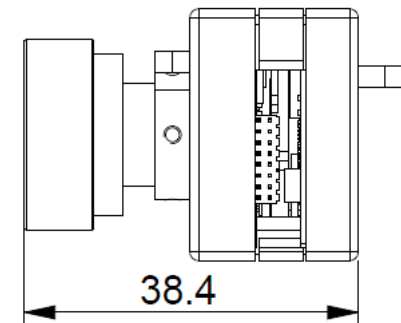 - Star tracker/Earth sensor development

UHF antenna

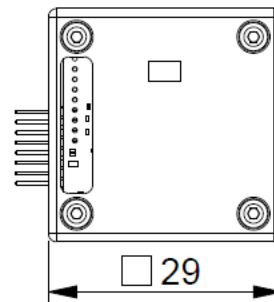GPS antenna

Sun sensor

Deployable panels
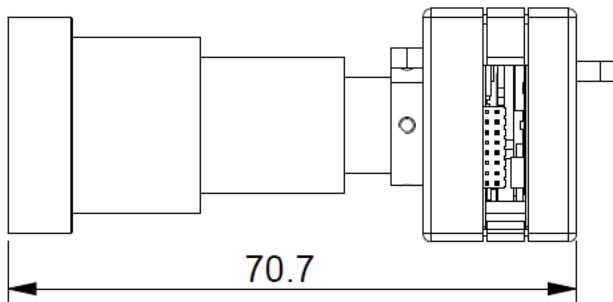
VHF antenna

S-band antenna

WAC

NAC

NanoFEEP

Y

X

Z

SNUSAT-2: NAC

❑ SNUCAM

Commercial NAC

❑ Hyperion Optical Imager

29

29

70.7

38.4
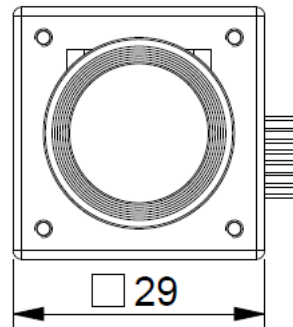
NAC and WAC

Parameters	Wide Angle Camera (WAC)	Narrow Angle Camera (NAC)
Pixel size (μm)	2.2	2.2
Sensor Size (mm)	5.7 x 4.28	5.7 x 4.28
Focal length (mm)	12	50
Ground Swath (km)	285 x 214	68 x 51
GSD (m/Pixel)	127	27

Autonomous Space Vision for Nano-Satellites

AoI pointing

Sun pointing

Sun pointing

Area of interest

sun
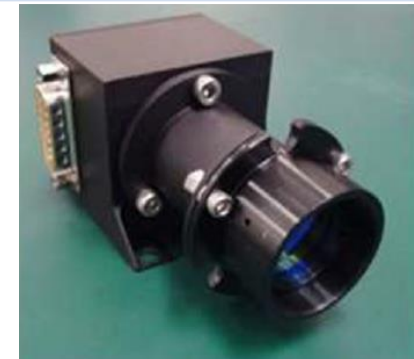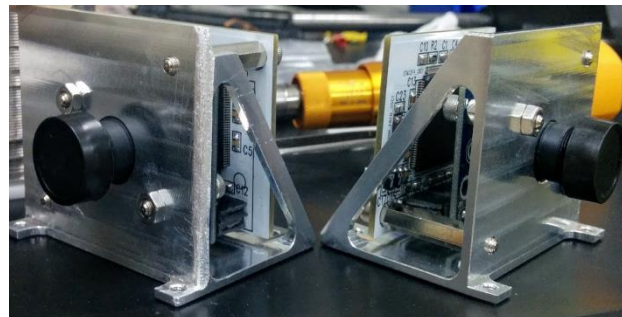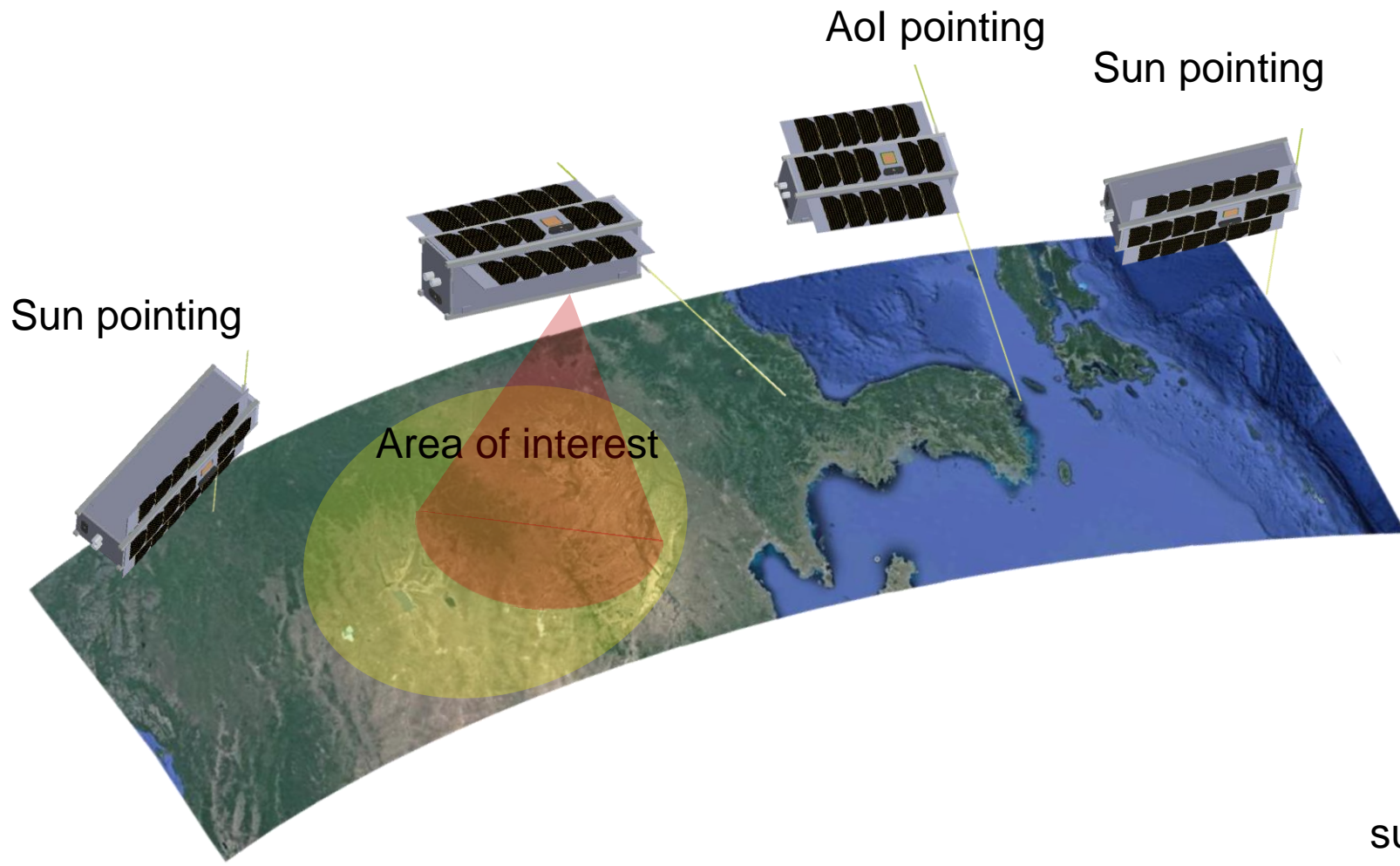
Triple band pass filter – G, R, NIR
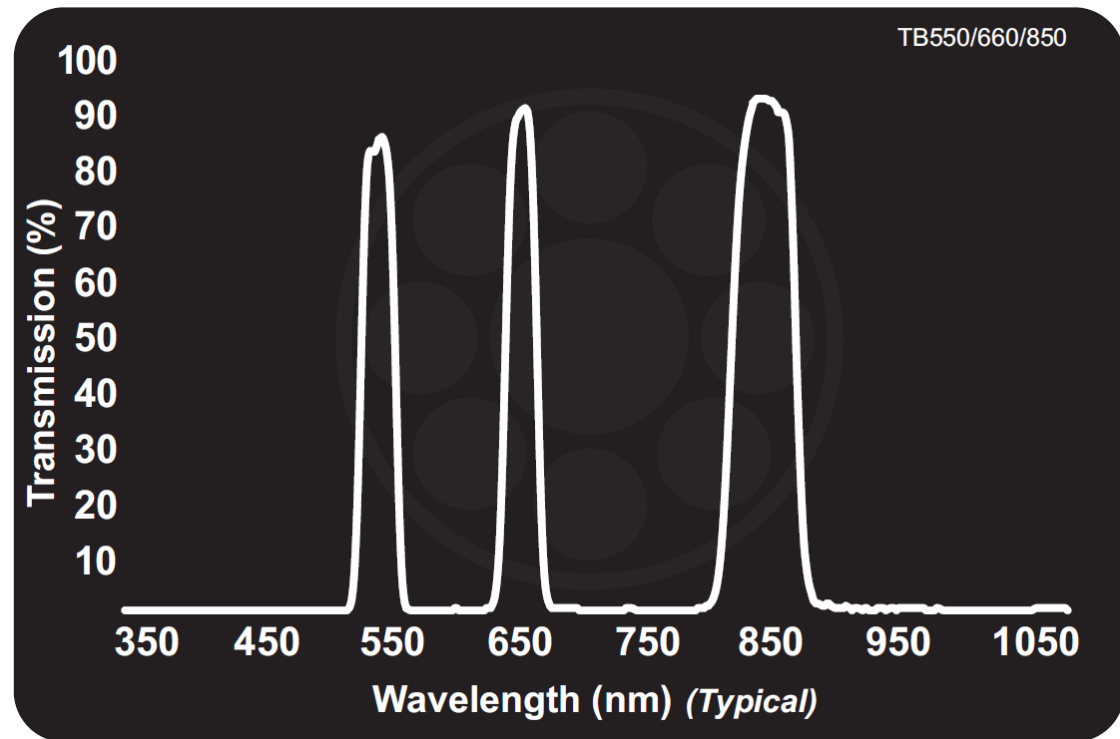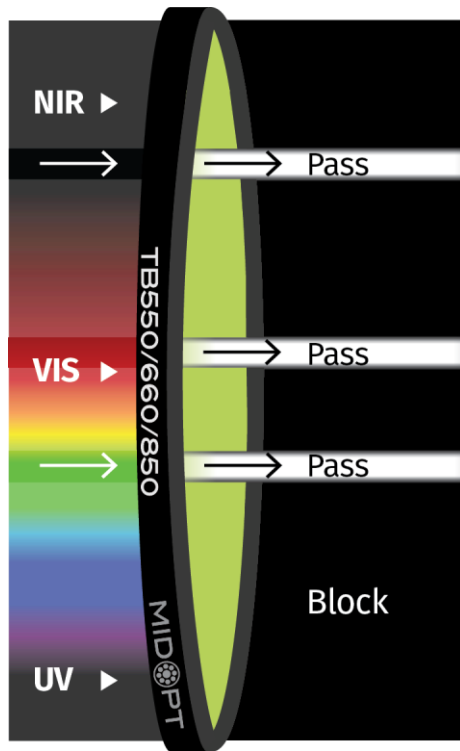
Normalized Difference Water Index

