Ten-Koh 2
LEO Research Satellite

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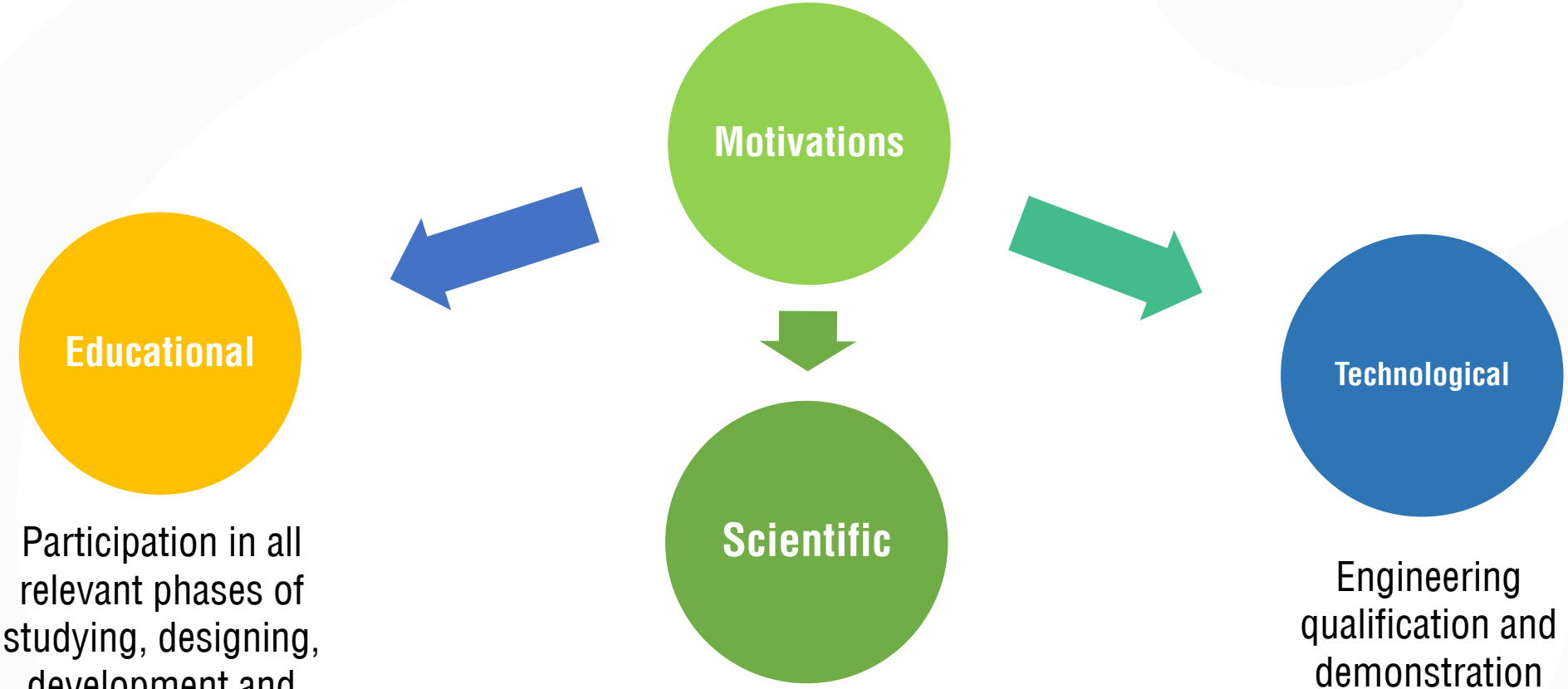
- GROUND SEGMENT

MOTIVATIONS



MISSION OBJECTIVES

The Ten-Koh 2 satellite missions are composed by the following main experiments

- Demonstration of operation of earth observation equipment (Sensor: CMOS plus optical lens)
- In-orbit testing of material properties and structural behavior of a 3D-printed PEEK/CFRP based CubeSat structure

MISSION OBJECTIVES

PRIMARY MISSION OBJECTIVES

ID	Objective	Minimum	Nominal	Maximum
PO1	To operate an earth observation equipment in LEO.	Taking images and download it to ground for a period of 6 months	Taking images and download it to ground for a period of 1 year	Taking images and download it to ground for a period of >= 1.5 years
PO2	To measure the thermal expansion properties of CF/PEEK in LEO.	To conduct strain, temperature and UV measurements for a period of 6 months	To conduct strain, temperature and UV measurements for a period of 1 year	To conduct strain, temperature and UV measurements for a period of >= 1.5 years

