

Use of BIRDS Open-Source Standardized BUS in Munal, Danfe and Danfe-2

Antarikchya Pratisthan Nepal

[Space Foundation Nepal]

May 10 2023

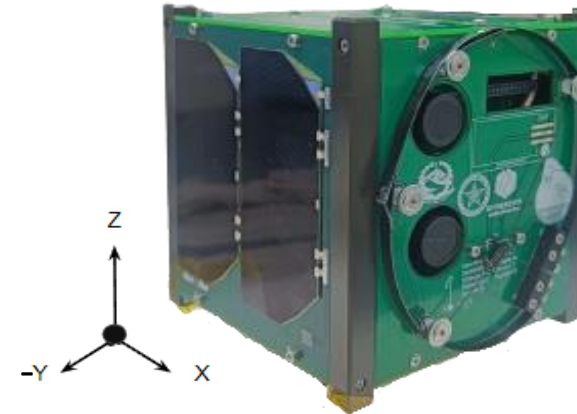
MUNAL

High School Satellite Consortium



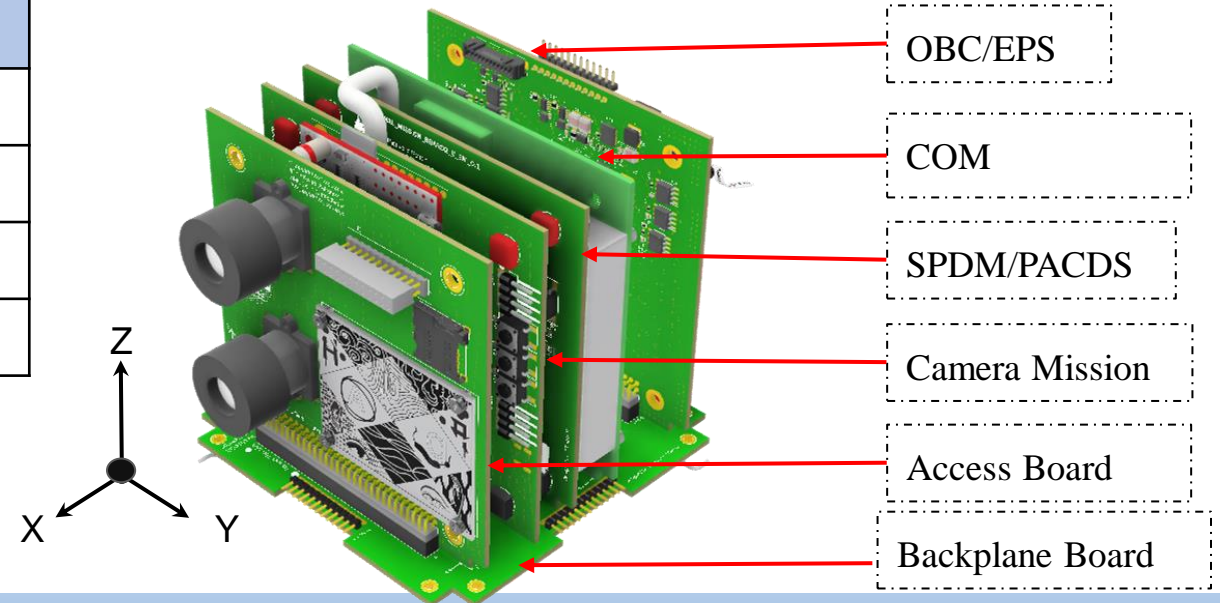
Objectives:

- In house design, build, test and launch of Nepal's first High School CubeSat
- To demonstrate novel SPDM based COM/OBC designed in-house
- To give continuity and improvement to two Missions of NepaliSat-1: Store & Forward (S&F) and Imaging Mission



Specifications	
Dimension	1U (100X100X113.5) mm
Weight	1.051 kg
Harness	Backplane Board
Missions	Camera, PACDS, SPDM, Art mission

OBC : On-Board Computer
 EPS : Electrical Power Supply
 SPDM : Satellite System on Chip Payload Demonstration Mission
 PACDS : Passive Attitude Control and Determination System



Orbital characteristics

- Expected launch from PSLV on August 2023

S.N.	Parameters	LEO	SSO*
1.	Inclination	51.64°	97.5 °
2.	Altitude	400 km	550 km
3	Orbital Velocity	7.5 km/sec	7.8km/sec
4.	Period	90 min.	95 min.

LEO: Low Earth Orbit
SSO: Sun-Synchronous Orbit

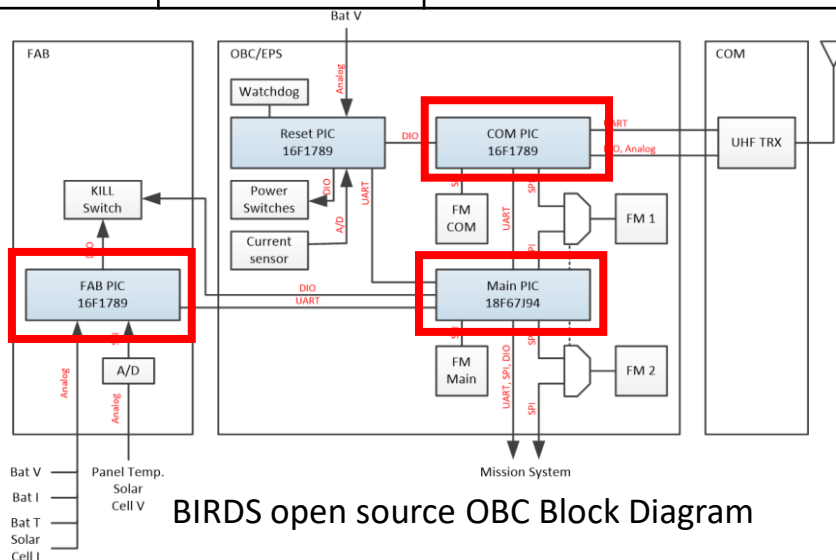
* Data presented according to previous Missions characteristics



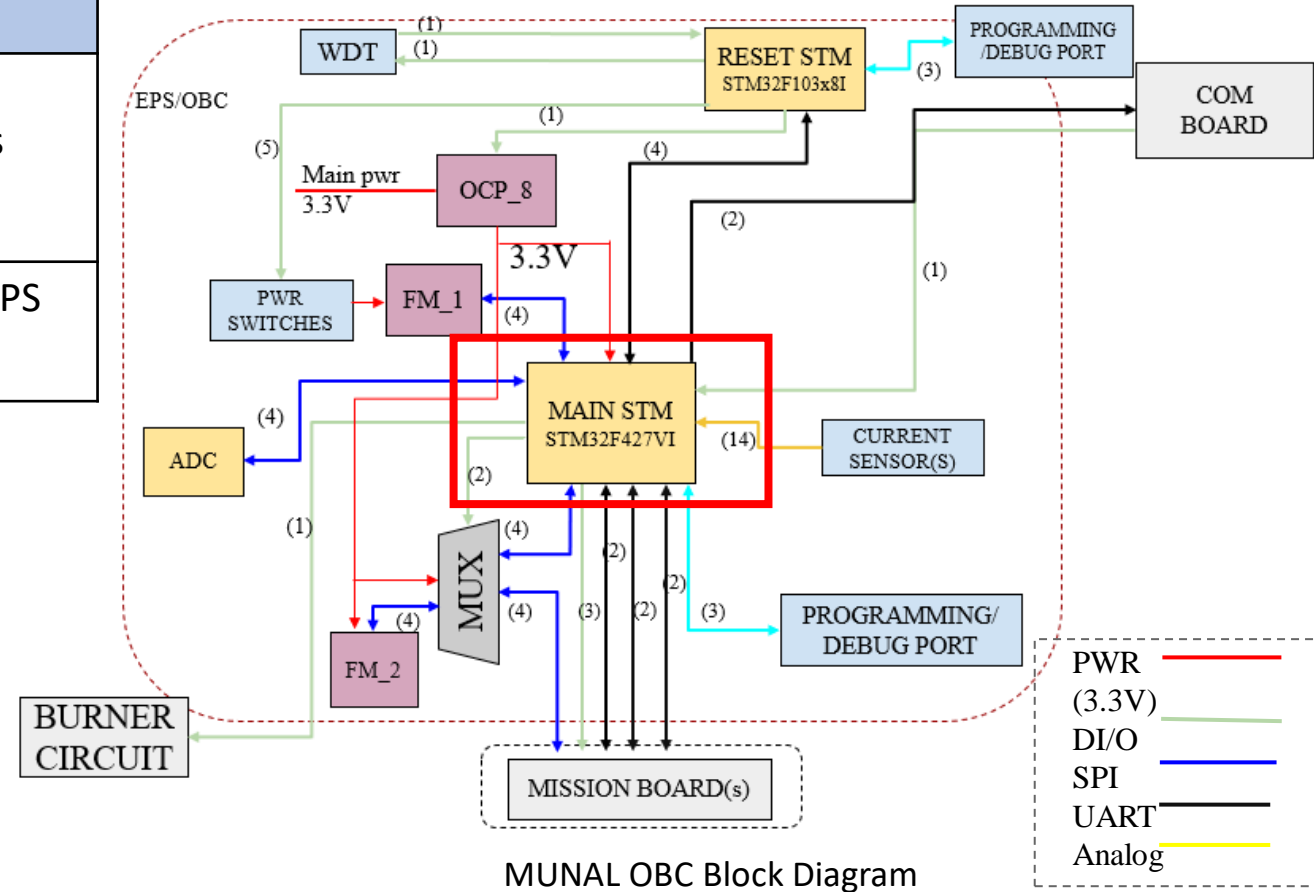
OBC/EPS (Single Board)

Changes from BIRDS open source bus

	BIRDS	MUNAL	Description
MCU	FAB, Main, COM PIC	Main STM (STM32F4 series)	Main STM in Munal used to perform task of all three PICs
Boards	FAB and OBC/EPS	OBC/EPS	FAB is integrated with OBC/EPS board.