- NDWI : (G − NIR) / (G+NIR)
- -1 to 0 (land) ; 0 to 1 (water)
- Quality : Turbidity of water (intensity of pixels)
- Quantity: Surface property of water (No. of pixels)
- Landsat-8 images (GSD 30m): Land viewer
  Cloud cover < 1%, Sun Elevation angle : 50˚ to 63˚
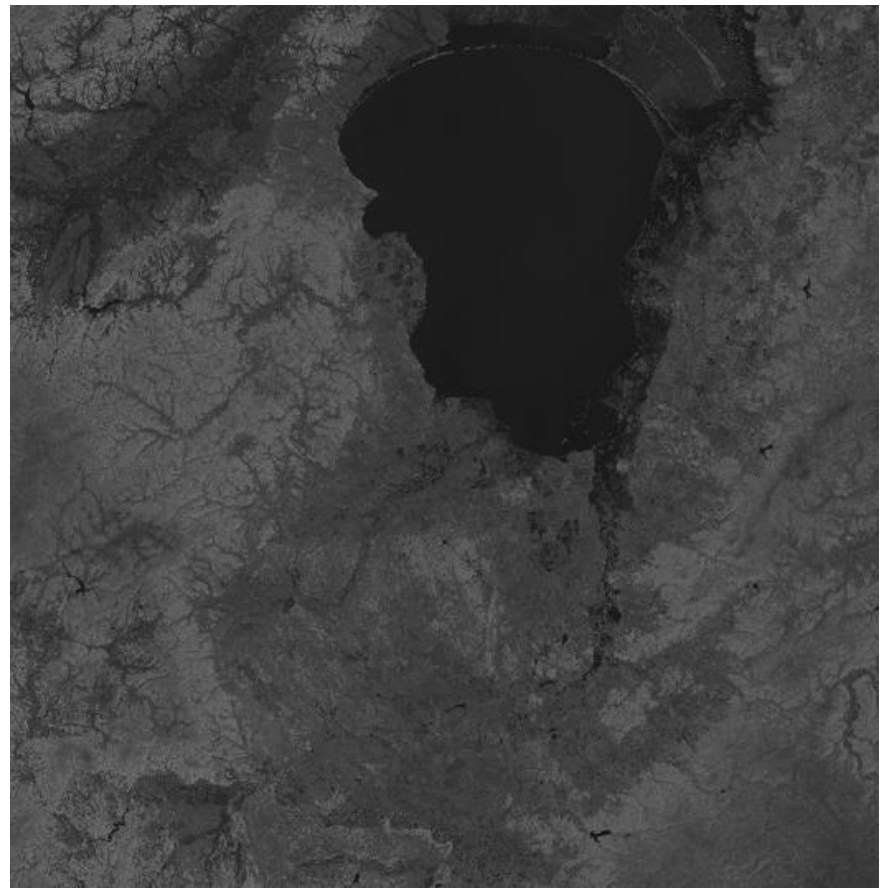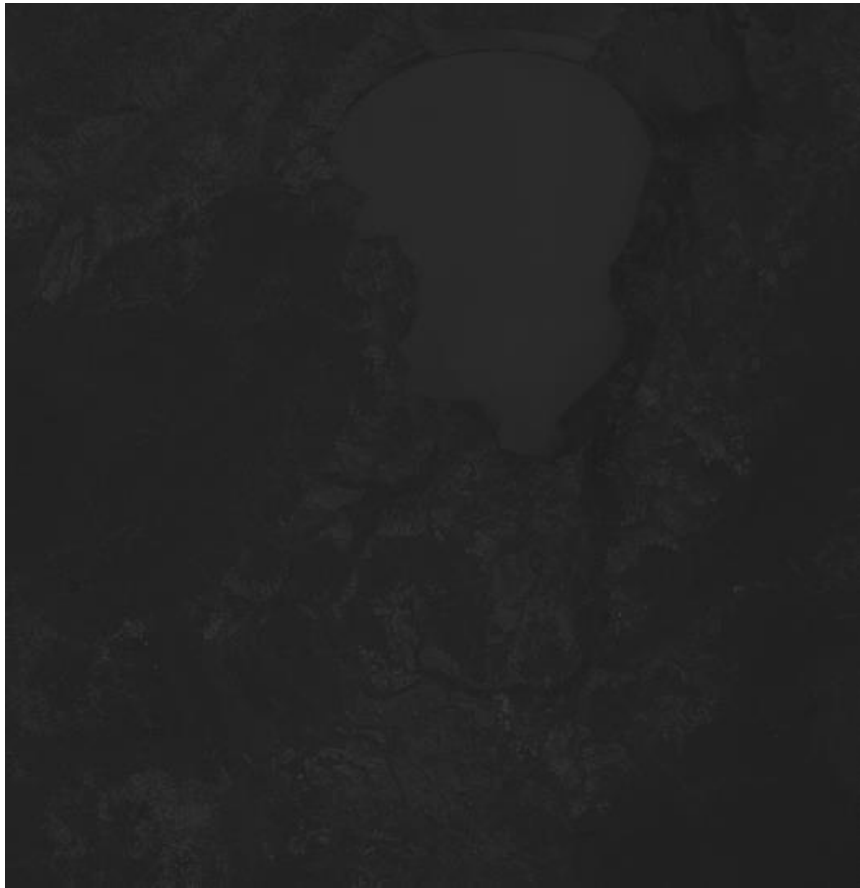- Image processing: Matlab

Surface Property of Water bodies

- Water Surface Area (Lake, River)
- Perimeter of water bodies (Lake, River)
- Length and width of water bodies (Lake, River)
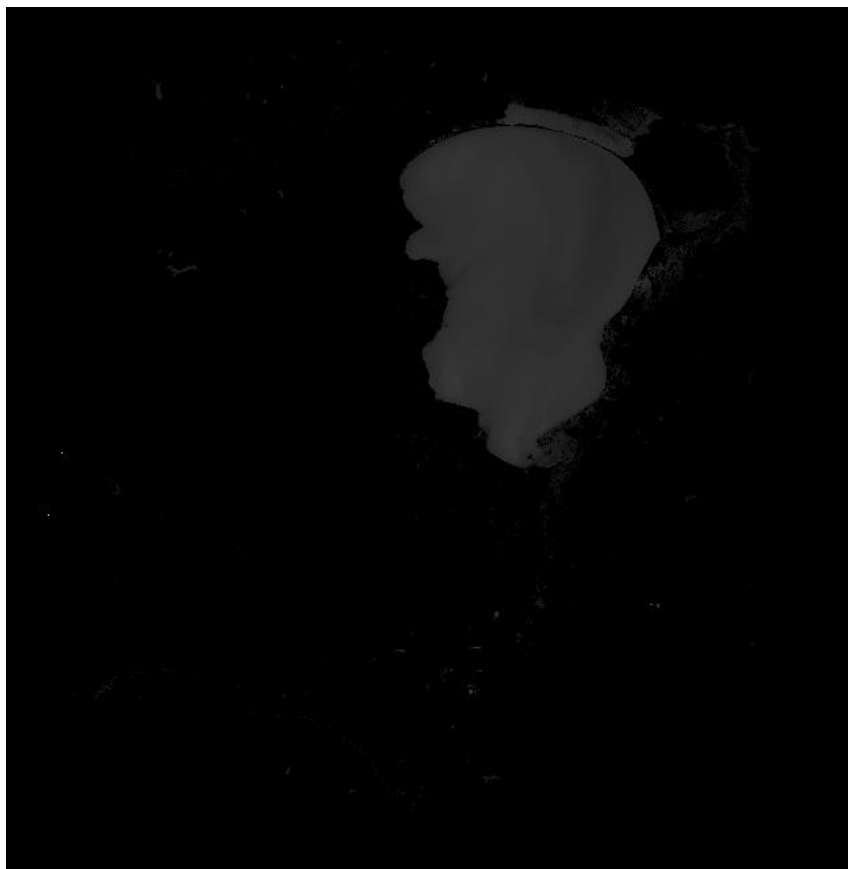- Disaster monitoring : Flood, Drought

Lake Khanka (Russia-China)

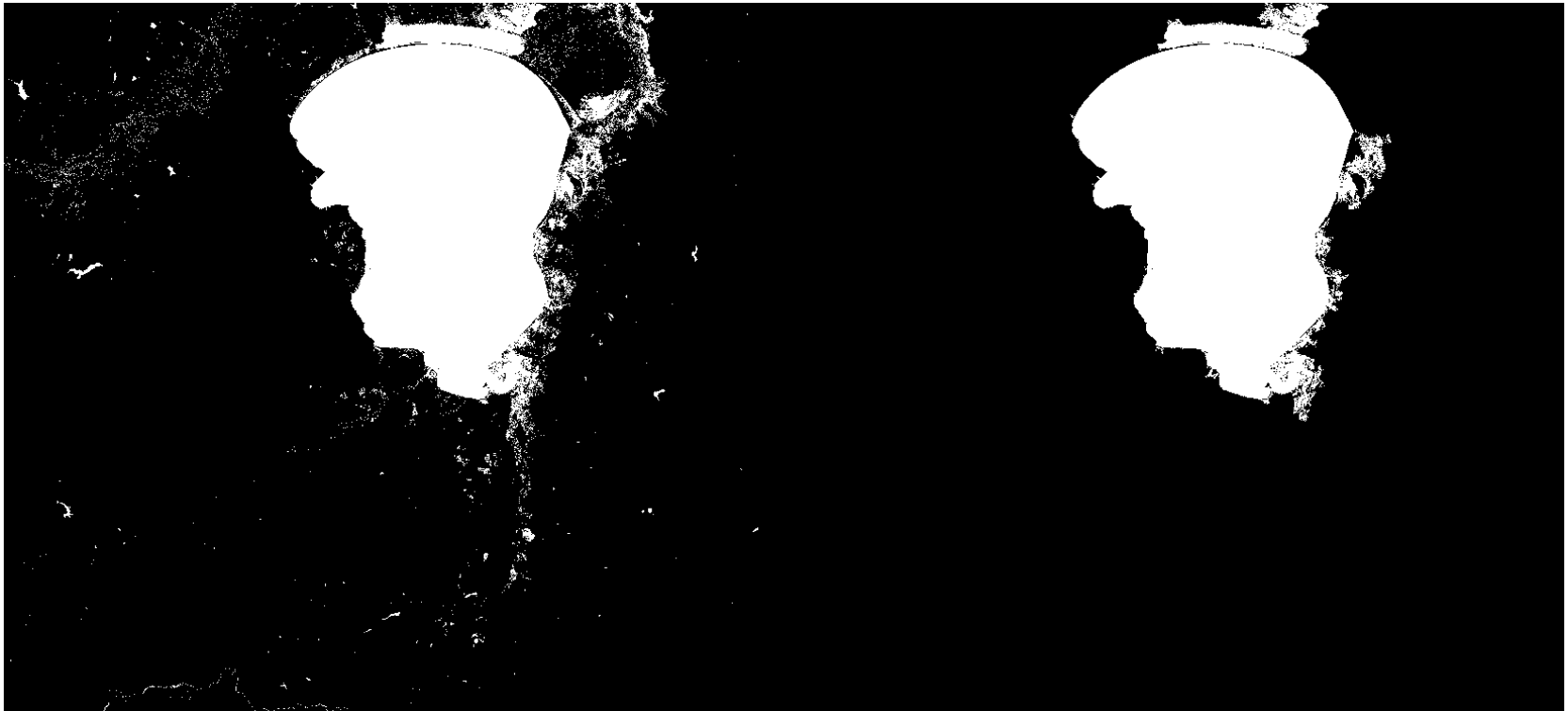# Lake Khanka: G, NIR band

NDWI – Grey image of lake Khanka

Lake Khanka extraction

Water Surface Area: 5188 Km²   Water Surface Area: 4697 Km²

Surface properties of Lake Khanka

Properties	Calculated value*	Ground data*
Surface Area (Km²)	4,697	4,510
Max. Length (Km)	99	90
Max. Width (Km)	65	45
Perimeter (Km)	1,385	

 * Imaged on May 21, 2016

The surface area of the water varies between 3940 km ² to 4510 km ².

*Status and Prospects of the Russian-Chinese Cooperation in Environment Conservation and Water Management, Materials of International Conference, Moscow, September, 2007.

Chennai Flood (Dec-2015), India.
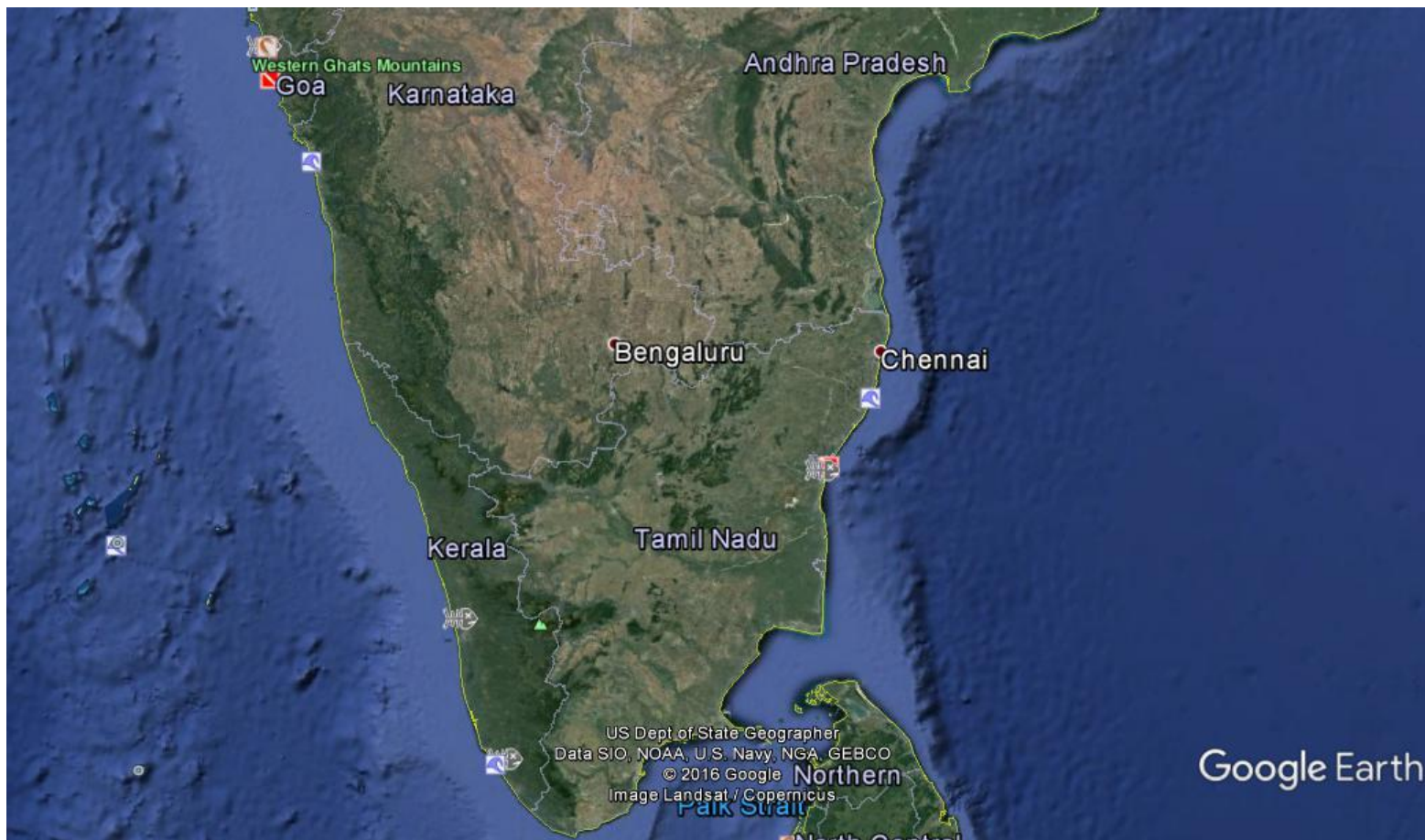
Green, NIR band of Chennai

