# CanSat 2021
# Critical Design Review (CDR)
## *Version 1.0*

**Team 1357**
**DTU ALTAIR**

# Presentation Outline

# Team Organization

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# Acronyms

| Acronyms | Meaning |
|---|---|
| **AoA** | Angle of Attack |
| **CDH** | Communication and Data Handling |
| **CMOS** | Complementary Metal oxide Semiconductor |
| **COTS** | Commercial off the shelf |
| **DCS** | Descent Control System |
| **EEPROM** | Electrically Erasable Programmable Read-Only Memory |
| **EPS** | Electrical Power System |
| **FSW** | Flight Software |
| **GCS** | Ground Control System |
| **GUI** | Graphic User Interface |
| **I2C** | Inter-Integrated Circuit |
| **LNA** | Low Noise Amplifier |
| **MSR** | Mechanical System Requirement |
| **PDM** | Payload Deployment Mechanism |
| **PLA** | Polylactic Acid |
| **CG** | Centre of Gravity |

| Acronyms | Meaning |
|---|---|
| **NVMC** | Non-Volatile Memory Controller |
| **RTC** | Real Time Clock |
| **SMD** | Surface Mount Device |
| **SP** | Science Payload |
| **SPI** | Serial Peripheral Interface |
| **SR** | System Requirement |
| **SS** | Sensor Subsystem |
| **LED** | Light Emitting Diode |

**Process Phase**

| Acronyms | Meaning |
|---|---|
| **R** | Research |
| **T** | Testing |
| **P** | Prototyping |
| **C** | Complete//Competition Requirement |

# System Overview

Aman Dadheech

# Mission Summary (1/2)

## MISSION OBJECTIVES:

- To design a CanSat consisting of a container and two auto-rotating maple seed science payloads. The Cansat will be launched to an altitude ranging 670 meters to 725 meters. CanSat container must hold and protect the science payloads during launch and deployment.
- To deploy the parachute of the container and descend at the rate of 15 m/s.
- To design a deployment mechanism to release one of the science payload at 500 meters and other at 400 meters.
- To design the auto-rotating maple seed which shall descend at a rate less than 20m/s.
- To monitor air pressure, air temperature, and rotation rate for the science payload and transmit to data to container.
- To monitor and transmit altitude, battery voltage and GPS position for the CanSat Container.

# Mission Summary (2/2)

## BONUS OBJECTIVES:

- To integrate a video camera into the science payload and point it towards the ground. It should capture the releases of both science payloads and capture the descent of the science payload

## EXTERNAL OBJECTIVES:

- To gain experience in designing and fabricating a modern satellite system and to get the necessary experience for future projects for our team DTU ALTAIR.
- To gain experience in various optimization techniques (ML, genetic algorithm, SQP) in MATLAB required for our future projects.

# Summary of Changes Since PDR (1/2)

| Subsystems | Changes Since PDR |
|---|---|
| **Sensor Subsystem** | Ublox NEO-6M GPS module is being used instead of Adafruit 746 |
| **Decent Control** | Wing Shape Modified |
| | Wing Structure Modified |
| **Mechanical Subsystem** | Container Structure and Material Modified |
| | Wing Material Modified |
| | Payload Pre Deployment Strategy Modified |
| | Payload Deployment Mechanism Changed |
| | Camera Spin Stabilization mechanism modified |
| **Communication and Data Handling** | XBee s2c used instead of XBee pro s2c, 5 xbee used instead of 4 xbee,onboard whip antenna used instead of esp8266 wifi antenna |
| **Electrical Power Subsystem** | Extra xbee was added and GPS sensor was changed. |

# Summary of Changes Since PDR (2/2)

| Subsystems | Changes Since PDR |
|---|---|
| **Flight Software** | Implemented a Transition Counter[TC] |
| | 2 XBees are being used instead of 1 |
| | FlashAsEeprom.h in the FlashStorage library will be used. |
| | XBee-PRO has been replaced with XBee S2C. |
| **Ground Control System** | XBee s2c used instead of XBee pro s2c, onboard whip antenna used instead of esp8266 wifi antenna |

# System Requirement Summary (1/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-1 | Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams. | High |
| BR-2 | CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing. | High |
| BR-3 | The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard. | High |
| BR-4 | The container shall be a fluorescent color; pink, red or orange. | High |
| BR-5 | The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open. | High |

# System Requirement Summary (2/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-6 | The rocket airframe shall not be used to restrain any deployable parts of the CanSat. | High |
| BR-7 | The rocket airframe shall not be used as part of the CanSat operations | High |
| BR-8 | The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket. | High |
| BR-9 | The Parachutes shall be fluorescent Pink or Orange | High |
| BR-10 | The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s. | High |

# System Requirement Summary (3/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-11 | All structures shall be built to survive 15 Gs of launch acceleration. | High |
| BR-12 | All structures shall be built to survive 30 Gs of shock. | High |
| BR-13 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | High |
| BR-14 | All mechanisms shall be capable of maintaining their configuration or states under all forces. | High |
| BR-15 | Mechanisms shall not use pyrotechnics or chemicals | High |
| BR-16 | Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire. | High |

# System Requirement Summary (4/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-17 | Both the container and payloads shall be labeled with team contact information including email address. | High |
| BR-18 | Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. | High |
| BR-19 | XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed. | High |
| BR-20 | XBEE radios shall have their NETID/PANID set to their team number. | High |
| BR-21 | XBEE radios shall not use broadcast mode | High |
| BR-22 | The science payload shall descend spinning passively like a maple seed with no propulsion. | High |

# System Requirement Summary (5/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-23 | The science payload shall have a maximum descent rate of 20 m/s. | High |
| BR-24 | The wing of the science payload shall be colored fluorescent orange, pink or green. | High |
| BR-25 | The science payload shall measure altitude using an air pressure sensor. | High |
| BR-26 | The science payload shall measure air temperature. | High |
| BR-27 | The science payload shall measure rotation rate as it descends. | High |
| BR-28 | The science payload shall transmit all sensor data once per second. | High |

# System Requirement Summary (6/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-29 | The science payload telemetry shall be transmitted to the container only. | High |
| BR-30 | The science payload shall have their NETID/PANID set to their team number plus five. | High |
| BR-31 | The container shall include electronics to receive sensor payload telemetry. | High |
| BR-32 | The container shall include electronics and mechanisms to release the science payloads. | High |
| BR-33 | The container shall include a GPS sensor to track its position. | High |
| BR-34 | The container shall include a pressure sensor to measure altitude. | High |

# System Requirement Summary (7/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-35 | The container shall measure its battery voltage. | High |
| BR-36 | The container shall transmit its telemetry and the payload telemetry received once per second in the format described in the Telemetry Requirements section. | High |
| BR-37 | The container shall stop transmitting telemetry when it lands. | High |
| BR-38 | The container and science payloads must include an easily accessible power switch that can be accessed without disassembling the cansat and science payloads and in the stowed configuration. | High |
| BR-39 | The container must include a power indicator such as an LED or sound generating device that can be easily seen or heard without disassembling the cansat and in the stowed state. | High |

# System Requirement Summary (8/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-40 | An audio beacon is required for the container. It may be powered after landing or operate continuously. | High |
| BR-41 | The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed. | High |
| BR-42 | Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed. | High |
| BR-43 | An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat. | High |
| BR-44 | An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat. | High |

# System Requirement Summary (9/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-45 | Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects. | High |
| BR-46 | The Cansat must operate during the environmental tests laid out in Section 3.5. | High |
| BR-47 | The Cansat shall operate for a minimum of two hours when integrated into the rocket. | High |
| BR-48 | The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets. | High |
| BR-49 | The container must maintain mission time throughout the whole mission even with processor resets or momentary power loss. | High |

# System Requirement Summary (10/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-50 | The container shall have its time set to UTC time to within one second before launch. | High |
| BR-51 | The container flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file. | High |
| BR-52 | In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the container altitude. | High |
| BR-53 | The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands. | High |
| BR-54 | The ground station shall command the Cansat to start transmitting telemetry prior to launch. | High |

# System Requirement Summary (11/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-55 | The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section. | High |
| BR-56 | Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission. | High |
| BR-57 | Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission. | High |
| BR-58 | Each team shall develop their own ground station. | High |
| BR-59 | All telemetry shall be displayed in real time during descent on the ground station. | High |
| BR-60 | All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) | High |

# System Requirement Summary (12/12)

| Requirement Number | Requirement | Priority |
|---|---|---|
| BR-61 | Teams shall plot each telemetry data field in real time during flight | High |
| BR-62 | The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna. | High |
| BR-63 | The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site | High |
| BR-64 | The ground station software shall be able to command the container to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE. | High |
| BR-65 | When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the container. | High |
| BR-66 | The science payloads shall not transmit telemetry during the launch, and the container shall command the science payloads to begin telemetry transmission upon release from the container. | High |