BIRDS open source OBC Block Diagram

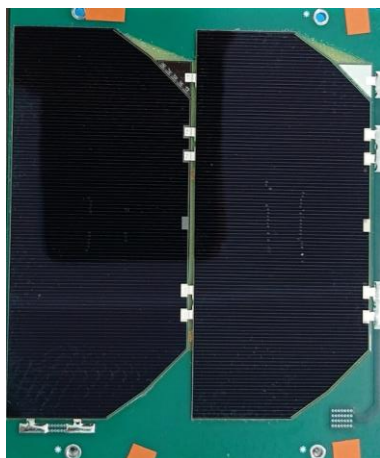


MUNAL OBC Block Diagram

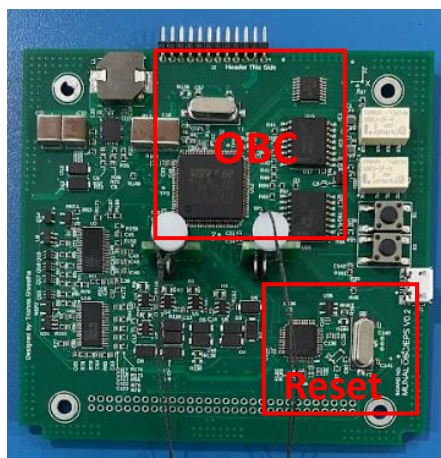
OBC/EPS BOARD: EPS (Electrical Power System)

Power Generation	
Cell Type	SolAero Cells
Cell Efficiency	29.5%
Electrical Performance	Voc = 2.726 V, Isc = 522mA
Area	30.4 cm ²
Azur Space Solar cells on -X Panel.	

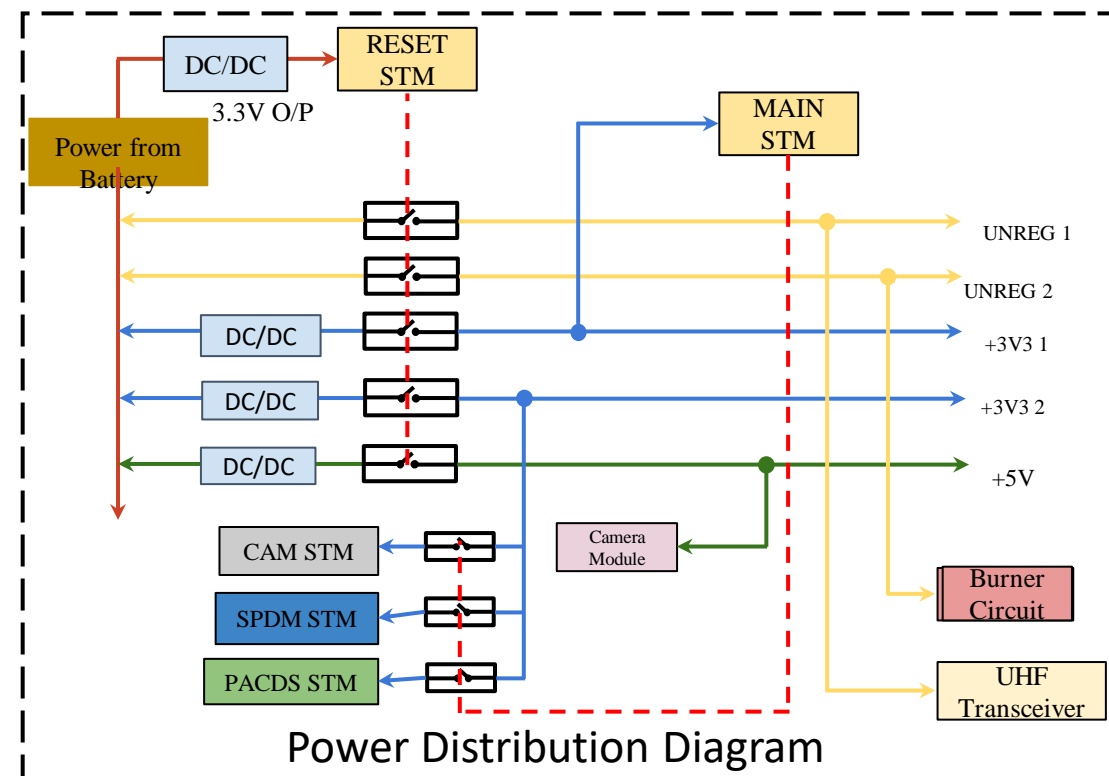
Power Storage	
Battery Type	Nickel Metal Hydride Batteries, AA
Capacity / nominal Voltage	2450 mAh / 1.2 Volts
Battery Configuration	3S2P



Solar Panel



EPS/OBC board

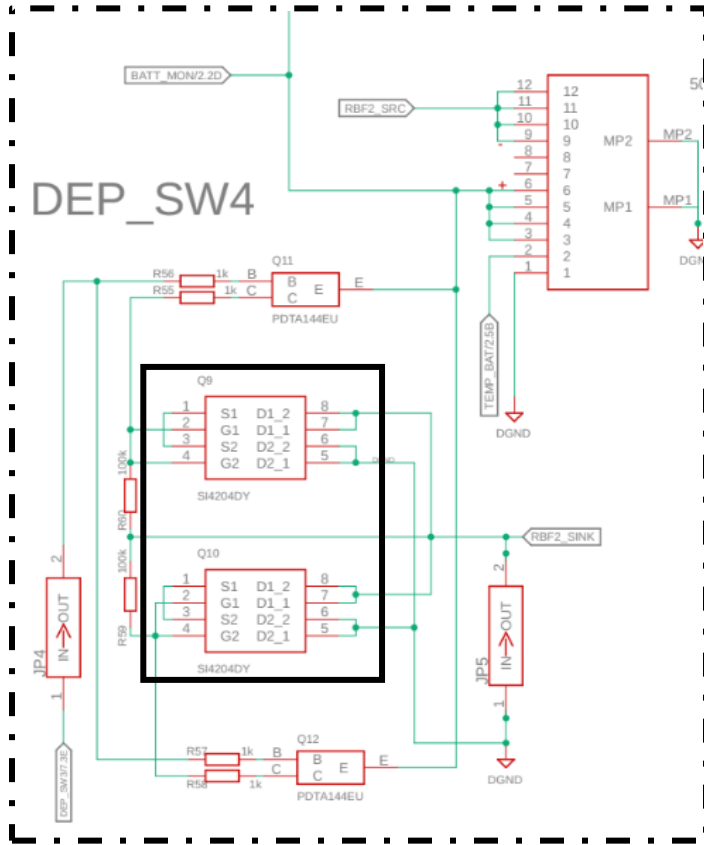


Power Budget

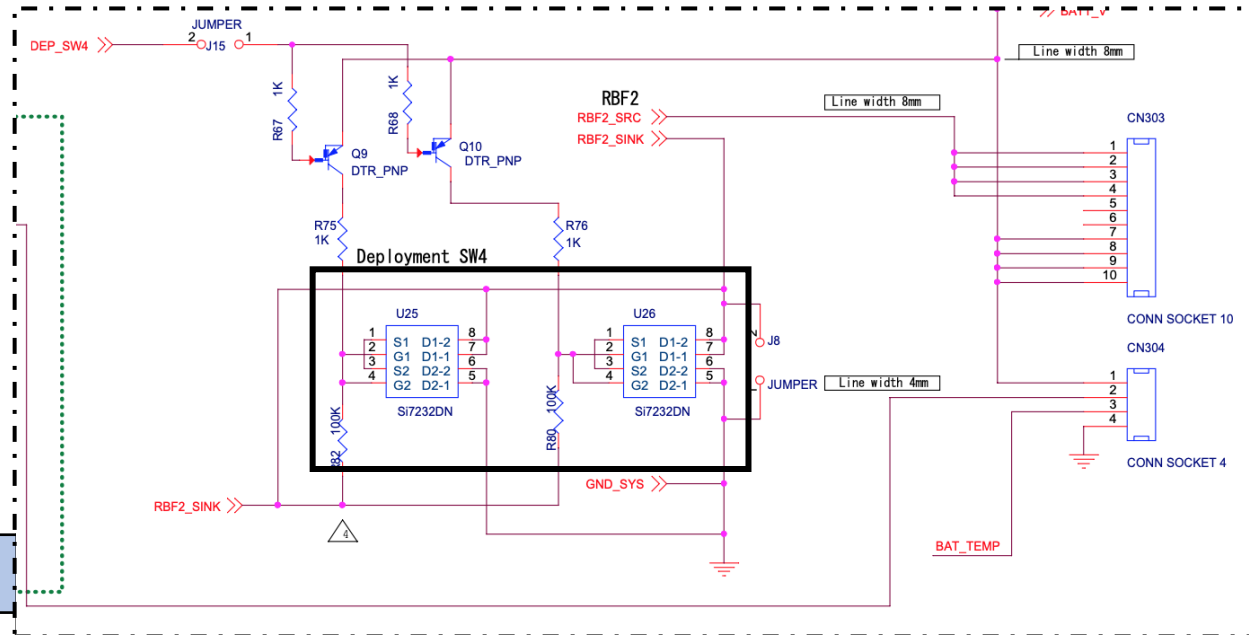
Subsystem/ Mission Modes	Power (mW)	Duration (H)	Energy (mWh)
OBC/ EPS	396	1.62	641.52
COM (RX)	170	1.13167	192.3839
COM (TX_CW)	800	0.485	388
COM (TX_Mission)	4200	0.1261	529.62
PACDS	132	1.13167	213.84
SPDM (TX)	389.4	0.485	188.859
SPDM (RX)	115.5	1.13167	130.07
CAM MCU	194.7	0.1832	35.67
Camera(x2)	2370	0.1832	434.14
Antenna Deployment	6720	0.00449077	30.178



OBC/EPS: Deployment Switch Issue



- Deployment switch 4 requires external source(Solar Panel) to get triggered initially. Satellite won't start through battery alone.
- The satellite will not turn on if its deployed in eclipse and only turns on when it comes out of eclipse.