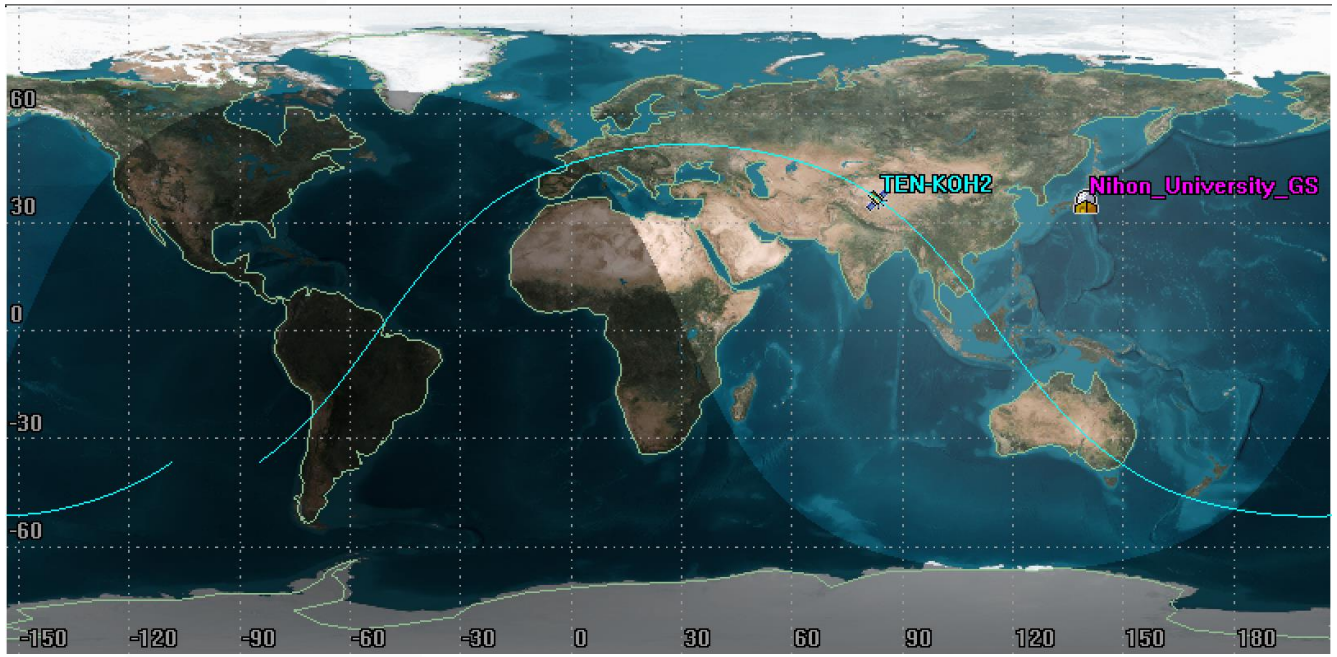
MISSION OBJECTIVES

SECONDARY MISSION OBJECTIVES

ID	Objective	Minimum	Nominal	Maximum
SO1	To develop a reliable, redundant and low-cost CubeSat bus system	Operate and upgrade of the Ten-Koh satellite bus for 6 months continuously	Operate and upgrade of the Ten-Koh satellite bus for 1 year continuously	Operate and upgrade of the Ten-Koh satellite bus for >= 1.5 years continuously

ORBIT DESCRIPTION

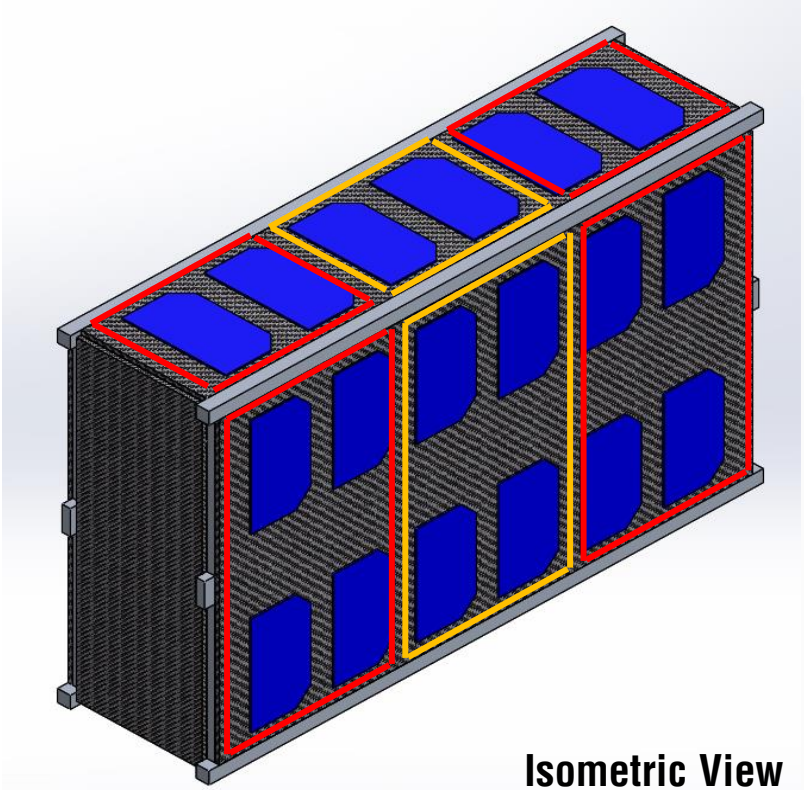
- Ten-Koh 2 is intended to be launched with the new HTV-X that will go to the ISS so the intended orbit is still to be defined. However, a consideration for an orbit similar to the ISS is selected as a first approach. The considered orbital parameters are:



Orbital element	Value
Perigee (km)	417
Apogee (km)	420
Inclination (deg)	51.6405
Longitude of the ascending node (deg)	100.7144
Eccentricity	0.0001796
Argument of perigee (deg)	348.2456
Mean anomaly (deg)	11.8652

SATELLITE GENERAL SPECIFICATIONS

- **NAME:** Ten-Koh 2
- **FORM FACTOR:** CubeSat 6U
- **SIZE:** 100 x 200 x 300 (mm)
- **MASS:** < 14 (kg)
- **NUMBER OF MISSIONS ON-BOARD:** 2
- **COMMUNICATIONS:** UHF
- **ATTITUDE CONTROL:** ACTIVE
- **LAUNCH DATE:** 2022 (TBD)
- **LAUNCH VEHICLE:** H3B
- **LIFETIME:** > 1 year in orbit