# Physical Layout (1/4)

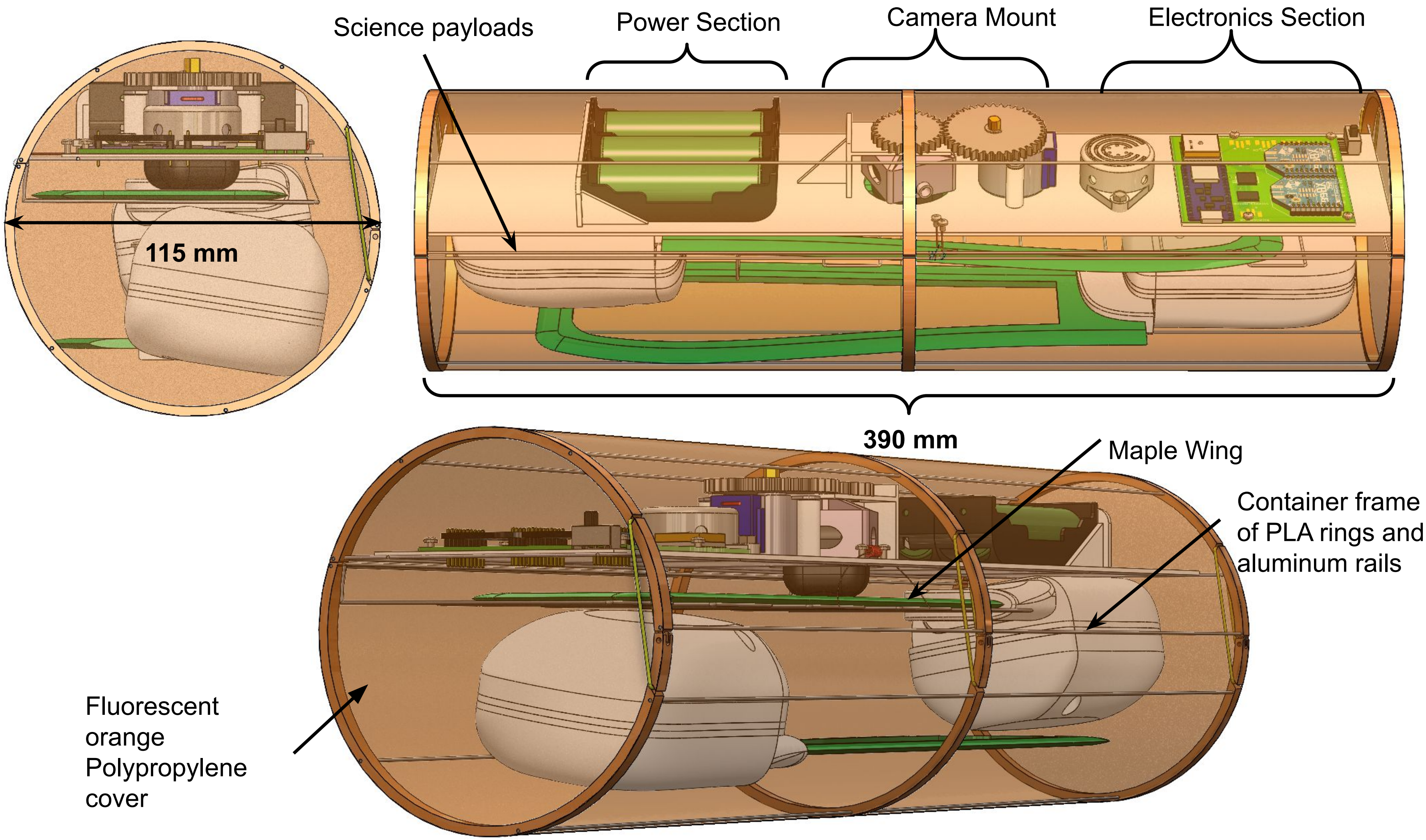



***Fig 2.1:*** *Cansat assembly with container dimensions*

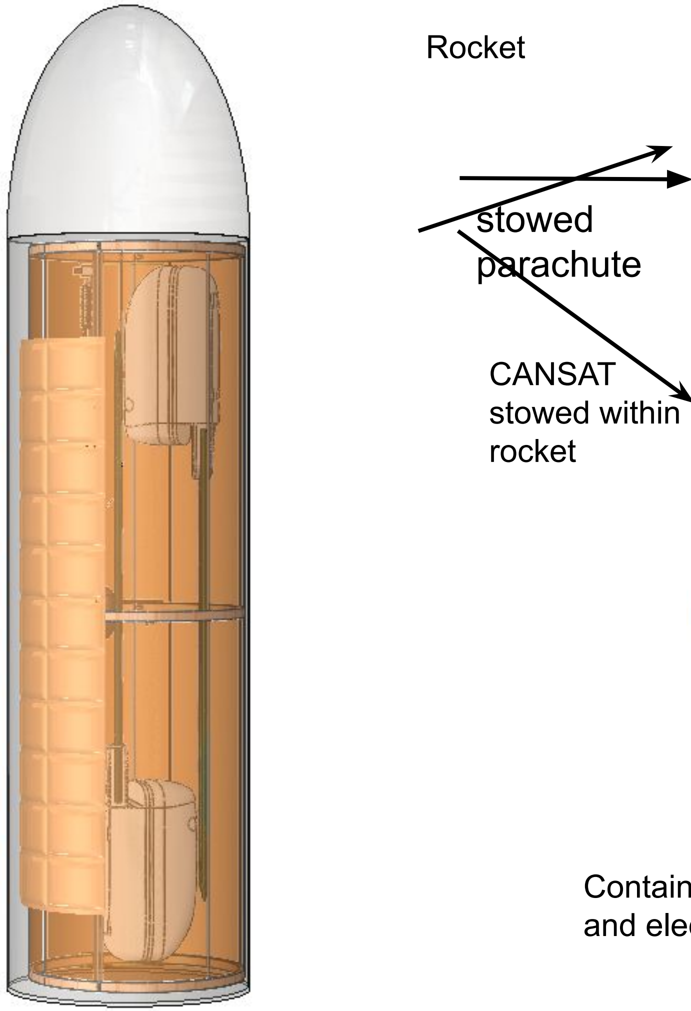



***Fig 2.2:*** *Launch Configuration*

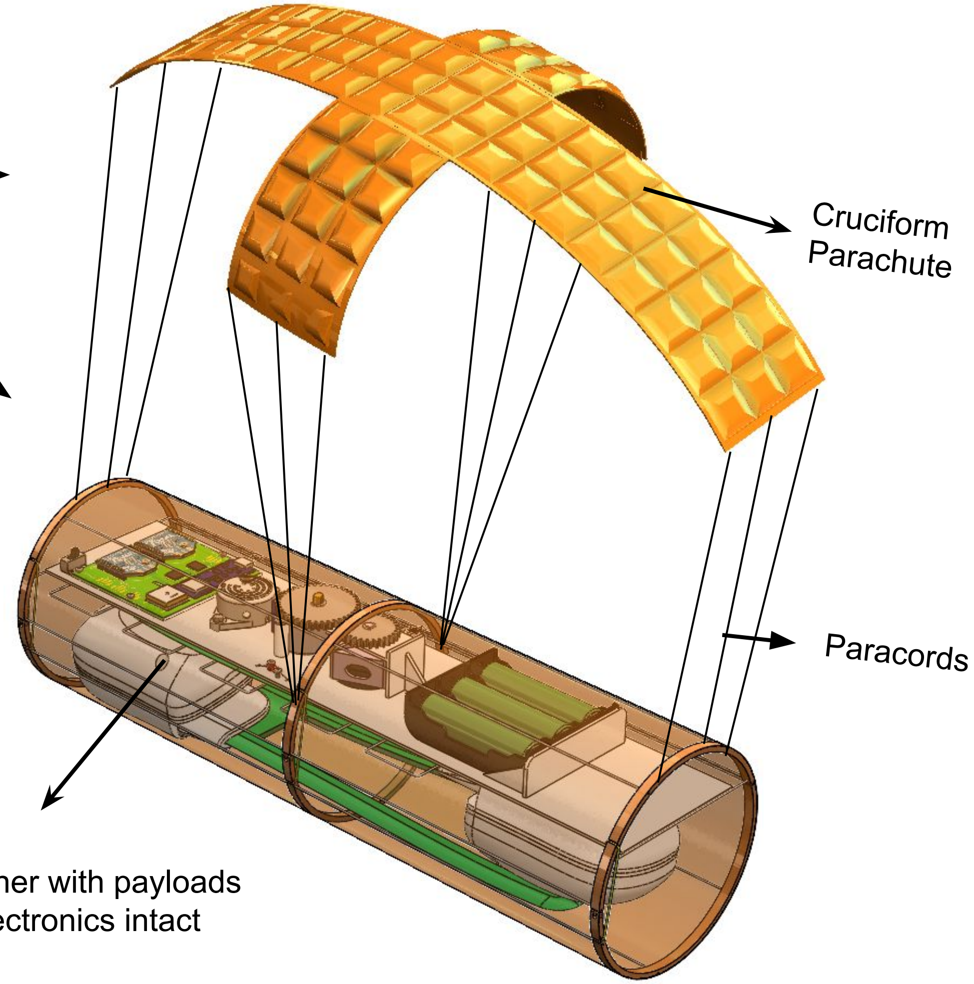



***Fig 2.3:*** *Cansat Deployment Configuration*

# Physical Layout (3/4)

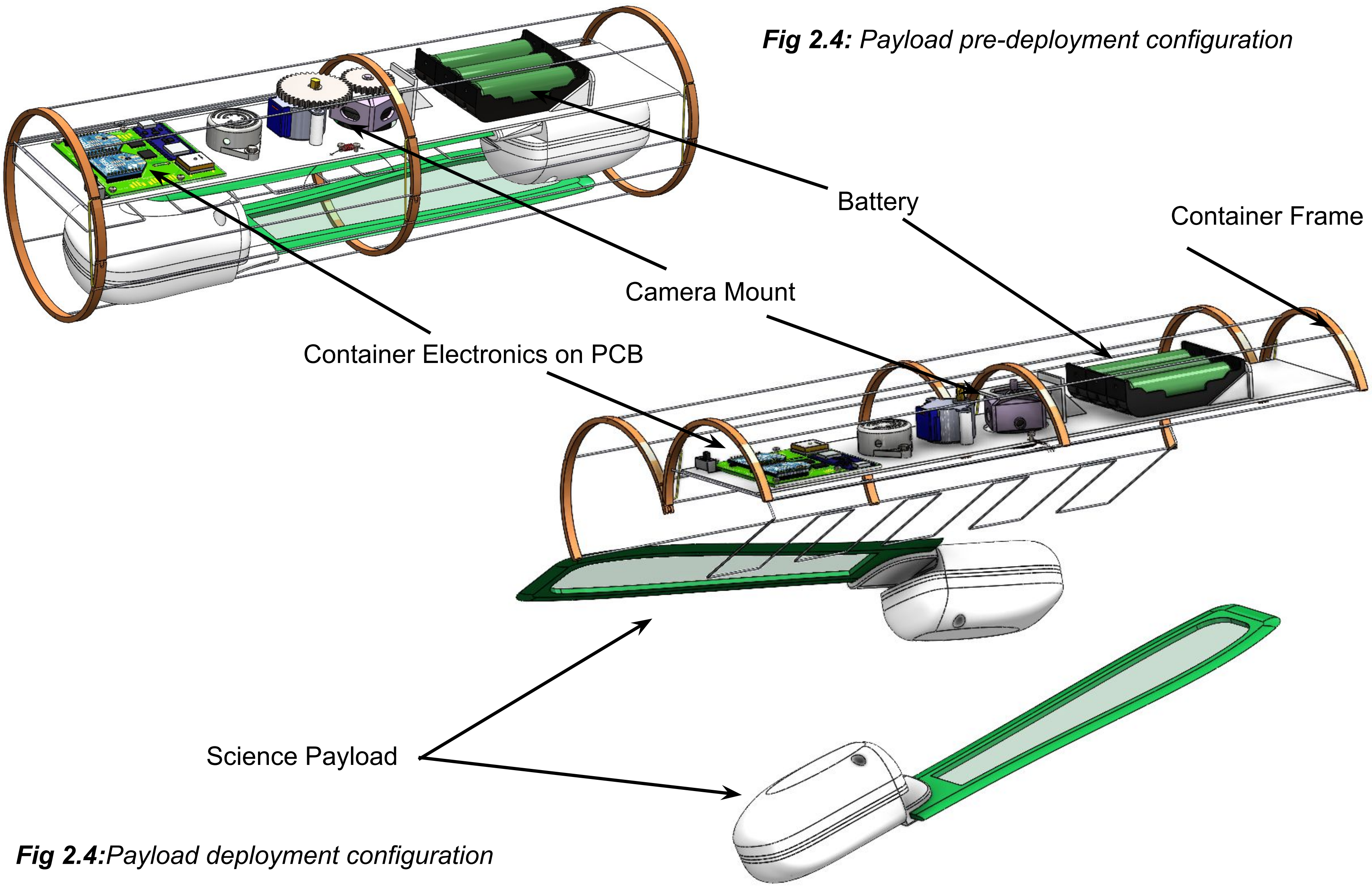



***Fig 2.4:** Payload pre-deployment configuration*

***Fig 2.4:**Payload deployment configuration*

# Physical Layout (4/4)

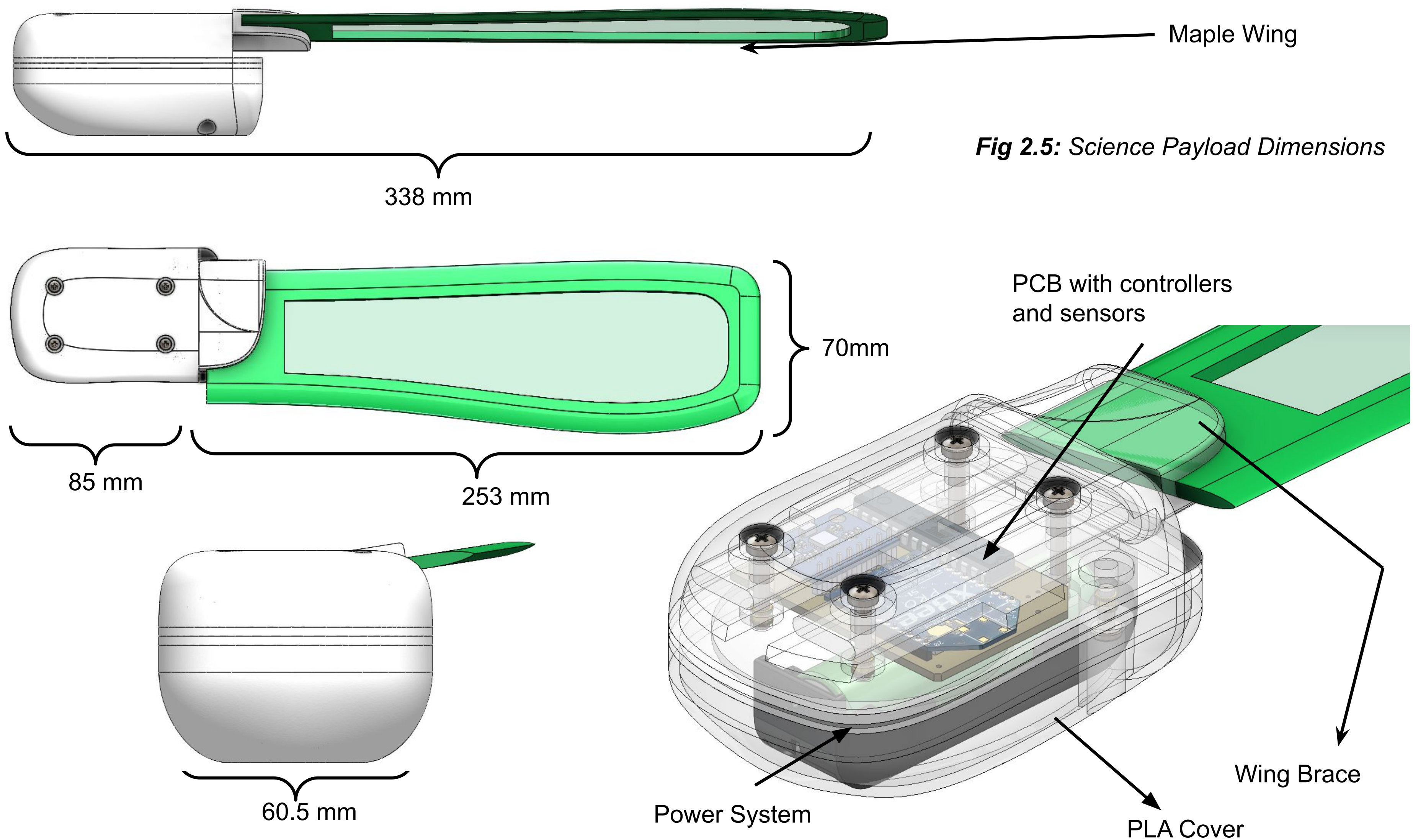
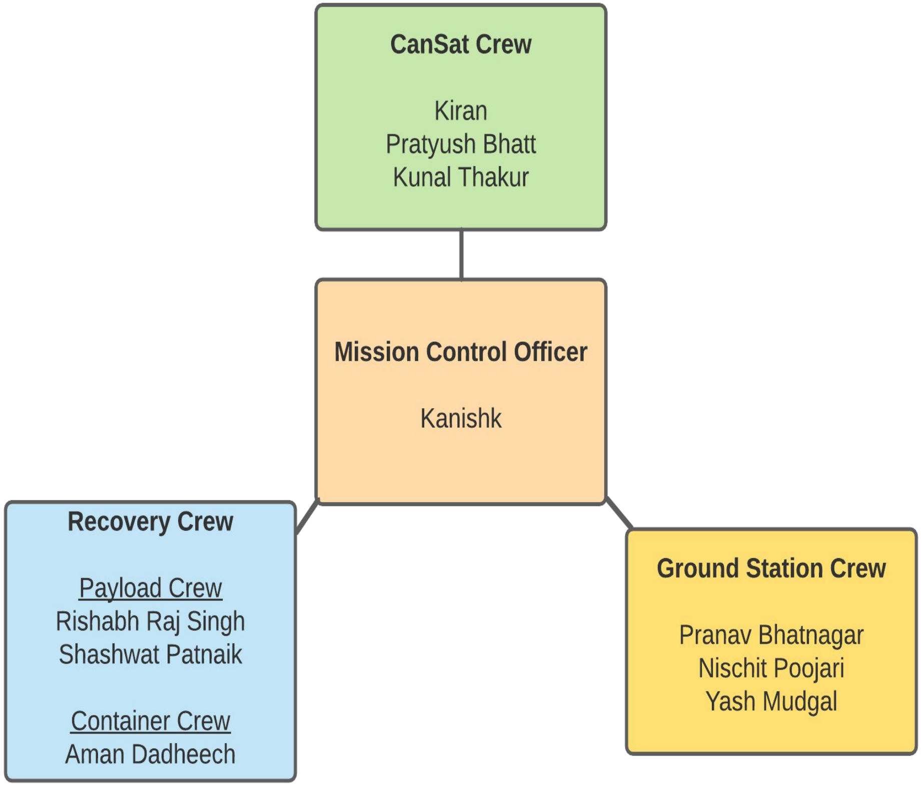



***Fig 2.5:*** *Science Payload Dimensions*

# System Concept of Operations (1/3)




**Pre-Launch Activities**

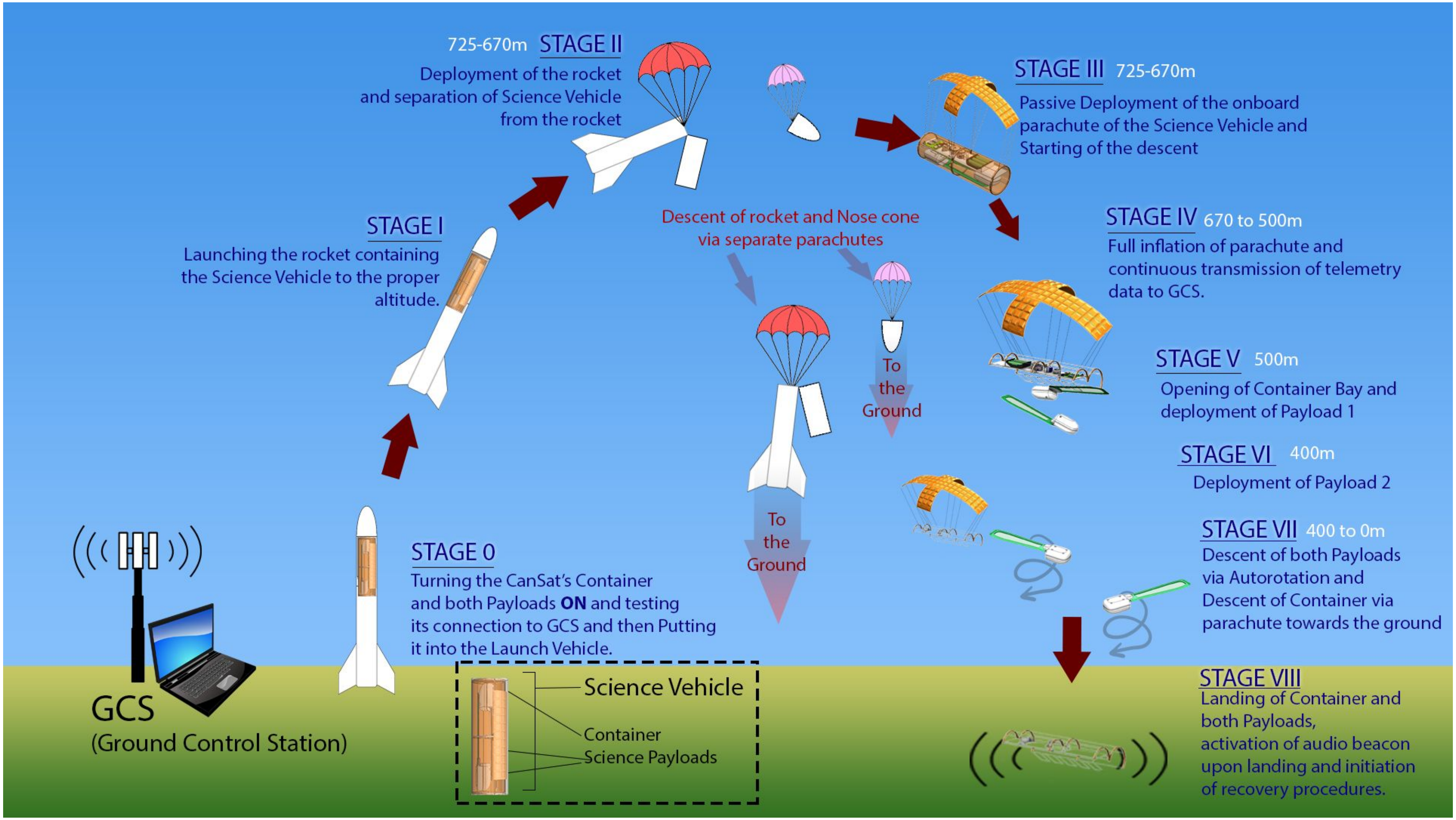
- Arrival at the launch site.
- CanSat Assembly.
- Set-up ground station.

**Pre-Launch Activities**

- Communication verifies will be controlled between the ground station and payload.
- Weight and fit check will be done by CC.
- CanSat will be inspected for safety.
- All mechanisms will be reviewed.
- The CanSat will be placed in the Rocket after the checklist was controlled by MCO.
- All flight operations will be checked by MCO.
- After the flight, the SD card will be delivered to the judge.

**Mission Control Officer**: Informs flight coordinator when the team and CanSat are ready for the flight.
**Ground Station Crew**: Those are responsible for monitoring the ground station for telemetry reception and sending commands to CanSat.
**Recovery Crew**: People who are looking for CanSat in the competition area.
**CanSat Crew:** Those who are preparing CanSat.

# System Concept of Operations (2/3)



# System Concept of Operations (3/3)

## Pre-Launch

- Set up ground system.
- Electronics and mechanic integrity checks.
- The payload system will be calibrated with the command sent from the ground station.
- Communication Tests
- Damage control before the flight by CanSat crew.

## Launch

- Placement of Cansat into the rocket.
- Launch of Rocket.
- The eletronic system will start sending data via GCS and creation of .csv file.
- Launch and events of CONOPS (given in previous slide).
- Telemetry data obtaining and .csv file creation via GCS software.

## Post-Launch

- The location of the payload will be located via GPS and buzzer.
- Recovery of container with indicators fluorescent color.
- Recovered CanSat is brought to GCS.
- SD card will be taken from the payload.
- Retrieve the video recording.
- Analyse the Data.
- Preparation of PFR.
- PFR presented to jury.