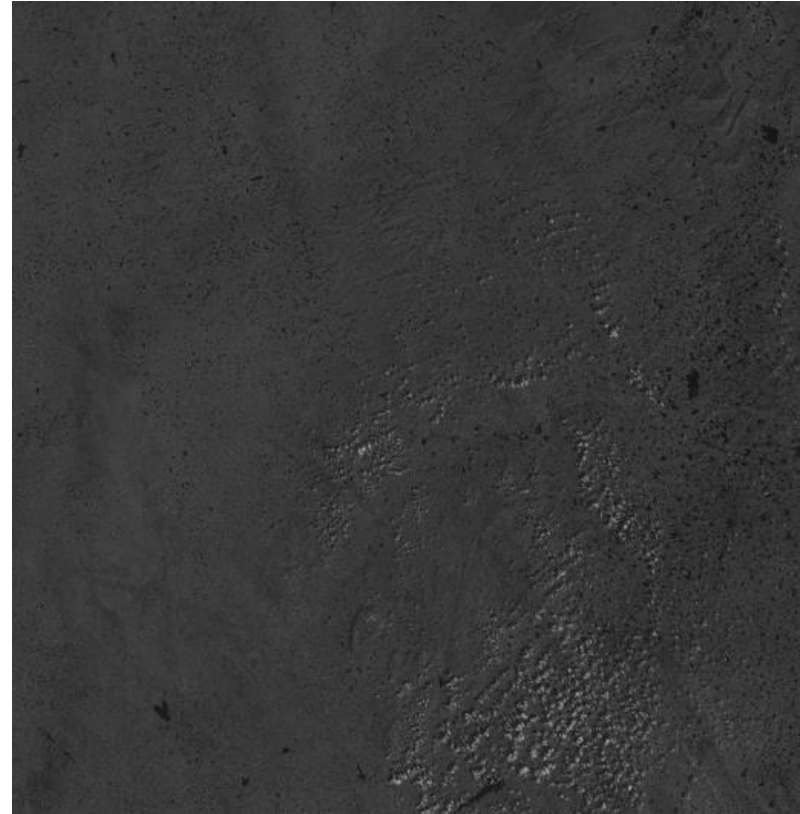# Binary images of chennai using NDWI (Before and after flood)
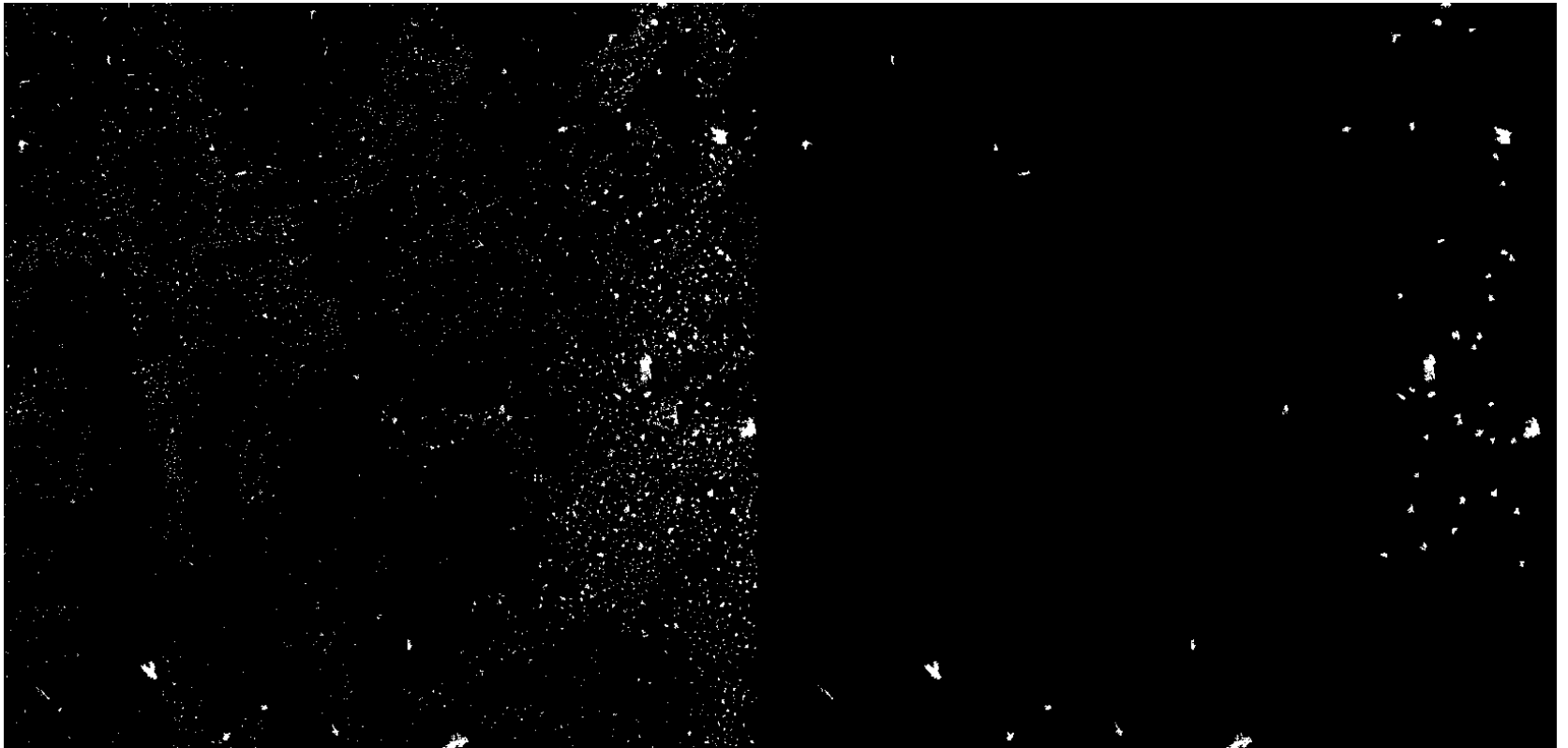
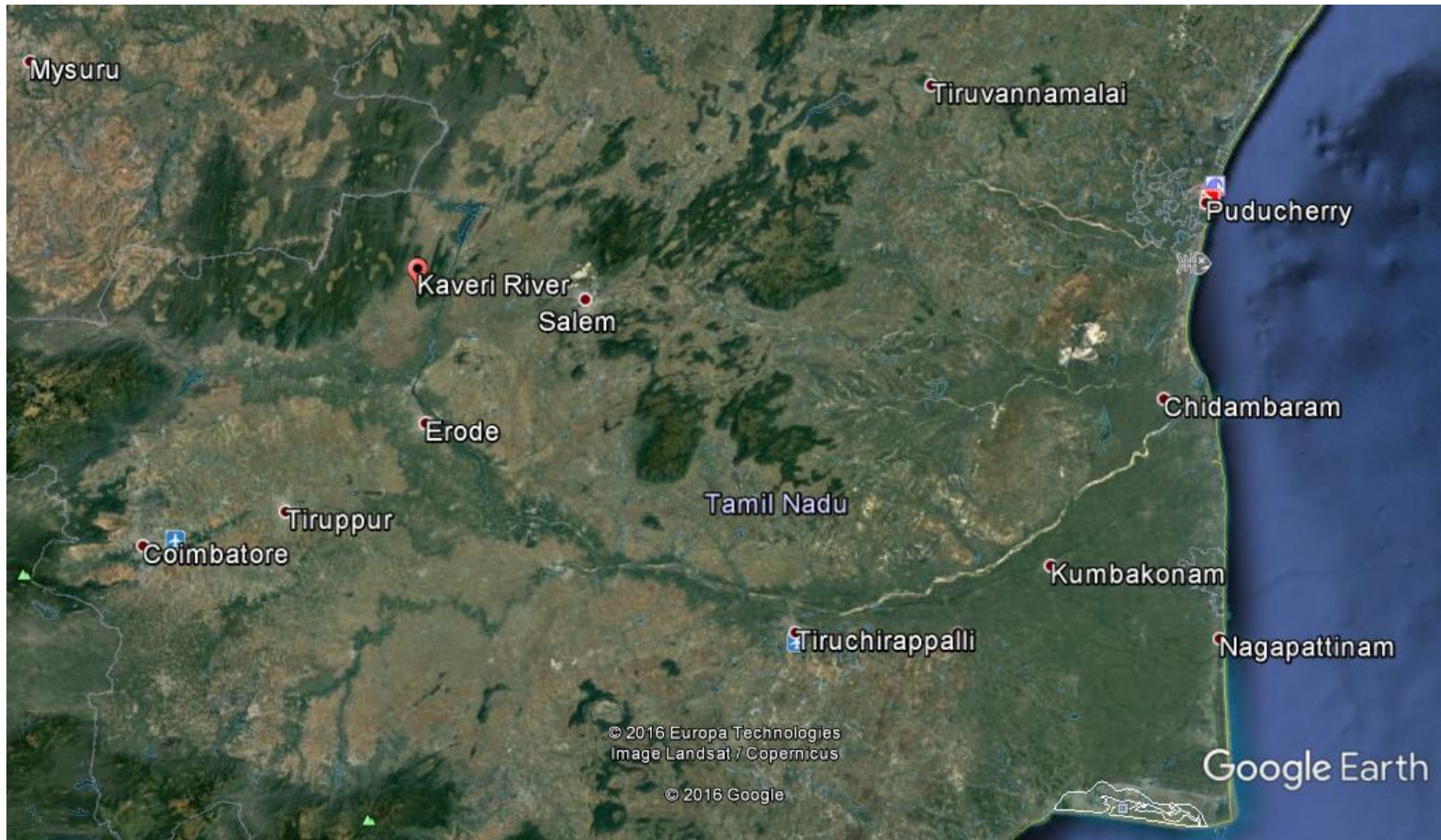Water Surface Area: 90 km²

Water Surface Area: 581 km²

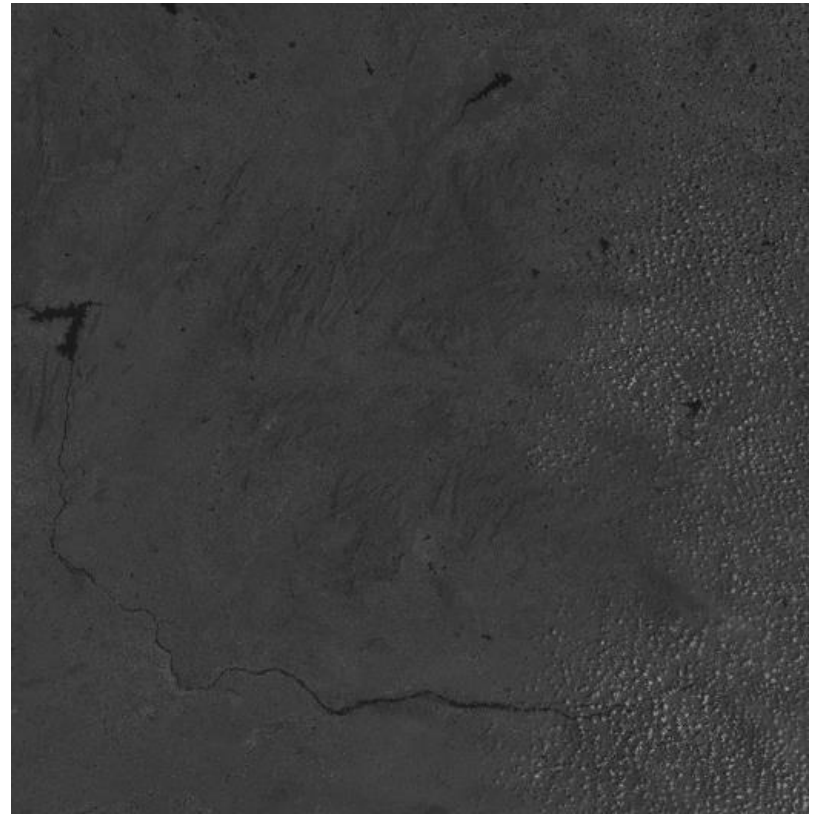# Water bodies based on Area

Cauvery river- drought 2017
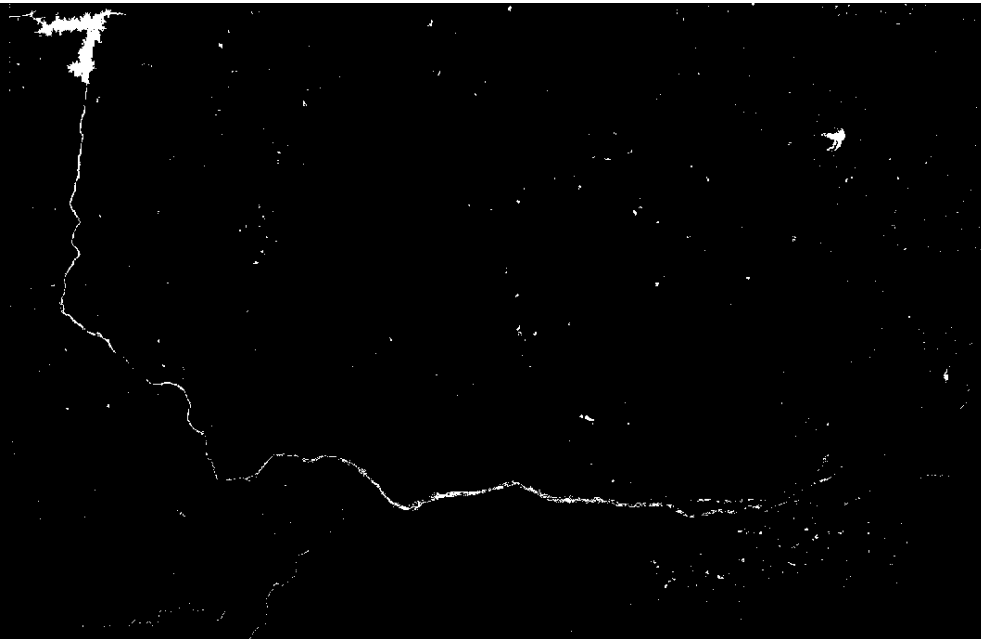
Green, NIR band of Cauvery river