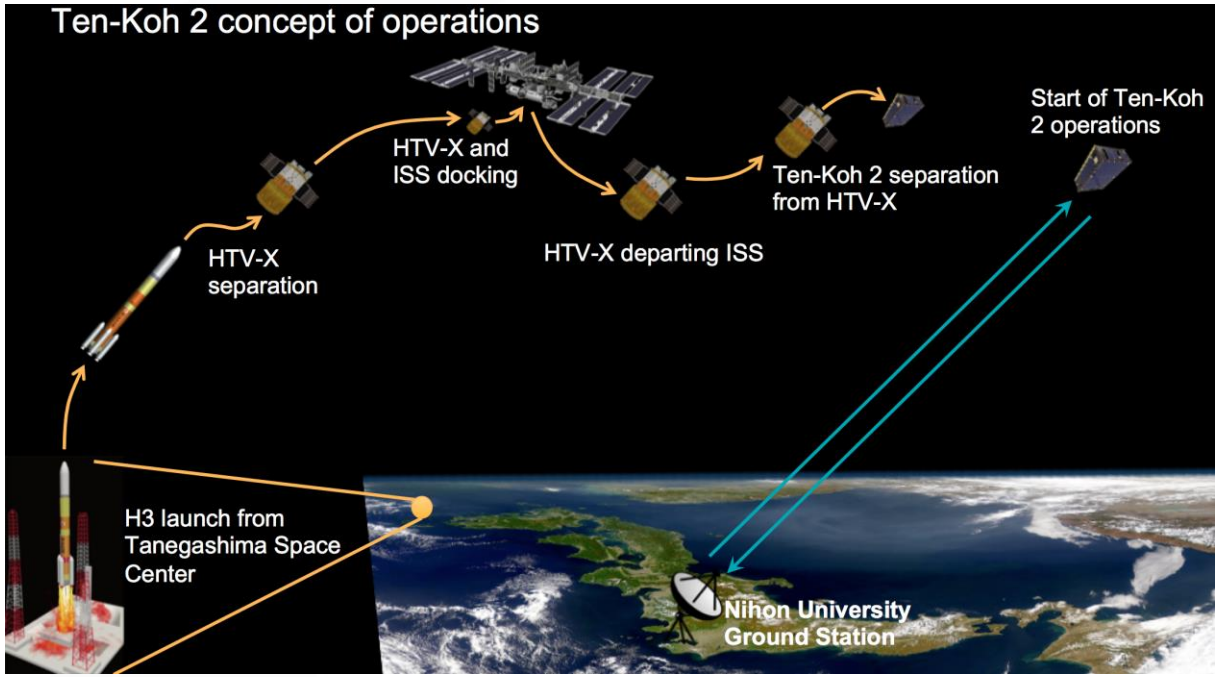


Isometric View

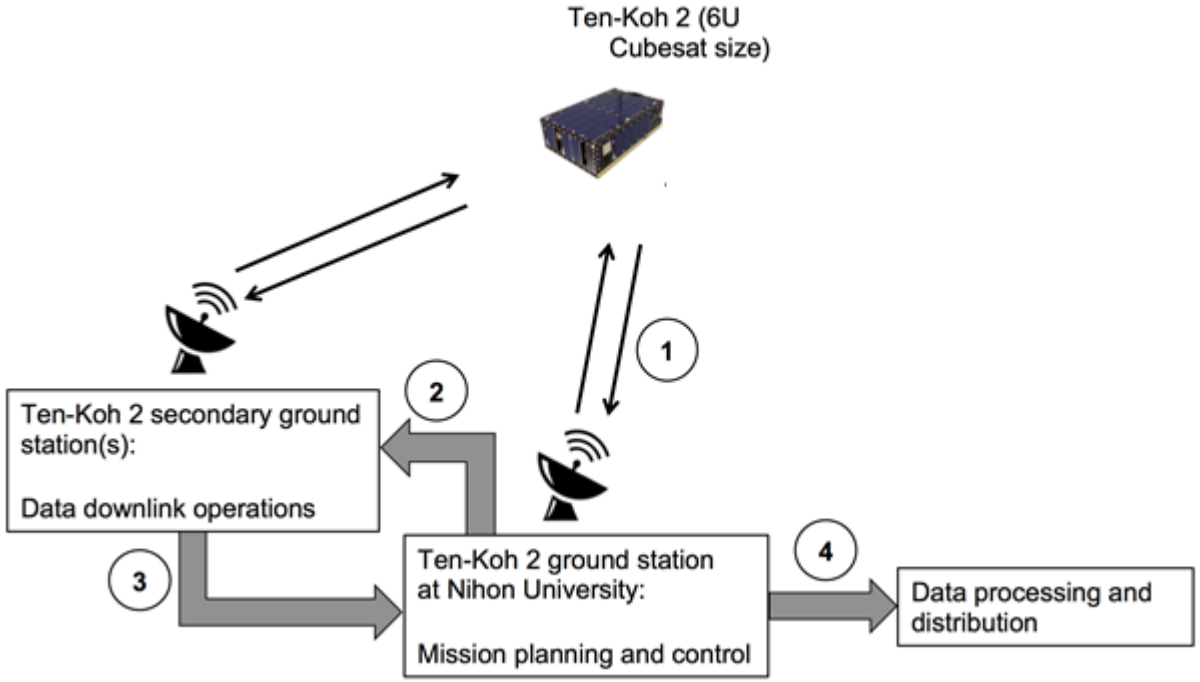
IN ORBIT OPERATIONS

No.	Mission Phases	Duration	Description
1	LEOP	2 weeks	• Starts after separation from HTV-X vehicle. • Deployment of antennas and solar panels (if applicable). • Subsystem and instruments power on. • Comprehensive satellite subsystem checkout. • Recording of satellite telemetry data (TM) • Downlinking and analysis of satellite TM (housekeeping and payload data) using the main ground station (GCS) and secondary ground station(s) (SGS). • Check the operation of the payload instruments. • Transition to Normal operation.
2	Normal operation	6 months - 12 months	• Science data collection. • Long and short term planning of payload instruments. • Communication sessions with the ground control station (GCS).
3	Extended operation	18 months	• Variations in science operations. • Orbital decay monitoring.
4	End of mission	After 18 months depending on orbital decay	• Planning and execution of end-of-life operations.

IN ORBIT OPERATIONS



Ten-Koh 2 concept of operations



Ten-Koh 2 communication architecture

SPACE SEGMENT

- The satellite bus architecture has been designed to be able to fit into 6U CubeSat.
- It has all the main subsystem for a complete operation in orbit and payloads (experiments)

- **The bus subsystems are:**
  - On-Board Computer (OBC)
  - Electronic Power System (EPS)
  - Communication System (COMM)
  - Attitude Determination and Control System (ADCS)
  - Thermal System (TCS)
  - Structure

- **The payloads are:**
  - Earth Observation Equipment (Sensor: CMOS + optical lens)
  - In-orbit testing of material properties of CF/PEEK