# Launch Vehicle Compatibility

The dimensions of the whole cansat is well within the specified dimensions and have enough tolerances for smooth deployment from the rocket. The outer surface of the Container do not have any sharp protrusions hence allowing smooth release from the rocket.
The rocket airframe is not used to restrain any deployable part of CANSAT. Moreover, the rocket airframe is not used for any CANSAT operation

Rocket payload dimensions based on mission guide:

- Height-**400mm**
- Diameter-**125mm**

Container dimensions:

- Height-**390mm**
- Diameter-**115mm**

Clearances

- Height-**10mm**
- Diameter-**10mm**

**The parachute is stowed on the side (cylindrical face) of the container**

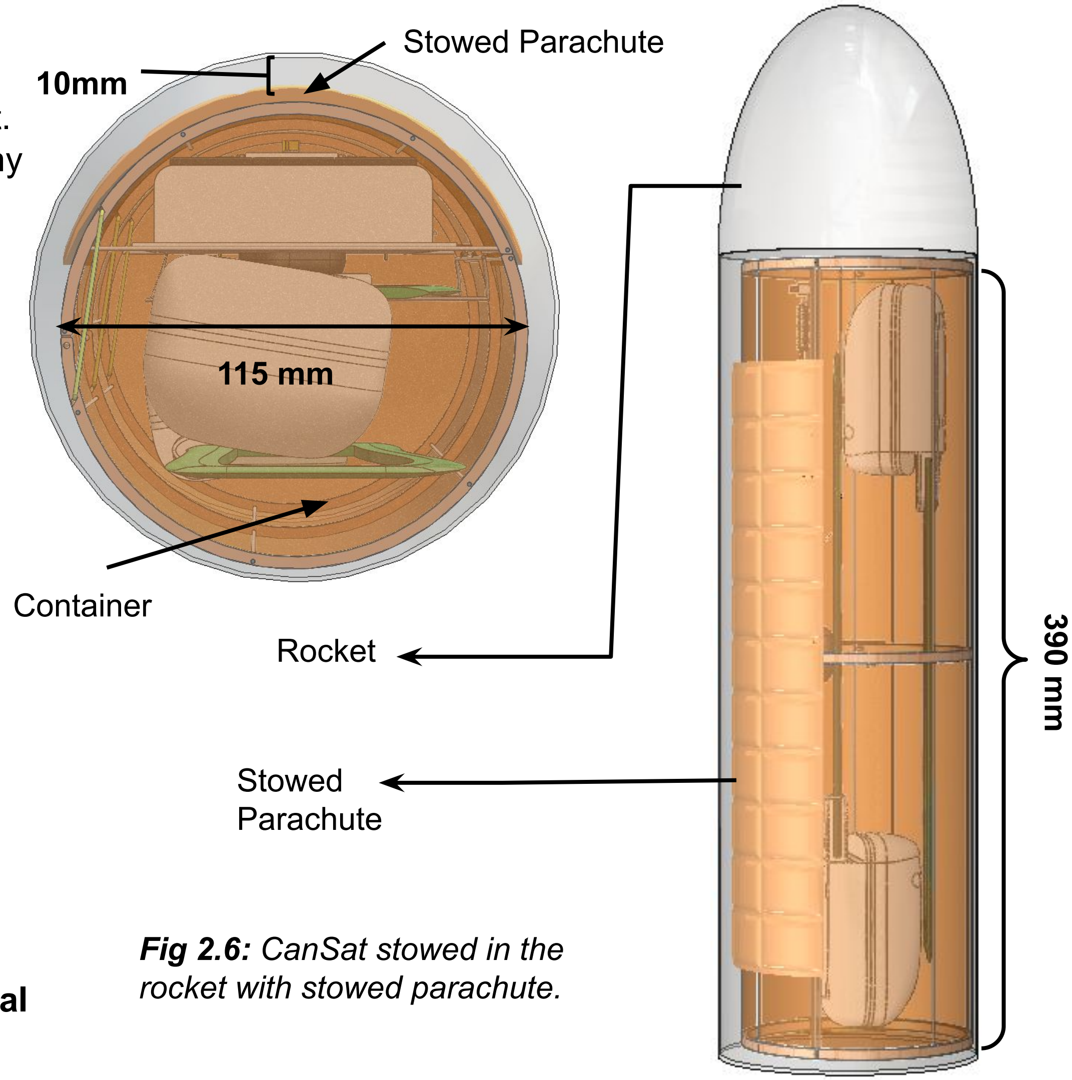



***Fig 2.6:** CanSat stowed in the rocket with stowed parachute.*

# Sensor Subsystem Design

Nischit Nagesh Poojari

# Sensor Subsystem Overview

| SNo. | Component Requirement | Selected Component | Function/Properties of the Component |
|---|---|---|---|
| 1. | Payload Air Temperature and Pressure Sensor | BMP 180 | Measurement of the air temperature and pressure of the payload |
| 2. | Payload Rotation Sensor | MPU 6050 | To determine the rotation of the payload |
| 3. | Container Air pressure Sensor | LPS22HB | Measurement of the air pressure around the container |
| 4. | Container GPS sensor | Ublox NEO-6M | Determination of the location of payload - longitude, latitude and altitude |
| 5. | Container Power Voltage Sensor | Arduino ADC | Measurement of the battery voltage of the payload |
| 6 | Camera | Mini 1920*1080P FPV camera | The camera is used for the bonus objective to record the descent of science payload |

# Sensor Changes Since PDR

| Component | Changes | Rationale |
|---|---|---|
| **GPS sensor** | **Ublox NEO-6M GPS module** has been selected as our container GPS sensor instead of the previously selected **Adafruit 746 GPS.** | The sensor was changed due to unavailability of Adafruit 746 GPS module in market. |

# Sensor Subsystem Requirements

| Base Requirement for Sensor Subsystem | | | | | | |
|---|---|---|---|---|---|---|
| Requirement Number | Requirement | Priority | Process Phase | | | |
| | | | R | T | P | C |
| SS - 01 | The science payload shall measure altitude using an air pressure sensor | High | | | | ✓ |
| SS - 02 | The science payload shall measure air temperature. | High | | | | ✓ |
| SS - 03 | The science payload shall measure rotation rate as it descends. | High | | | ✓ | |
| SS - 04 | The science payload shall transmit all sensor data once per second | High | | | | ✓ |
| SS - 05 | The container shall include a GPS sensor to track its position. | High | | | | ✓ |
| SS - 06 | The container shall include a pressure sensor to measure altitude. | High | | | ✓ | |
| SS - 07 | The container shall measure its battery voltage. | High | | | ✓ | |
| SS - 08 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | Medium | ✓ | | | |

# Payload Air Pressure and Temperature Sensor Summary

| Part Number | Manufacturer | Sensor Type | Operating Temperature (°C) | Weight | Voltage Supply (V) | Resolution | Accuracy - Highest (lowest) | Mounting type | Data Format |
|---|---|---|---|---|---|---|---|---|---|
| BMP180 | Bosch | Analog /Digital | (-)40 - (+)85 | 6g (breakout) | 1.8 - 3.6 | ±0.1°C,0.02 hPa | ±1.5°C(±2° C),±1hPa | SMT | Float X.XX hPa X.XX °C |

**Final Air temperature and Pressure sensor: BMP180**

1. I2C **precision temperature and pressure sensor**. The BMP180 is a compact, piezoresistive
2. BMP 180 is built into a **single sensor module GY-87** consisting of IMU as well..
3. **Low Power** required - 1.8 V to 3.6 V supply voltage, internally regulated

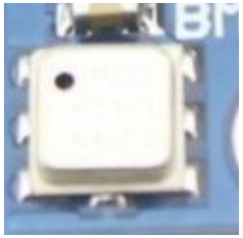


***Fig 3.1:****BMP180*

**Data Processing**

```
#include <SFE_BMP180.h>
SFE_BMP180 bmp180;
bool success = bmp180.begin();
status = bmp180.getTemperature(T);
status = bmp180.startPressure(3);Serial.print("Pressure:
");Serial.print(P);Serial.println(" hPa");
Serial.print("Temperature: ");
Serial.print(T);
Serial.println(" C");
```

**Data Output Sample**

```
Temperature: 26.28 C
Pressure: 1009.80 hPa
Temperature: 26.28 C
Pressure: 1009.80 hPa
Temperature: 26.28 C
```

# Payload Rotation Sensor Summary

| Part Number | Manufacturer | Interface | Operating Temperature (°C) | Weight | Voltage Supply (V) | Sensitivity (°/s) | Accuracy (g) | Gyroscope Range | Data Format |
|---|---|---|---|---|---|---|---|---|---|
| MPU-6050 | InvenSense | I2C | (-)40 - (+)85 | 6g (breakout) | 2.3 - 3.4 | 65.5 (±500°/sec) | 61 n | ±250, ±500, ±1000, and ±2000°/sec | Float |

**Final Payload Rotation sensor: MPU-6050**

1. The **MPU6050** devices combine a 3-axis gyroscope and a 3-axis accelerometer.
2. It is built in to single breakout board GY-87 which consist of all the required sensors.

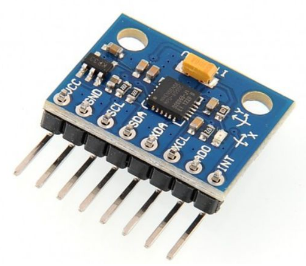


***Fig 3.2:*** *MPU-6050*

**Data Processing**

```
#include<MPU6050.h>
mpu.setAccelerometerRange(MPU6050_RANGE_16_G);
mpu.setGyroRange(MPU6050_RANGE_250_DEG);
mpu.setFilterBandwidth(MPU6050_BAND_21_HZ)
sensors_event_t a, g;
mpu.getEvent(&a,&g,&temp);Serial.print(a.acceleration.x);
Serial.print(a.acceleration.y);
Serial.print(",");Serial.print(a.acceleration.z);Serial.p
rint(",
");Serial.print(g.gyro.x);Serial.print(",");Serial.print(
g.gyro.y);Serial.print(",");Serial.print(g.gyro.z);
 Serial.println("");
```

**Data Output Sample**

```
Acceleration X: 1.19, Y: 3.47, Z: 8.83 m/s^2
Rotation X: 0.06, Y: -0.02, Z: -0.00 rad/s
```

# Container Air Pressure Sensor Summary

| Part Number | Manufacturer | Sensor Type | Operating Temperature (°C) | Weight | Voltage Supply (V) | Resolution | Accuracy - Highest (lowest) | Mounting type | Data Format |
|---|---|---|---|---|---|---|---|---|---|
| LPS22HB | ST Microelectronics | Analog /Digital | (-)40 - (+)85 | 6g (breakout) | 1.7 - 3.6 | 10mV/C | ±1.5°C | SMD/SMT | Float X.XX KPa |

**Final Air Pressure sensor: LPS22HB**

1. Sensor **built in to Arduino nano 33 BLE sense.**
2. **Pressure sensor with altimetry**. I2C or SPI digital output interface Low Power Required **1.7V to 3.6V** supply voltage internally regulated.

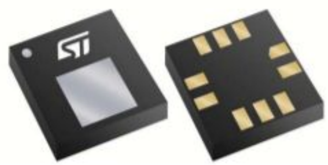


***Fig 3.3:*** *LPS22HB*

### Data Processing

```
#include<Arduino_LPS22HB.h>
float pressure = BARO.readPressure();
Serial.print("Barometer: ");
Serial.print(pressure);
Serial.print('\t');
```

### Data Output Sample

```
Barometer: 97.77
Barometer: 97.77
Barometer: 97.77
Barometer: 97.77
Barometer: 97.77
Barometer: 97.76
Barometer: 97.76
Barometer: 97.77
Barometer: 97.76
Barometer: 97.73
Barometer: 97.77
```

# Container GPS Sensor Summary

| Communication Interface | Manufacturer | Channels | Operating Temperature (°C) | Size and Weight | Power Required | Sensitivity (dbm) | Position Accuracy | Data Format |
|---|---|---|---|---|---|---|---|---|
| Serial | Ublox NEO-6M | 50 | (-)40 - (+)85 | 20mm x 30mm x 4mm, 12g | 2.7-3.6V, 45mA | (-)161 | 2.5meters | Float and Integer |

**Final GPS sensor :Ublox NEO-6M Ultimate GPS Breakout**

1. Ublox NEO-6M has Satellites: **22 tracking, 50 searching**, and hence 50 channels
2. Smaller in **packaging size** when compared to its counterpart **- 25.5mm x 35mm x 6.5mm.**
3. Better **Position Accuracy**: **< 3 meters**
4. Industrial grade **operating temperature** from **-40 - 80 C**.

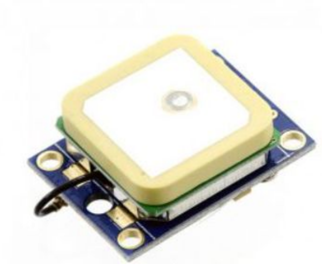


***Fig 3.4:*** Ublox NEO-6M

**Data Processing**

```
int GPSBaud = 9600;
SoftwareSerial gpsSerial(RXPin,TXPin);
Serial.begin(9600);
gpsSerial.begin(GPSBaud);
while (gpsSerial.available() > 0)
      Serial.write(gpsSerial.read());
```

**Data Output Sample**

$GPRMC, 123519, A, 4807.038, N, 01131.000, E,022.4, 084.4, 230394, 003.1, W*6A

**Data output left to right :** UTC Time,Status, Latitude, Longitude, Speed over ground (knots), Track angle,CurrentDate,Magnetic Variation

# Container Voltage Sensor Summary

| Manufacturing Number | Manufacturer | Communication Interface | Operating Temperature (°C) | Voltage Supply (V) | Resolution | Accuracy (V) | Data Format |
|---|---|---|---|---|---|---|---|
| On Board Arduino ADC | Arduino LLC | - | Any | 3 - 5 | 0.8mV | 0.0005 | Float X.XX (V) |

**Selected Power Voltage Sensor: On Board Arduino Analog to Digital Converter (ADC)**

1. Mounted along with Arduino so there is no for **extra size or weight** calculation.
2. Industrial grade **operating temperature**.
3. Highest **Accuracy** and highest **Resolution 12 bit ADC**.

**Data Processing:**

$A_{is}$ = Analog Input Signal (0/1023)
$V_{in}$ = Input Voltage (0/5V)

$$V_{in} = \frac{A_{is} \times 5}{1023}$$

```
anlg_sgnal = analogRead(A0);

V_in = (anlg_sgnal * 5) /1023.0;
```

**Data Output Sample**

```
Voltage: 3.30 V

Voltage: 3.30 V

Voltage: 3.30 V
```

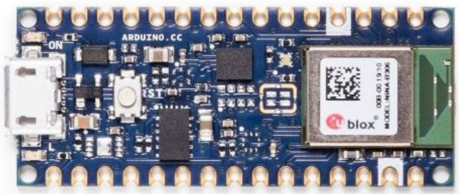



***Fig 3.5:*** *Arduino Digital to analog converter*

# Bonus Objective Camera Summary

| Model | Video resolution | Frame per second | Voltage Supply (V) | Size | Communication interface | Video Format |
|---|---|---|---|---|---|---|
| Mini 1920*1080P FPV camera | 1080p | 30 | 5 | 25 mm x 25 mm x 26 mm | Digital | MP4 |

**Final Camera Selection is Mini 1920*1080P FPV Camera:**

1. Appropriate video resolution and fps values considering bonus mission requirements.
2. The camera supports up to **32GB SD card**.
3. Light and have its own power source
4. Recording time **upto 70 minutes**.
5. **The resolution of the camera meets the requirement of 640x640 pixels in colour**.

***Fig 3.6:*** *FPV Camera*

# Descent Control Design

**Kanishk**

# Descent Control Overview

**Descent Control System is composed of a parachute for the container and Two Science payloads in the form of Auto-rotating maple seed pods.**

The DCS consists of mainly two systems

- <u>Container</u>
- <u>Science Payloads</u>

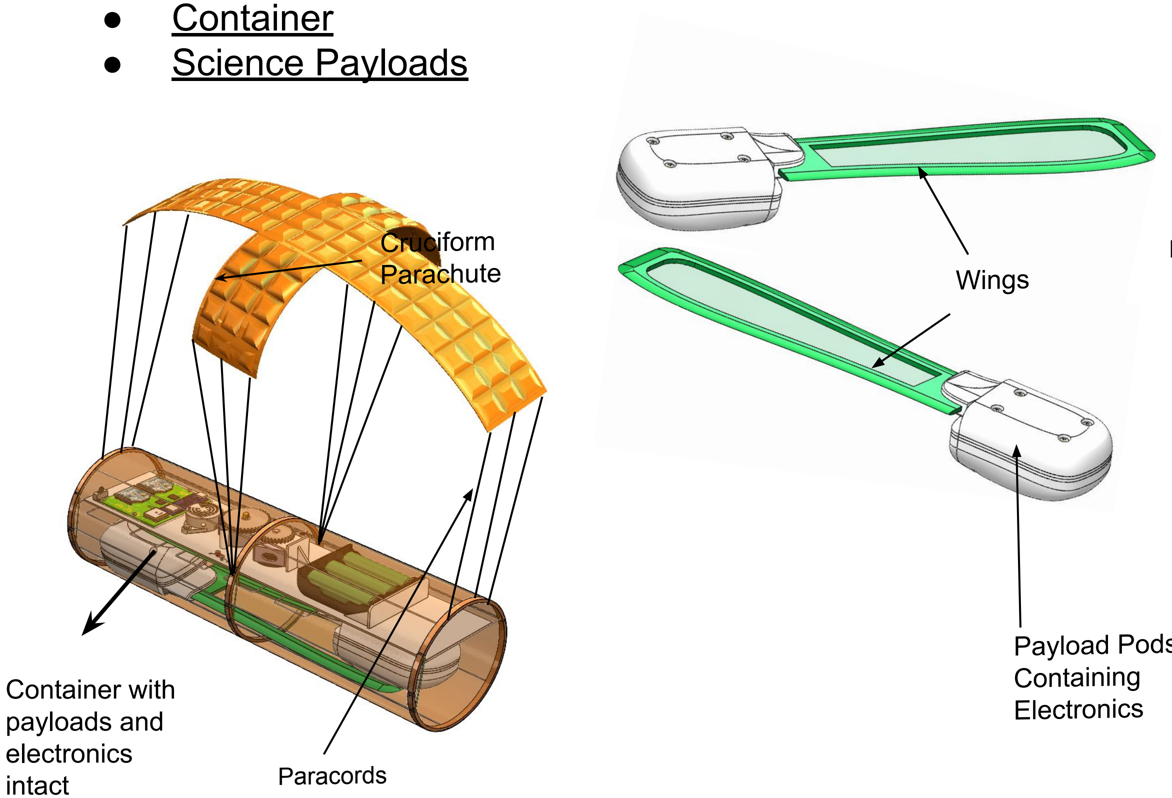
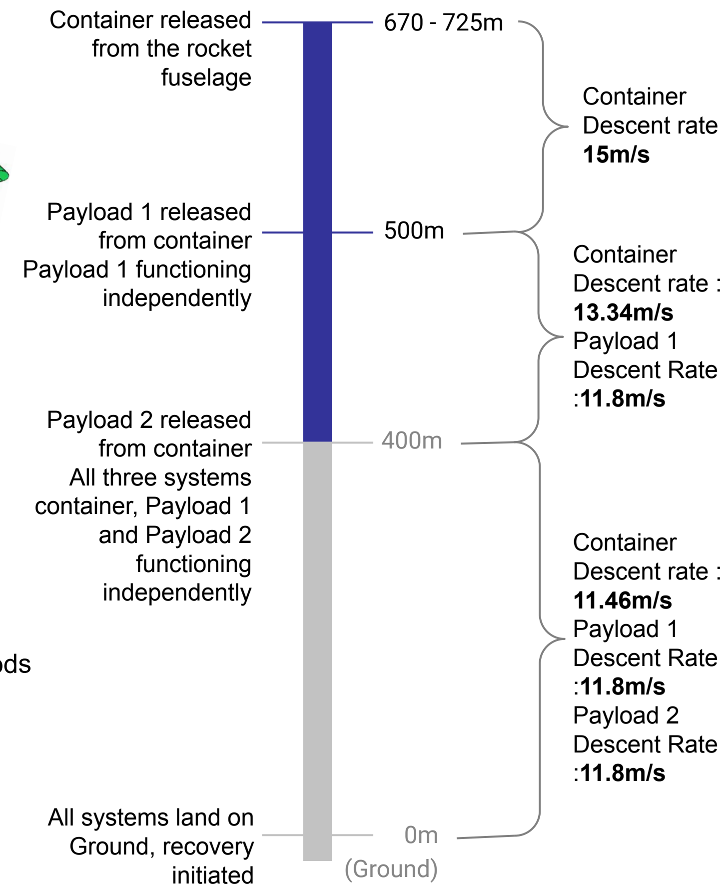



