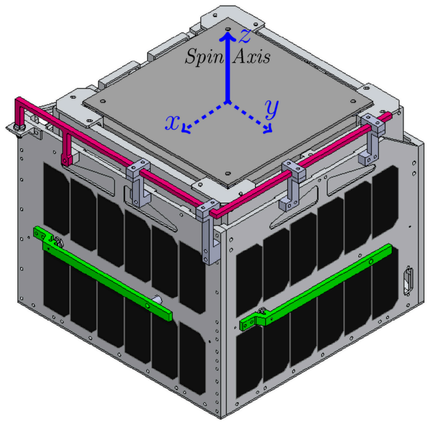
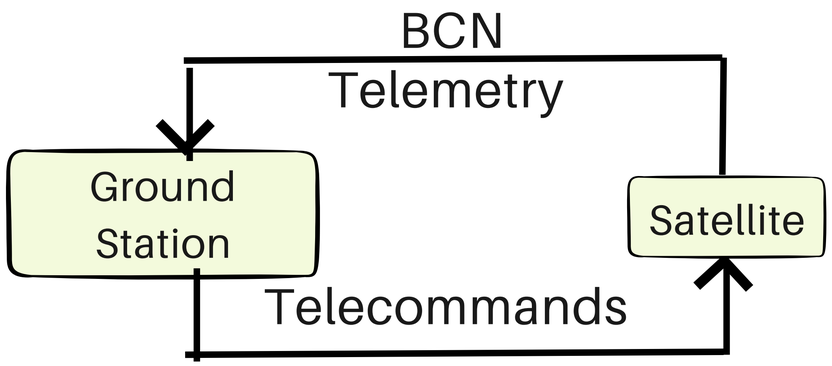
COMMUNICATION SYSTEMS