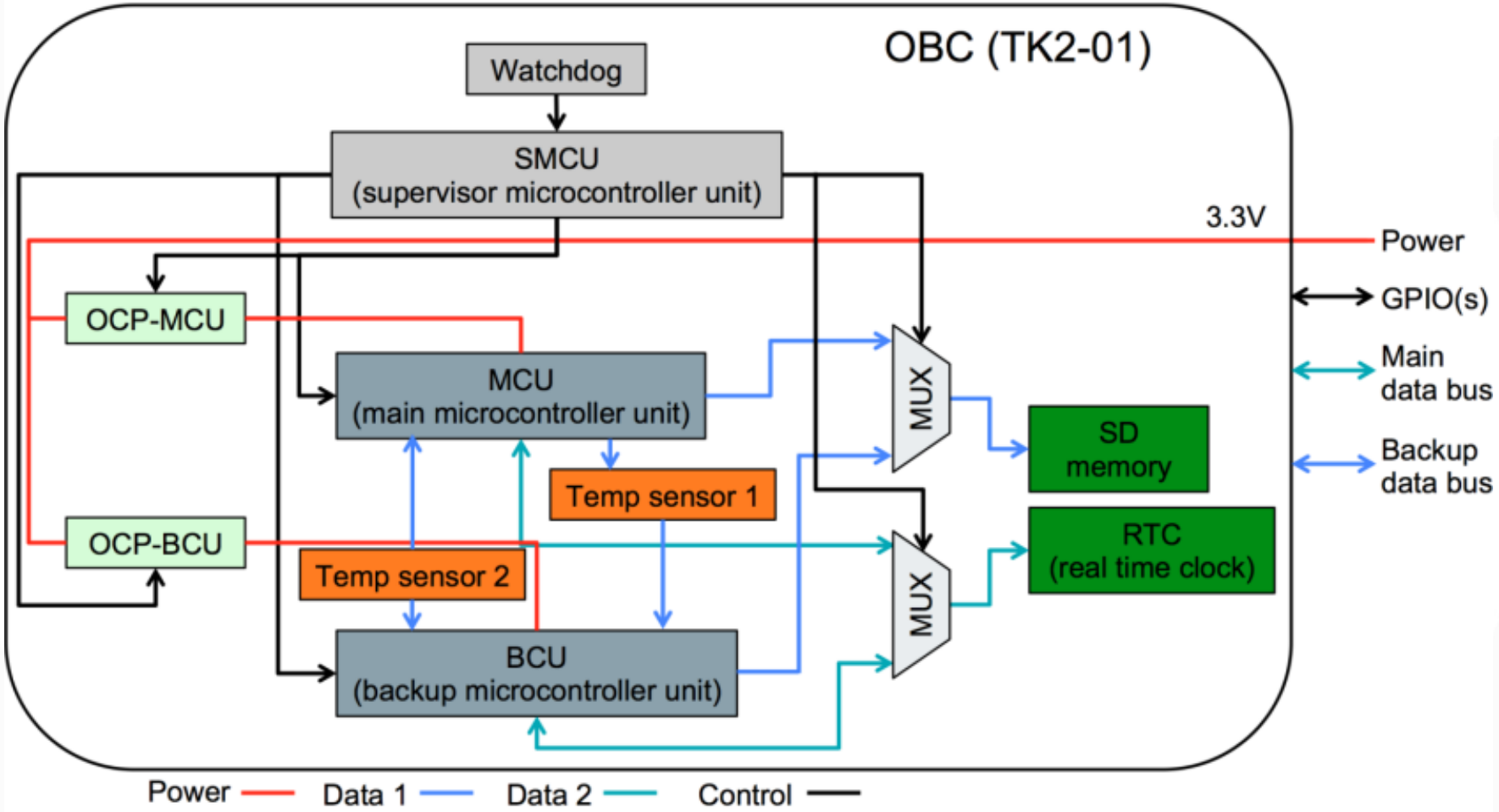
SPACE SEGMENT (BUS)

ON-BOARD COMPUTER (OBC)

- It is responsible for commanding other sub-systems and payloads, as well as managing all data.
- It would be similar to the one of Ten-Koh.
- It contains 2 cold-redundant programmable integrated circuits (PIC), one SD card memory and one Real Time Clock (RTC)
- It connects to other subsystems and peripheral devices using 3 different protocols: I2C, SPI and UART
- The same protocols are used in all subsystems. This allows maximum software reuse, which reduces development time.

SPACE SEGMENT (BUS)

ON-BOARD COMPUTER (OBC) ARCHITECTURE



SPACE SEGMENT (BUS)

ELECTRICAL POWER SUBSYSTEM (EPS)

- The Power Subsystem shall provide a regulated voltage (12V and 5V) and enough power during all the satellite operating modes for a minimum period of 1 year, and all mission's scenarios, from orbit until the end of mission. A system with redundancy shall be included.

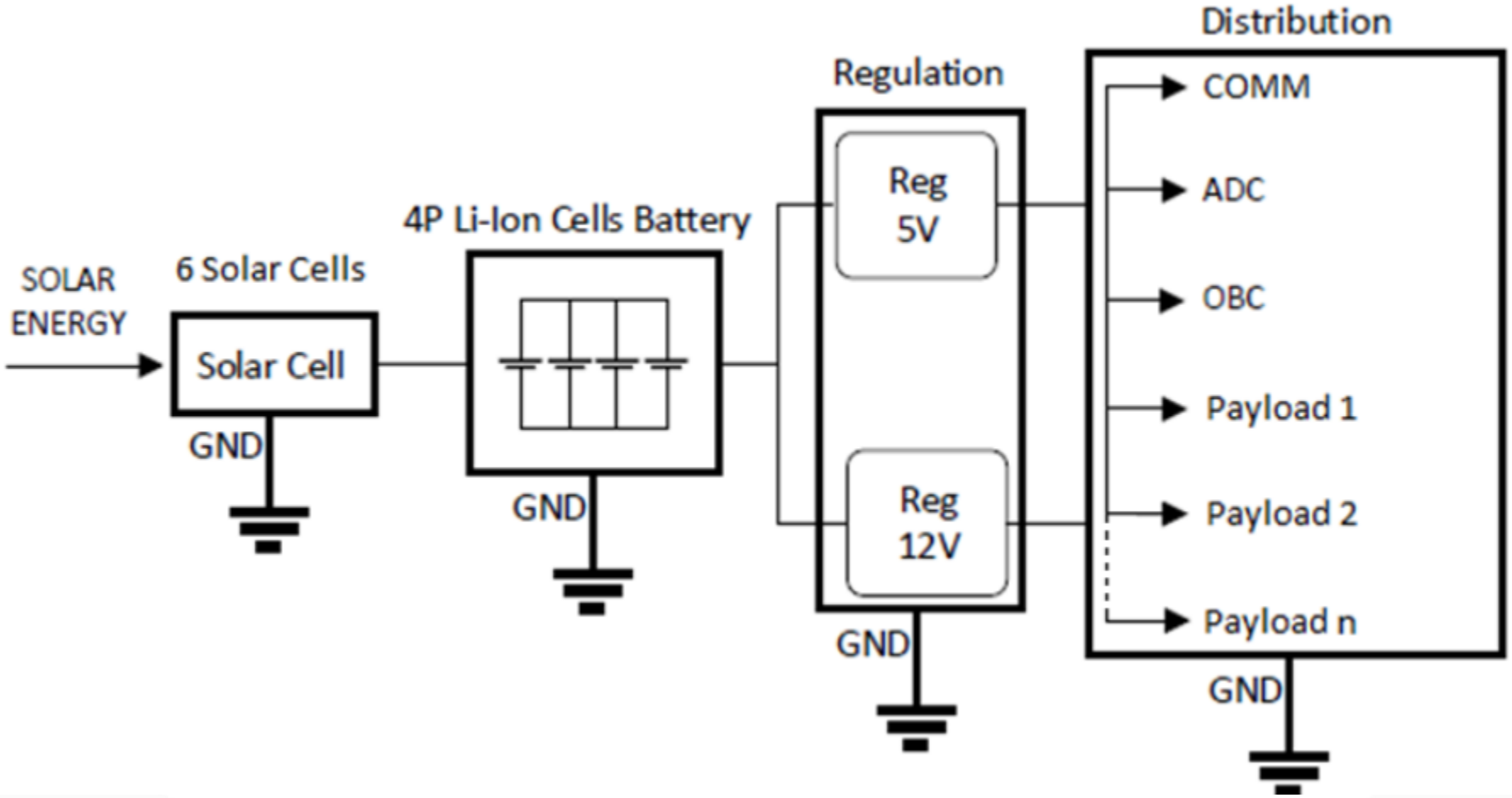
- Power is provided during sunlight operation by using six triple junction solar cells mounted on one panel, and for all the four lateral panels of the structure.