***Fig 4.1** Container and Payload Descent Configurations and important parts*



# Descent Control Changes Since PDR (1/4)

| Component | Change | Rationale |
|---|---|---|
| Payload Wing Shape | Appropriate shape calculated for the wing. | A new and modified approach for wing shape calculation lead to a better performing wing. |

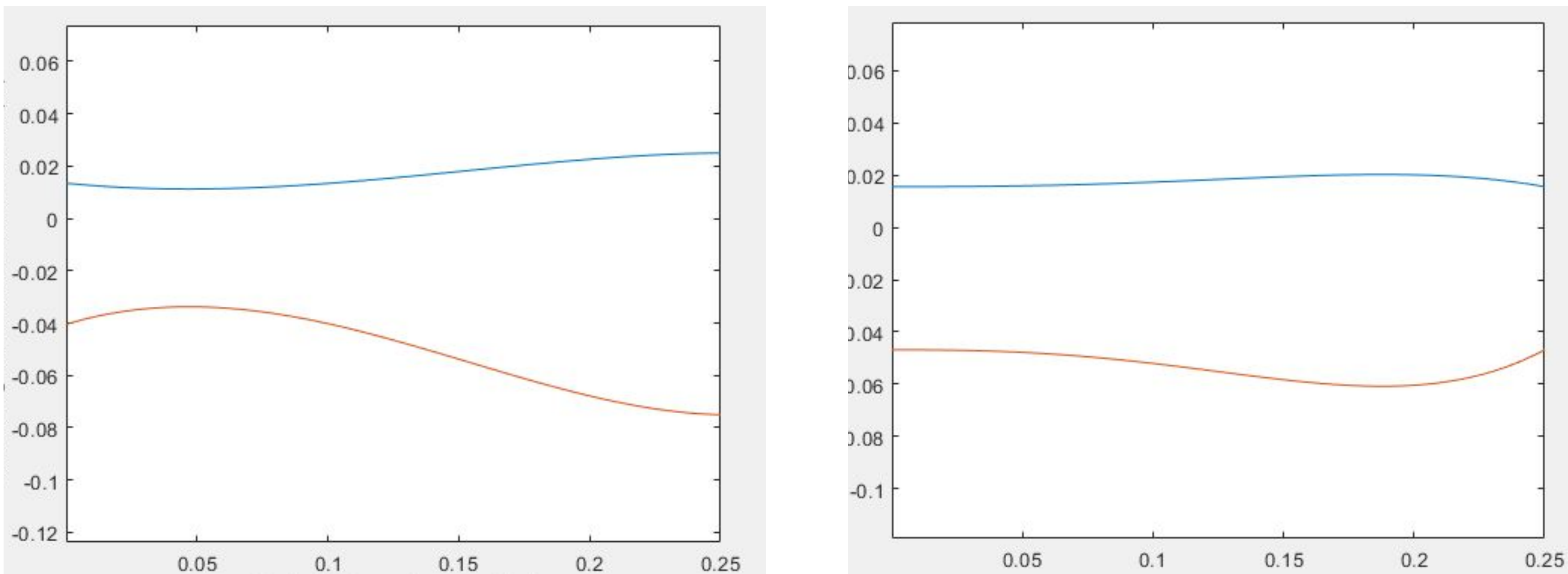



***Fig 4.2** Planform view of wing of the science payload*

# Descent Control Changes Since PDR (2/4)

| Component | Change | Rationale |
|---|---|---|
| Payload Wing Structure | Hollow from the middle, covered with tinted clear plastic sheet | Lesser weight, Optimized Inertia for Simulation purposes, transparent section for better camera views for capturing the release of both payloads. |

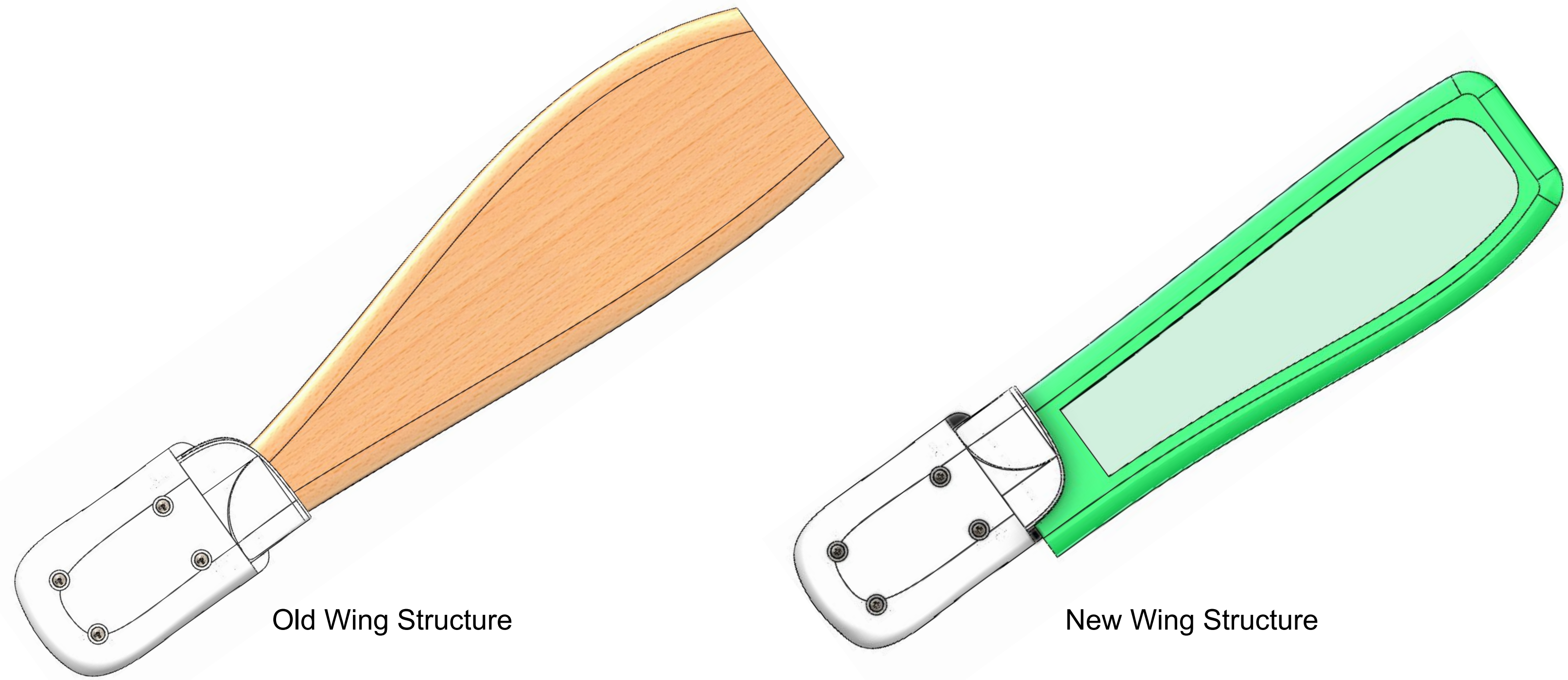



***Fig 4.3*** *Wing Changes since PDR*

## Prototyping Progress

- The wing and payload shell were printed and assembled.
- The dimensions of the printed parts are accurate.
- The 3D printed parts have the specified tolerances
- All the electronics fit correctly inside the payload shell


***Fig 4.4*** *Fabricated prototype of science payload*

# Descent Control Changes Since PDR (4/4)

## Prototype Testing

Only preliminary Prototypes of the Payload were made.

Rest of the prototyping and testing is pushed towards the early weeks of April due to sudden rise in **COVID-19** cases in New Delhi, India.

We have focused on thorough and intensive simulations for the design verification. We will be testing the real prototypes as soon as the situation gets better.

# Descent Control Requirements

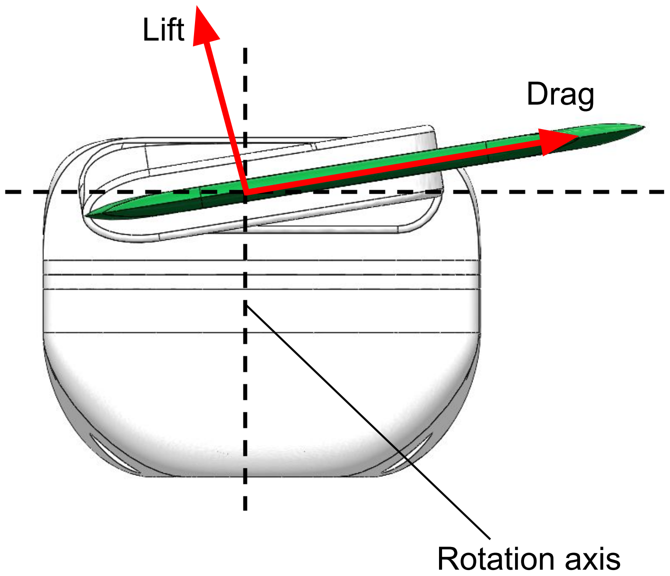
| Basic Requirements | | | | | | |
|---|---|---|---|---|---|---|
| Require-ment Number | Requirement | Priority | Process Phase | | | |
| | | | R | T | P | C |
| DCR-1 | The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket | High | | | | ✓ |
| DCR-2 | The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s. | High | | ✓ | | |
| DCR-3 | The container shall release one science payload at 500 meters and the second science payload at 400 meters (+/- 10 meters) | High | | | | ✓ |
| DCR-4 | The science payloads shall descend after being released and spin rapidly enough so its descent rate is less than 20 m/s. | High | | ✓ | | |
| DCR-5 | The science payload shall be an auto rotating maple seed. | High | | | | ✓ |
| DCR-6 | All descent control device attachment components shall survive 30 Gs of shock. | High | ✓ | | | |

## Payload Descent Method

A monoblade Auto-rotating payload will serve as the descent mechanism for the science payloads.

The system works only if the forces acting on the wing establish an **equilibrium condition** by inducing rotation which will in-turn produce lift.

This equilibrium must exhibit a constant descent velocity to cancel out the lift and also must maintain a sable rotation rate throughout the descent.



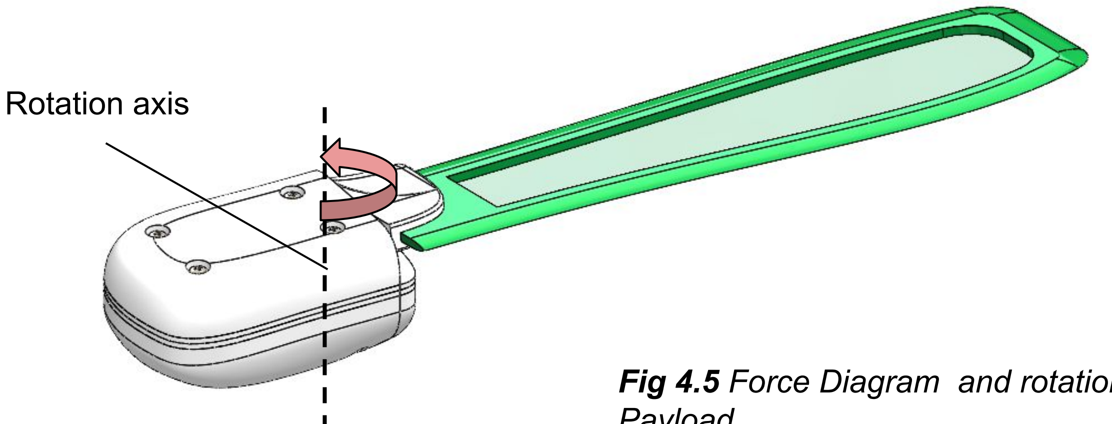




***Fig 4.5*** *Force Diagram and rotation illustration of the Science Payload*

# Payload Descent Control Hardware Summary (2/7)

## Payload Descent Method

A monoblade Auto-rotating payload will serve as the descent mechanism for the science payloads.

- The **centre of gravity** of the science payload was ensured that it lies towards the electronic housing of he payload.

- The position of the CG of the payload determines the stability of the payload. Referring to numerous research papers, we determined that the *maple seed's stability improved as the Centre of Gravity was moved towards one of its ends.*

- Moreover, it provides the payload to initiate rotation about its CG - axis. It was also determined that the maple seed's *angular velocity increased drastically when the CG moved towards one of its ends*.

- Further, we have planned to optimized the Center of gravity of the science payload even more to obtain desire stability.

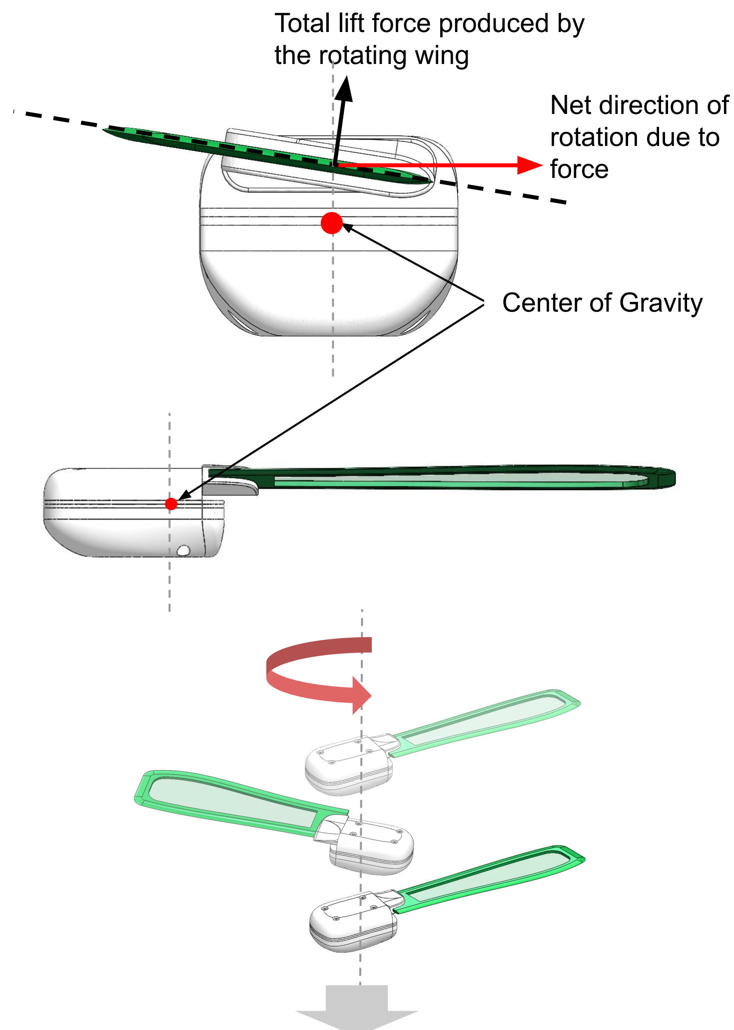



***Fig 4.6 :*** *Illustrating the descent control of the science payload*

## Passive Custom Designed wings

The Wing geometry is decided by iterative computational methods using **MATLAB R2019B** for optimal performances depending upon the system's stable condition and its performance in those conditions. **Element-based computational method** was employed in order to estimate the geometry of the planform of the wing according to the airflow at each element.

The steps involves:

1. Deciding the geometry of the wing subjecting to various boundary conditions
   - that the chord length is a continuous $n^{th}$ degree polynomial of the wing length. Here n = 6.

     $$c(r) = a_0 + a_1 r + a_2 r^2 + + a_3 r^3 + + a_4 r^4 + + a_5 r^5 + + a_6 r^6$$

   - optimize this nth degree polynomial depending upon the following factors:
     i. The area of the wing cannot exceed more than a certain value to limit the weight of the payload.
     ii. Maximum length of the wing is fixed. Here it is **0.25 m**.
     iii. The coefficient of power should be maximum
     iv. **AoA** if the predefined wing is **9 degrees**.
     v. Moment around wing axis is balanced.
2. A stable wing giving the specified performance is calculated.
3. The descent velocity and rotational velocity of the payload is calculated through 6-DOF simulation.

## Coefficient of Power

We use the **Glauert's Model of Blade Element Momentum Theory** (BEMT), which splits the wing into many blade elements for individual calculations and takes tip losses into account. BEMT is used to derive the coefficient of power which is then maximized using MATLAB R2019B's optimization tools.

Glauert's model ultimately consists of a system which links together three variables **a, a* and ϕ** associated with a ring of fluid.

1. The value of *axial induction factor (a), angular induction factor (a*)* and *relative angle deviation (ϕ)* are guessed for each element by initializing the guessing algorithm with some arbitrary values of 'a' and 'a*' along with functions for the coefficient of lift and drag for a rectangular slab.

   - 'a' and 'a*' is given by

   $$a = \frac{U_{-\infty} - U_0}{U_{-\infty}} \qquad a^* = \frac{w}{w\Omega}$$

   - where U−∞ and U+∞ are the upstream and downstream velocities
   - Uo is the descent velocity

2. The estimated values of 'a', 'a*', and 'ϕ' are then utilized to figure out the coefficient of power.

   - The coefficient of power depends upon twist **'$\gamma_\lambda$'**, chord **'$c_\lambda$'**, 'a', 'a*', and 'ϕ' is given by the equation:

$$C_P\left(\gamma_\lambda, c_\lambda, \varphi, a, a^*\right) = \frac{8}{\lambda^2_{max}} \int_{\lambda_{min}}^{\lambda_{max}} \lambda^3 J_\lambda\left(\gamma_\lambda, c_\lambda, \varphi, a, a^*\right) d\lambda$$

## Coefficient of Power

- The coefficient of power is given by:

$$C_p\left(\gamma_\lambda , c_\lambda , \varphi , a , a*\right) = \frac{8}{\lambda^2_{max}} \int_{\lambda_{min}}^{\lambda_{max}} \lambda^3 J_\lambda\left(\gamma_\lambda , c_\lambda , \varphi , a , a*\right) d\lambda$$

- **λ** is given by: $\lambda = \frac{\Omega r}{U_{-\infty}}$ where Ω is the rotation speed Ω

- where **Jλ** is a function of ‘γλ’, ‘cλ’, ‘a’, ‘a*’, and ‘ϕ’ and is given by:

$$J_\lambda\left(\gamma_\lambda , c_\lambda , \varphi , a , a*\right) = F_\lambda(\varphi)\ a*(1-a)\left(1 - \frac{C_d\ (\varphi - \gamma\lambda)}{C_l\ (\varphi - \gamma\lambda)} \tan^{-1}(\varphi)\right)$$

- where **Fλ is the Prandtl tip function** and is introduced to account for ***tip loss corrections***, it is given by:

$$F_\lambda(\varphi) = \frac{2}{\pi} \cos^{-1}\left(\exp\left(-\frac{\frac{B}{2\ (1 - \frac{r}{R})}}{(\frac{r}{R}) \sin(\varphi)}\right)\right)$$

# Wing Geometry Solution

- The conditions are set according to equilibrium conditions as discussed above.