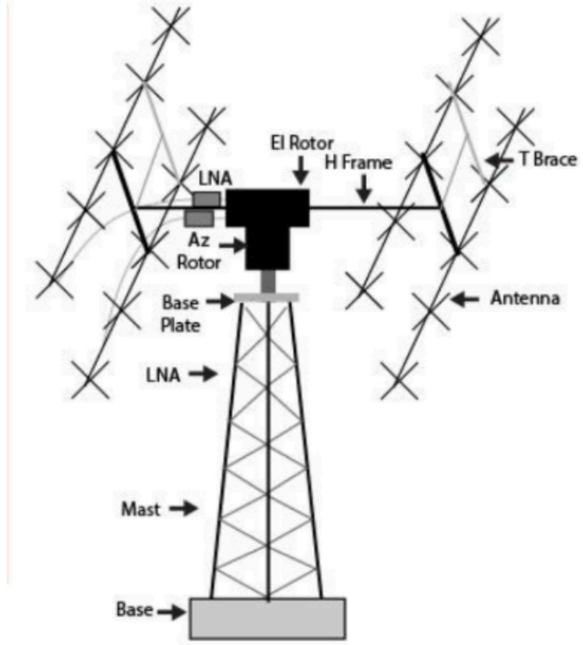
Onboard Structure



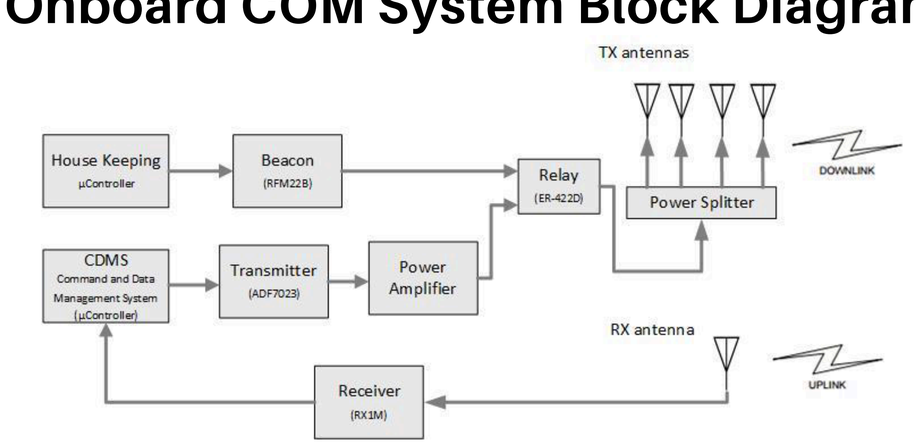
Onboard COM System Block Diagram



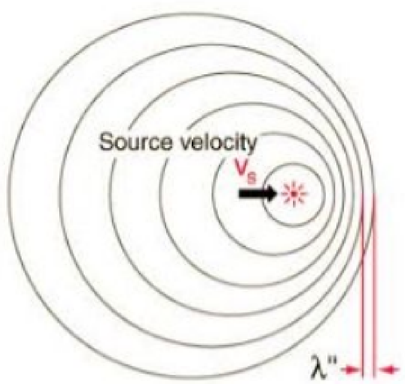
Ground Station Setup

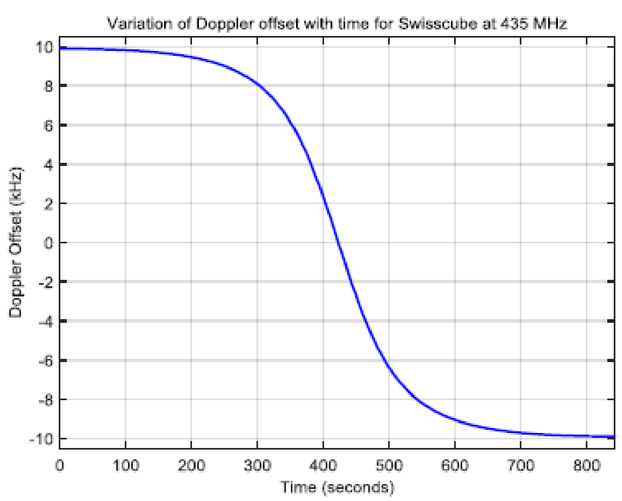


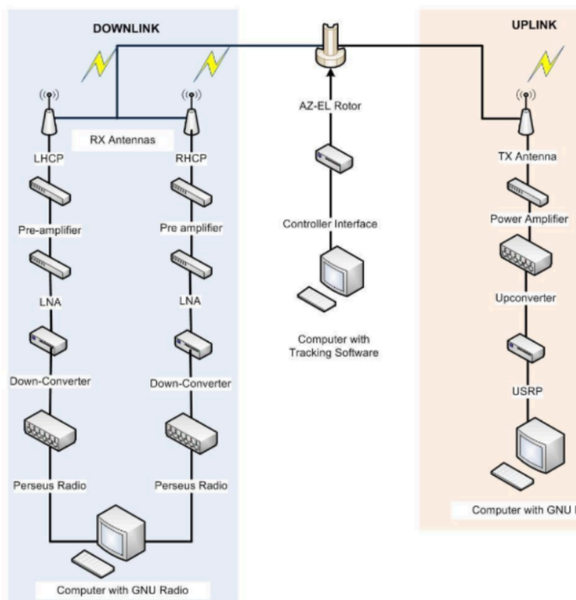
Onboard COM System Block Diagram



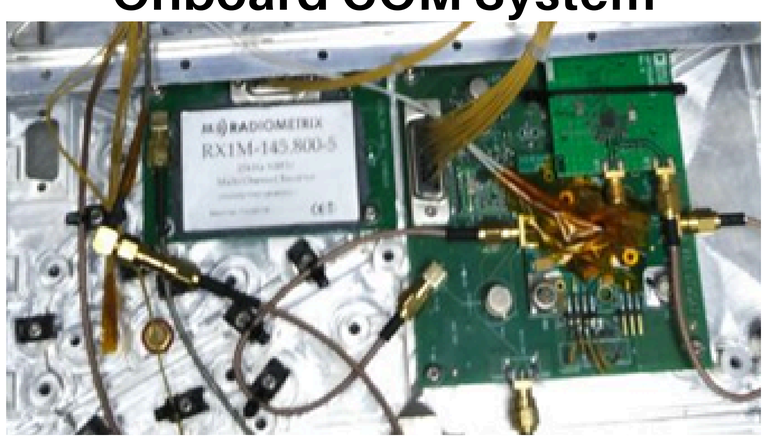
Doppler Shift and Compensation



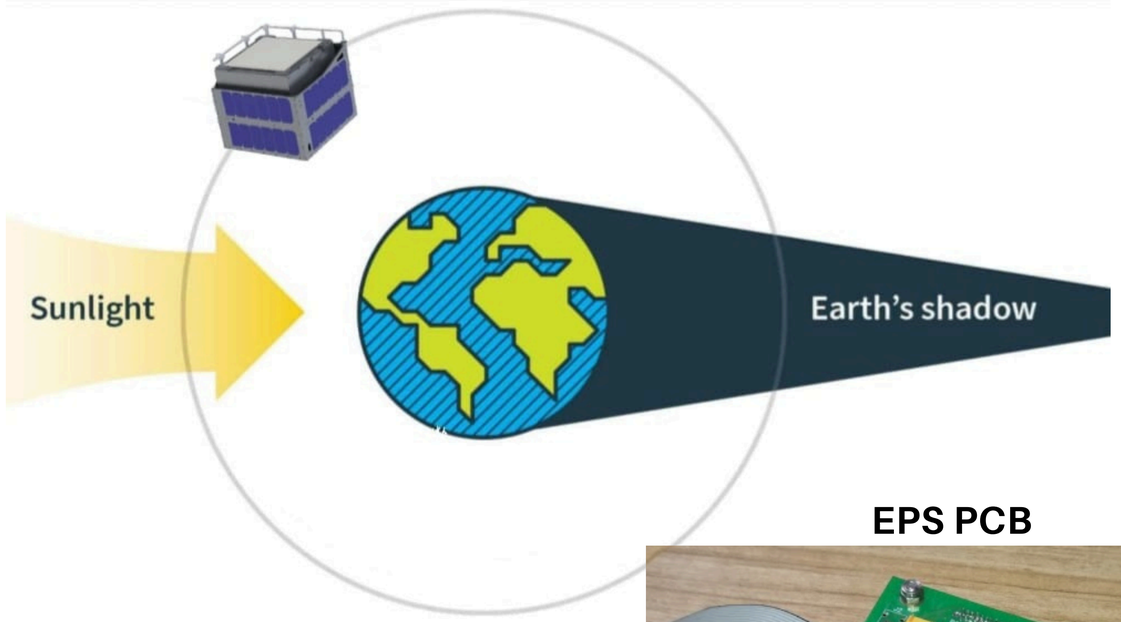


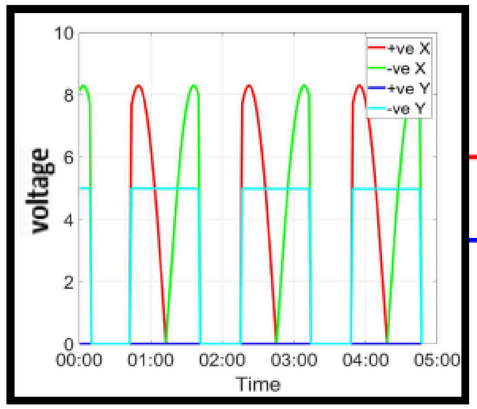


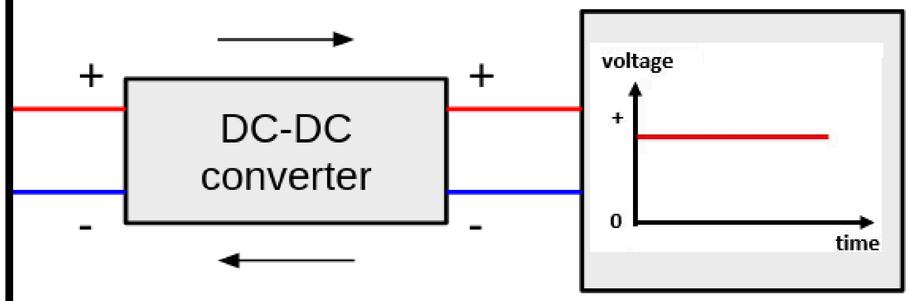
Onboard COM System



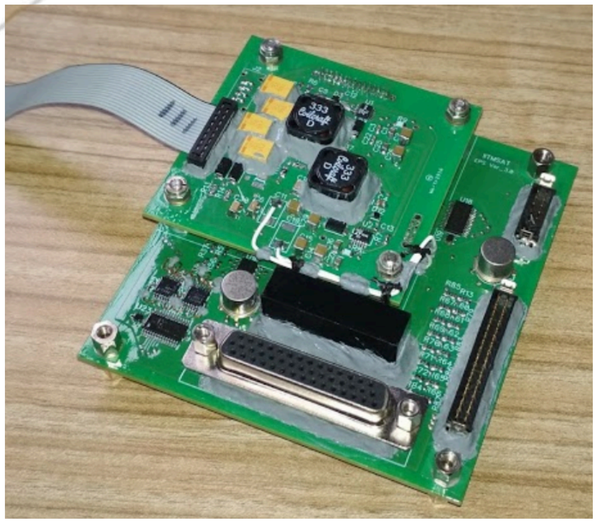
ELECTRICAL POWER SYSTEM (EPS)