- During the eclipse, 4 Li-ion Batteries will be used as the secondary power source. The nominal rated capacity is 3200mAh (~10Wh) for one cell

- Ten-Koh 2 batteries shall be designed to have the capability to power all the satellite bus and missions without any other source, it shall be designed to provide power to all the missions and bus system at its maximum power and each modes.

SPACE SEGMENT (BUS)

ELECTRICAL POWER SUBSYSTEM (EPS) ARCHITECTURE



SPACE SEGMENT (BUS)

ATTITUDE DETERMINATION AND CONTROL SYSTEM (ADCS)

- This system is responsible to maintain the orientation of the satellite with the required accuracy to guarantee the correct functionality of the image equipment payload.
- The pointing accuracy should be ~ 3 degree
- The pointing knowledge should be ~ 1 degree

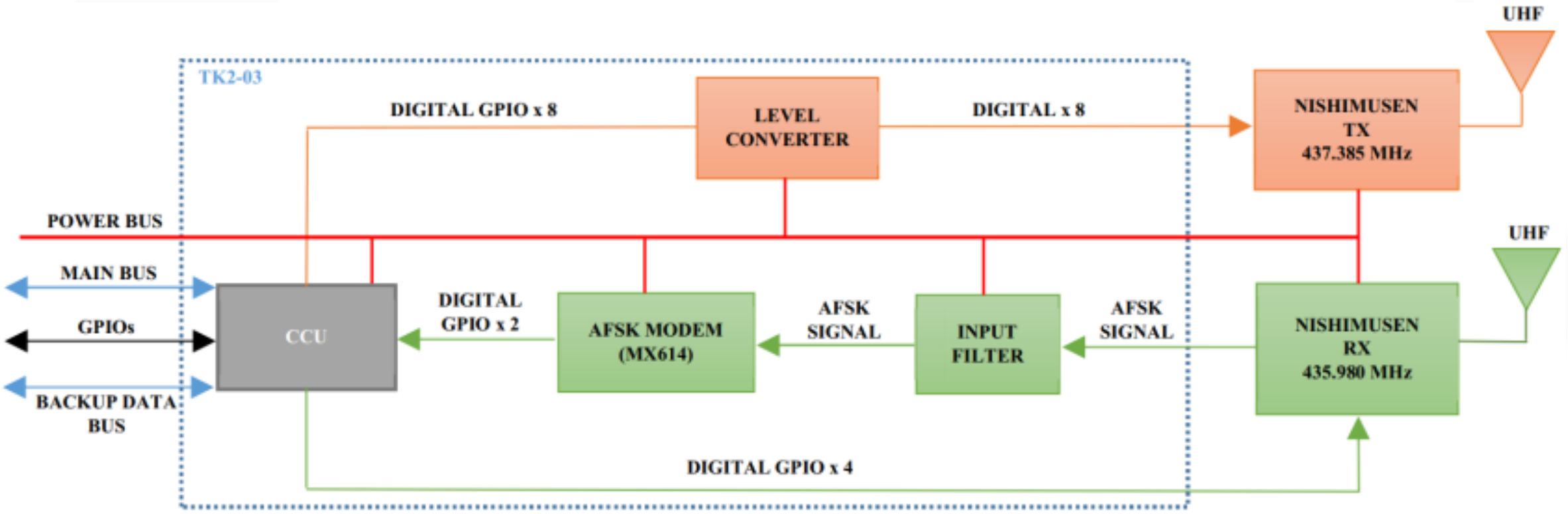
SPACE SEGMENT (BUS)

COMMUNICATION SUBSYSTEM (COMM)

- The Ten-Koh 2 communication subsystem consists of two lines of communications, both were designated to work in the Ultra-High-Frequency (UHF) band.
- The downlink line includes a transmitter at 437.390 MHz and the uplink line includes a receiver at 435.285 MHz for downlink.
- The main purpose of the communication system is to receive uplink commands from the ground station and downlink data from satellite to ground station using the specified frequencies.