Cauvery river 2016 & 2017

Water Surface Area: 175 km²

Water Surface Area: 35 km²

SNUSAT-2: Star Tracker
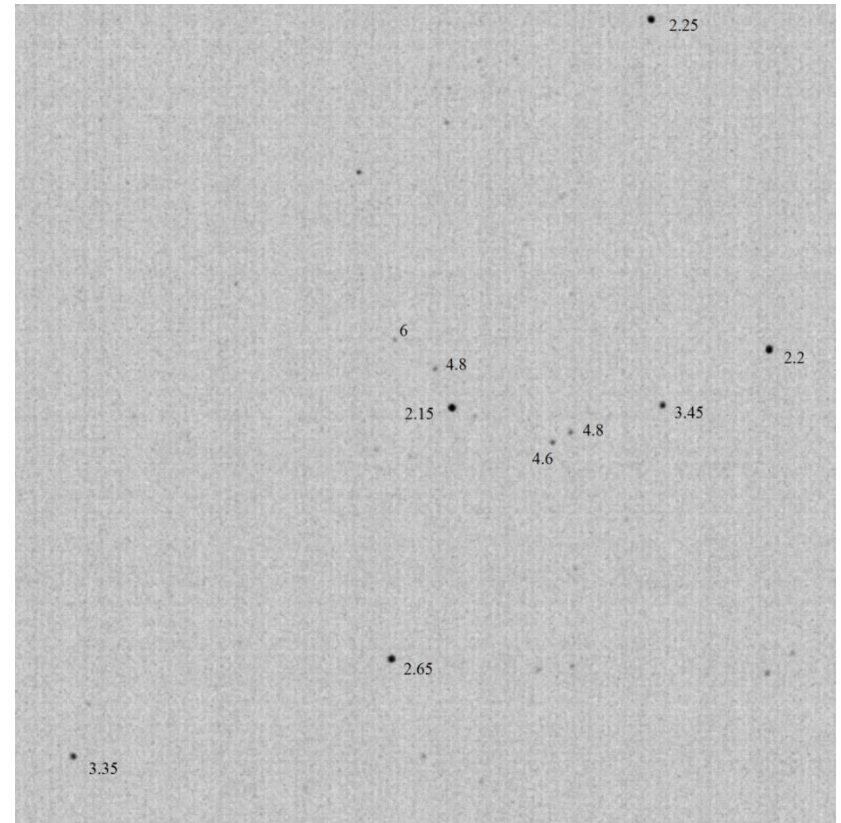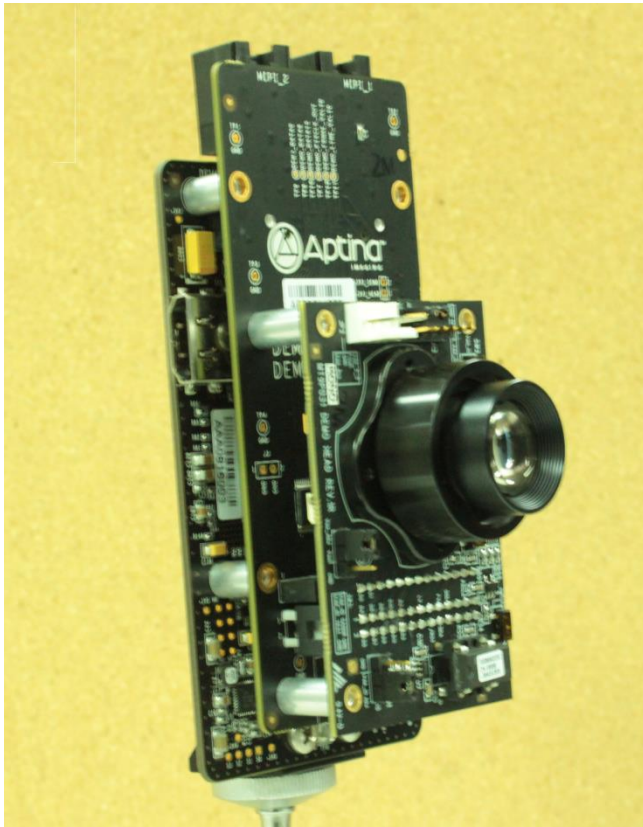
❑ NanoStar

SNUSAT-2: Star Tracker

❑ NanoStar
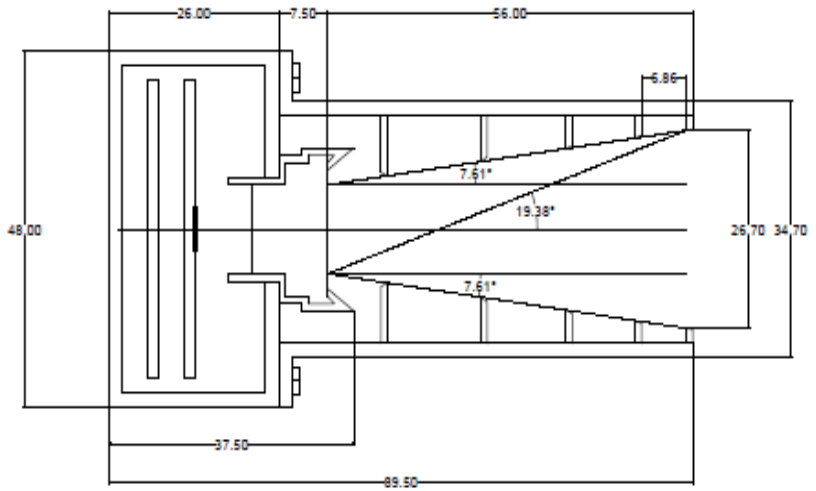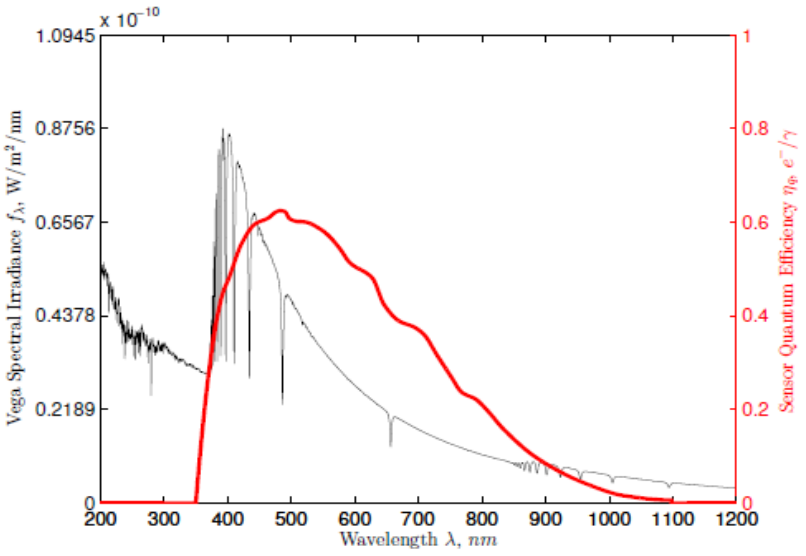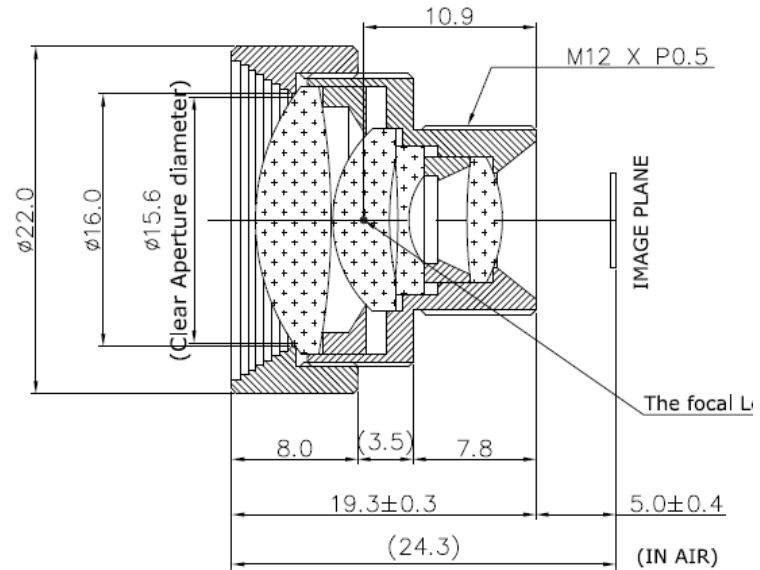
Thresholding (5σ) and labelling
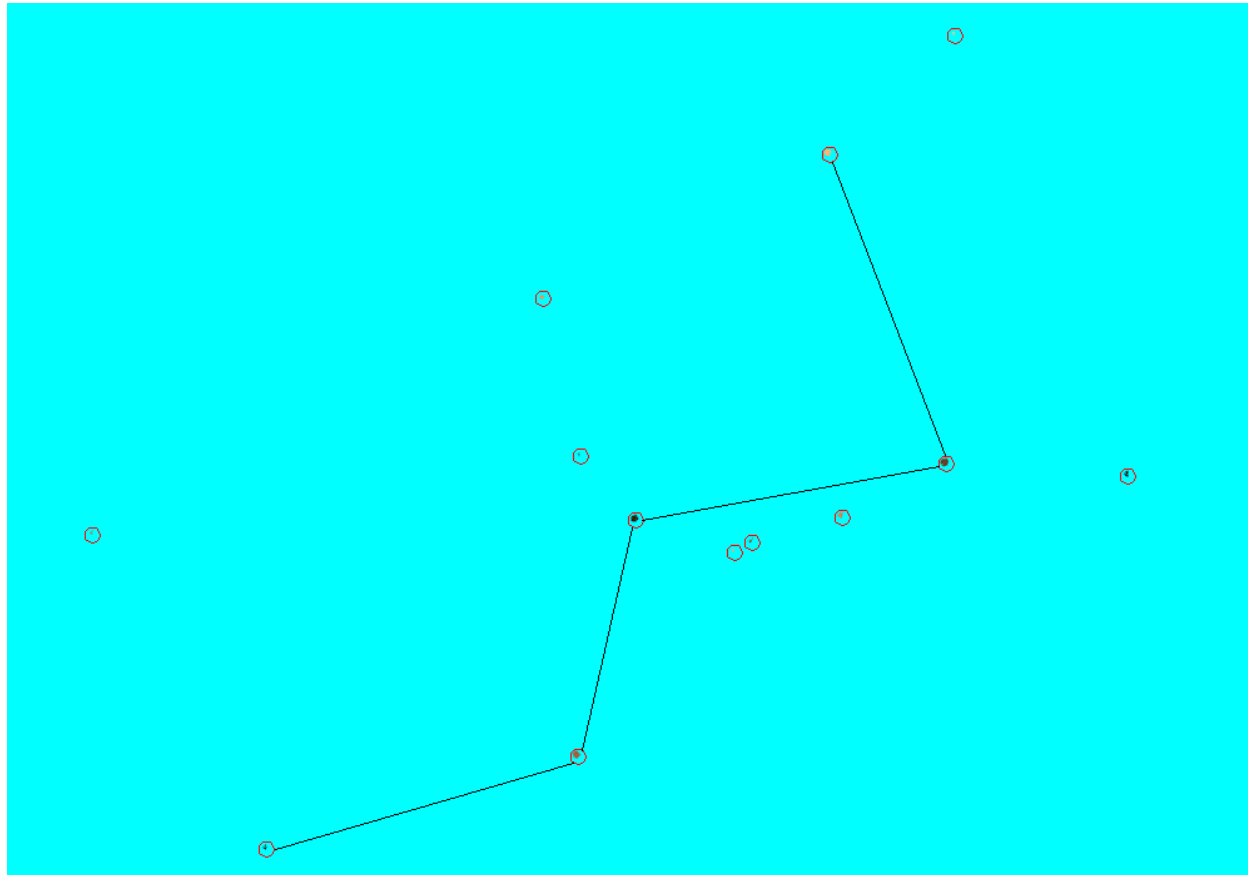
Cassiopeia Constellation