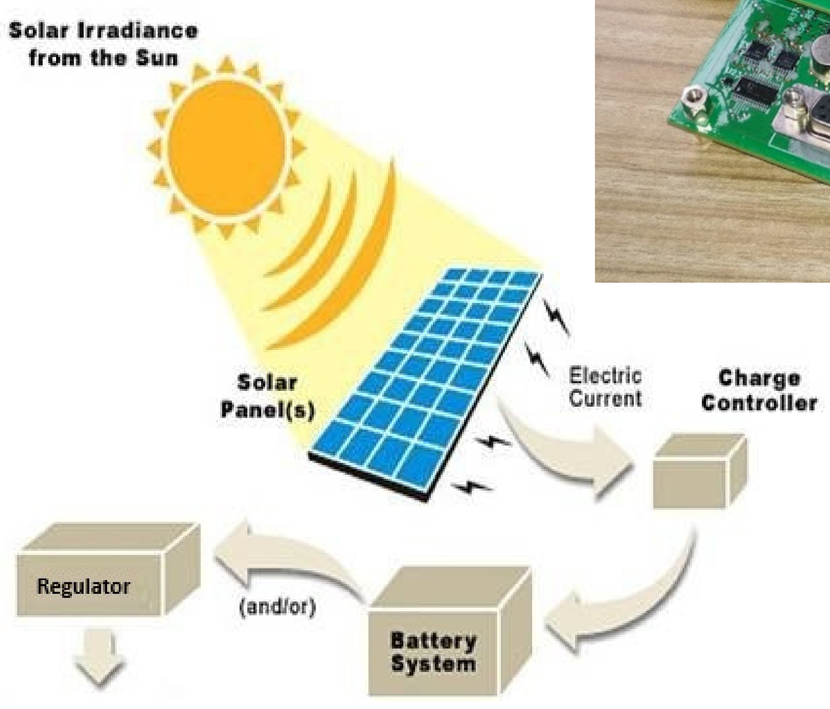


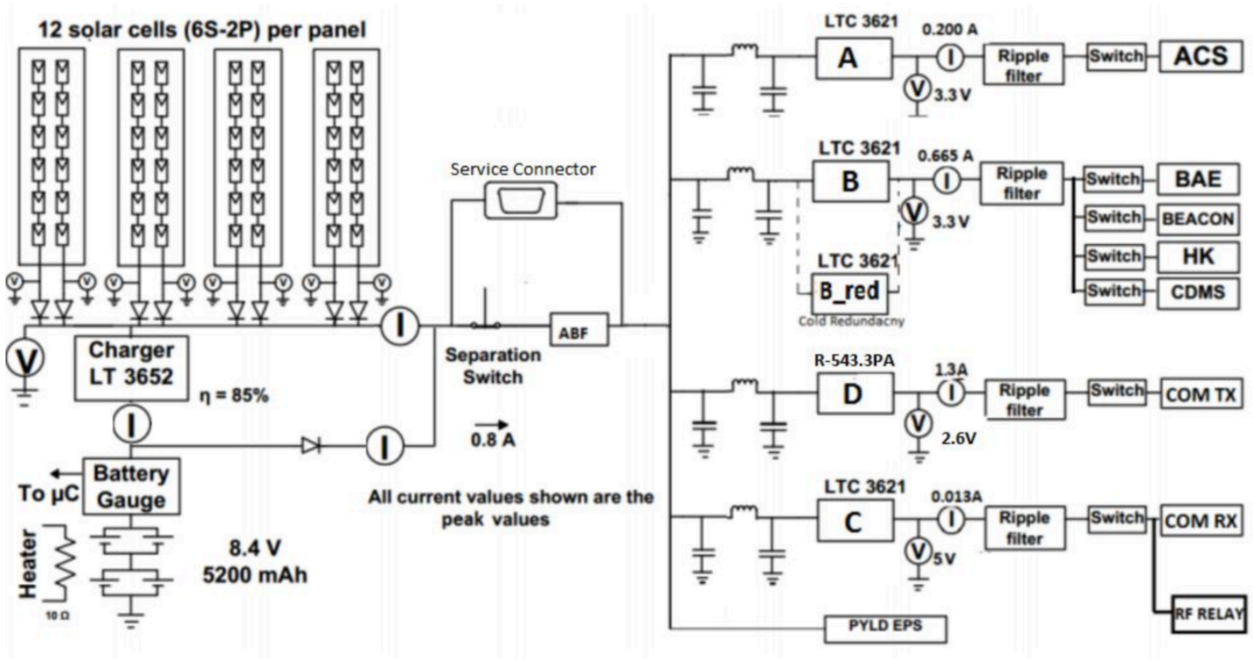


EPS PCB



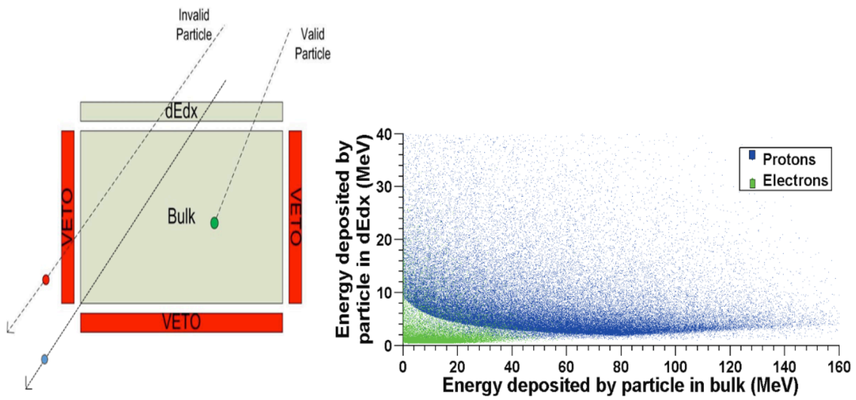
Power System Architecture



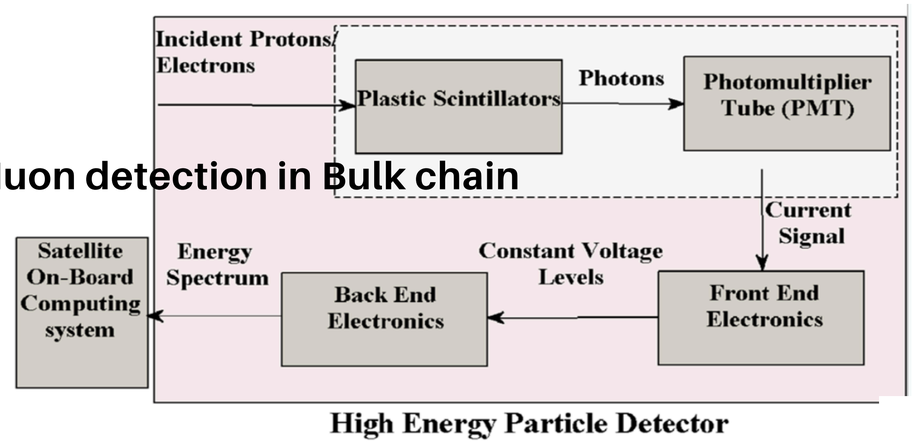


PAYLOAD SUBSYSTEM - HIGH ENERGY PARTICLE DETECTOR

Dectector Schematics, E Delta E method



Payload Architecture



High Energy Particle Detector

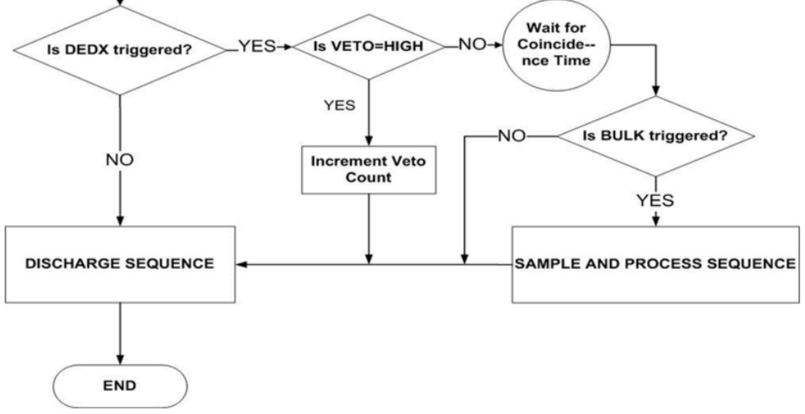
Muon detection in Bulk chain

- To detect the precipitation of high energy particles from lower Van Allen Belt
- Payload is designed to have an aperture of area 501.76 cm2.
- seismic activities create Ultra low frequency(ULF) EM waves.
- SPEED can be used to identify the correlation between the ULF wave and particle bursts.