- Adhering to the previous assumption and constraints, the negative Coefficient of Power ($C_P$) is minimize through 'fmincon' function in **MATLAB R2019b**'s optimization toolbox using **Sequential Quadratic Programming(SQP)** solver in order to **maximize $C_P$** and solve for the polynomial function c(r) mentioned below and to obtain optimal values for the polynomial coefficients:

$$c(r) = a_0 + a_1 r + a_2 r^2 + + a_3 r^3 + + a_4 r^4 + + a_5 r^5 + + a_6 r^6$$

- From plotting the function c(r), we obtained the Chord length at each radius from root to tip. To obtain the planform profile of the Science payload wing, we centred the chord length at ¼$^{th}$ of chord at each point along the radial length of the wing.

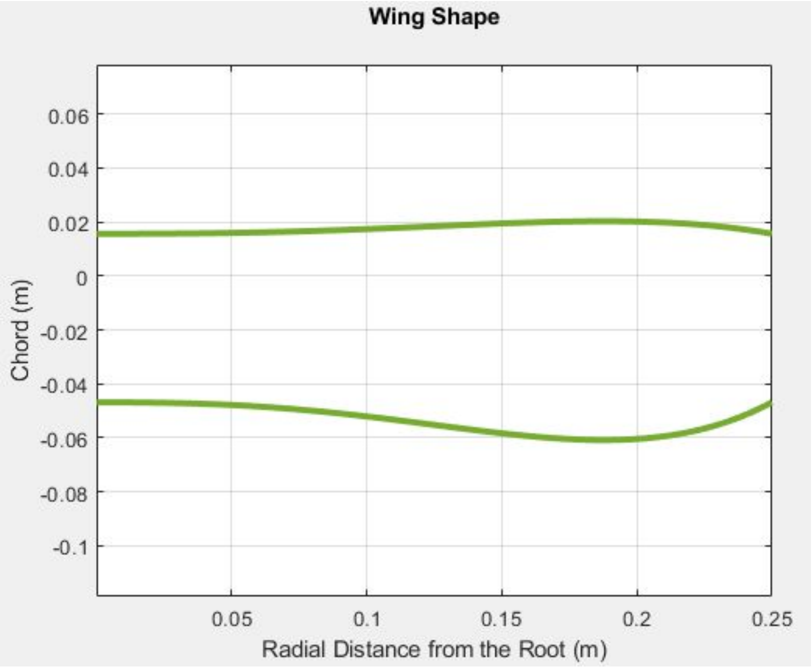



***Fig 4.7** Planform view of wing of the science payload*

## Payload Material/Color Selection:

Payload Pods are primarily printed with PLA.

Wings are also made out of PLA but have a clear plastic sheet inserted into the frame.

As mentioned in the requirements, the wing would be of **Fluorescent Green**, so that it is easy to spot from the ground. The clear sheet is also tinted in **Fluorescent green** colour.

The payload pod will remain **white** in colour.

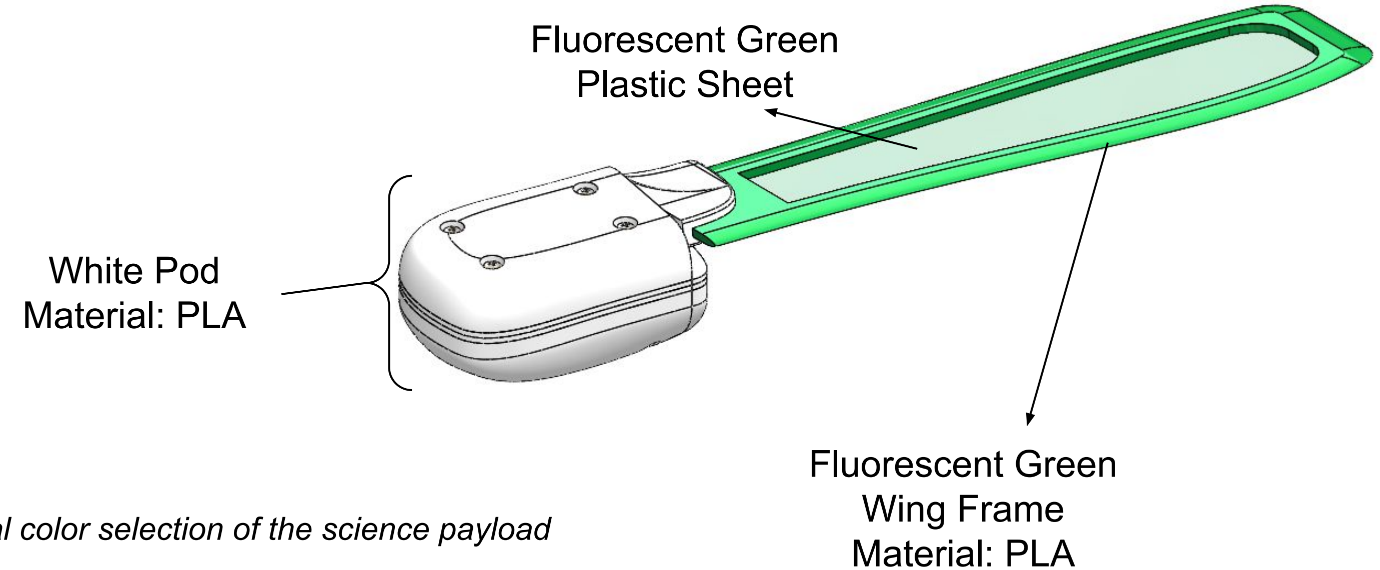



***Fig 4.8*** *Material color selection of the science payload*

## Equilibrium Conditions and Constraints

The conditions are set according to stable condition where the system has enough rotation that it is stabilized along its rotation axis as well as wing axis and descents at a specific descent rate.

Stabilization requires:

- **Vertical force balance:** All our calculation and derivation have assumed that the science payload is descending at terminal velocity which implies,

  $L_\theta = D_\theta'$

- **Wing moment balance:** All our calculation and derivation have assumed that the net moment at ¼ of the chord length of the science payload is zero which implies,

  $$M_{Net} = \int M\,dr = 0$$

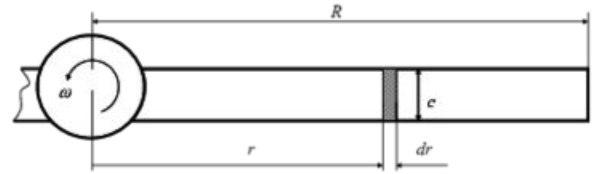



*Fig 4.2: Illustration of a section of a wing (Blade element momentum theory)*

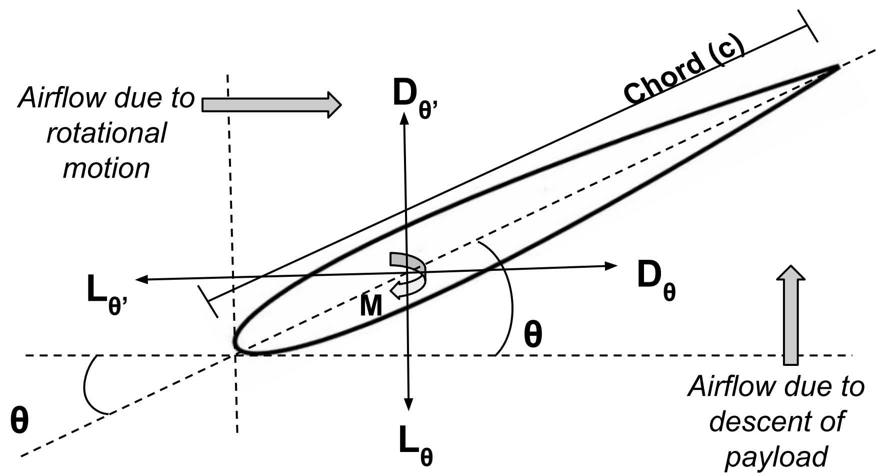


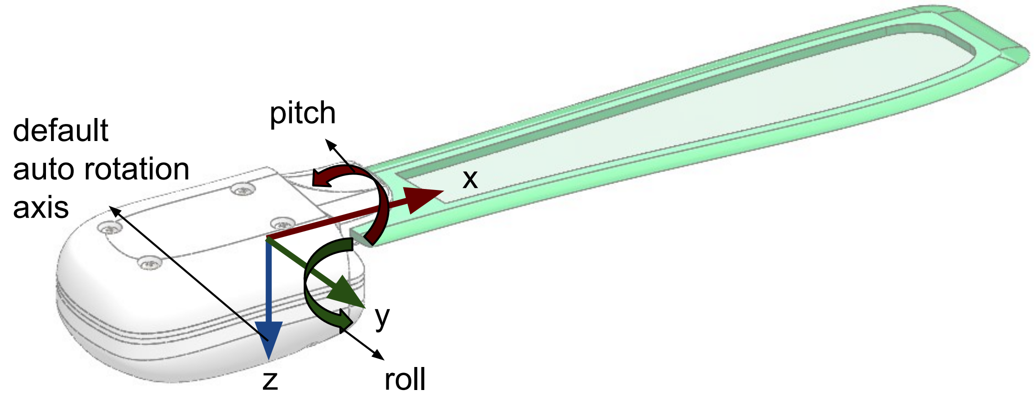

***Fig 4.9:** Force diagram on a section of the wing during descent*

# Payload Descent Stability Control Design (2/2)

Moreover, **6-DOF Simulation** on Simulink suggests that the *system stabilizes itself after release*.

The payload maintains a **negligible tilt in both pitch and roll angles** while descending down at a stable rotation rate.

This was anticipated as the *lift and drag at each blade element are dependent on the downward descent rate and the rotation rate* and should come at an equilibrium to maintain a steady state.



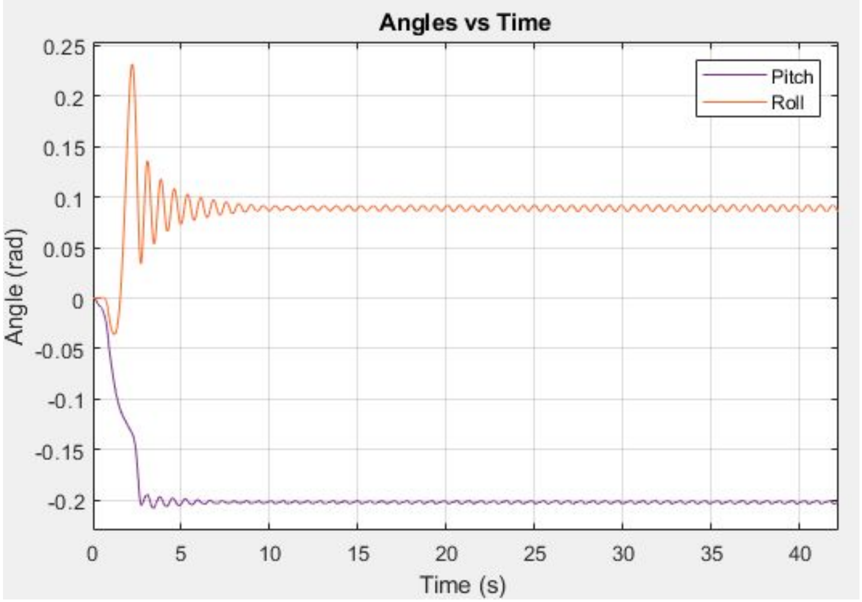




***Fig 4.10*** *Graph representing Pitch and Roll angle of science payload (SIMULINK)*

## Parachute - Passive Deployment

### Shape and Dimensions

- The containers descent control hardware is a cross shaped cruciform parachute since the lengthwise horizontal descending CANSAT needs a wider length chute to maintain stability and thus a smooth decent with minimal twisting-tumbling-wobbling is ensured.
- The chute has a longer arm of **500mm x 80mm** and a shorter arm of **167mm x 80mm**
- The chute is **fluorescent orange** in color for easy detection.

### Material Selection

- **Ripstop nylon** was selected for parachute of payload because of its zero porosity, tear resistance, and its lightweight.
- **Nylon 6-6** was selected for the twelve paracords used because of its high strength, flexibility, and shock resistance.

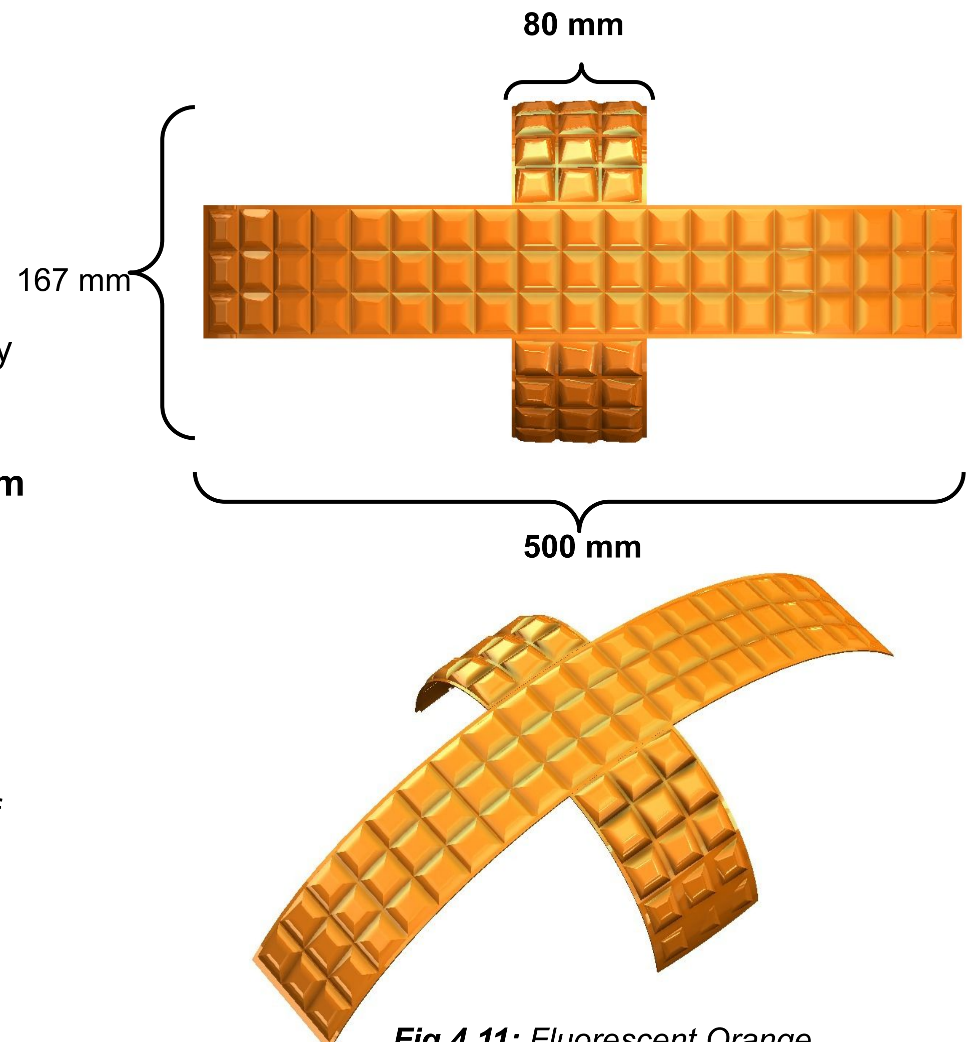



***Fig 4.11:*** *Fluorescent Orange Cruciform Parachute for container*

## Stowed Configuration

In accordance to the deployment requirements, the container parachute is folded and stowed on the cylindrical face of the container and is attached to the container with the help of 12 nylon paracords tied directly on the PLA rings of the container.

## Deployment Method

The parachute on the container is deployed passively as soon as CANSAT separates from the rocket at a height of **670-725 m**.

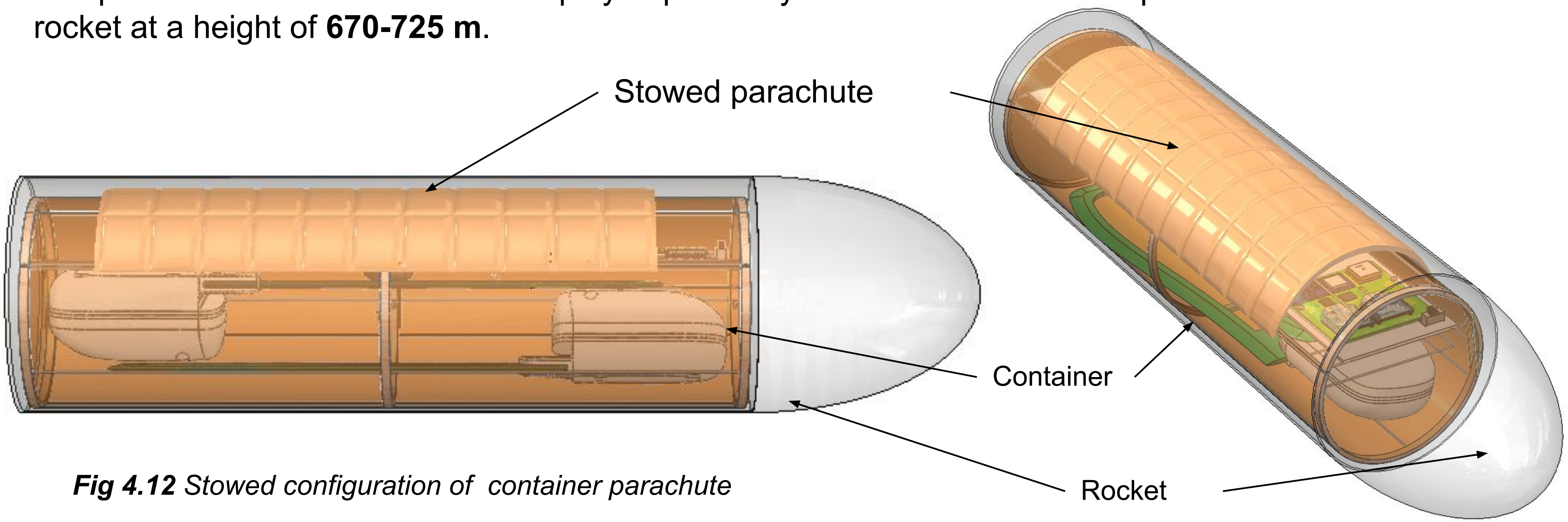



***Fig 4.12*** *Stowed configuration of container parachute*

## Deployed Configuration

The cross shaped parachute is tied directly to the PLA rings of the container with the help of 12 paracords for uniform load distribution on all sides. The CANSAT descends using the parachute with a velocity of **15m/s**.