Centroid of weight

X: 1646
Y: 312.1
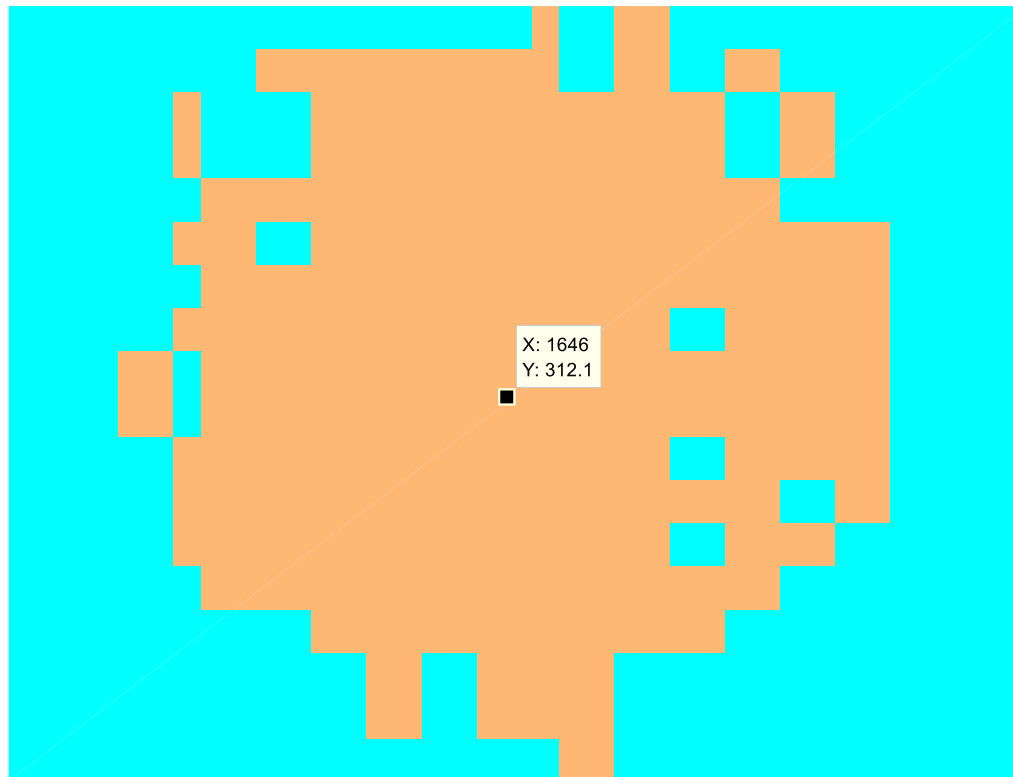
Cas11

SNUSAT-2: Earth Sensor

❑ NanoEarth

Space reference

Measurement
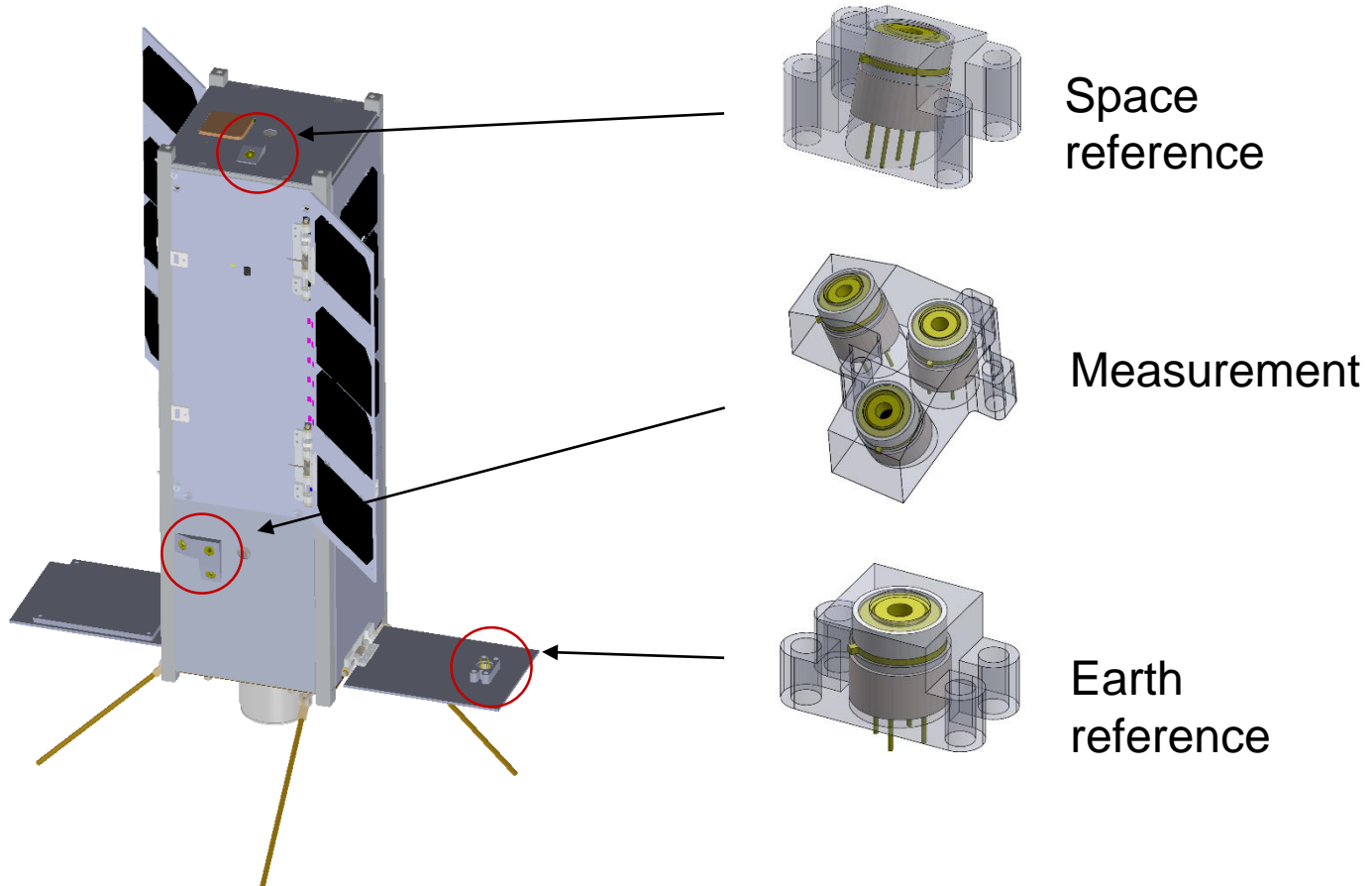
Earth reference

Outgoing Longwave Radiation

- Sun and Earth spectrum

Black Body Emission Curves of the Sun and Earth
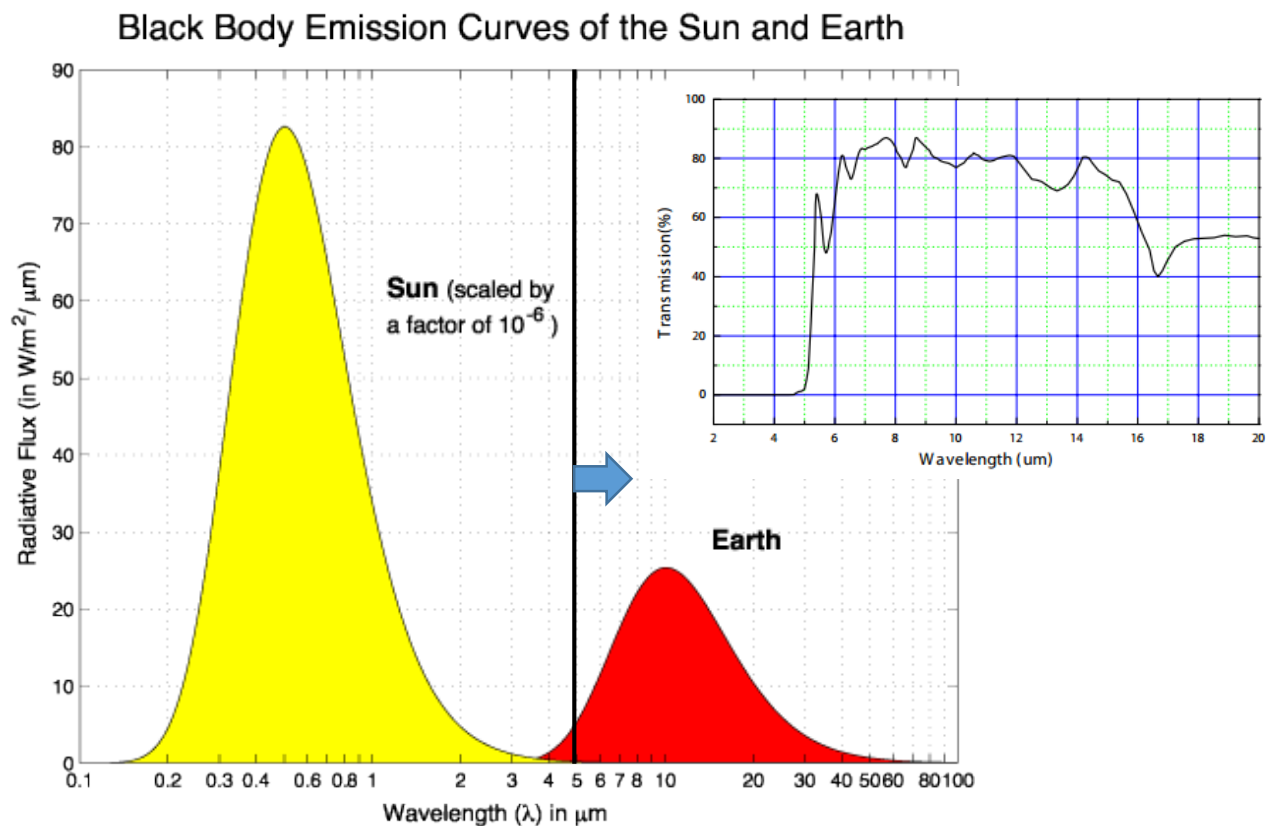
Sensor mounting

Tam Nguyen, MIT
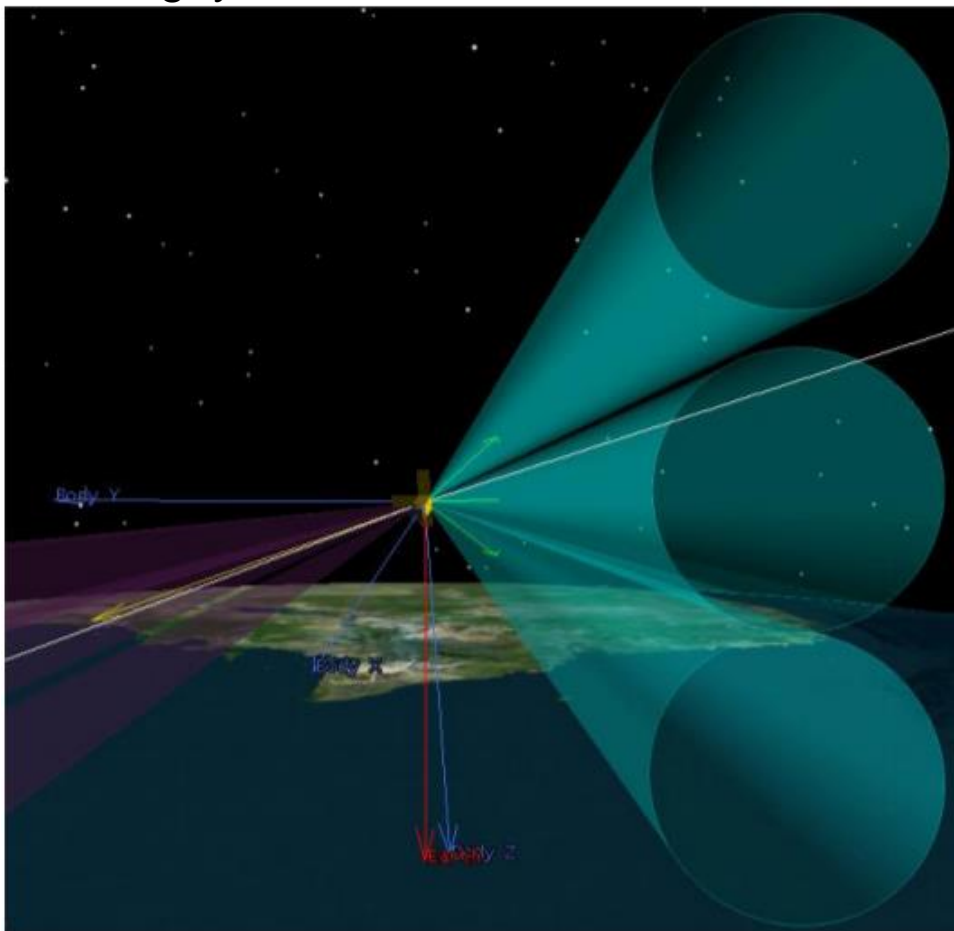
3 sensors/mount

"Space" sensor
- "cold" reference
- 0% obscuration

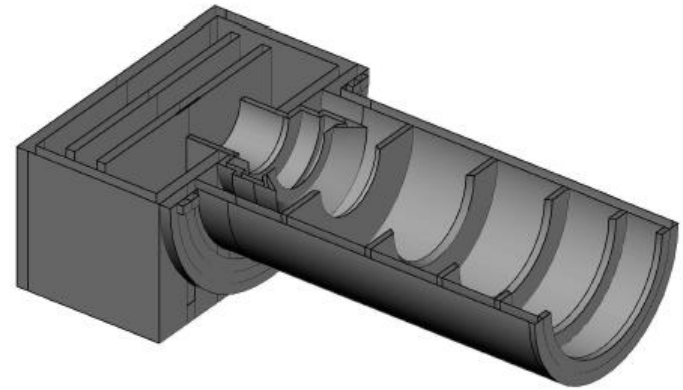**Horizon sensor**
- Partial obscuration

"Earth" sensor
- "hot" reference
- 100% obscuration

SNUSAT-2: NanoFEEP Thruster

- Active self orbit removal using high specific impulse electrical thrusters (FEEP)
  - High voltage generation demonstration (LEOP)
  - Orbit control capability demonstration (Deorbit)

Extractor electrode
Porous LMIS
Thermal/Electrical insulation
Heater assembly
Thruster board