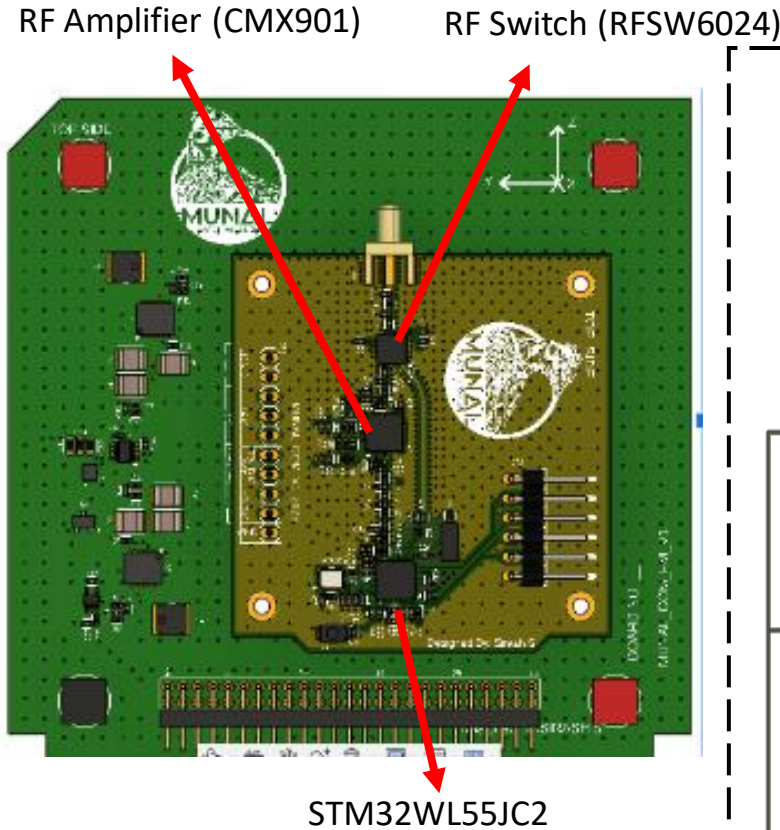
Changes

BIRDS	MUNAL
Si7232DN (out of stock)	Si4204DY

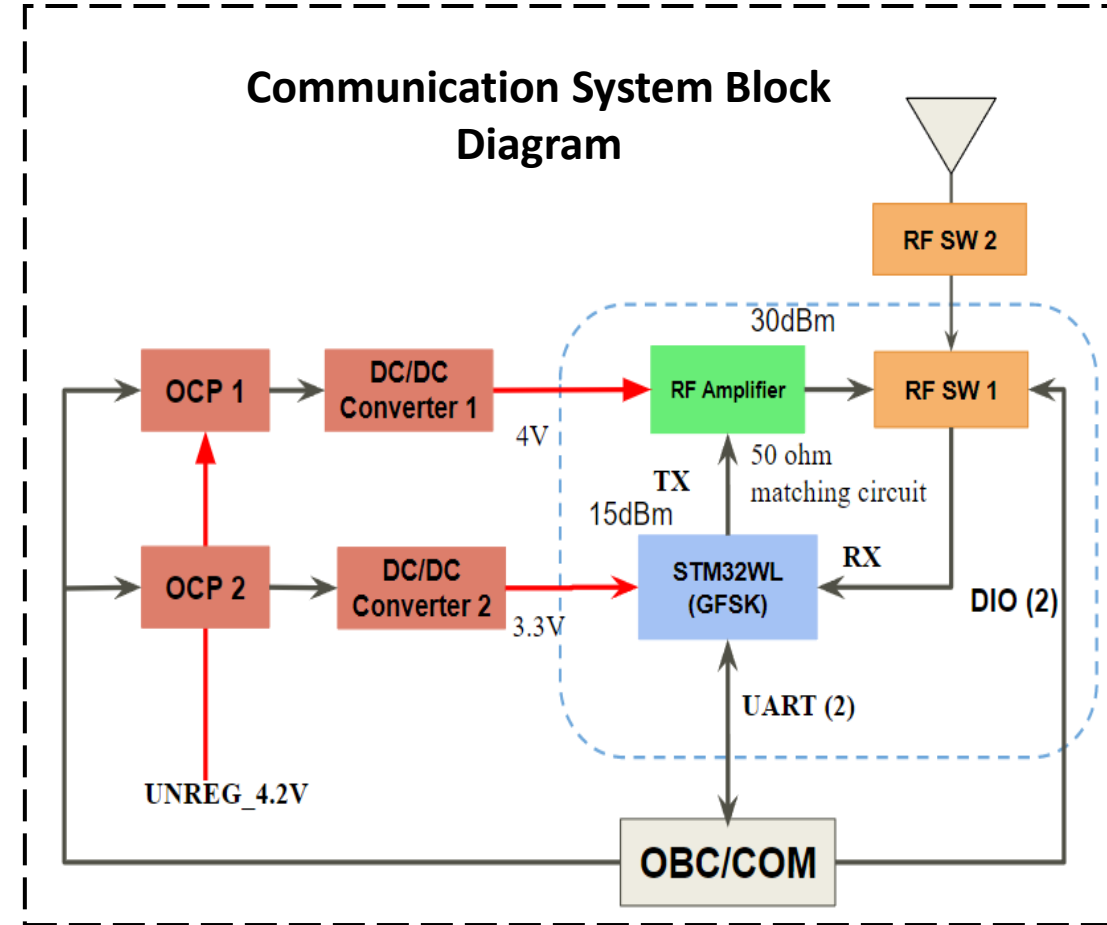
Communication Board (In-house)



Pseudo COM Board (EM)
Development Board
(Nucleo-wl55jc2)



FM COM Board





COM: Communication Subsystem



Telemetry and mission data downlink	
Downlink Rate	4800bps
Bandwidth	26KHz
Downlink Frequency	401.375 MHz
Modulation	GFSK

Command Uplink	
Uplink Rate	4800 bps
Bandwidth	26KHz
Uplink Frequency	402.375 MHz
Modulation	GFSK

CW Beacon	
Data Rate	20wpm
Bandwidth	50Hz
Frequency	401.375 MHz
Modulation	ON/OFF Keying

Uplink data format

Elements	Header	Call sign	Control	PID	Info	Checksum	Footer
Size (bytes)	1	14	1	1	13	2	1

Alternative:

Beacon transmits 1 packet data every two minutes.

Packet format (AX.25)

Downlink data format

Elements	Header	Call sign	Control	PID	Info	Checksum	Footer
Size (bytes)	1	14	1	1	80	2	1

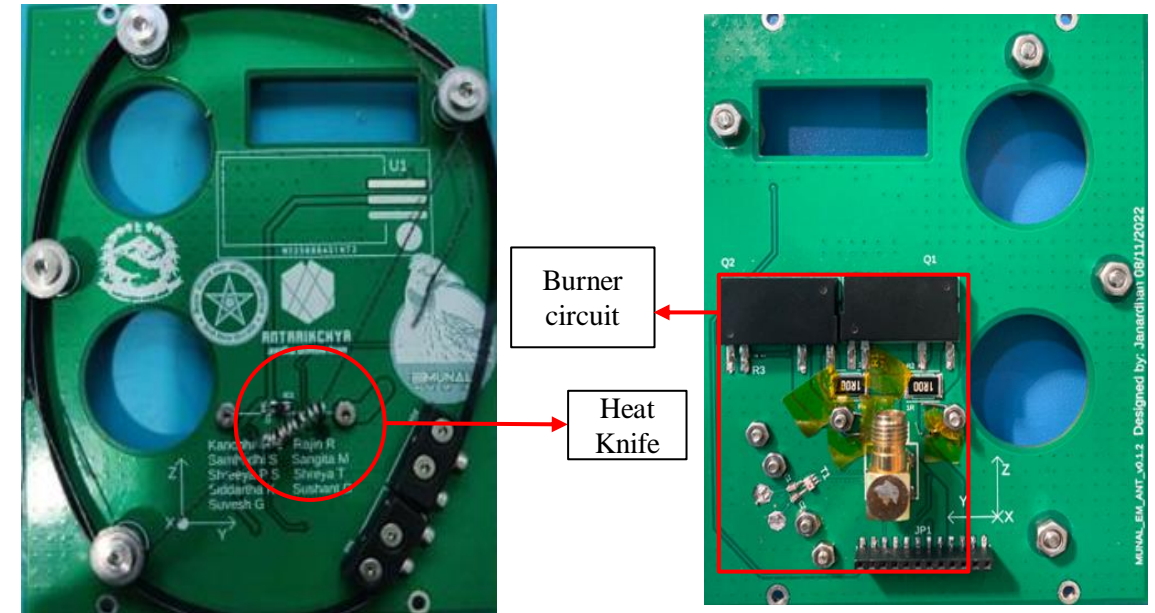
Uplink/ Downlink Budget

Ground Station	Command Uplink GFSK					
TX power [W]	50 (17 [dBw])	50	50	50	50	50
Line Loss [dB]	3	3	3	3	3	3
Antenna Gain [dBi]	22	22	22	22	22	22
GS EIRP [dBw]	37	37	37	37	37	37
UPLINK Path						
Orbital Altitude [km]	550	550	550	550	550	550
Elevation Angle [degree]	10	15	20	30	60	80
Slant Range [km]	1815.08	1518.02	1293.55	992.78	626.89	557.80
GS Ant. pointing Loss [dB]	1	1	1	1	1	1
Polarization Loss [dB]	3	3	3	3	3	3
Path Loss [dB]	149.64	148.09	146.70	144.40	140.41	139.39
Atmohperic Loss	1	1	1	1	1	1
Ionospheric Loss	0.4	0.4	0.4	0.4	0.4	0.4
Rain Loss	0	0	0	0	0	0
Isotropic Signal at Satellite [dbW]	-118.04	-116.49	-115.10	-112.80	-108.81	-107.79
Satellite RX sensitivity						
Antenna Pointing Loss	5	5	5	5	5	5
Antenna Gain [dBi]	0.9	0.9	0.9	0.9	0.9	0.9
Line Loss [dB]	3	3	3	3	3	3
RX power at LNA input [dBw]	-125.14	-123.59	-122.20	-119.90	-115.91	-114.89
RX power at LNA input [dBm]	-95.14	-93.58	-92.199	-89.9	-85.9	-84.89
Receiver Sensitivity [dB]	-100	-100	-100	-100	-100	-100
Link Margin [dB]	4.86	6.42	7.801	10.1	14.1	15.11

Satellite	Downlink Telemetry
TX Power [W]	0.8 (-1 dBw)
Line Loss [dB]	3
Antenna Gain [dBi]	0.9
Satellite EIRP [dBw]	-3.1
Downlink Path	
Orbital Altitude [km]	550
Elevation Angle [degree]	10
Slant Range [km]	1815.08
Satellite Ant. pointing Loss [dB]	5
Polarization Loss [dB]	3
Path Loss [dB]	149.64
Atmohperic Loss	1
Ionospheric Loss	0.4
Rain Loss	0
Isotropic Signal at Satellite [dbW]	-162.14
Ground Station	
GS Ant. Pointing Loss [dB]	1
GS Ant. Gain [dBi]	22
GS Total Line loss [dB]	3
GS Effective Noise Temp. [K]	1000
RX Power at GS LNA Input [dBw]	-144.14
GS Receiver Bandwidth [Hz]	12500
GS Receiver Noise [dB]	-127.63
SNR at GS Receiver [dB]	14.5
Required SNR at GS Receiver [dB]	10
System Link Margin [dB]	4.5