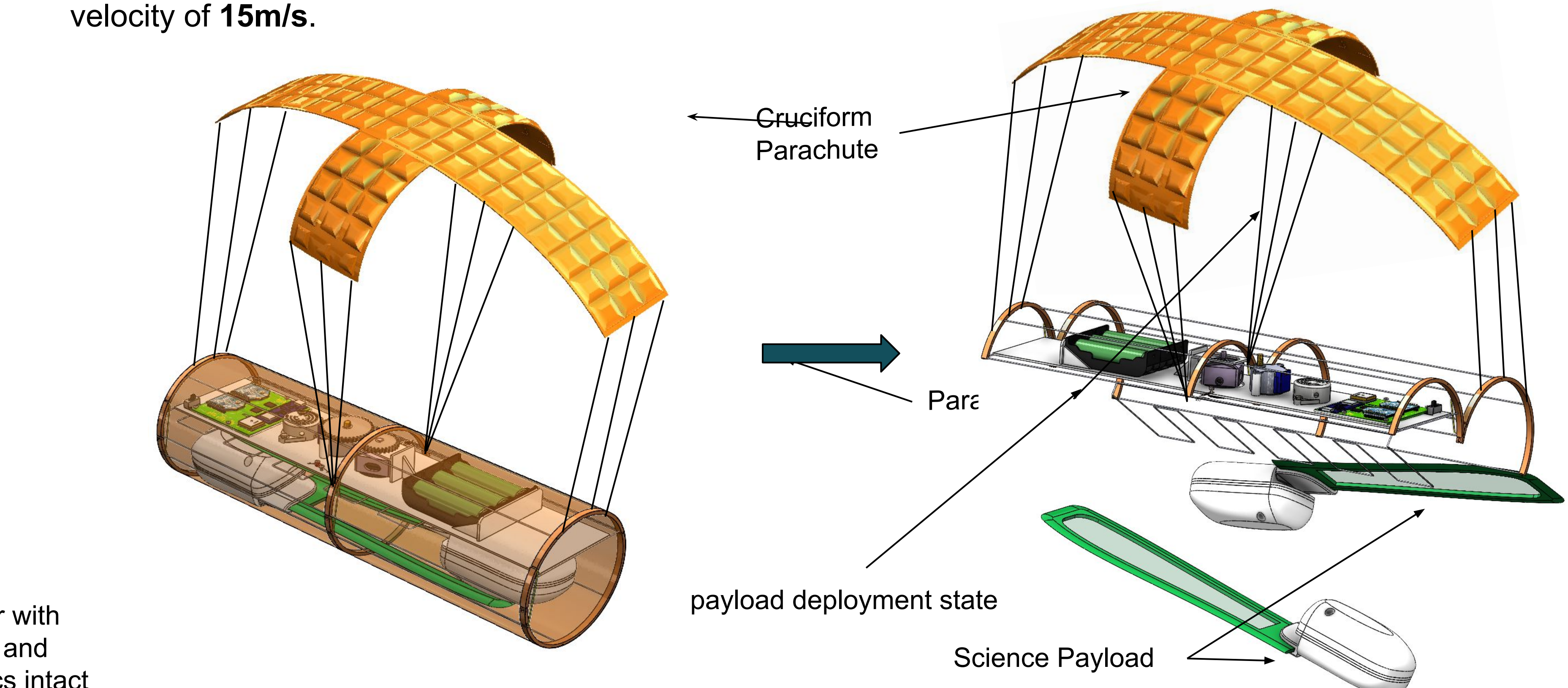



***Fig 4.13** Deployed configuration of container parachute*

## Calculation - container parachute dimensions

**Drag Equation:** $$F_D = \frac{1}{2}\rho C_D A v^2 = mg$$

$$A = \frac{2 * m * g}{\rho * C_d * v^2}$$

$$A = \frac{2 * 0.5988 * 9.81}{1.225 * 0.8 * 15 * 15}$$

**A = 0.053384 $m^2$ = 53384 $mm^2$**

For an arm ratio of 3:1

**Area of longer arm = 53384*3/4 = 40040 $mm^2$**
**length of longer arm= L1 = 500mm**
**width of longer arm= W = 80mm**

**Area of longer arm = 53387*1/4 = 13360 $mm^2$**
**length of shorter arm = L2 = 167mm**
**width of shorter arm= W = 80mm**

**Descent rate is 15 m/s**

**Where:**

**Fd** is the drag force.

**m** is the mass of cansat (container + payloads) = 598.8g = 0.5988Kg

**g** is the acceleration due to gravity = 9.81m/$s^2$

**ρ** is the density of air = 1.225 kg/$m^3$

**$C_d$** is the drag coefficient of the chute =0.8

(for a cross-shaped chute with arm ratio 3:1 and equal arm width).

**A** is the area of the parachute .

**v** is the descent velocity of cansat=15 m/s

# Descent Rate Estimates (Parachute) (2/10)

Solidworks CFD of the parachute container assembly(598.8g) indicates that the force in the **Y-direction(Lift force)** comes out to be **6.05N** for a descent with velocity **15m/s** which is equal to the values estimated by numerical calculations.

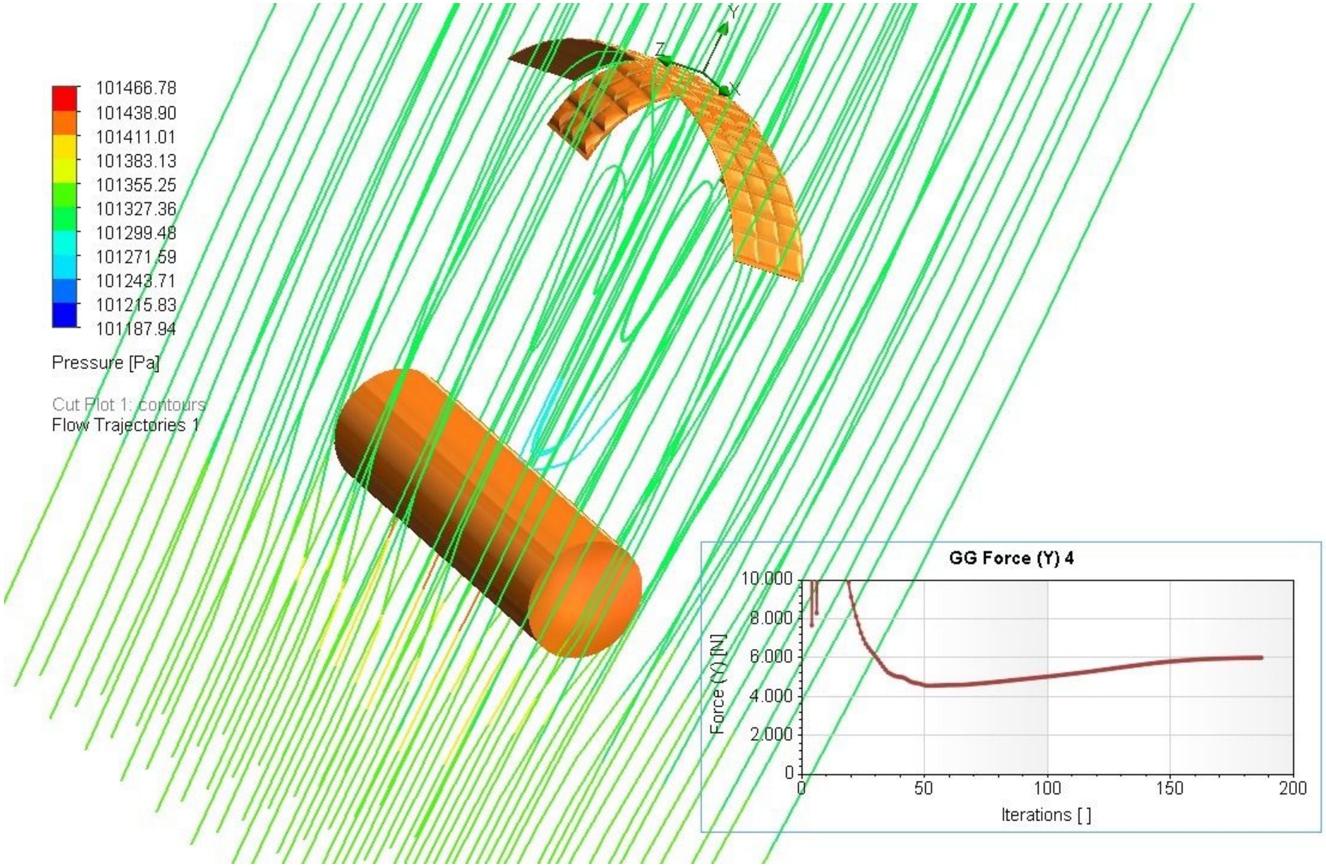



***Fig 4.14** CFD simulation of Container - pre deployed state*

## Container velocity post deployment of Payload 1

**Drag Equation:** $$F_D = \frac{1}{2}\rho\, C_D\, A\, v^2 = mg$$

$$v^2 = \frac{2\ mg}{\rho * C_d * A}$$

$$v^2 = \frac{2 * 0.4745 * 9.81}{1.225 * 0.8 * 0.053384}$$

**v = 13.34 m/s**

Where v is the approx decent rate of container after it deploys the first scientific payload

**Where:**

**Fd** is the drag force.

**m** is the (mass of container + payload 2) = 350.2g + 124.3g = 474.5g = 0.4745 kg

**g** is the acceleration due to gravity = 9.81m/s$^2$

**ρ** is the density of air = 1.225 kg/m$^3$

**$C_d$** is the drag coefficient of the parachute = 0.8 (for a cross-shaped chute with arm ratio 3:1 and equal arm width).

**A** is the area of the parachute on can = 0.053384m$^2$ = 53384mm$^2$

## Container velocity post deployment of Payload 2

**Drag Equation:** $$F_D = \frac{1}{2}\rho\, C_D\, A\, v^2 = mg$$

$$v^2 = \frac{2\,mg}{\rho * C_d * A}$$

$$v^2 = \frac{2 * 0.3502 * 9.81}{1.225 * 0.8 * 0.053384}$$

**v = 11.46 m/s**

Where v is the approx decent rate of container after it has deployed both first and second scientific payload

**Where:**

**Fd** is the drag force.

**m** is the mass of container = 350.2g = 0.3502 kg

**g** is the acceleration due to gravity = $9.81 m/s^2$

**ρ** is the density of air = $1.225\ kg/m^3$

$\mathbf{C_d}$ is the drag coefficient of the parachute = 0.8 (for a cross-shaped chute with arm ratio 3:1 and equal arm width).

**A** is the area of the parachute on can = $0.053384 m^2 = 53384 mm^2$

## Payload estimates

- We have developed a **6-DoF simulation** of the science payload in **Mathworks SIMULINK**. Through which we verified the rotation rate and the descent velocity of the science payload.

- Moreover, the stability of the science payload was verified through the 6-DoF simulation by monitoring different rotation angles throughout its descent.

- To further verify the validity of our dynamic model, we have planned to conduct the flight test of the science payload after the fabrication.

- The descent velocity of the science payload is **11.8 meter per second** (as per current assumptions).

# Descent Rate Estimates (6/10)

To get an idea of how the system will perform, a **6 DoF Simulation** was performed on **Mathworks Simulink**. The cumulative vertical force on every element is calculated by the *'eleforce' function* and the axial moment is calculated by *'elemoment' function*. These are then combined with the direction of gravitation force and fed into the 6DoF block to calculate the required performance parameters of the selected wing. The results regarding stability and descent estimates of a scenario where the payload is dropped from a height of 500m is shown in subsequent slides.

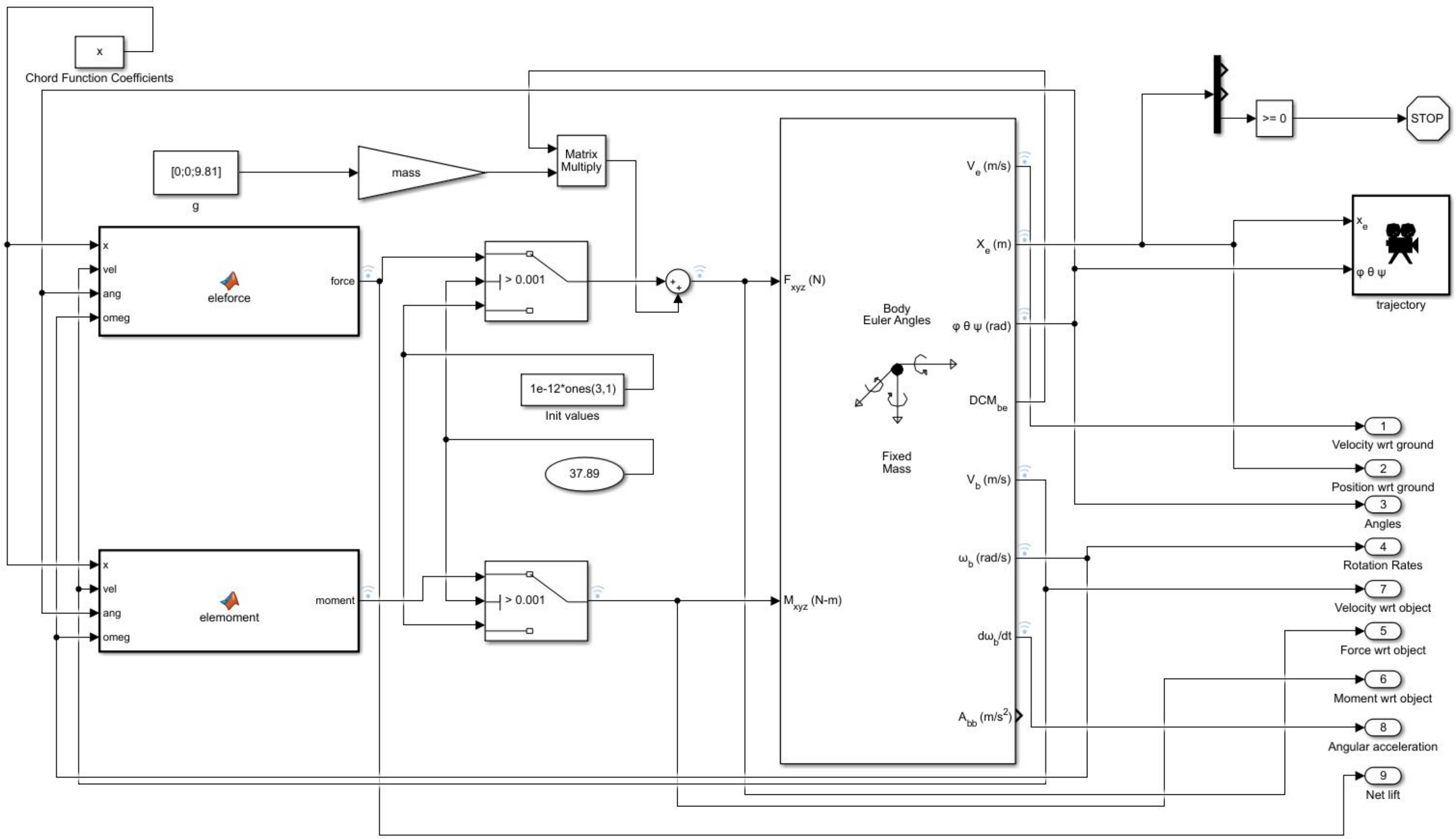



***Fig 4.15*** *Dynamic model of science payload in Simulink*

The selected wing gives a very stable descent and rotation rates as it falls down.

We are assuming that the simulation data is true and the model will give similar performance characteristics.

From the graphs we can infer that after initial **2.5 seconds**, the system stabilizes to a rotation rate of **~8.7 rad/s** or **83.08 RPM** and the descent velocity becomes stable at **11.8 m/s**.