Extractor Electrode
Capillary
Particle Spray
Liquid
Taylor Cone

http://lmts.epfl.ch/MEMS-ion-source
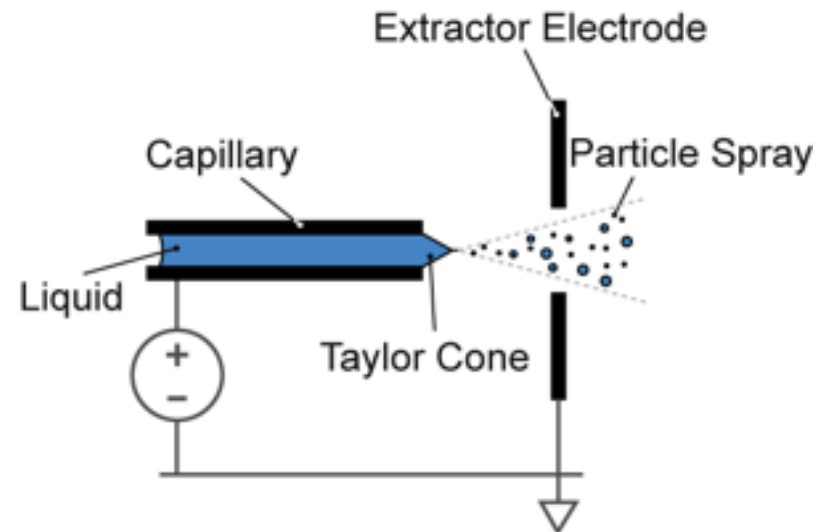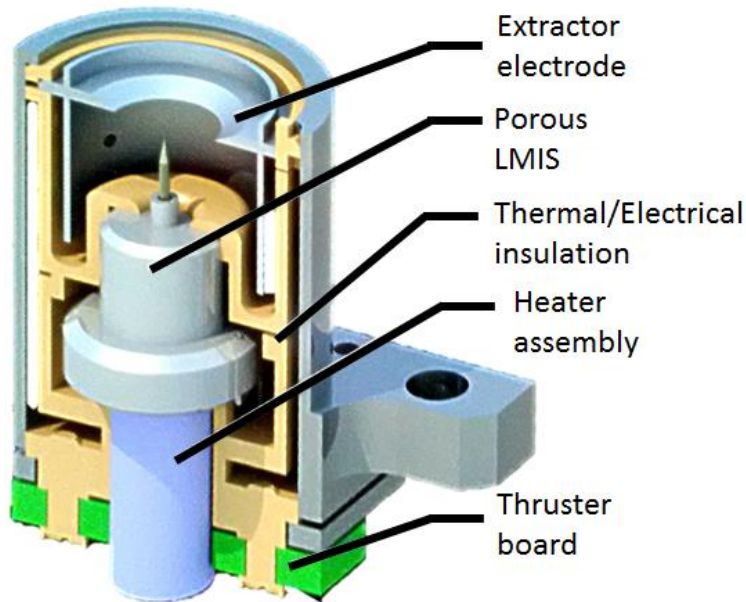
NanoFEEP Thruster BBM

❑ NanoThrust
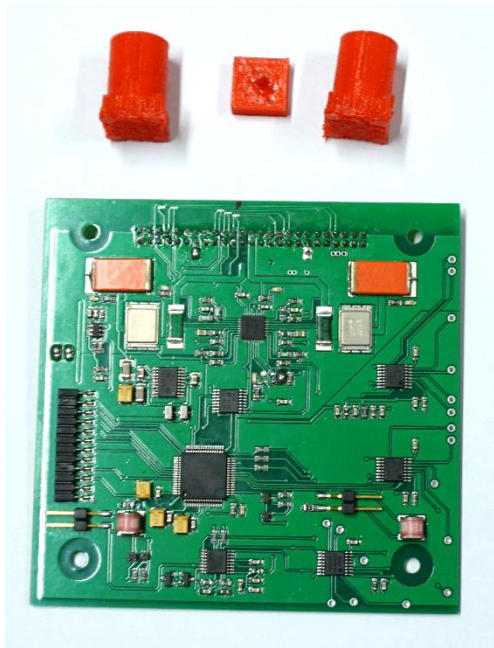
NanoFEEP 2
(GBS Elektronik)

NanoFEEP 1
(Spellman HV)

GBS Elektronik HV

Spellman HV
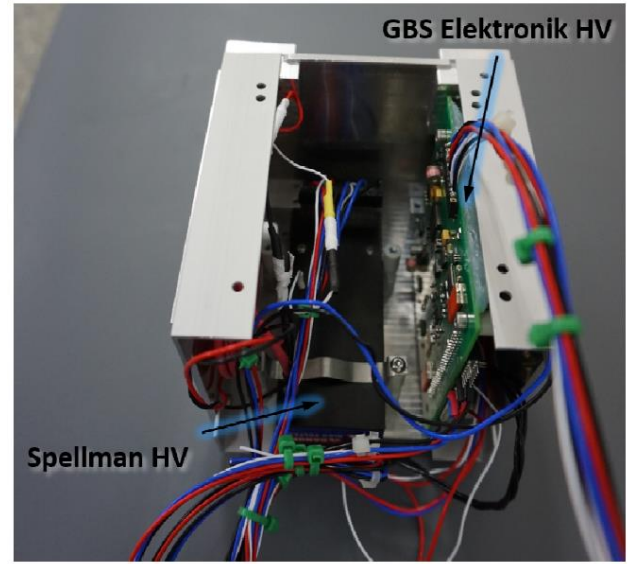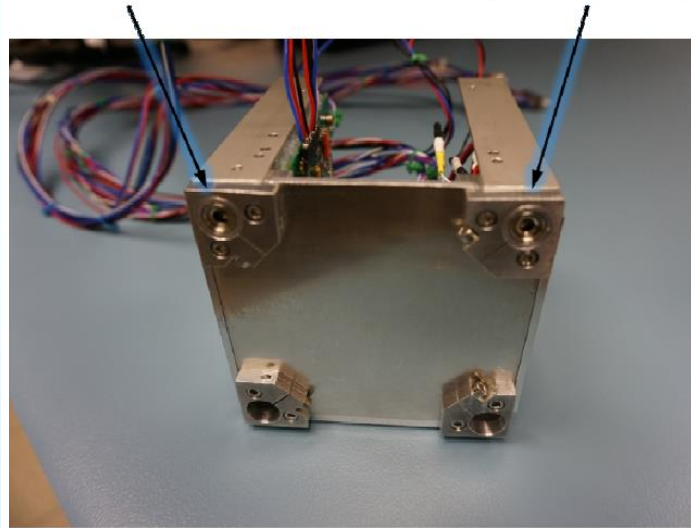
NanoFEEP Thruster BBM Test

❑ NanoThrust
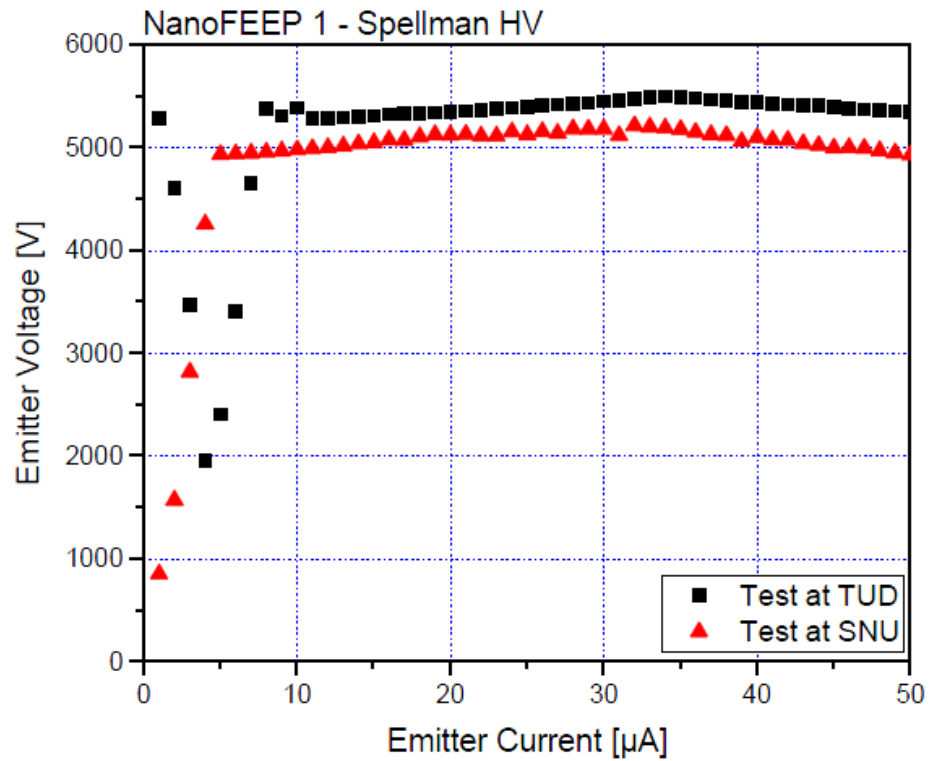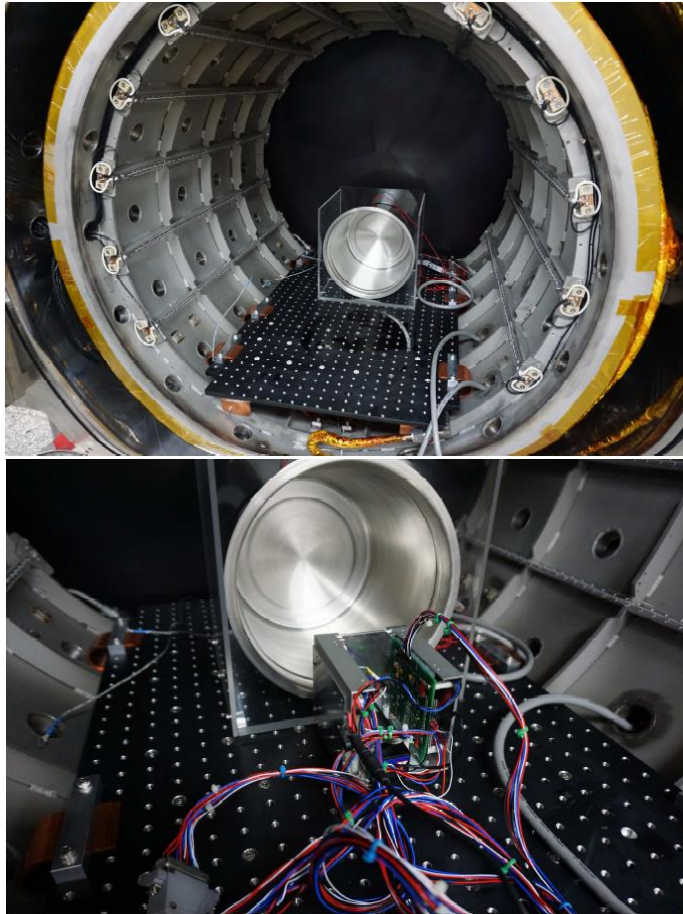
NEX·SAT

Near **E**arth space e**X**ploration
Serving for SNUSAT-3

SNUSAT-3(NEX·SAT): Overview

- Technical Objectives
  - Validation of scientific payload
  - Demonstrate orbit transfer method for space weather measurement and space debris mitigation de-orbit

- Academic Objectives
  - Fostering aerospace engineers

- Budget
  - $ 150,000 (Korea Aerospace Research Institute)

NEX·SAT Objectives

- Payload
  - SNIPE (Near Earth-space environment measurement)
    - Magnetometer
    - Solid state telescope
    - Langmuir probe
  - Micro-PPT (Pulsed Plasma Thruster)

- Target Orbit: 500~600 km (TBD)

- Mission Lifetime ~ 1 Years

Collaboration

- International Collaboration
  - Nanyang Technological University (Singapore): Micro-PPT (For orbit control & deorbit maneuver)

- Domestic Collaboration
  - Korea Astronomy & Space Science institute: Scientific payload for space weather measurement (SNIPE)