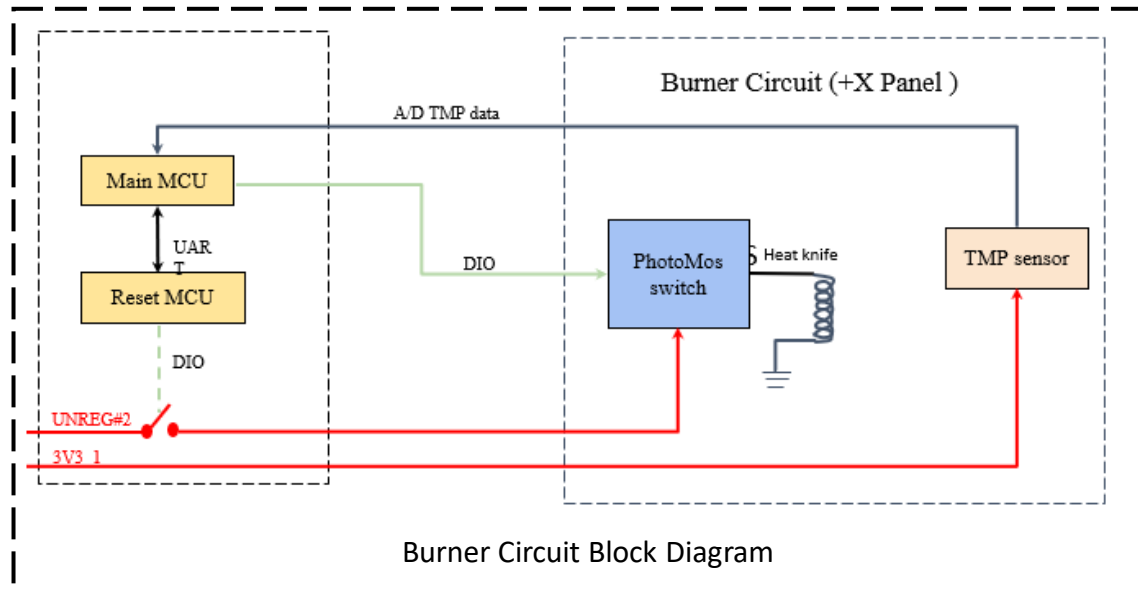
Antenna

Specifications	
Antenna Type	UHF dipole Antenna
Antenna Length	17.9 cm (one arm)
Antenna material	SK-85(Carbon Steel)



Antenna Panel

Antenna Panel's design is similar to BIRDS' design



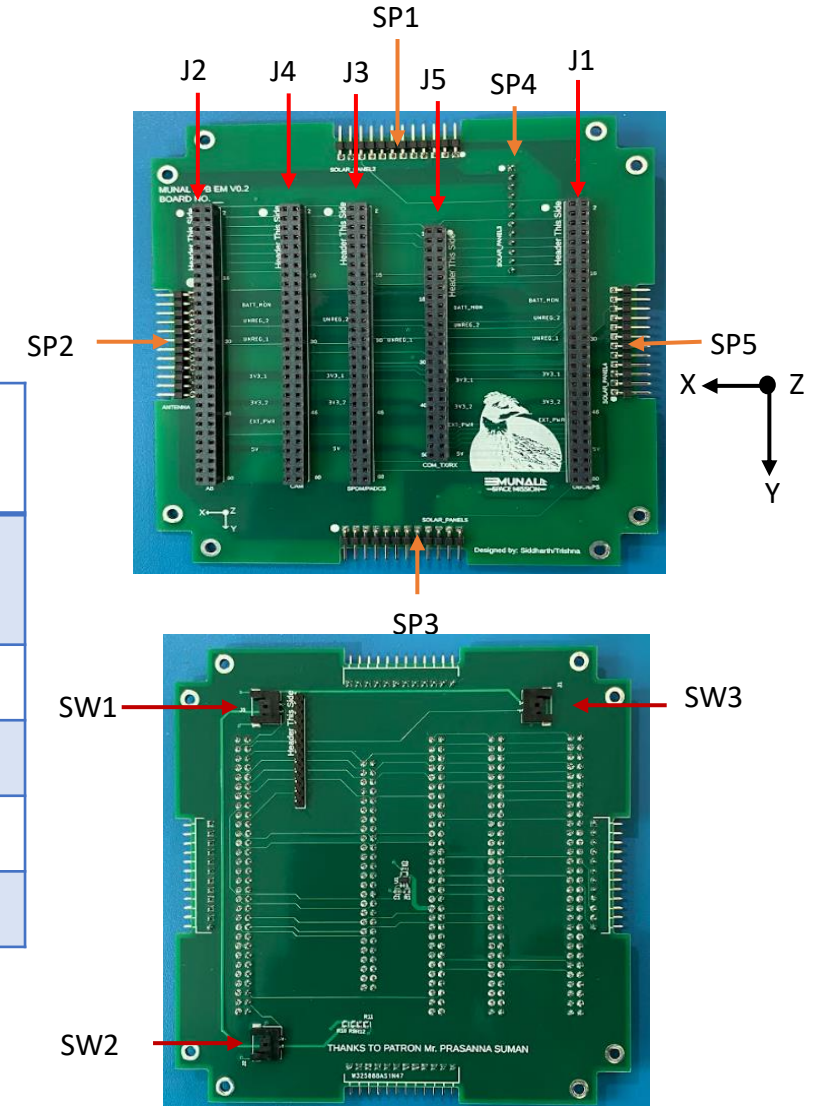
BPB: Back Plane Board

- 60 pin connectors are used for all the mission boards and EPS/OBC.
- 50 pin connector for COM board (Reference: Addnics COM board ICD)



Boards placement on BPB

Connector Name	No. of Pins	Description
J1-J4	60	OBC/EPS, AB, SPDM/PACDS, CAM
J5	50	COM Board
SP1-SP4	12	Solar Panels
SP5	12	Antenna Panel
SW1-SW3	2	Deployment switch





CAM: Camera Mission



Feature	Specification
Cameras	OpenMV H7 Plus (RGB & NIR)
Ground Swath	168*95 km (550km orbit)
Ground Sampling Distance	131m
Resolution	1280x720

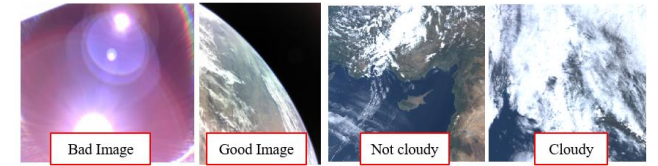
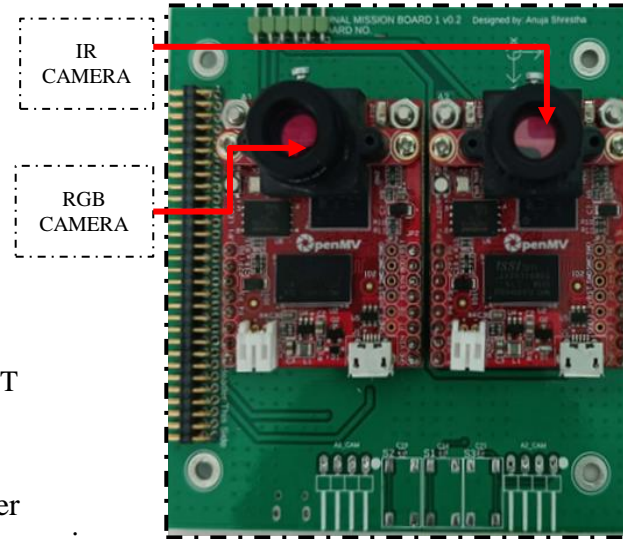
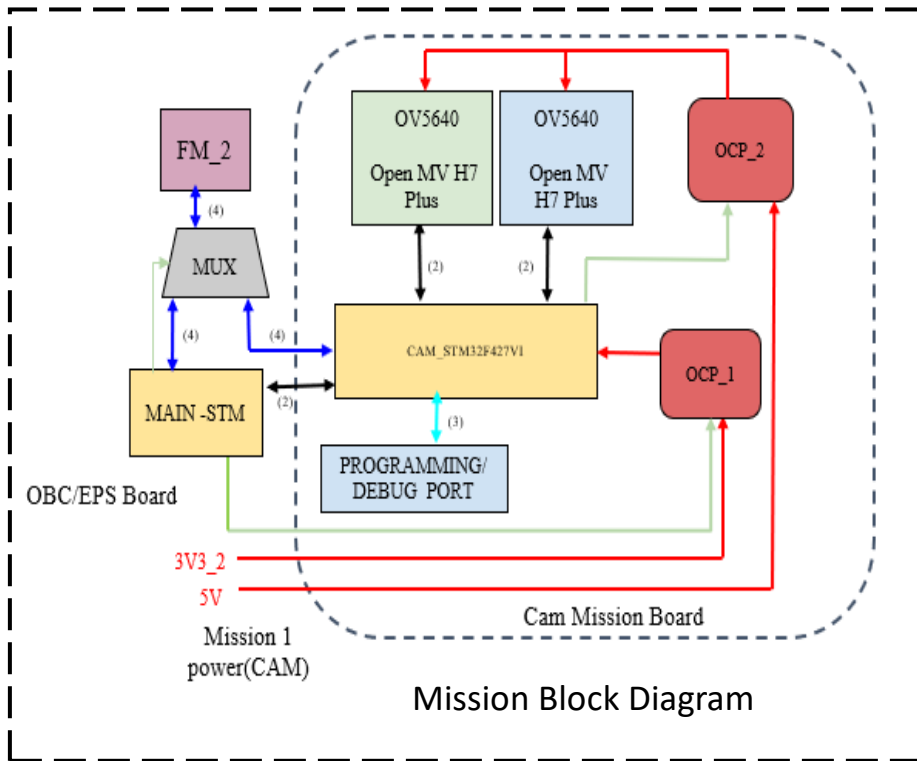
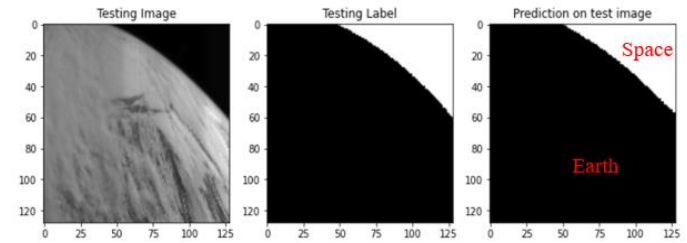
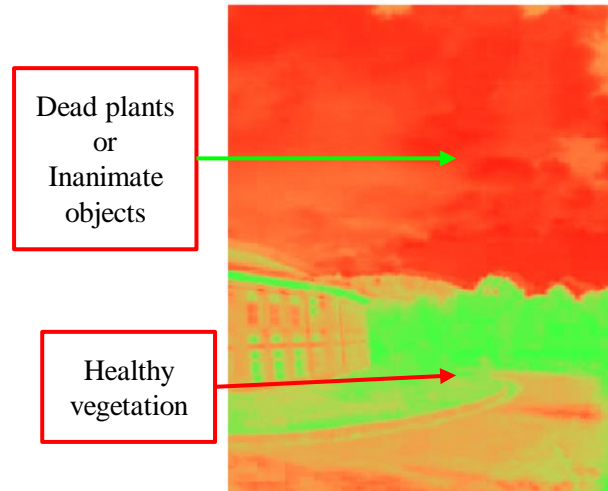