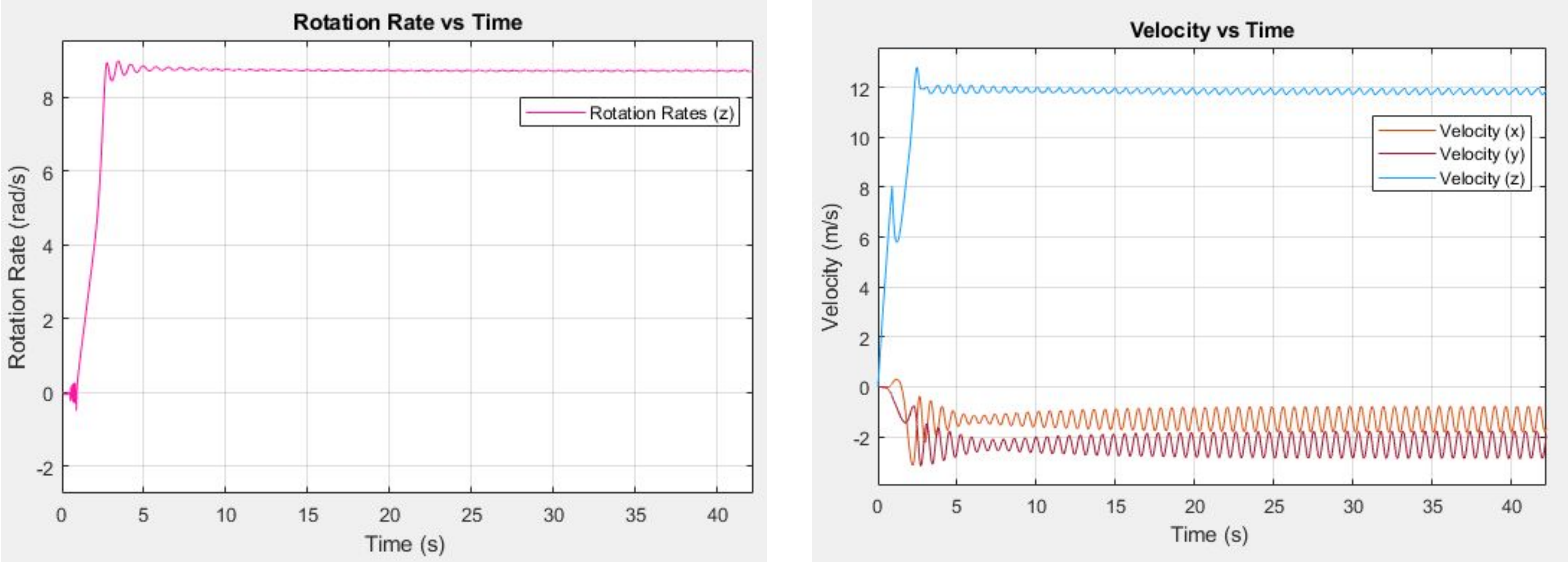
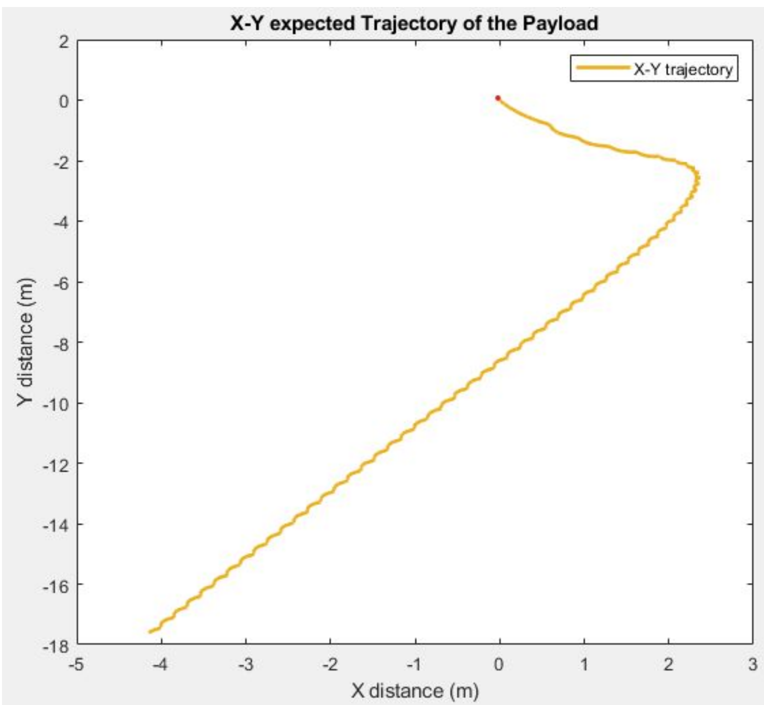



***Fig 4.16*** *Rotation rate and Descent velocity of the payload throughout its descent*

# Descent Rate Estimates (8/10)

From the Simulink Simulation, the following expected trajectories were calculated.
We expect the payload to ***touch the ground in 42 seconds after release***. Moreover, its x-y displacement is limited to **<20m** from the dropping point coordinates considering there is no wind.



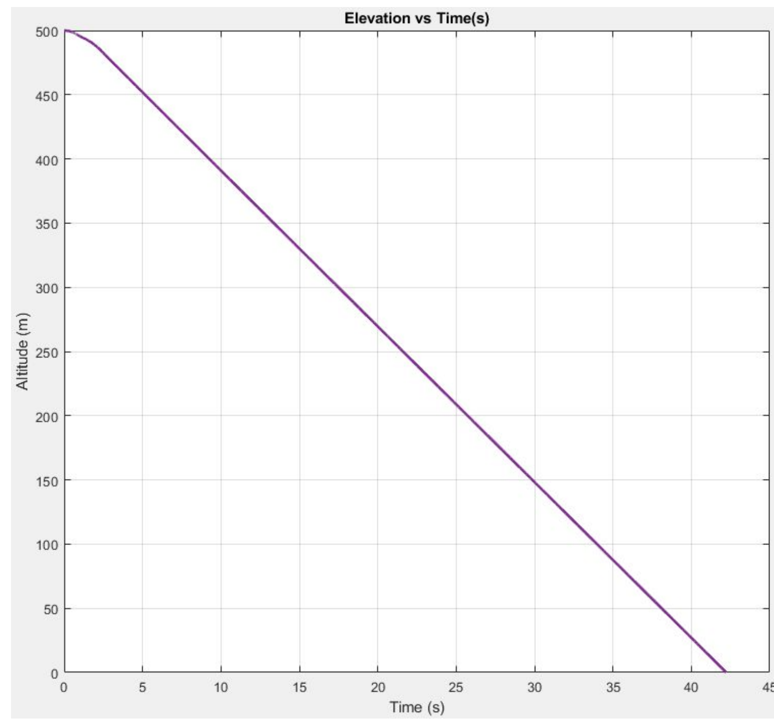
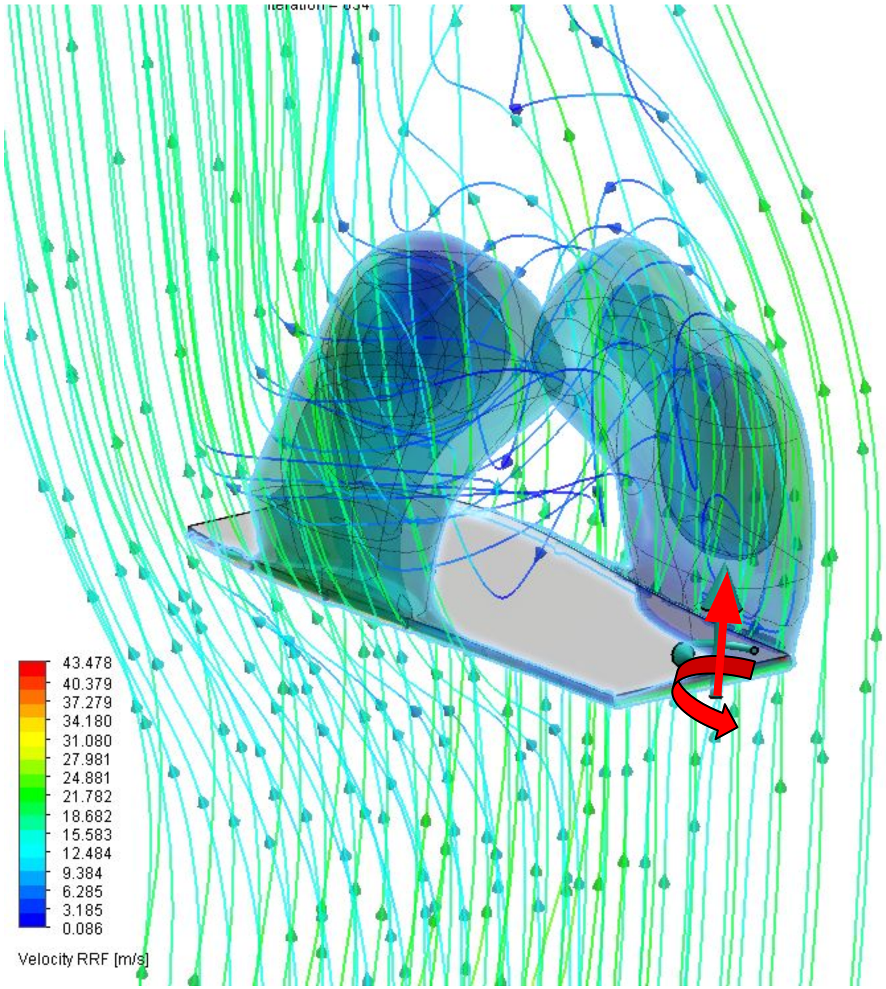




***Fig 4.17*** *Trajectory of the science payload with respect to XYZ axes*

# Descent Rate Estimates (9/10)

*Steady state CFD Simulations* of the wing performed in **Solidworks Flow Simulation** verified the independently done Simulink 6DOF simulation. The wing produces an upward lift of **1.98N** while revolving and descending with steady descent rates calculated by the Simulink Simulation. This force is more than enough for providing lift for each payload



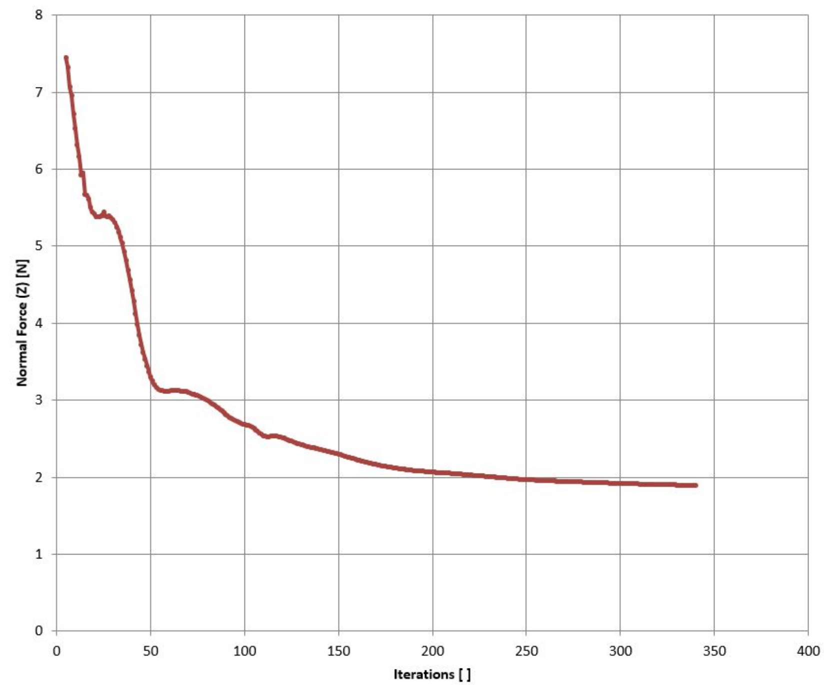




***Fig 4.18** Steady State CFD simulation of the science payload*

# Descent Rate Estimates (10/10)

## SUMMARY

| CANSAT RELEASE | FIRST PAYLOAD RELEASE | SECOND PAYLOAD RELEASE |
| --- | --- | --- |
| At the height of about **700m** the cansat releases from the rocket and immediately **parachute of cross arms 500x80mm and 167x80mm** is passively released and the descends with a **velocity of about 15 m/s.** | At the height of about **500 m** the first payload is released from the container and the container now descends with the **velocity of 13.34 m/s.**<br><br>The **first deployed payload** now starts rotating and descends down with a net velocity of **11.8 m/s.** | At the height of about **400 m** the second payload is released from the container and the container now descends with the **velocity of 11.46m/s.**<br><br>The second **deployed payload** now starts rotating and descends down with a net velocity of **11.8 m/s.** |

# Mechanical Subsystem Design

**Sampreet**

# Mechanical Subsystem Overview (1/2)

## Container Exploded View

**1. Container Electronics**

- Container electronics mounted on **PLA board**.
- The board supports the sensors, controller, power and communication systems for the container.

**2. Container Structure**

- **Aluminium 1060 linear rails incorporated with PLA rings** for rigidity.
- Covered by **fluorescent orange polypropylene film** for easy detection

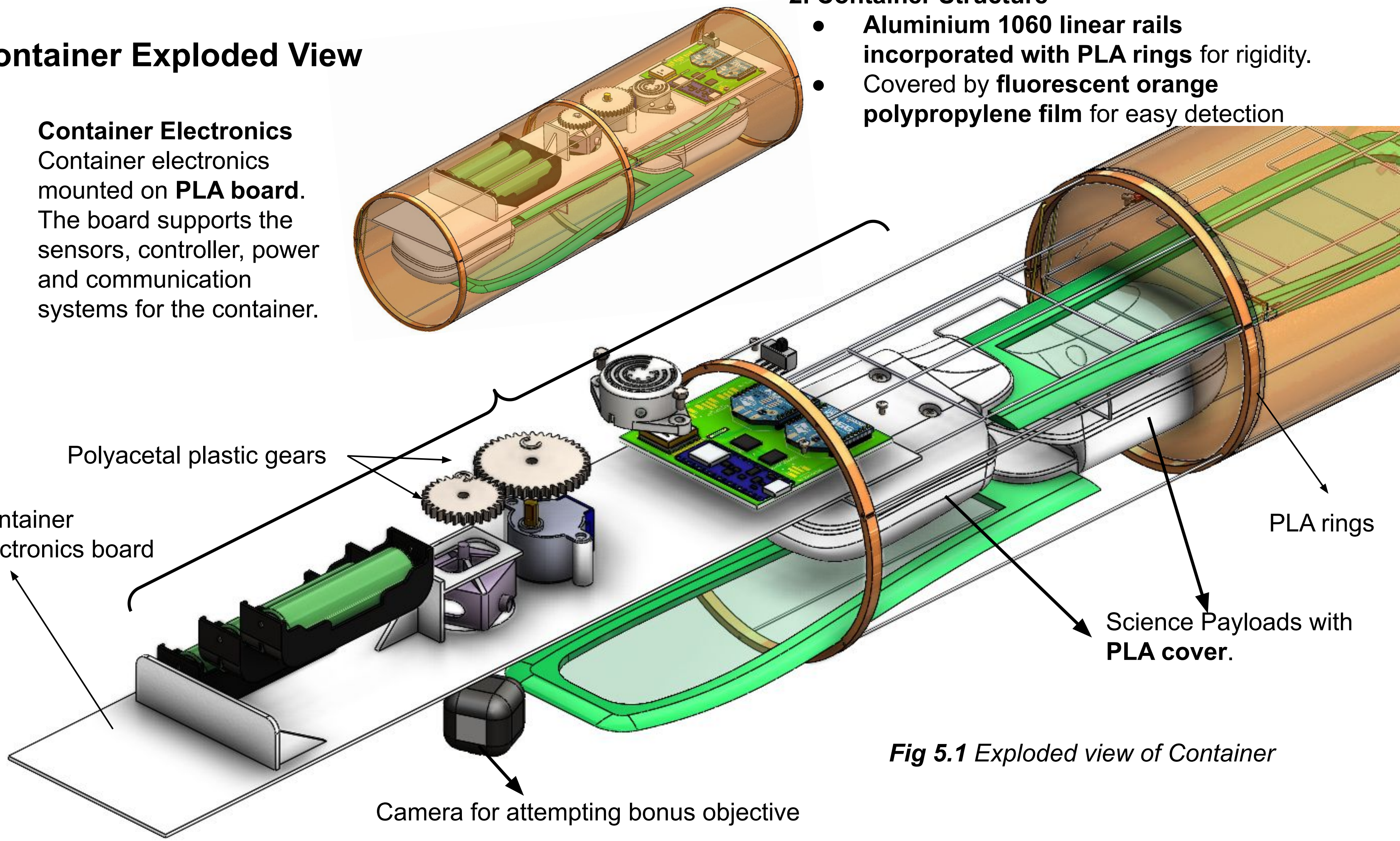



***Fig 5.1*** *Exploded view of Container*

## Science Payload Exploded View

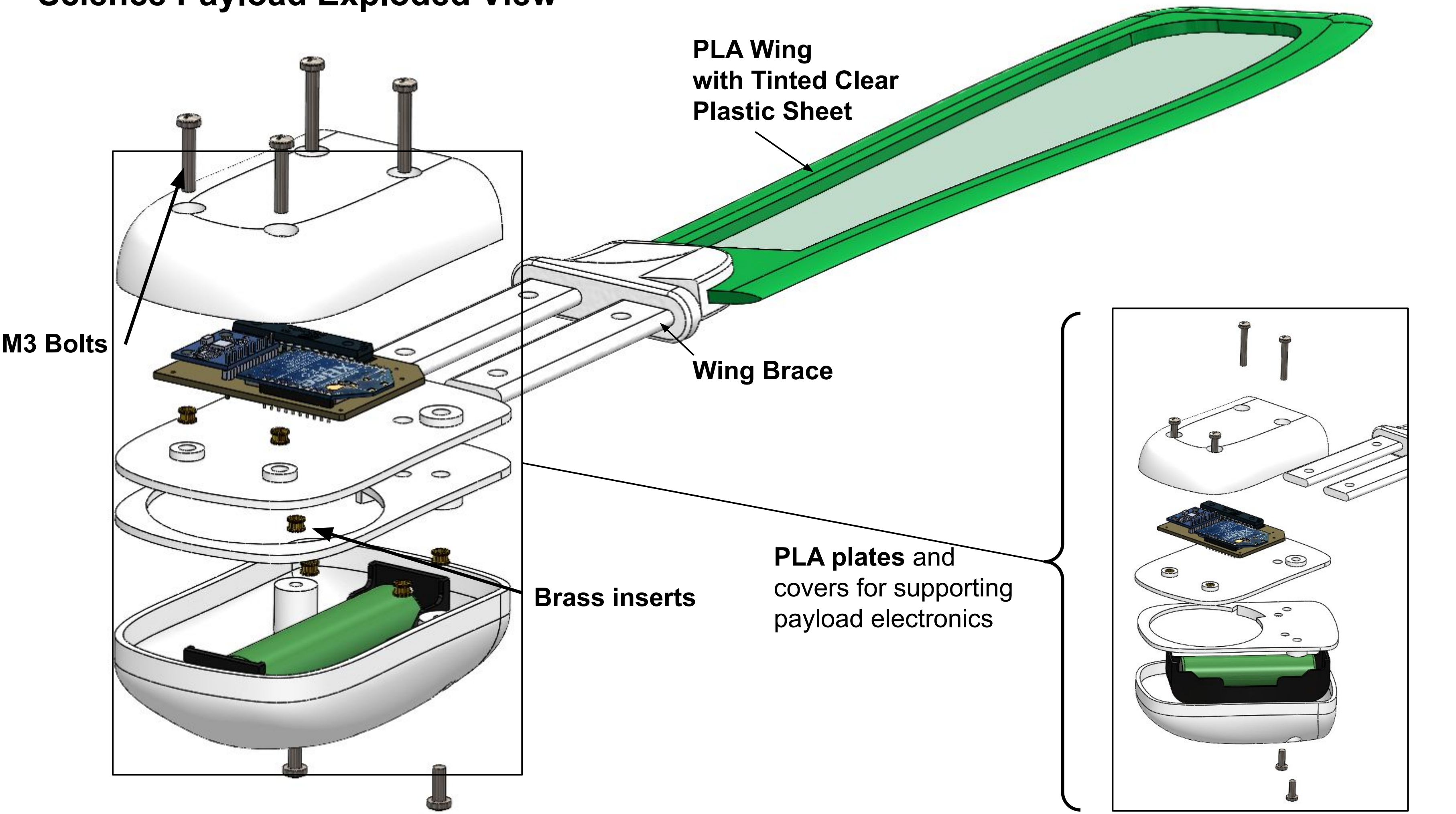



***Fig 5.2:*** *Exploded view of science payload*

# Mechanical Subsystem Changes Since PDR (1/5)

| Component | Changes | Rationale |
|---|---|---|
| **Container** | The structure was changed from pure aluminum wire frame to hybrid of PLA rings and aluminum wire rails. | Increases structure rigidity and facilitates assembly and integration of linear rails. |