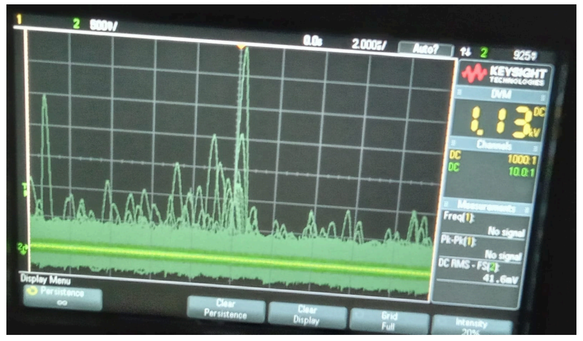
TABLE I: Requirements on Mission [1]

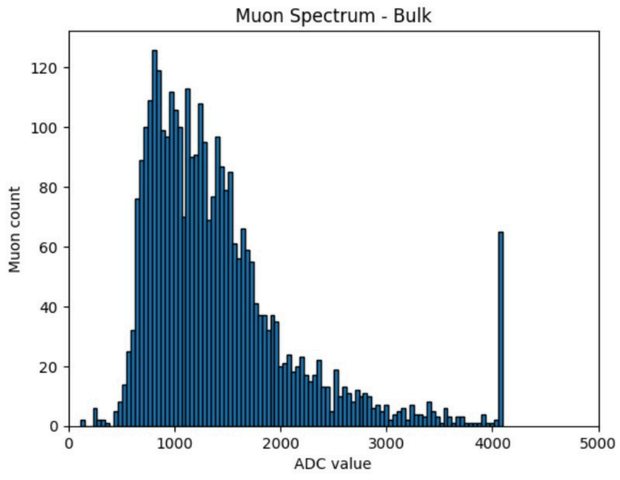
Science data products	Energy spectrum of protons and electrons Pointing direction of the detector Position of the satellite Time
Energy Range and Particle Type	Protons: 1 to 100 MeV Electrons: 1 to 15 MeV
Resolutions	Energy <5 MeV Time <0.4s Spatial <15 km
Coverage	L-shells: 1.15 L to 1.75 L Altitude: 600 to 800 km
Attitude	$0^{B}$with respect to the magnetic field line
Aperture	As large as possible within the constraints of the mission
Mission lifetime	1 year

Coincidence Algorithm

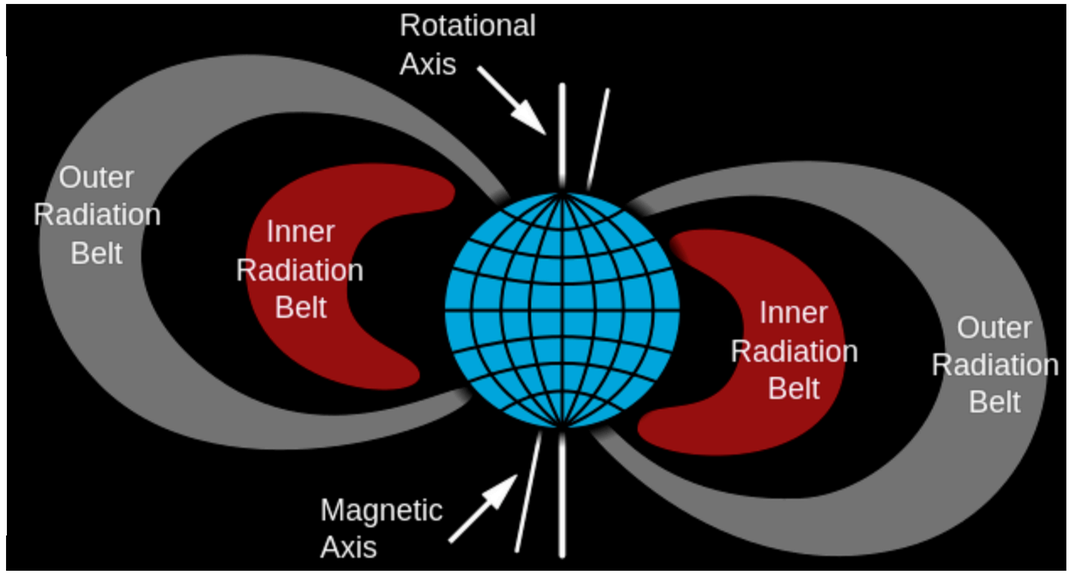


Particle signals in CSPA





Van Allen Radiation Belts



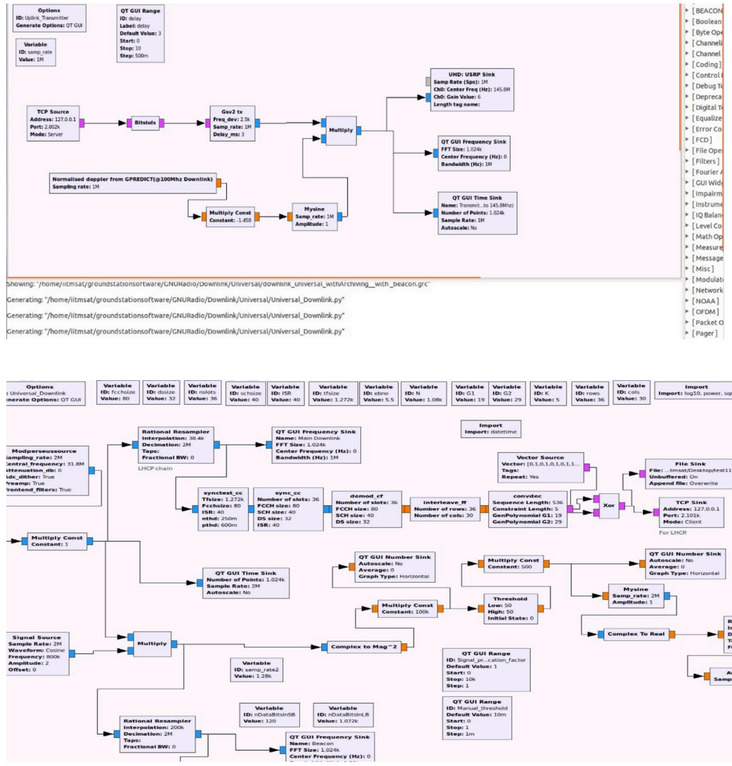
GROUNDSTATION(GS)

GNU Radio

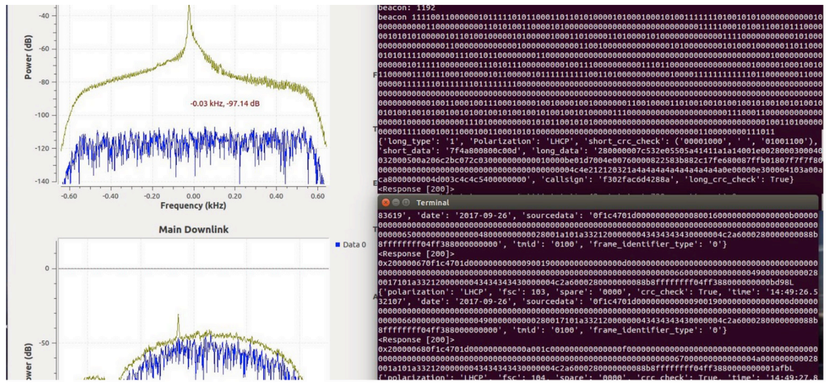
Uplink

- Takes data from APS through a TCP connection
- Modulates data into an FSK signal as required by the On-board COTS receiver (Rx1M)
- Doppler correction values are given by PREDICT Satellite tracking software, provided TLE & GS information
- FEC is done and on-board receiver is robust above reqd. SNR
- Modulated samples are sent to USRP via. Ethernet, up-converted to 145.975 MHz and the analog output is fed to the Tx antenna. (after PA)
- Data Rate : 1kbps