Payload

Launch
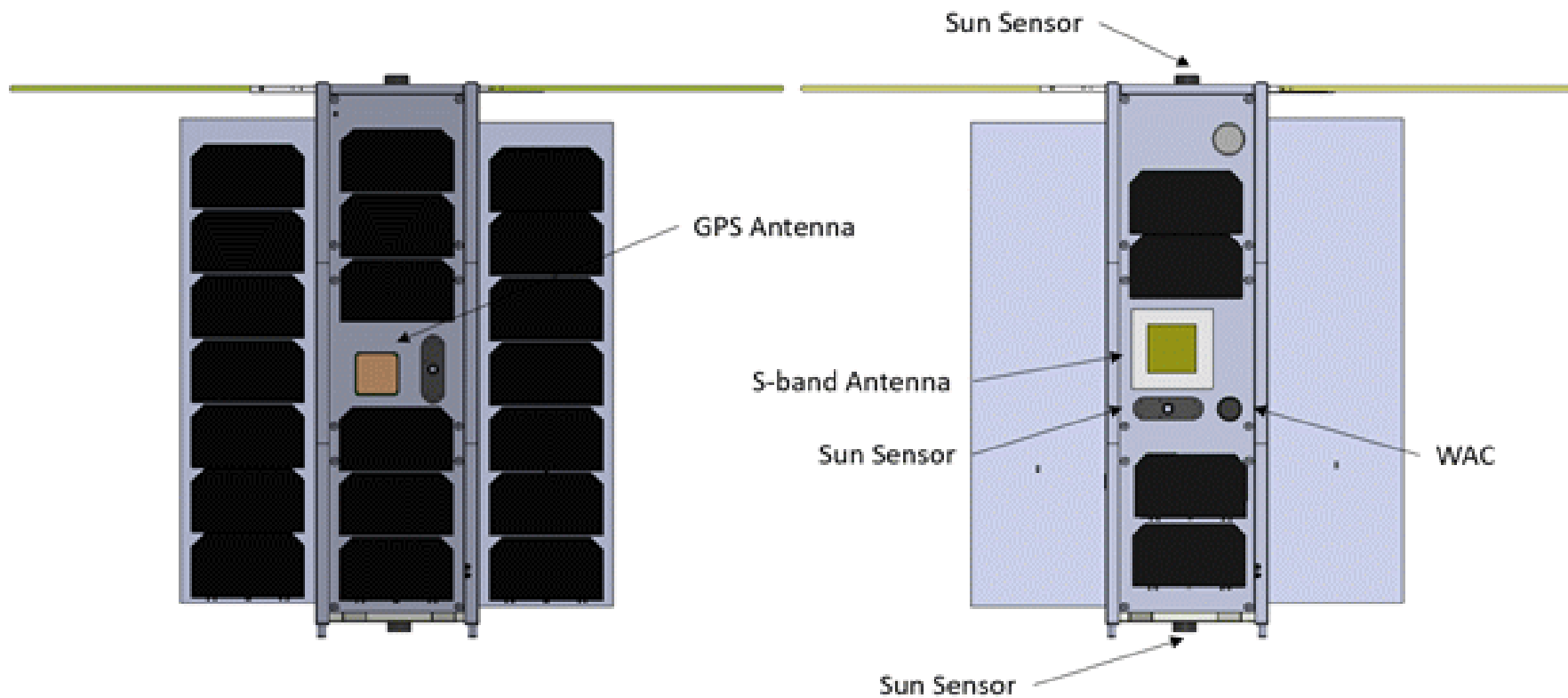
System Overview

System Overview
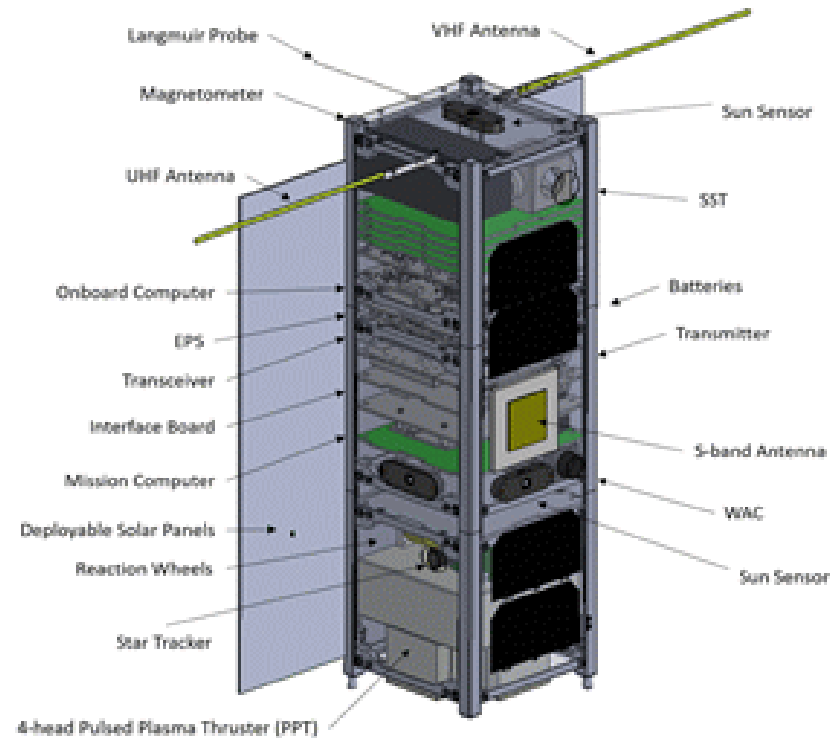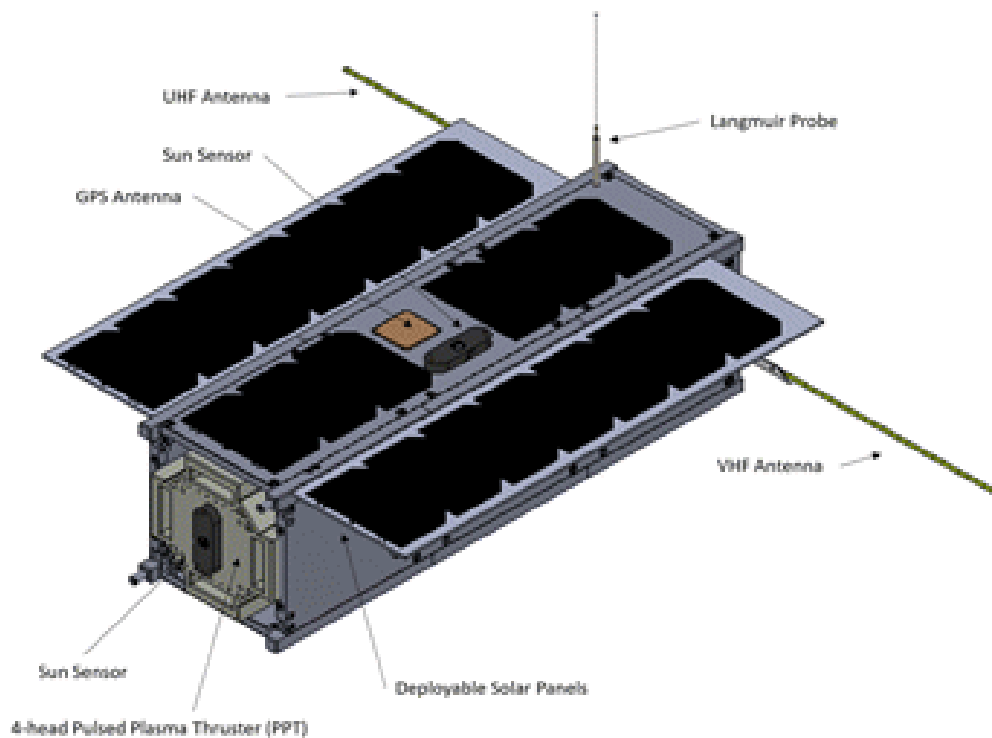
System Configuration

Operation Modes
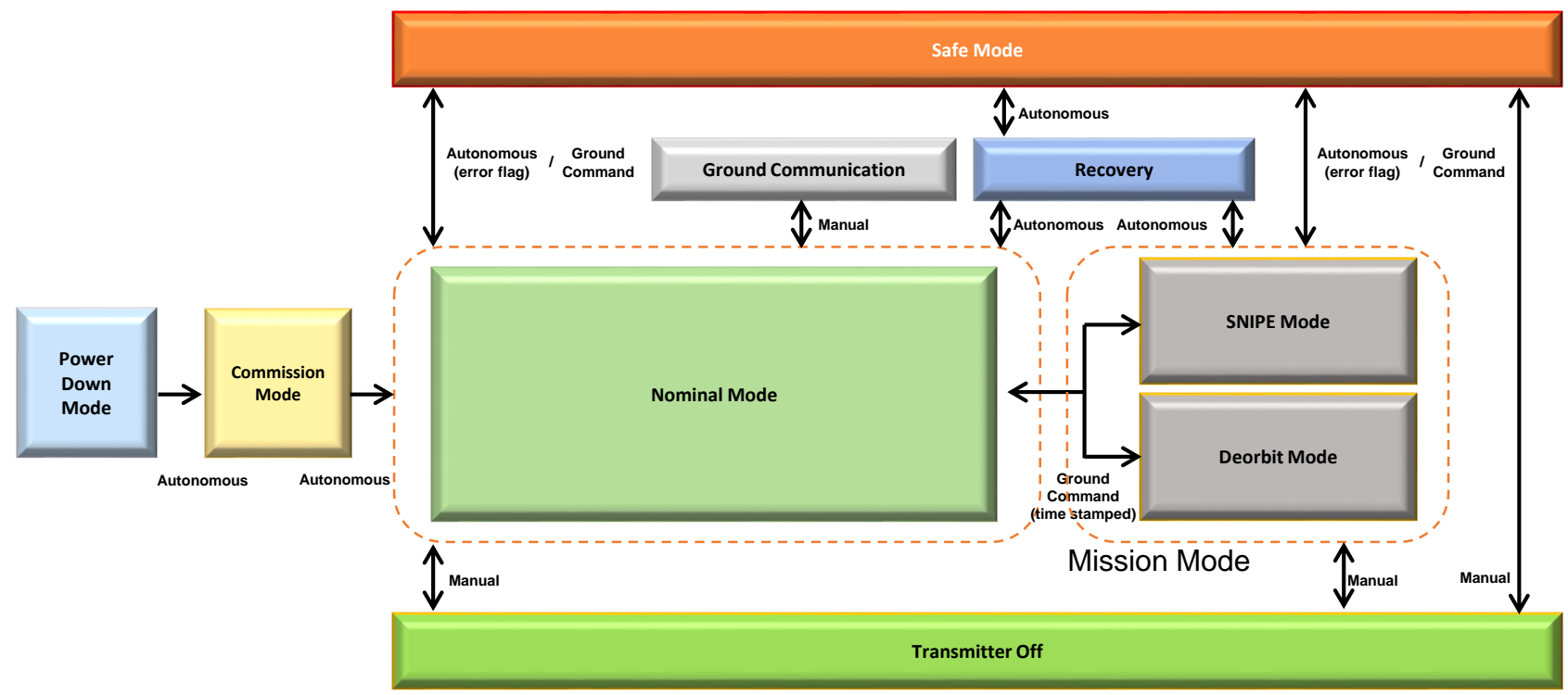
SNIPE

- Spatial measurement of plasma density, electron, magnetic wave
    - Energy dispersion of electron microbursts
    - Electron density and temperature in polar cap patches
    - Plasma trough during magnetic storms
    - Measure length of coherence for bubbles/blobs
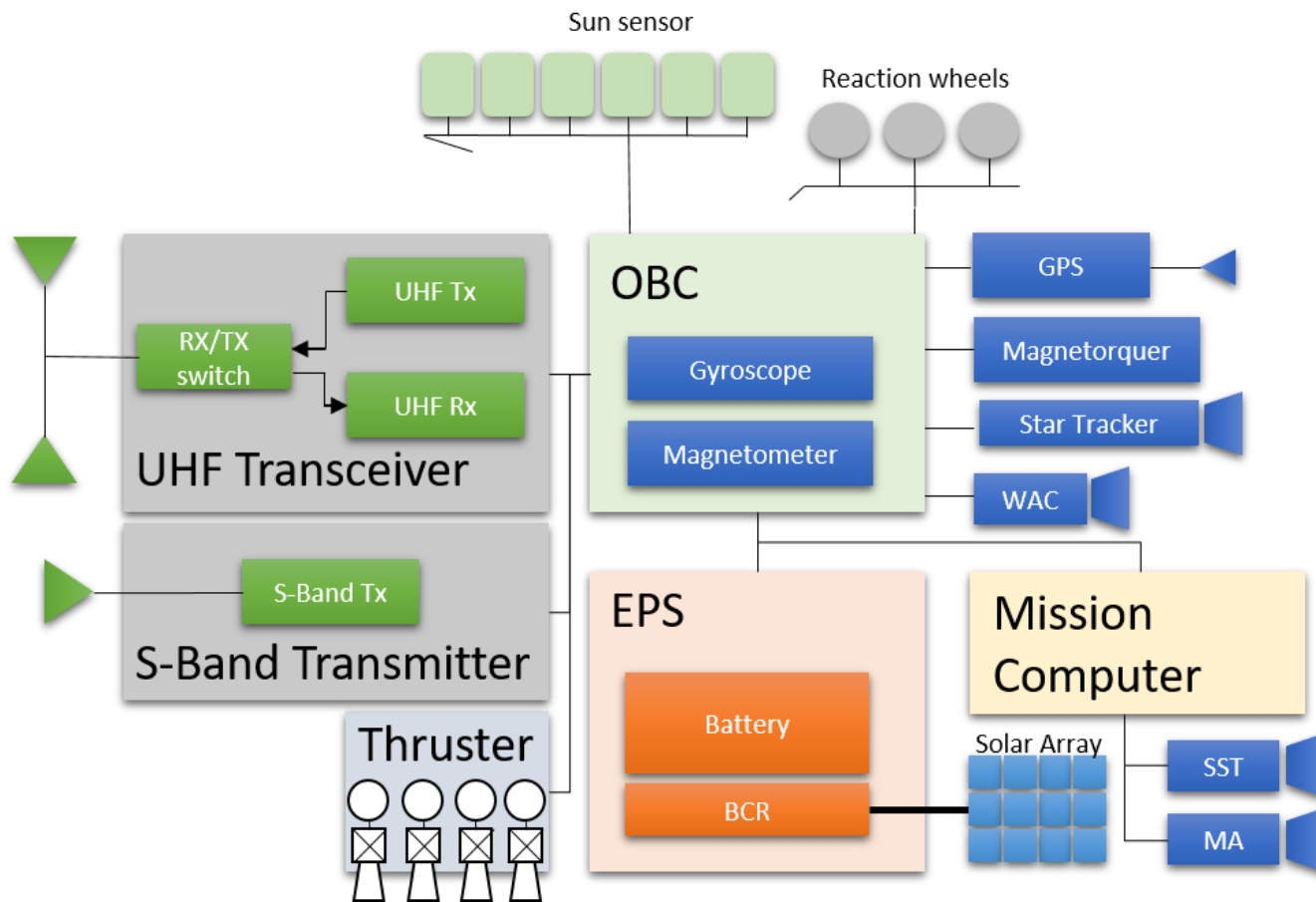   - EMIC waves at top of ionosphere
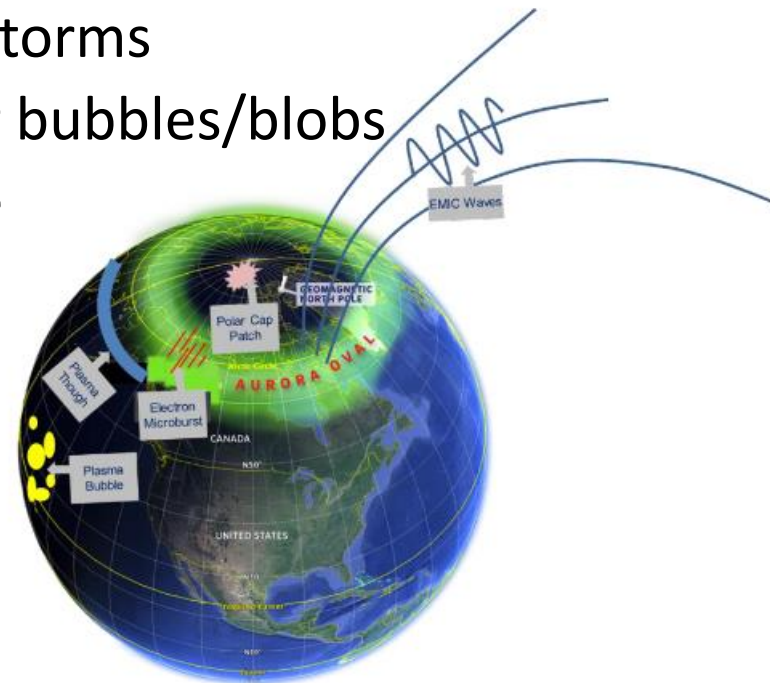
SNIPE