Image Classification

Image Segmentation

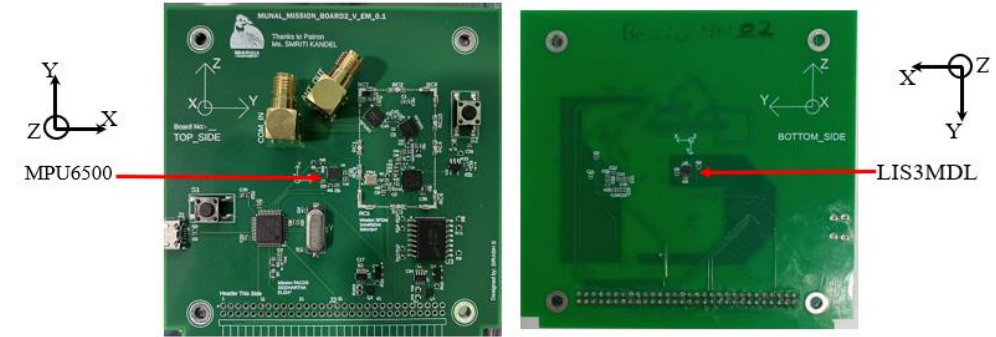
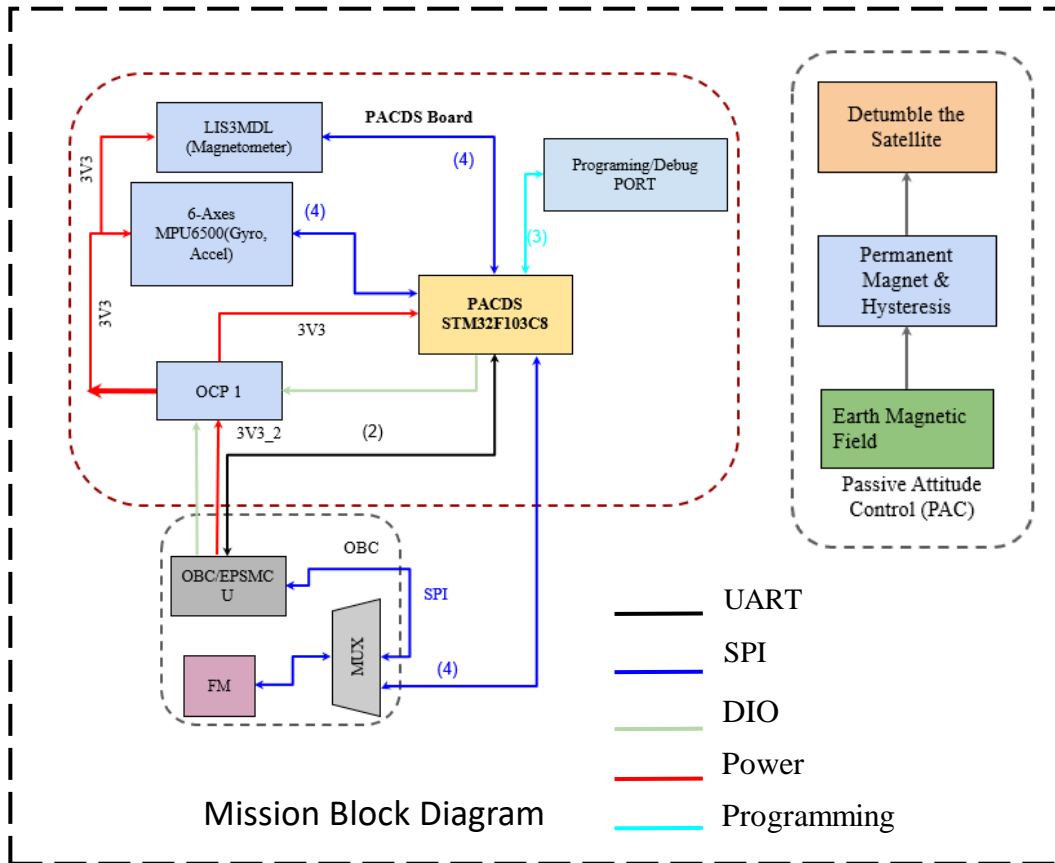


- UART
- SPI
- DIO
- Power
- Programming

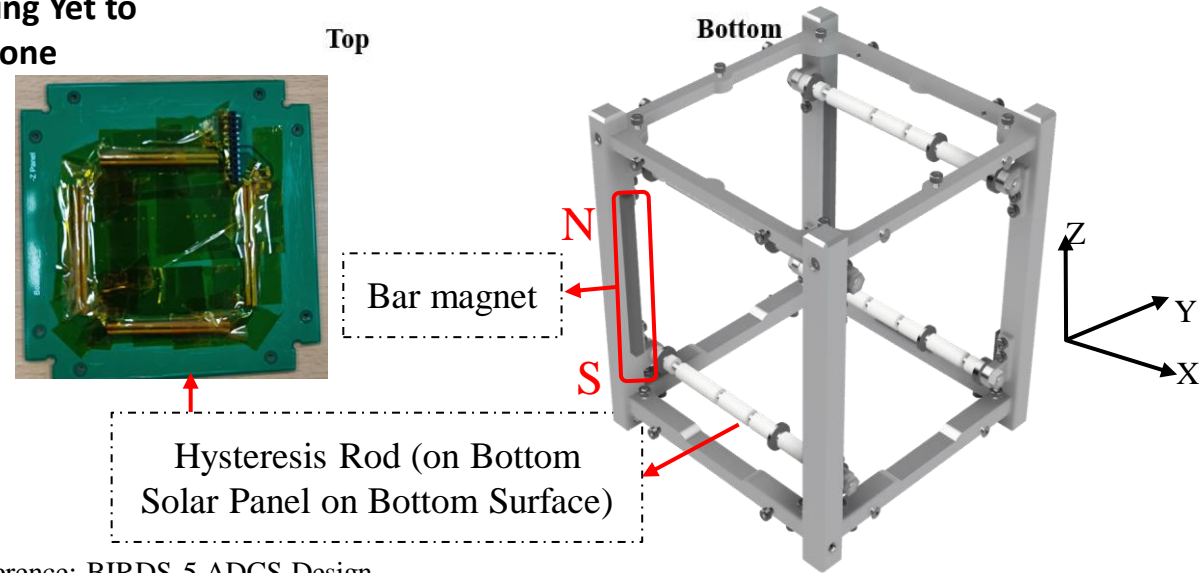


RGB Image

IR-Image



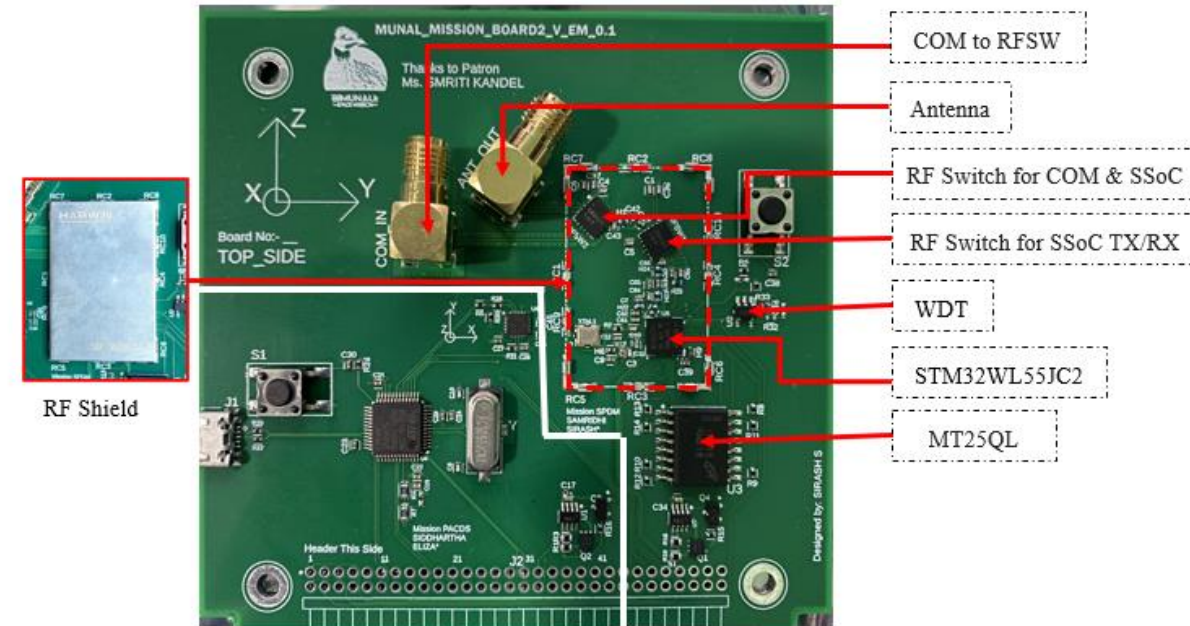
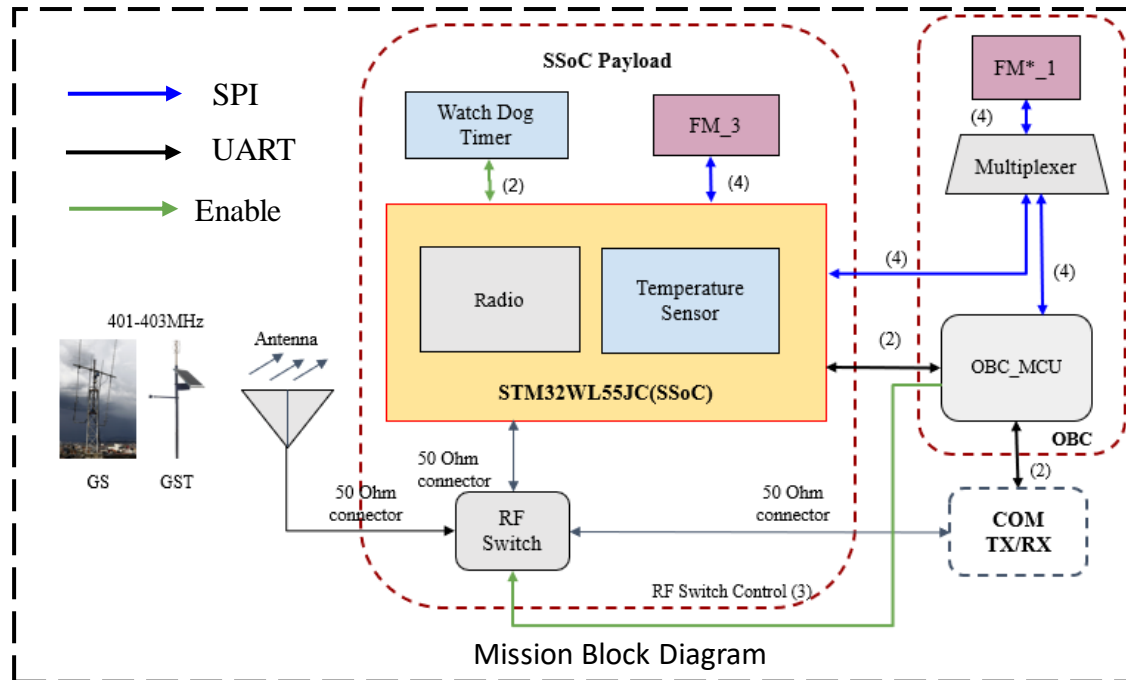
Testing Yet to be done