SPACE SEGMENT (BUS)

COMMUNICATION SUBSYSTEM (COMM) ARCHITECTURE



SPACE SEGMENT (BUS)

THERMAL CONTROL SYSTEM (TCS)

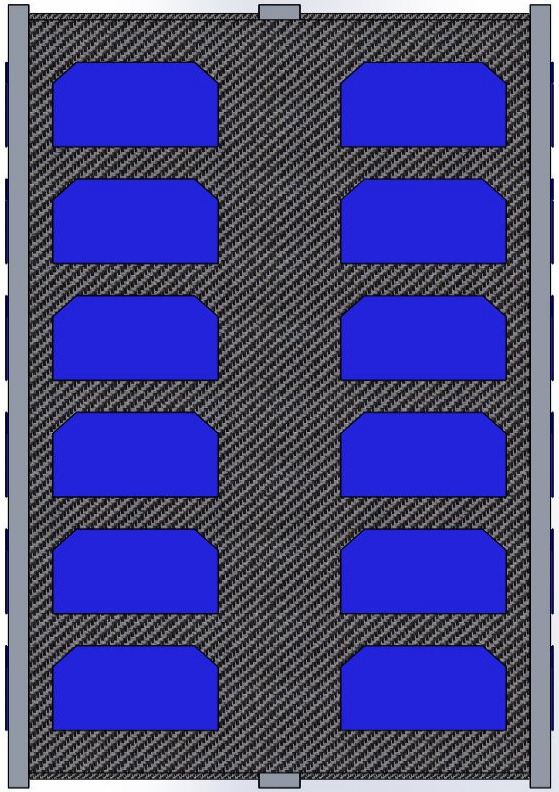
- TCS shall control satellite and components temperature range, temperature difference, temperature gradients, temperature stability, and temperature uniformity. TCS shall store satellite and components thermal energy and release it when needed.

- TCS shall consist on passive control,

- When a passive thermal system is used, the complexity of a satellite is reduced, and there are more resources available on small satellites to be used for payload function.

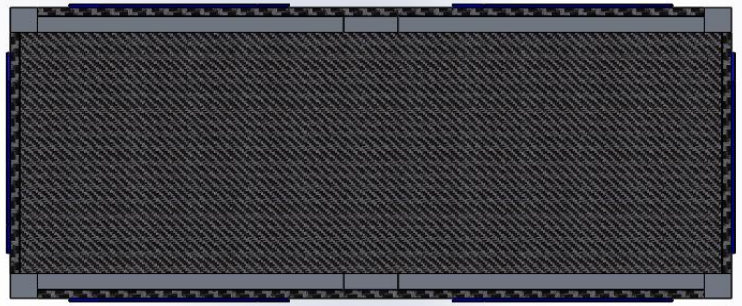
SPACE SEGMENT (BUS)

STRUCTURE

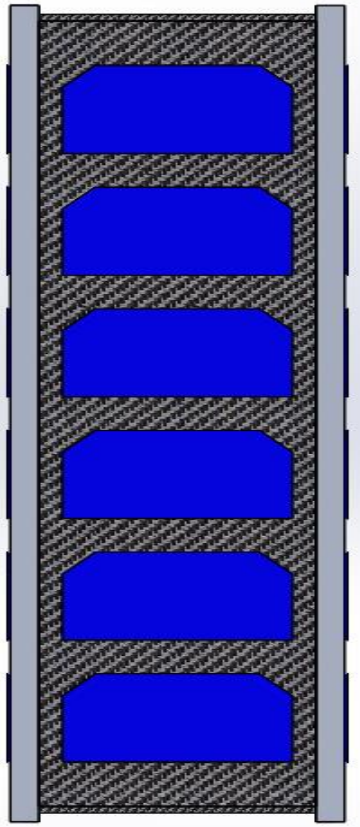


Front View

- Satellite structure will be made by aluminum and CF/PEEK material,
- All panels will be 3D printed CF/PEEK
- The corner rail by aluminum,



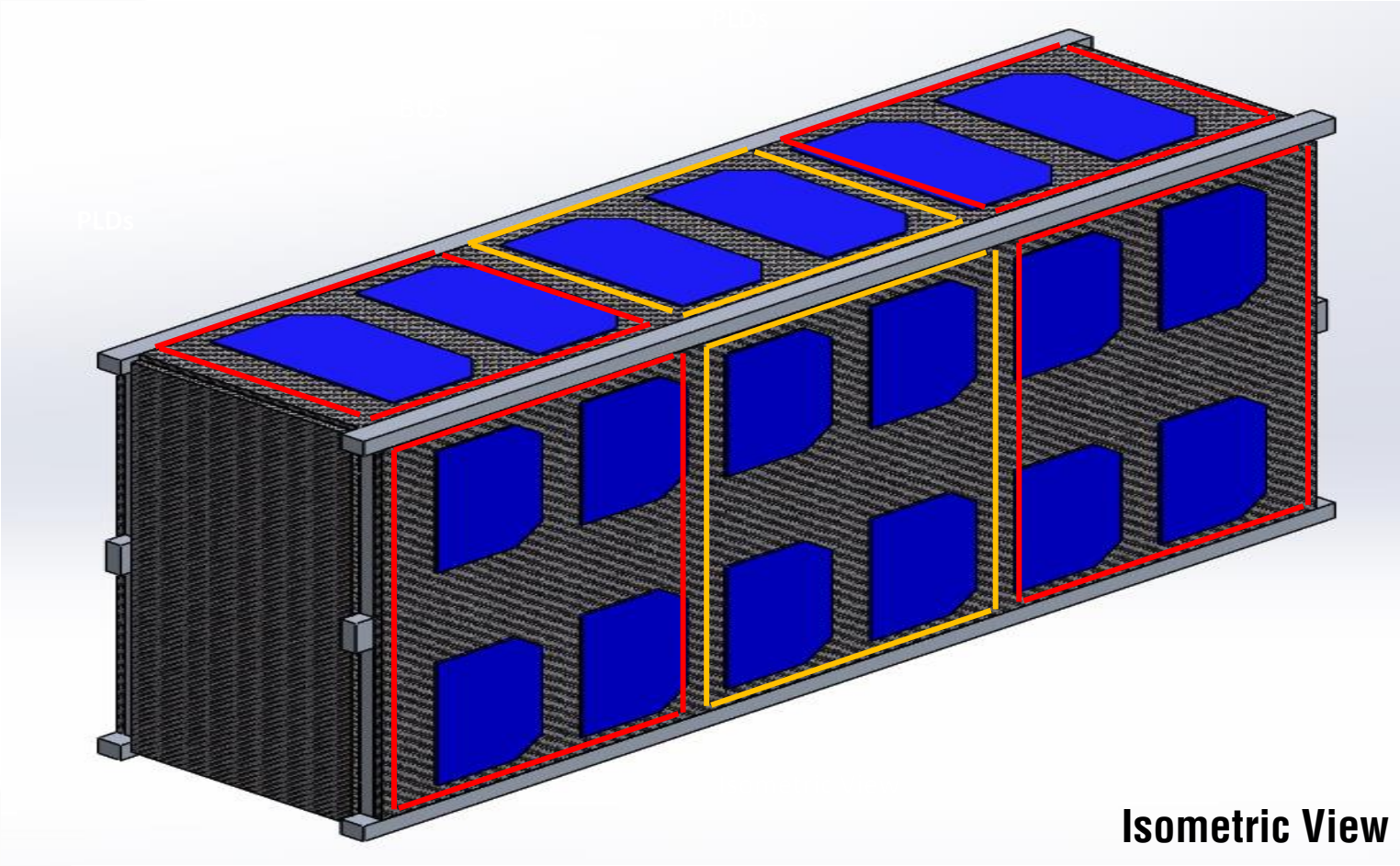
Top View



Side View

SPACE SEGMENT (BUS)