- Configuration of the scientific payload

Magnetometer

Electronic Boards

SST
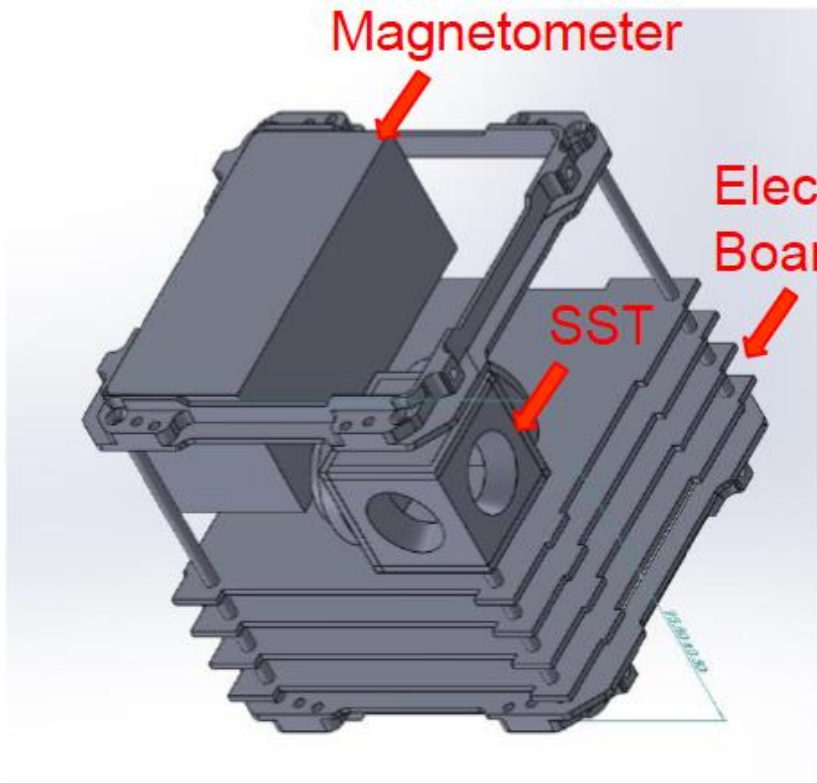
Langmuir Probe, will be attached on the Solar Panel.

Micro-Plasma pulsed thruster

- Maneuvering of the orbit needed for scientific payload measurement
- De-orbiting technology after the mission, to solve the space debris problem
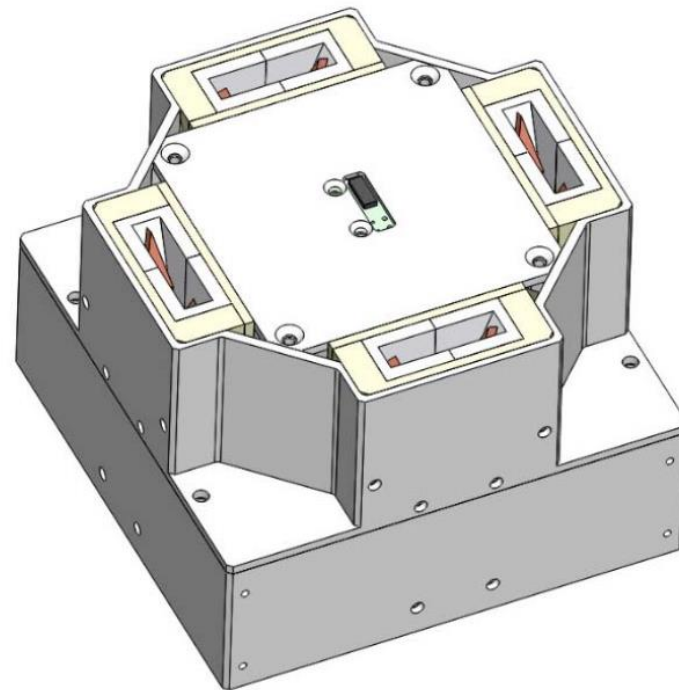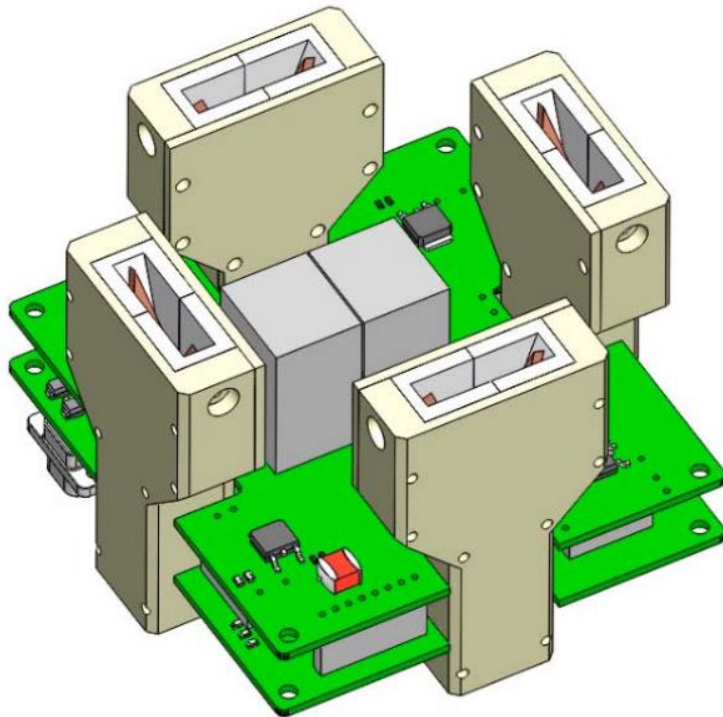
Schedule

Development status	Date
EM development	2018.06
Qualification test	2018.07~08
FM development	2018.12
Integration and acceptance test	2019.01~02

Near-Term Roadmap

Beginning Phase

Maturing Phase

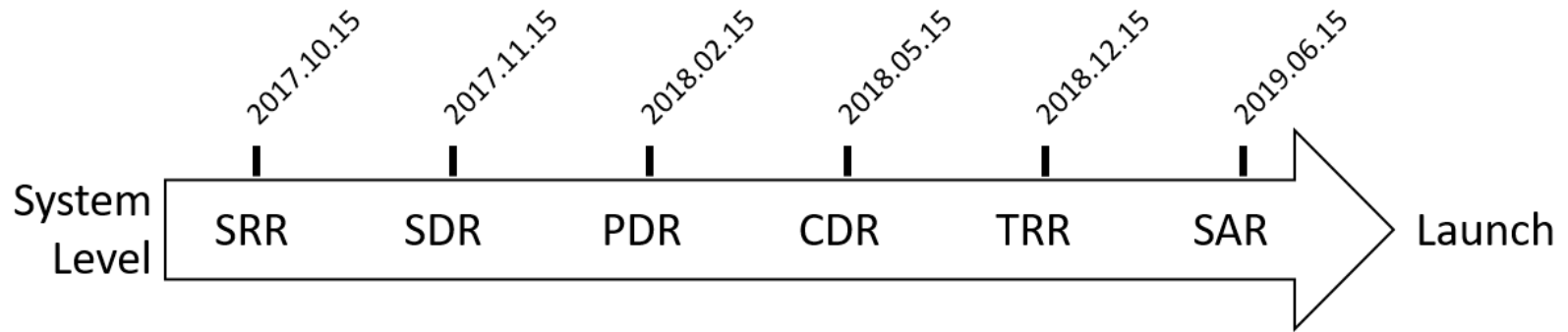SNUSAT-1/1b   SNUSAT-2   SNUSAT-3   SNUSAT-4   SNUSAT-5
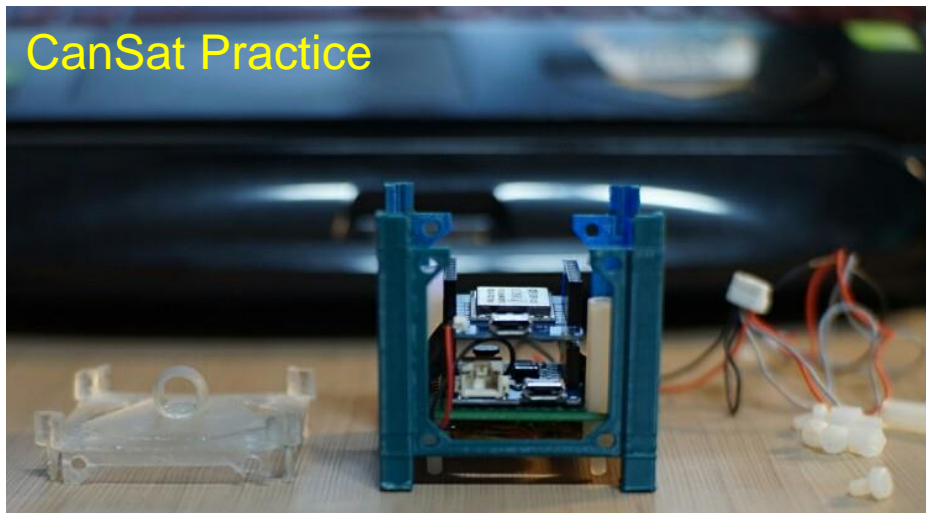
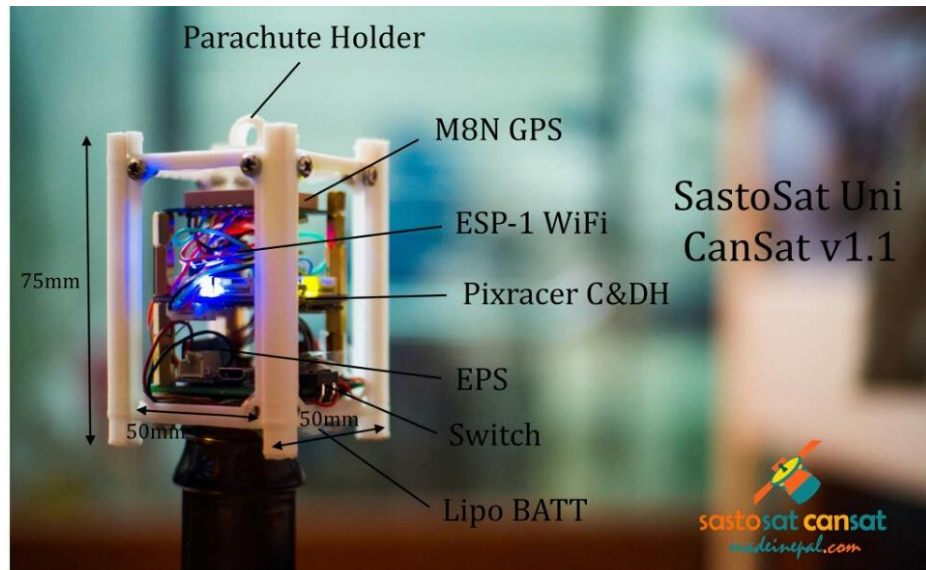2016   2017   2018   2020   2021

SNUSAT-E

- Learn the aspects of systems engineering and understand the practical aspects of a space project
- Learn how to schedule operation for the ground station and the satellite
- Develop education means using CubeSat

- Develop an advanced platform for future science and technology missions
- Increases international space project collaboration capability
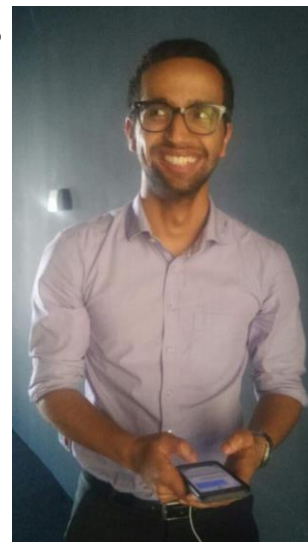- Actively participate in space sector pursuing academic achievements

Opportunities in Nepal

CanSat Practice

Next Generation Kids

Parachute Holder
M8N GPS
ESP-1 WiFi
Pixracer C&DH
EPS
Switch
Lipo BATT
75mm
50mm
50mm
SastoSat Uni CanSat v1.1
sastosat cansat
madeinepal.com

UN
Space Research

International Experts