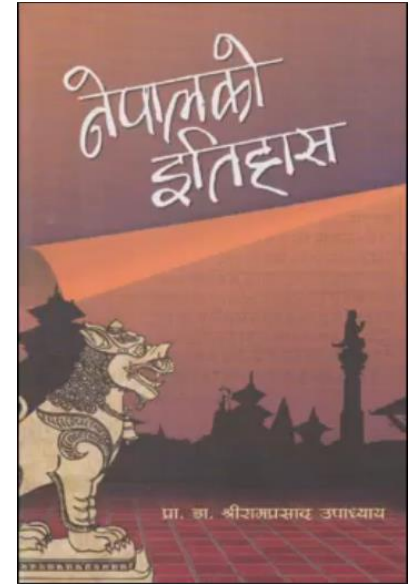
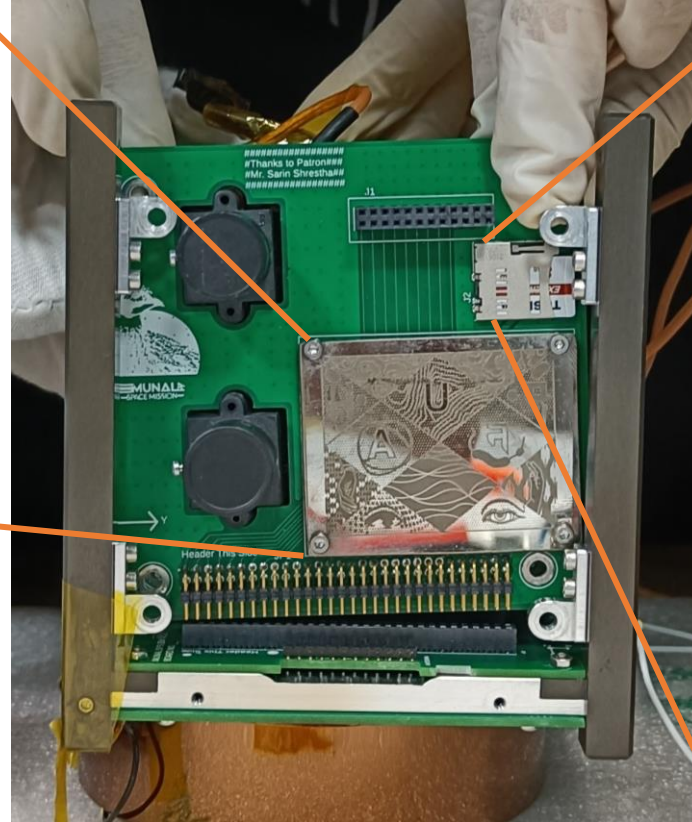
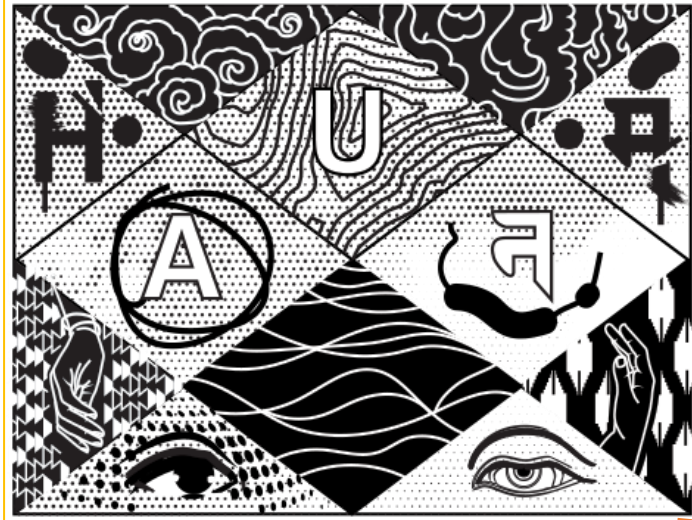
*Reference: BIRDS-5 ADCS Design

Bar Magnet	4*4(each rail)	AlNiCo 5
Hysteresis Rod	8	HyMu80

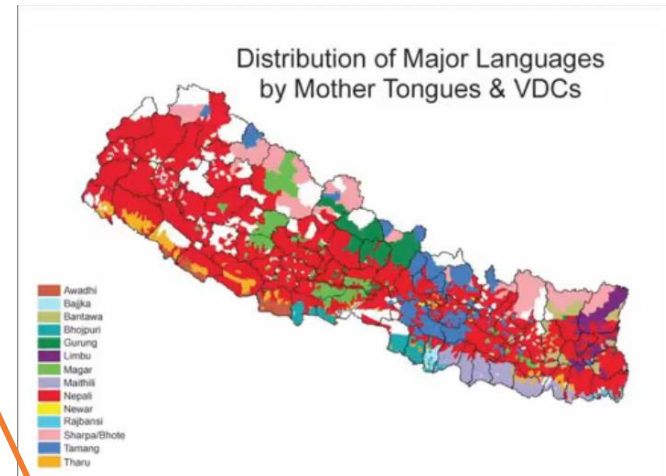
- Demonstrate the use of integrated Communication(COM) and On-Board Computer(OBC) subsystem based on novel SSoC for future cubesat missions using LoRa(Long Range) Modulation.
- ARM based Dual Core Processor with Radio
- +22 dBm Transmitting power
- -148 dBm Receiving sensitivity



Art and Culture Mission



धन २	व्यय १२
सहज ३	तनु १
सुख ४	१० कर्म
सुत ५	७ जाया
रिपु ६	९ धर्म
	८ रन्ध्र



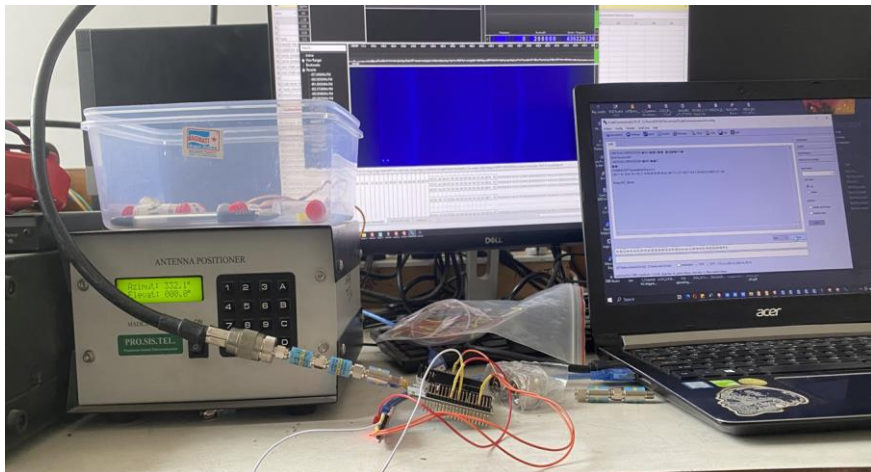
Long Range Test



Satellite

Chobhar Hill

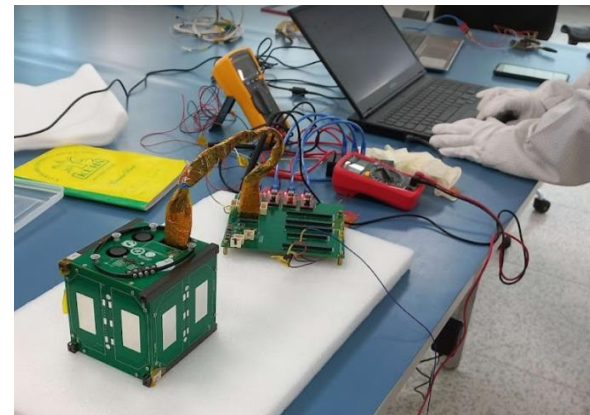
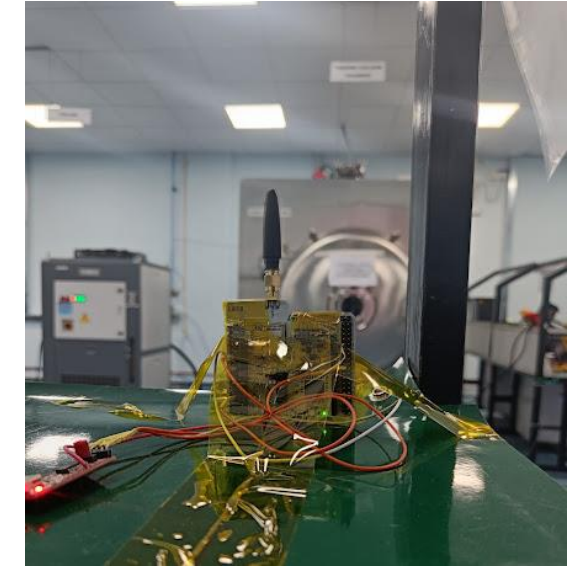
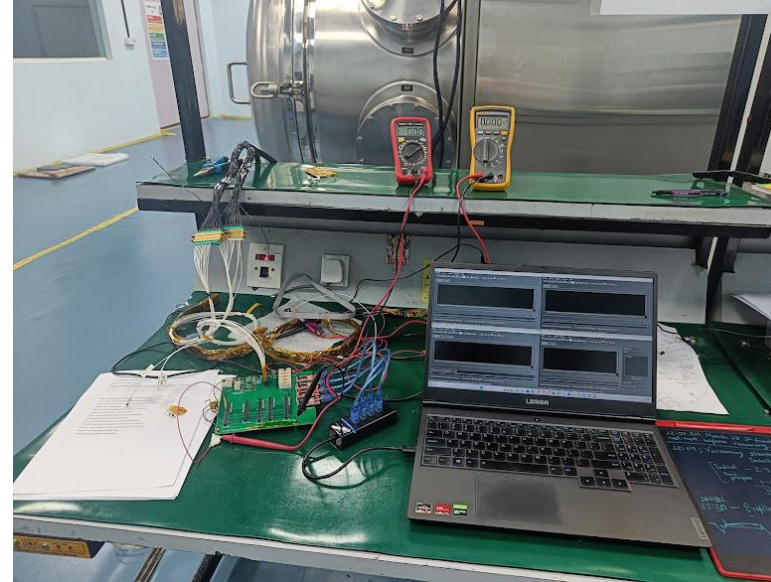
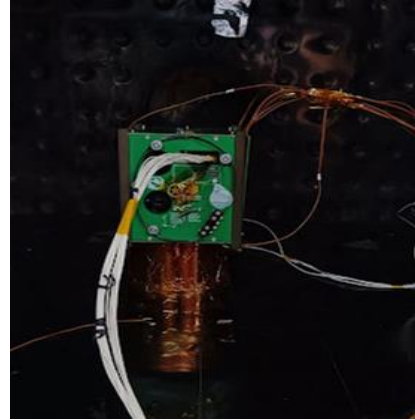
Distance: 3.565km
Path Loss : 92.97 dB
Operating Freq: 435-437MHz
[To use BIRDS GS Freq Changed
from 401/402 MHz]
TX power: 22dBm
RX sensitivity: -100dBm