STRUCTURE



Isometric View

SPACE SEGMET (PAYLOADS)

EARTH OBSERVATION EQUIPMENT

The purpose of this payload is to demonstrate the operation of a camera system developed by the National Cheng Kung University in Taiwan

- **SIZE:** 2U
- **MASS:** Approximately 700g (Optical Equipment: 450g + Other: 250g)
- **POWER CONSUPTION:** TBD

SPACE SEGMET (PAYLOADS)

MATERIAL MISSION

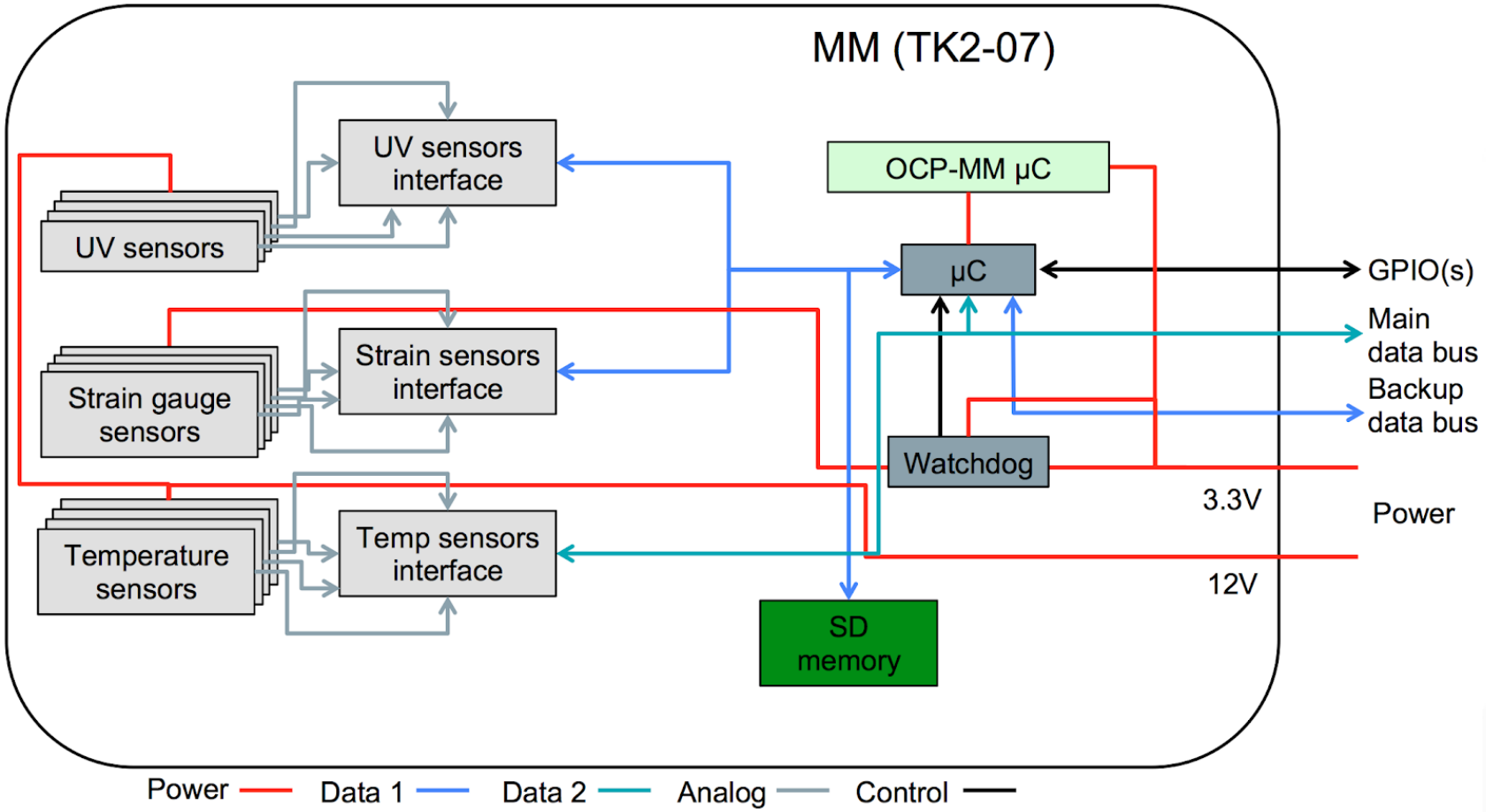
The purpose of the material mission experiment is to measure the long duration thermal expansion behavior of carbon fiber/ polyether ether ketone (CF/PEEK) in space.

REQUIRED HARDWARE

- Four 2-element strain gauge four strain measurements.
- Four temperature sensors for temperature measurements.
- Four UV sensors to measure UV irradiation intensity.
- One real-time clock (RTC) for time stamp of the data generation,
- One SD card for data storage,
- One microcontroller for the control, management of the data acquisition, and communication with OBC.