Onboard COM System Block Diagram

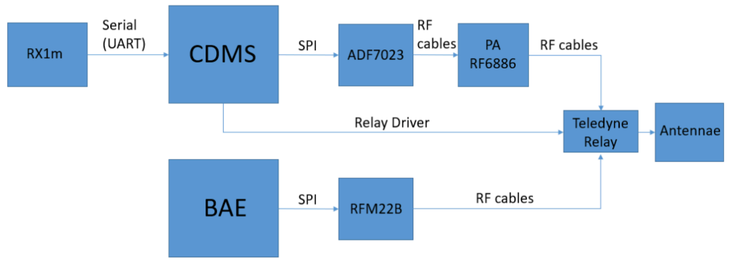


GNU Radio Downlink and Uplink, Beacon /GMSK



MISSION CONTROL SYSTEM (MCS)

Onboard COM System Block Diagram



Auxiliary Python Script

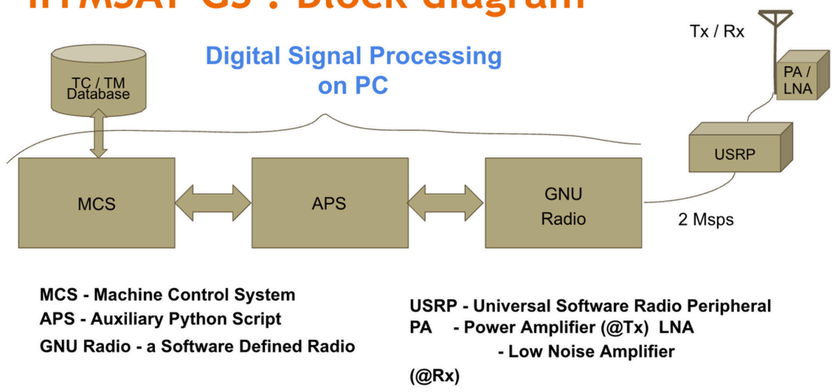
- **Uplink**

Implements Ax.25 v2.0 data link layer protocol
Includes Bit-stuffing, CRC check and 7E insertion
Consolidates TCs into a list with appropriate last packet bit

- **Downlink**

Converts TM / Beacon data into json format and hands it to MCS
Time-Stamps for decoded frames are added at this point

Onboard COM System Block Diagram

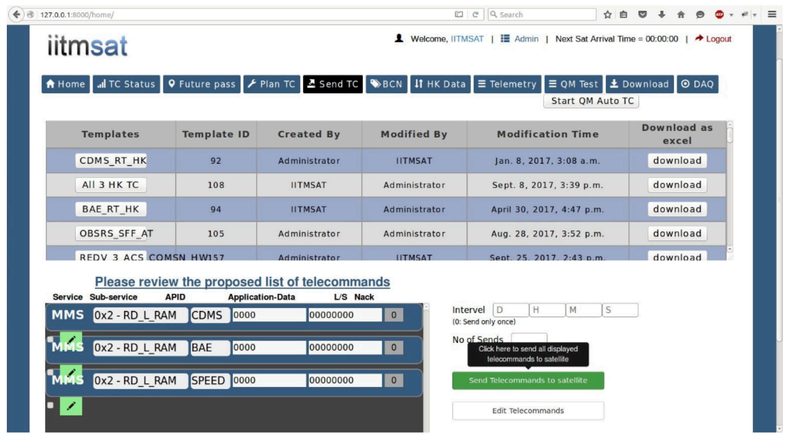


Mission Control System

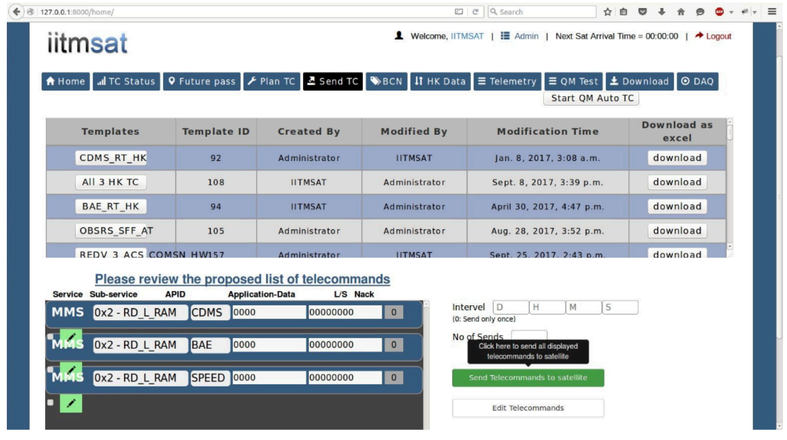
Key features

- Reads TC from database according to user-input
- Frontend : User-interface that let's you plan/send TCs, see ACK / NACK status of TM, analyse data of interest.
- Default templates let's you send TCs instantly.
- Backend : De-calibration for various HK parameters like V, I, Temp, etc.
- Received TM is displayed in a user-understandable form

Sending TC



HK

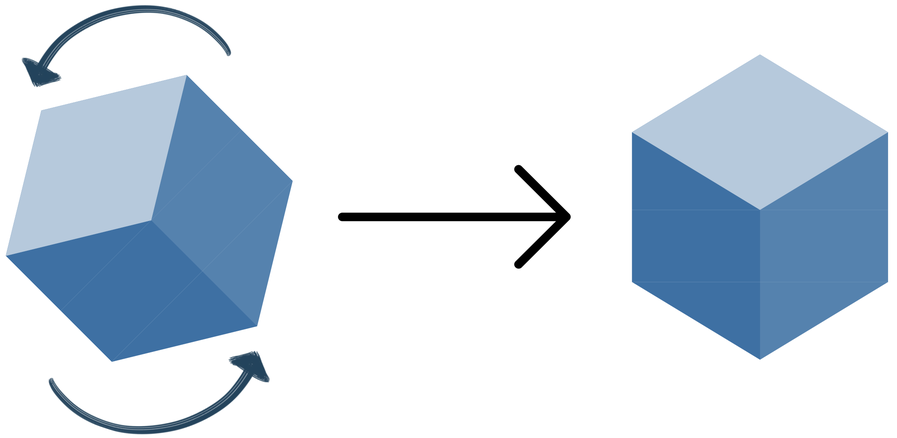


ATTITUDE CONTROL SYSTEM (ACS)

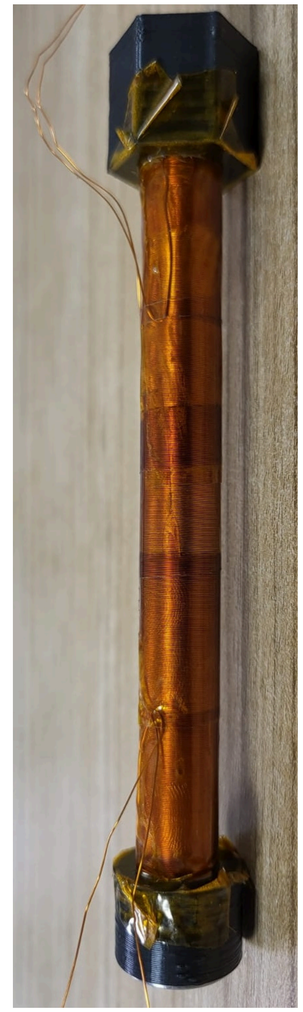
Need for ACS

- No Solar Power Harvesting before detumbling, so we need to detumble for collecting solar power.
- Communication with Ground Station requires specific orientation of satellite.
- Payload (SPEED) needs satellite to be stable and aligned to earth's magnetic field for proper data. collection.