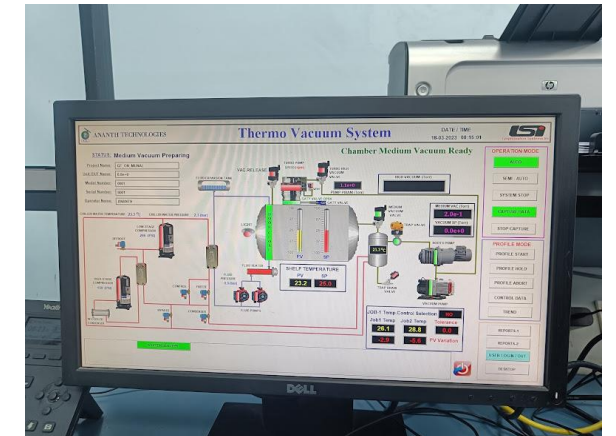
NAST Ground Station

Space Qualification Test : TVT

Satellite Setup for TVT



Functional Test Before TVT



Thermovac Controller

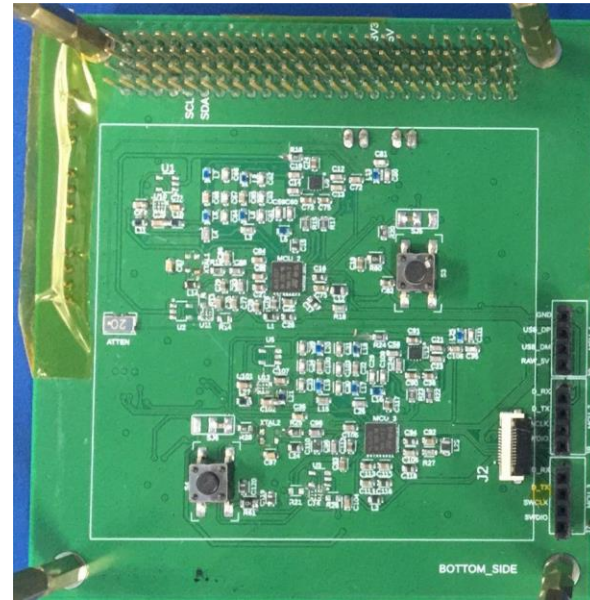
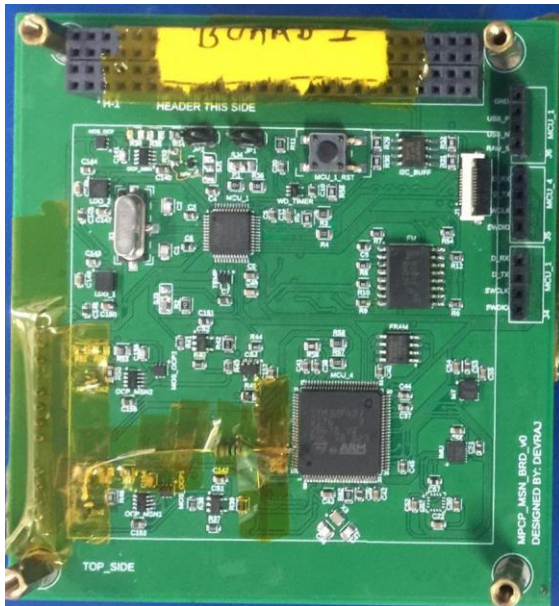
RoadMap



Danfe Space Mission

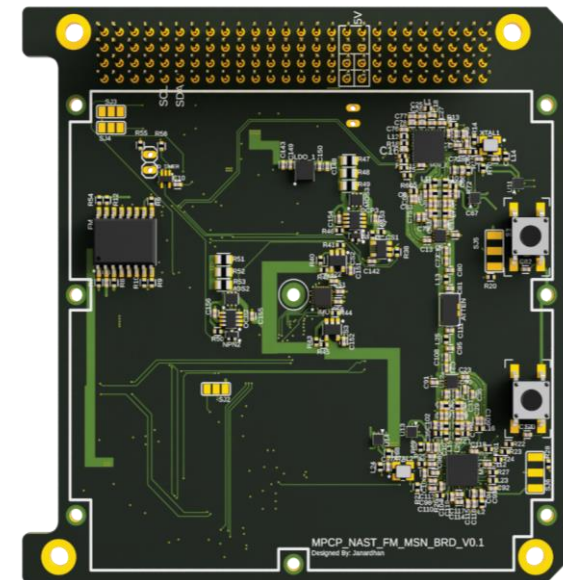
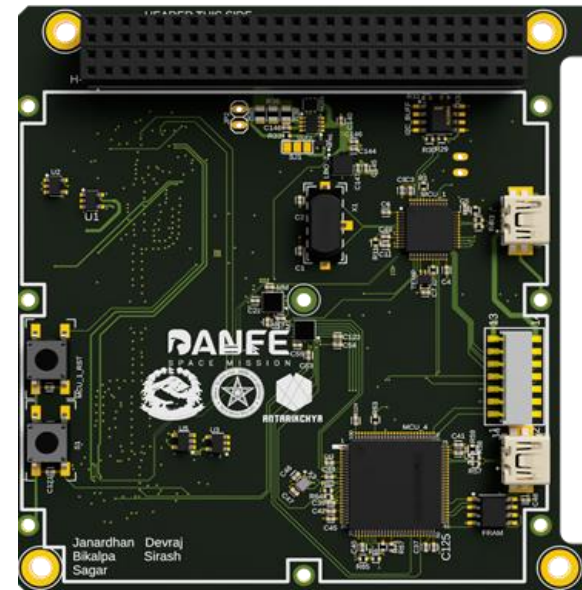
Multi Payload CubeSat Platform (MPCP)