SPACE SEGMET (PAYLOADS)

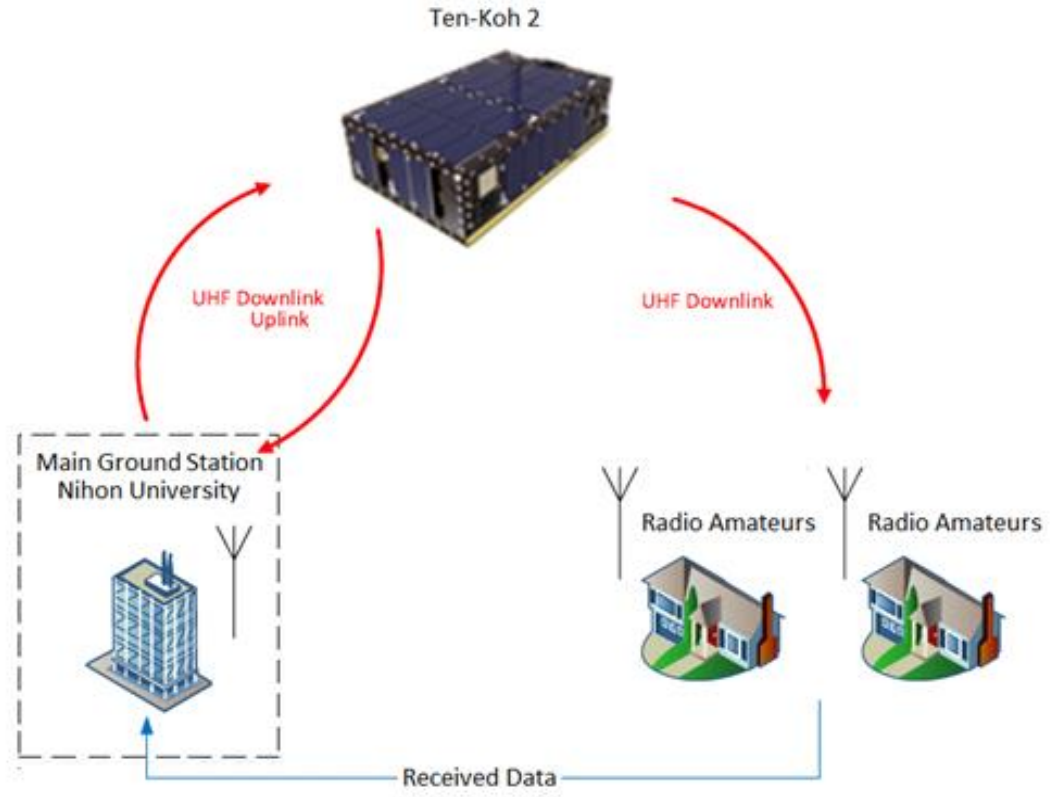
MATERIAL MISSION ARCHITECTURE



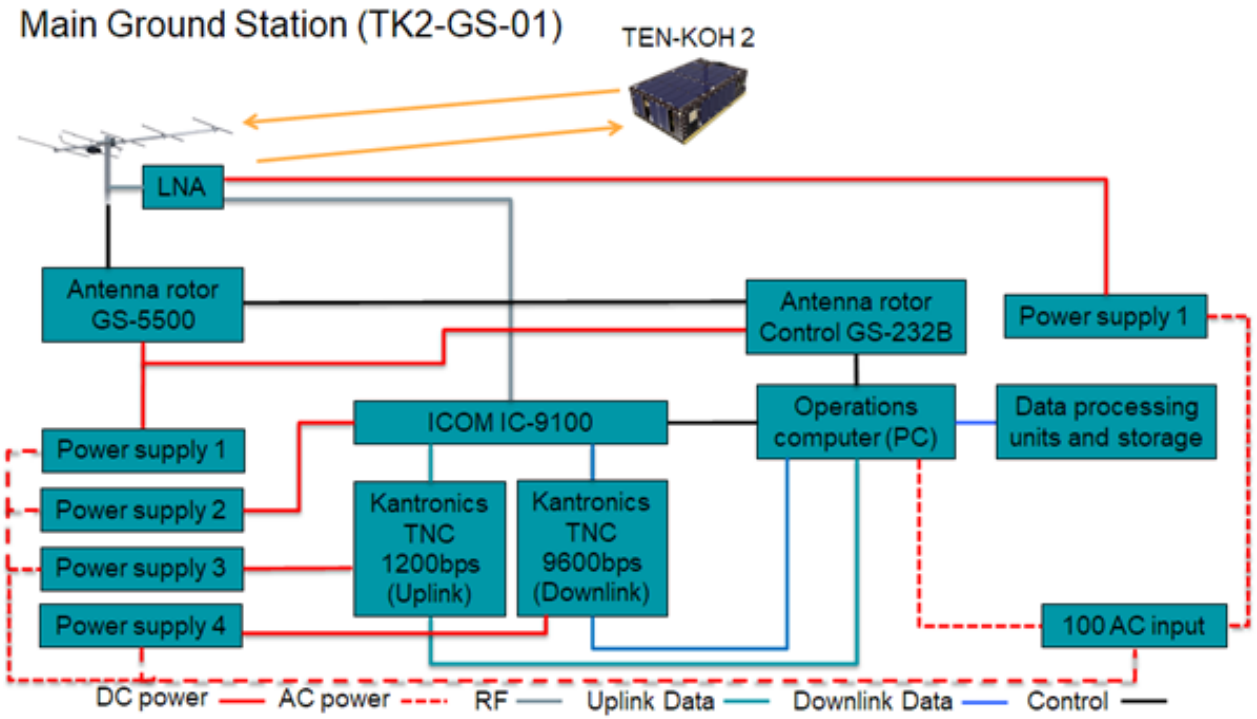
GROUND SEGMENT

- Using the same communication module as heritage from Ten-Koh, the communication with Ten-Koh 2 shall use the same ground station equipment as Ten-Koh.
- Ten-Koh 2 will use amateur radio band frequencies for communication, and the allocation frequency shall be the same as for Ten-Koh.
- The location of the main ground station shall be in the designated facilities at Nihon University.
- The communication between the Main Ground Station (MGS) and the radio amateur community resides on the use of regular internet connection. The communication between the Ten-Koh satellite and the MGS uses a UHF bidirectional radio link with 1200 bps for the uplink and 9600 bps for the downlink. The downlink between the satellite and the radio amateur community is implemented by the reception of the continuous wave (CW) beacon signal, containing basic satellite housekeeping telemetry and status. It will be represented in the following pictures.
- A dedicated software for decoding the satellite beacon signal shall be provided by the Ten-Koh 2 team to the radio amateur community with instructions about its installation and use.

GROUND SEGMENT



Graphical representation of the operations of the Ten-Koh 2 satellite using a radio amateur band and the support of the amateur community around the world.



MGS block diagram

THANK YOU FOR YOUR ATTENTION