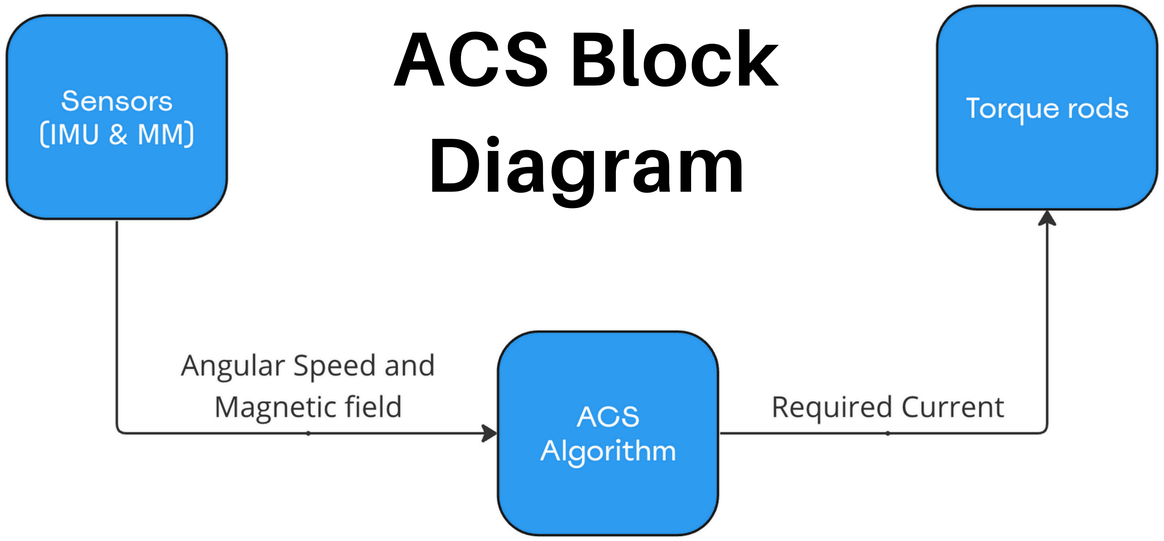
Detumbling Mode



Detumbling Mode- Reduce the angular speed of the satellite, facilitating operation of the nominal algorithm

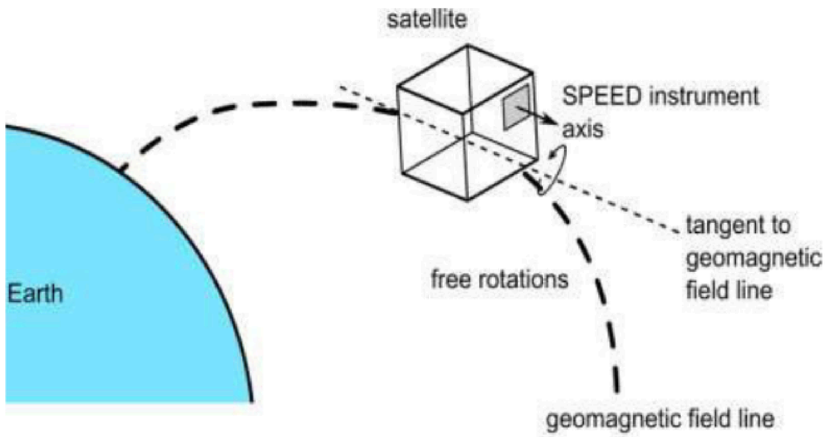


ACS Block Diagram

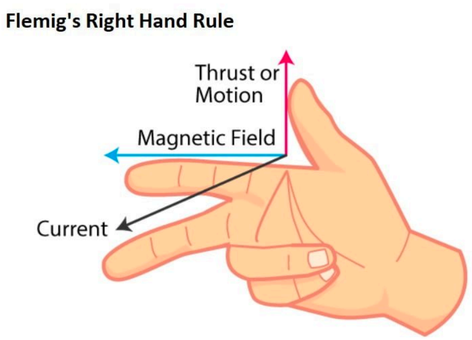


The IMU gives the Angular speed and the magnetometer gives earth's magnetic field. This is used to calculate the current to the Torque rods.

Nominal Mode

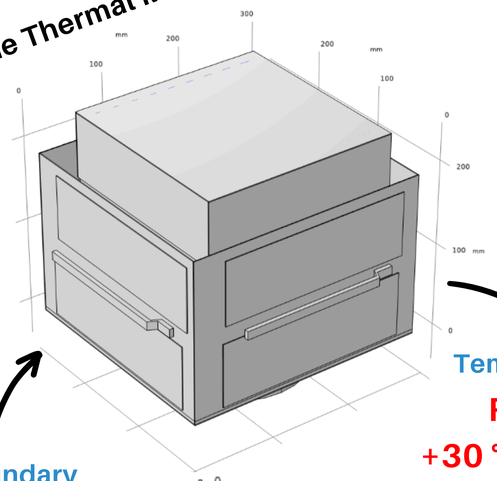


Nominal Mode - Pointing the payload along earth's magnetic field.



THERMAL CONTROL SYSTEM (TCS)

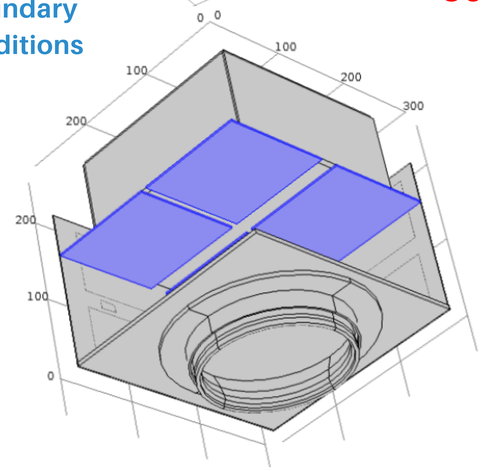
The Thermal Model



boundary conditions

Temperatures

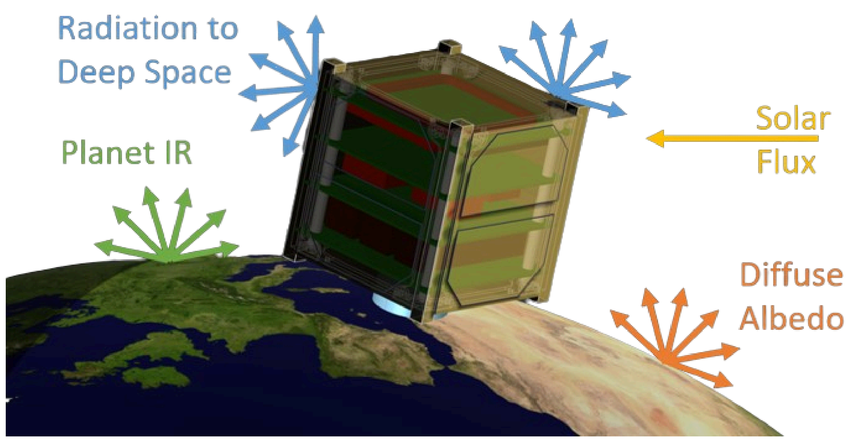
Range:
+30 °C to -20°C



Aim: make sure PCBs are in the operational range

- The model is an lumped model with features that approximates the complex geometry of the Physical model.