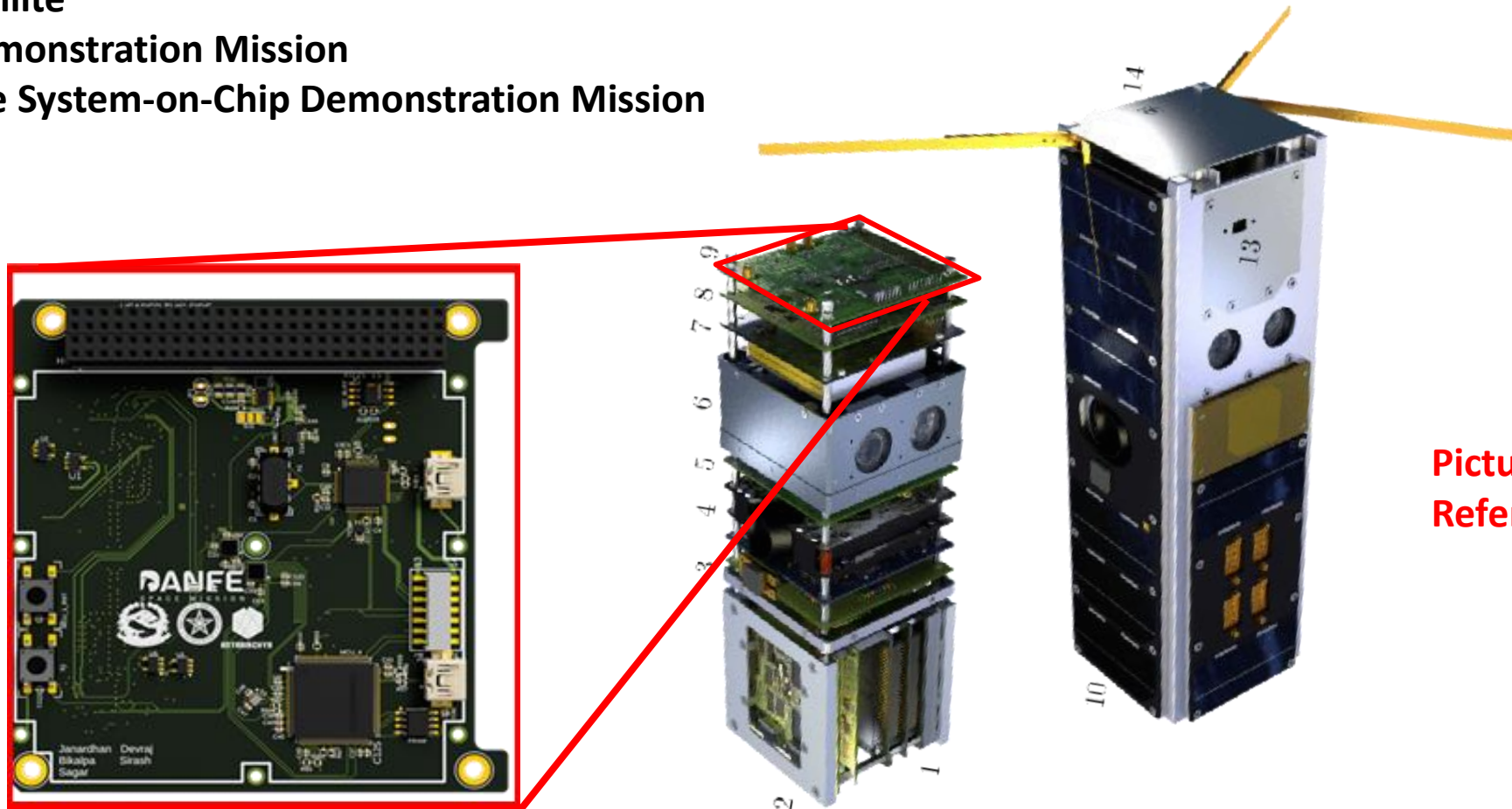
EM Boards

FM Boards



Overview

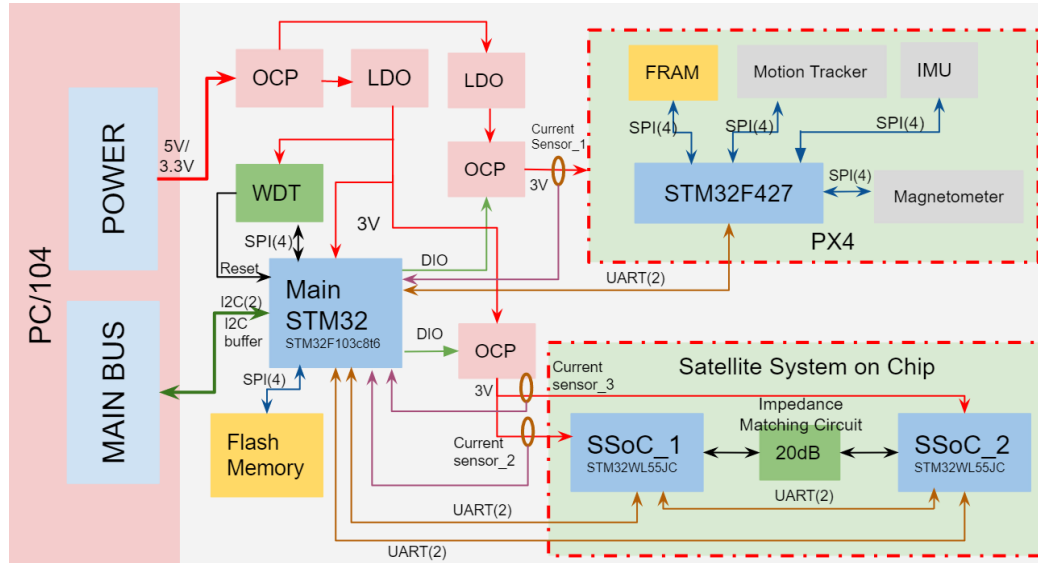
- ❑ 3U Satellite
- ❑ PX4 Demonstration Mission
- ❑ Satellite System-on-Chip Demonstration Mission



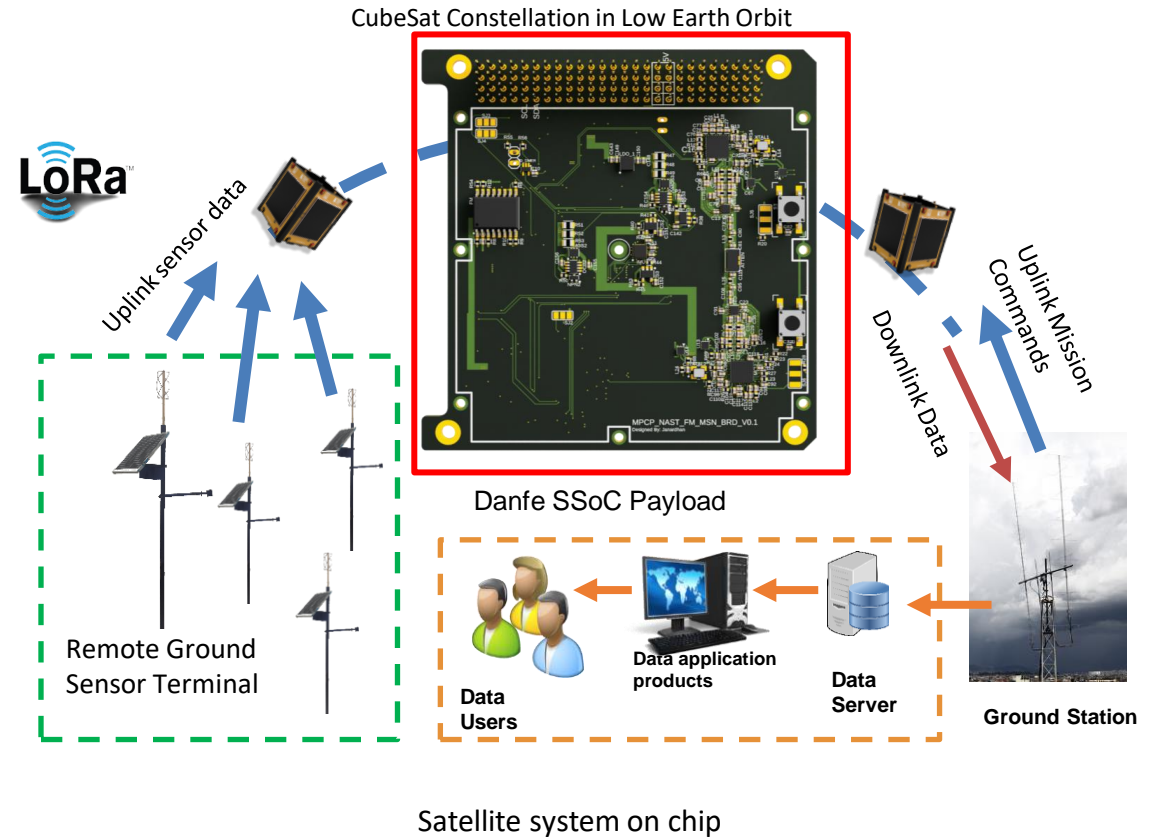
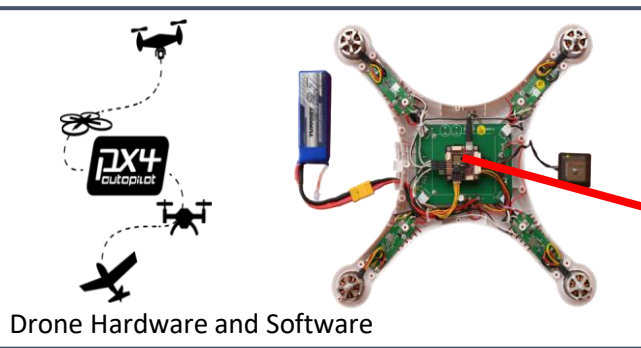
Picture for
Reference only

Source: Aalto-1, multi-payload CubeSat: Design, integration and launch

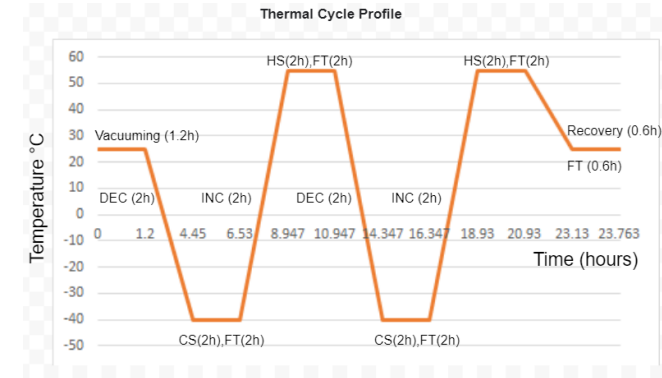
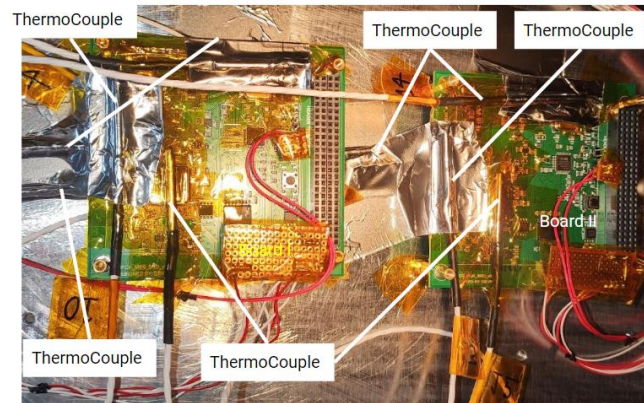
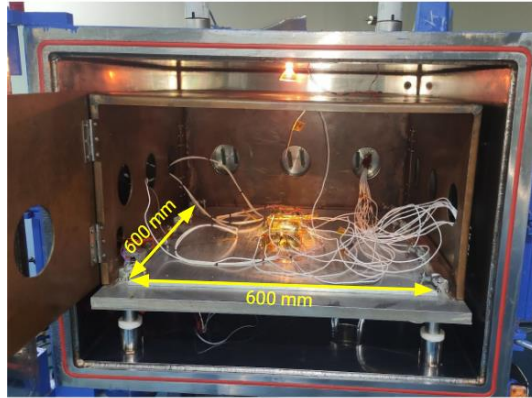
Danfe Space Mission



Danfe mission Block Diagram



Space Qualification Test



Thermal Vacuum Test at Centum Electronics, Bangalore, India



Thermal Vacuum Test at Centum Electronics, Bangalore, India



Electromagnetic Compatibility Test at Khwopa Engineering College, Bhaktapur, Nepal

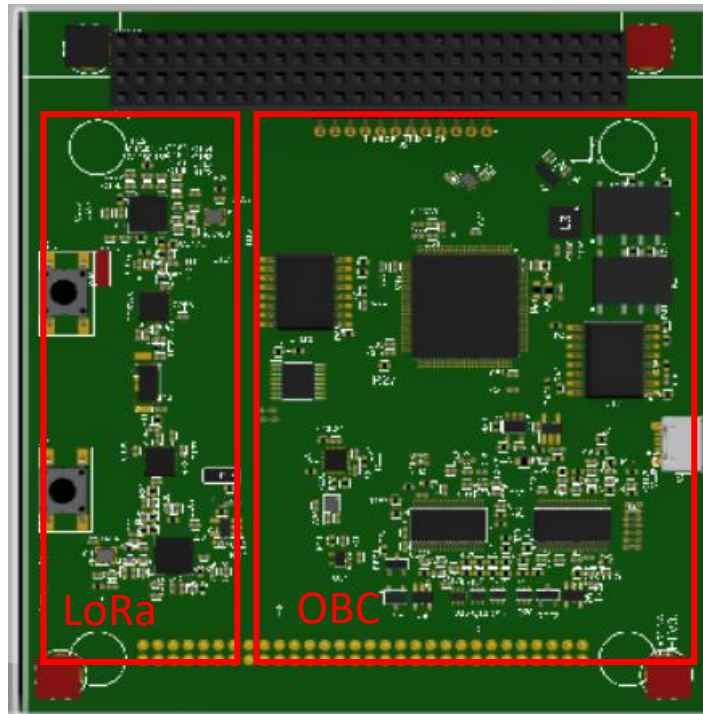
Danfe-2 Mission

Payload Hosting Initiative



Danfe-2

- UNOOSA's Access to Space for all: Payload Hosting Initiative project.
- MBRSC'S 12U satellite: (PHISat)
- Munal's OBC/EPS and Danfe Space Mission in a single board. (Modular Design)
- Integrated OBC, EPS and Communication system (Bus system in a single board)
- PDR completed on May 9



Danfe-2 Power Budget

- Sun-synchronous Orbit
- Total Duty cycle provided is 30%

Power Budget		
	Power(W)	Duty Cycle
Main System	1.005	12%
HK logging	1.15	6%
LoRA	1.635	9%

Thank You