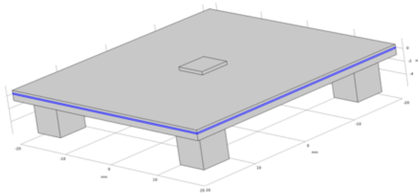
Where is the Heat going?

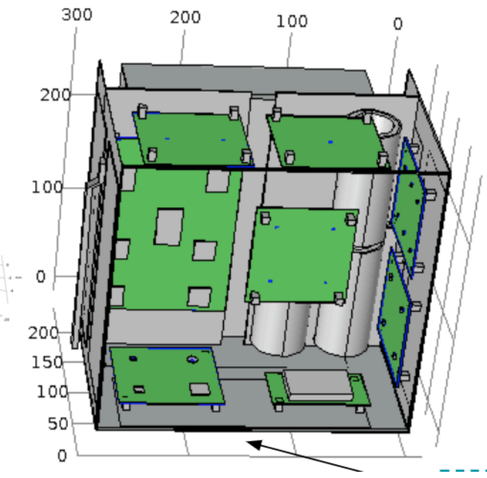


Inputs of Heat: Solar, Earth IR, Albedo, electronics
Outputs: Radiation to deep space

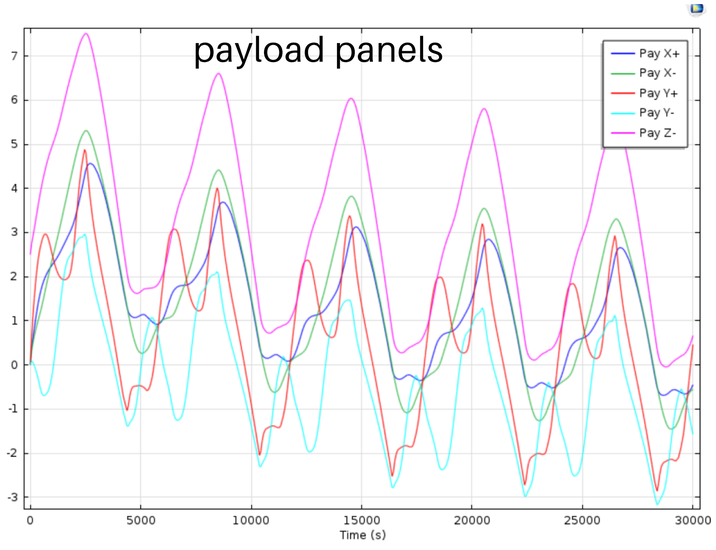
Components	Temp. Range (°C)		
	Operational	Survival	Predicted in-orbit temperatures
COM TX PCB	-40 to +85	-40 to +85	-10 to +25
COM RX PCB	-10 to +60	-30 to -70	+5 to 10
EPS PCB	-20 to +80	-20 to +80	+0 to +40
SBC PCB	-10 to +60	-40 to +85	+5 to +20
PL PCB	-55 to +70	-65 to +150	+0 to +10
Battery PCB	10 to +40	10 to +40	5 to +15

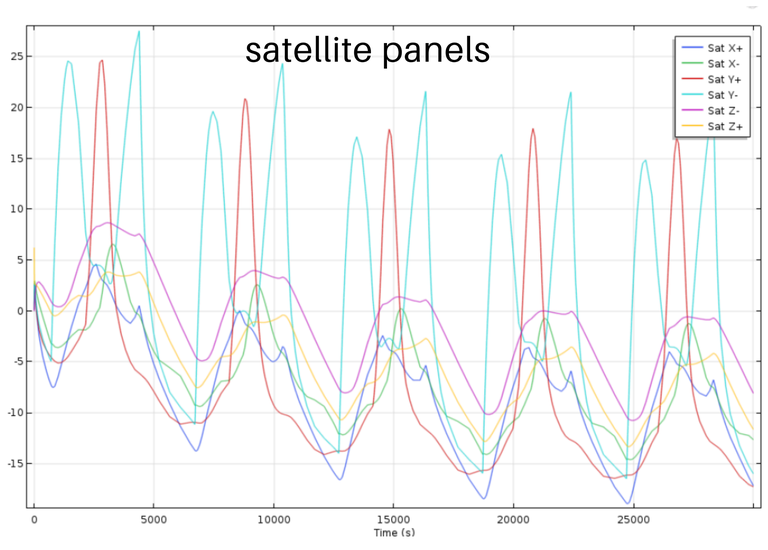
The PCBs

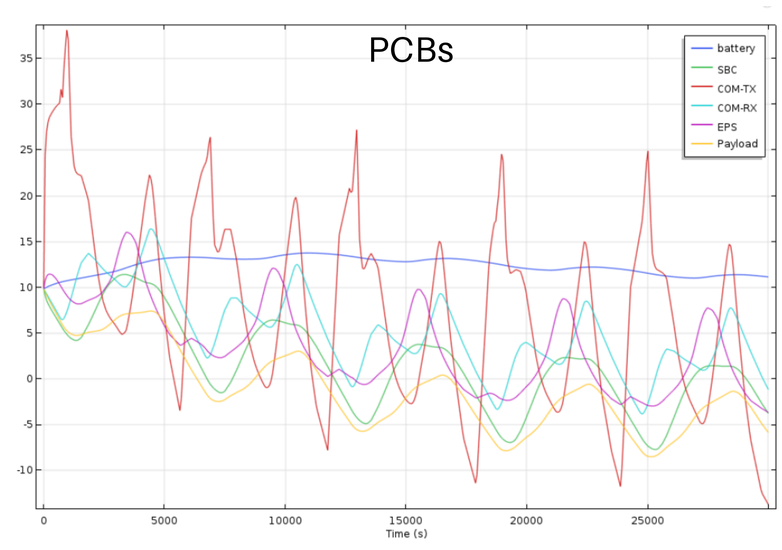




RESULTS

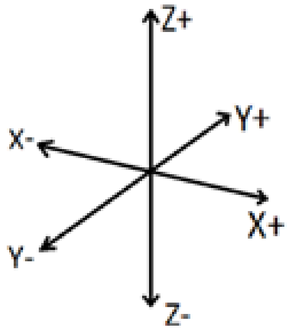




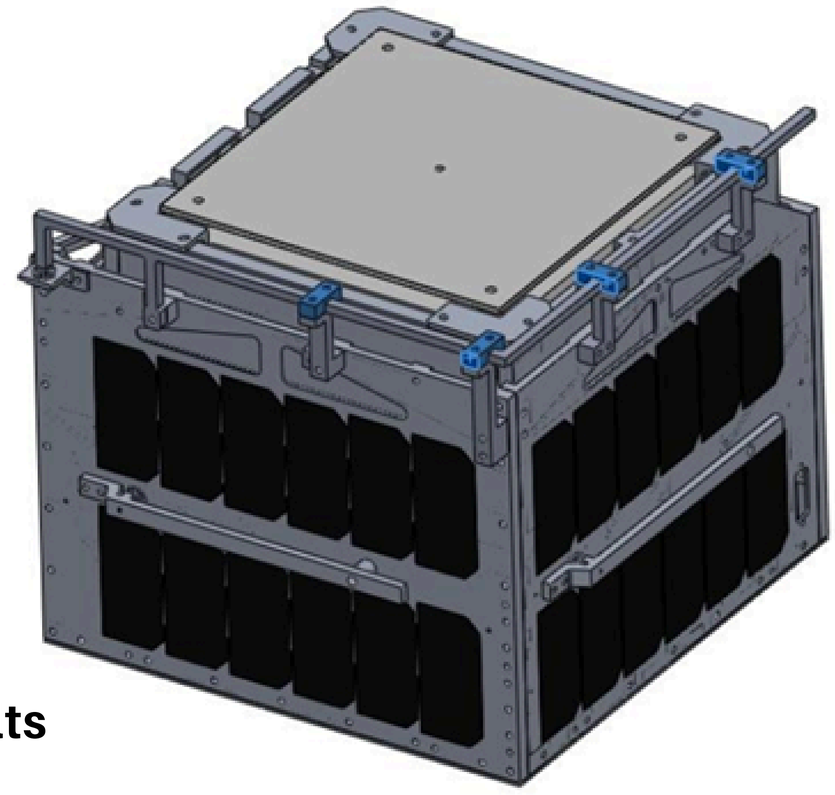


The battery PCB temp is below operational range. Therefore, extra heat must be generated by battery so that it remains in operational range.
Simulation was done to determine that It was found that 0.45W heat is required to maintain average temp as 20 degC

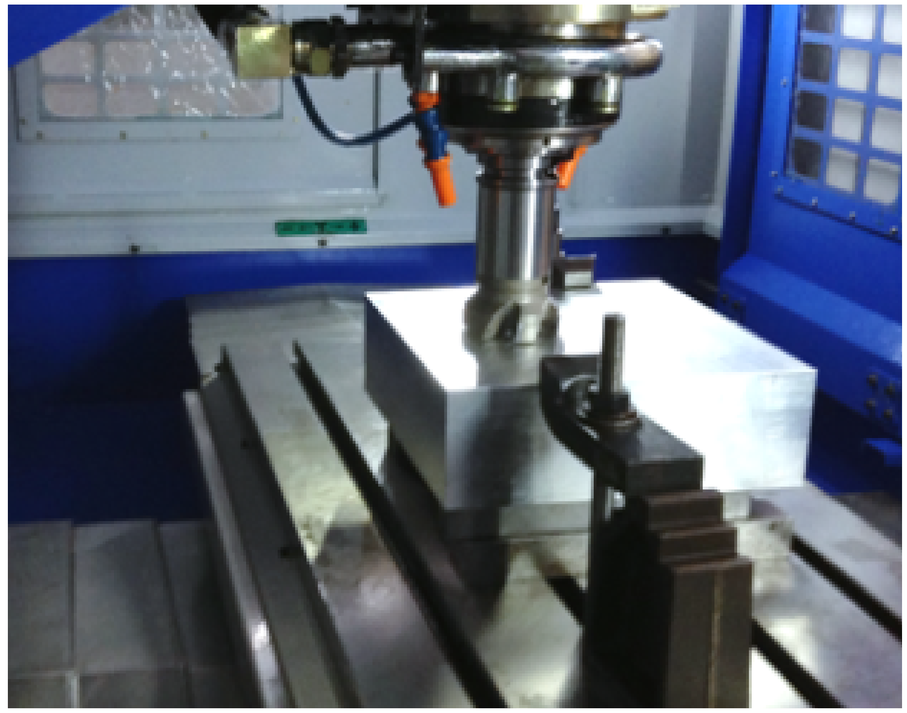
MECHANICAL SUBSYSTEM



Satellite and Orientation



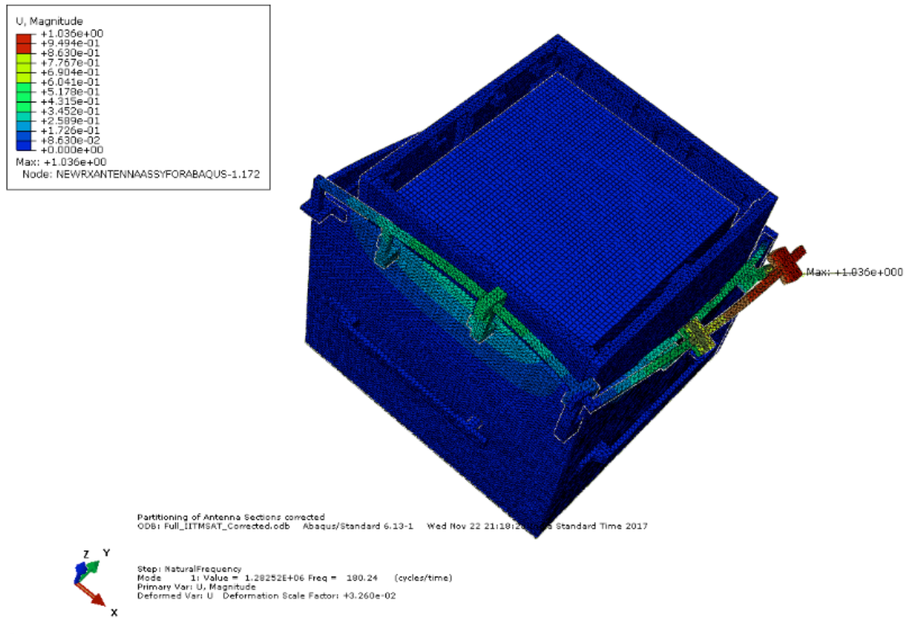
CNC Fabrication



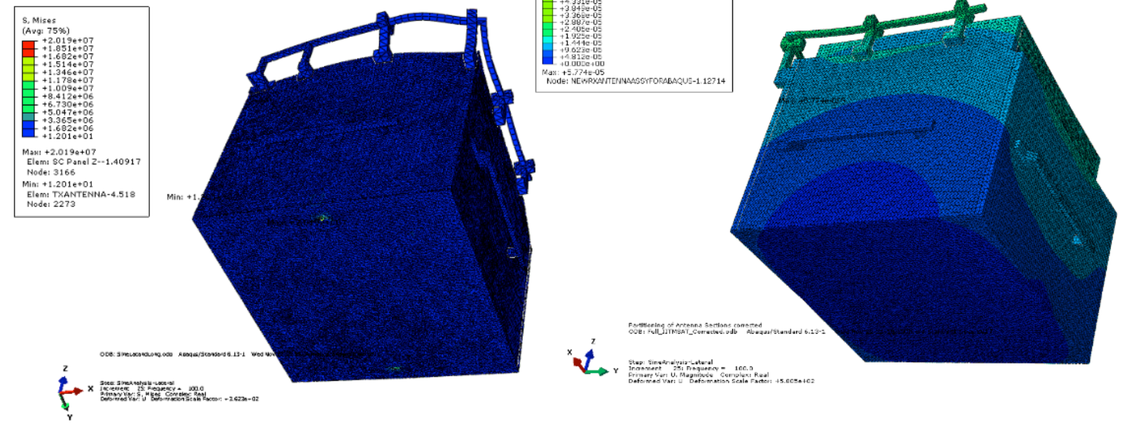
Simulation Results

Number	Frequency(Hz)
1	180.24
2	222.92
3	249.22
4	257.73
5	339.69
6	375.3
7	420.63
8	450.18
9	456.39
10	493.14

Natural Frequency



Sine Analysis - Lateral



Max von Mises Stress – 19 MPa

Displacement – 0.057mm