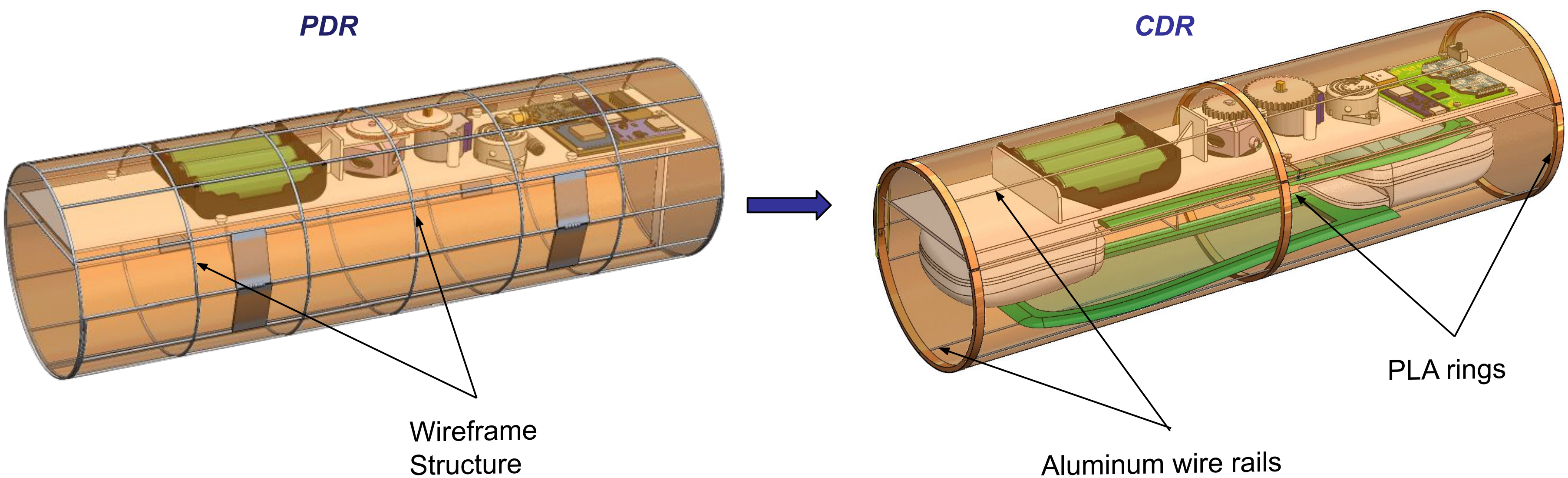



***Fig 5.3:*** *Design changes in container structure*

# Mechanical Subsystem Changes Since PDR (2/5)

| Component | Changes | Rationale |
|---|---|---|
| **Wing** | The material of the wing was changed from Balsa wood to PLA. | Availability of PLA material, ease of manufacture |

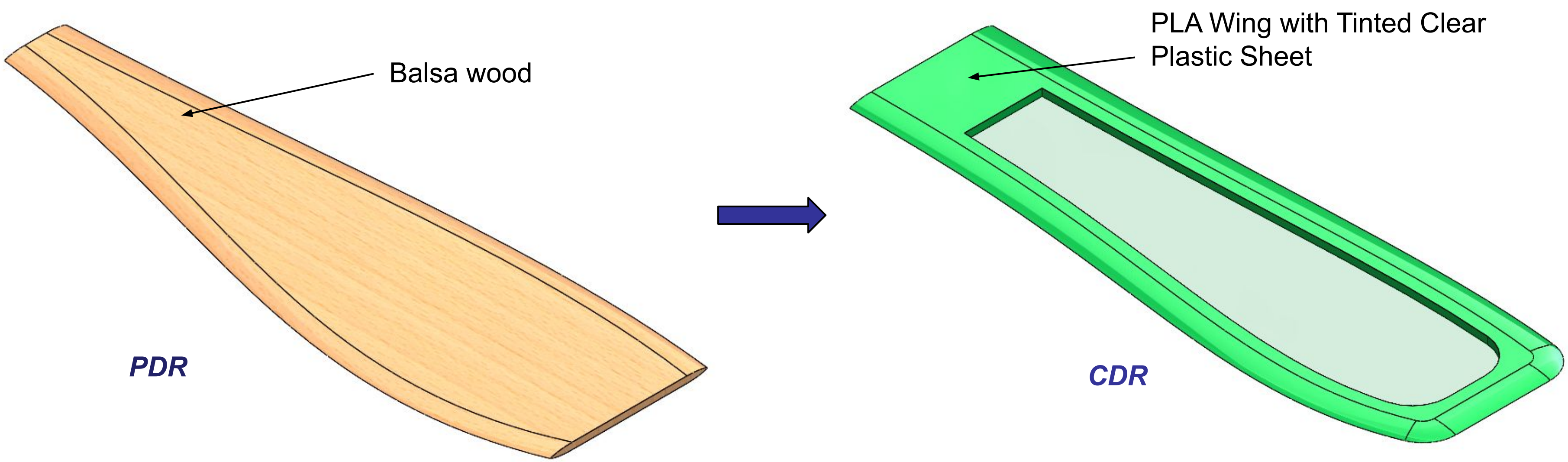



***Fig 5.4:*** *Design changes in fabrication of science payload*

# Mechanical Subsystem Changes Since PDR (3/5)

| Component | Changes | Rationale |
|---|---|---|
| **Payload Predeployment attachment mechanism** | A comb structure was added to support the second payload predeployment instead of nylon tie lines. | Rigid support for the payload decreases the chance of failure of attachment of payload to container and thus ensures deployment at the required altitude |

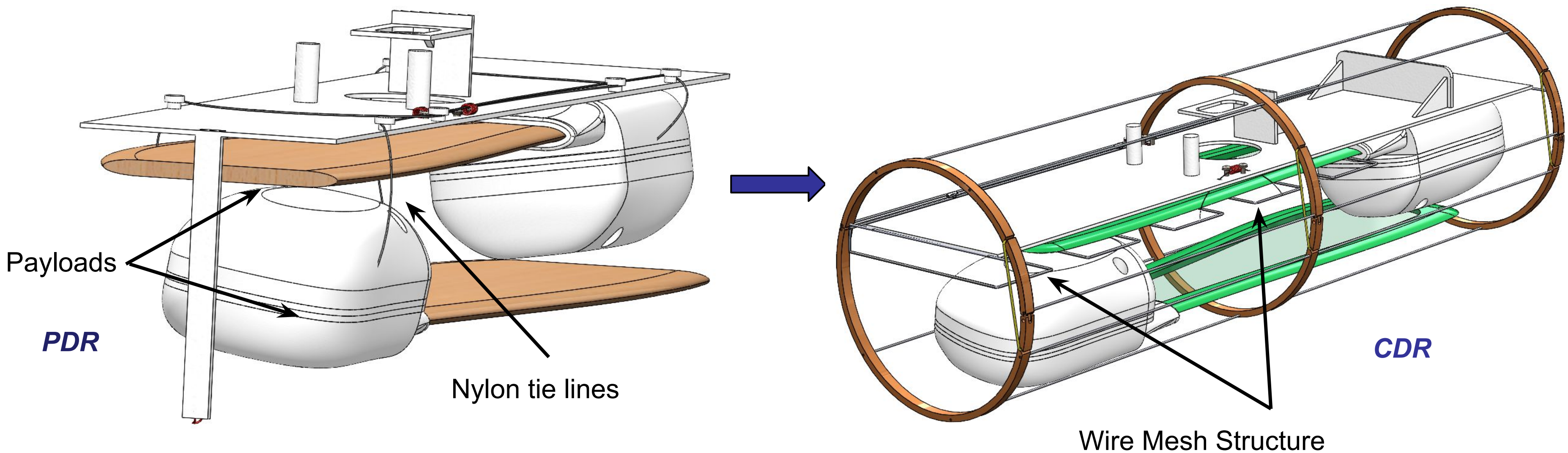



***Fig 5.5:*** *Design changes in Payload attachment mechanism*

# Mechanical Subsystem Changes Since PDR (4/5)

| Component | Changes | Rationale |
|---|---|---|
| **Payload release mechanism** | Torsion spring hinges were removed and replaced with regular hinges and elastic band mechanism. | Simplification of deployment mechanism to reduce chances of failure and ease of manufacturing |

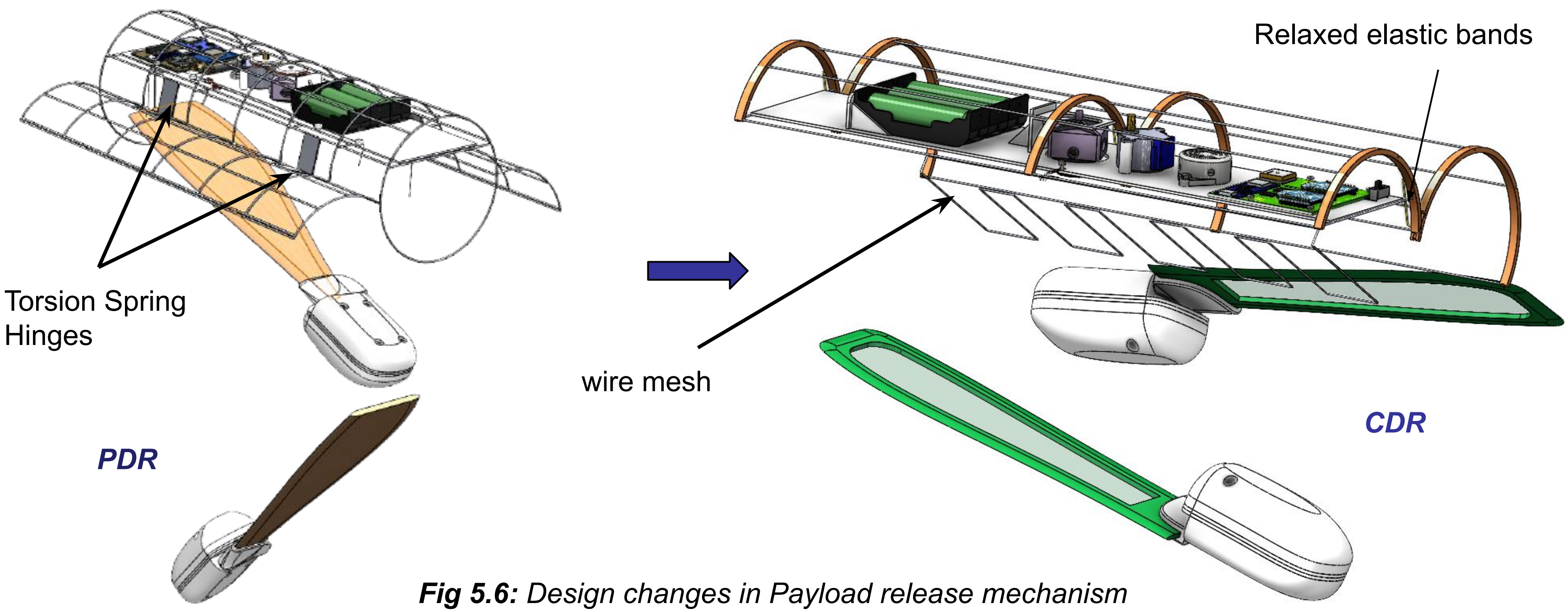
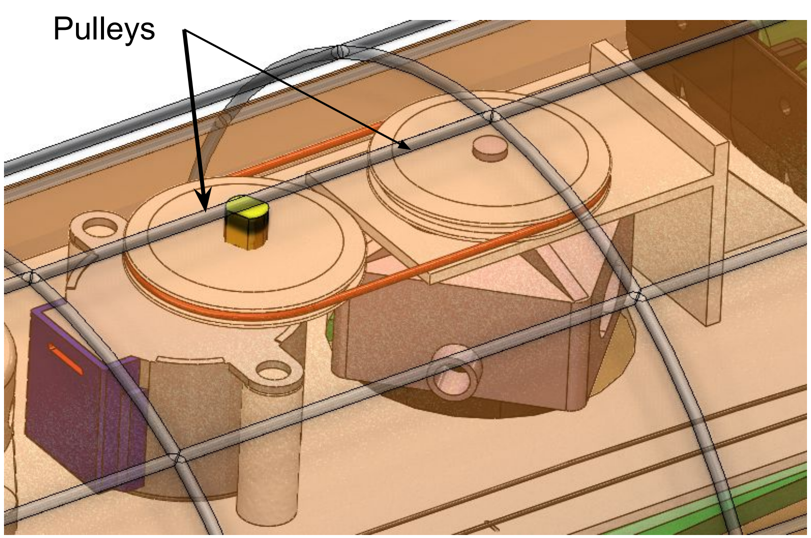


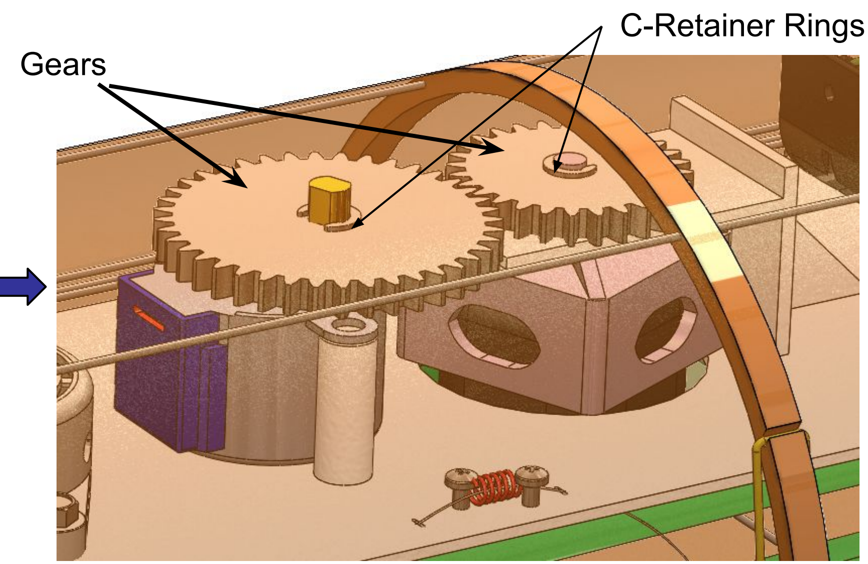

***Fig 5.6:*** *Design changes in Payload release mechanism*

# Mechanical Subsystem Changes Since PDR (5/5)

| Component | Changes | Rationale |
|---|---|---|
| **Camera spin stabilization mechanism** | Instead of using a pulley and an elastic band to connect the stepper motor to the camera, gears were added on camera holder and motor shafts. | Ease of assembly and better control over camera spin by selecting an appropriate gear ratio. |




PDR




CDR

***Fig 5.7:*** *Design changes in Stabilization mechanism of camera*

# Mechanical Sub-System Requirements (1/3)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| MSR-1 | All structures shall be built to survive 30 Gs of shock. | High | | ✓ | | |
| MSR-2 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | High | | | ✓ | |
| MSR-3 | All mechanisms shall be capable of maintaining their configuration or states under all forces. | High | | ✓ | | |
| MSR-4 | Mechanisms shall not use pyrotechnics or chemicals. | High | | | | ✓ |
| MSR-5 | Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire. | High | | | | ✓ |
| MSR-6 | The Parachutes shall be fluorescent Pink or Orange. | Medium | | | | ✓ |
| MSR-7 | Both the container and payloads shall be labeled with team contact information including email address. | Medium | | | | ✓ |

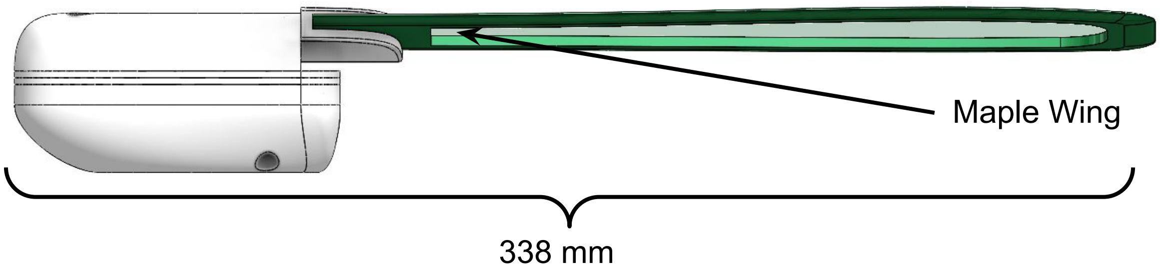
# Mechanical Sub-System Requirements (2/3)

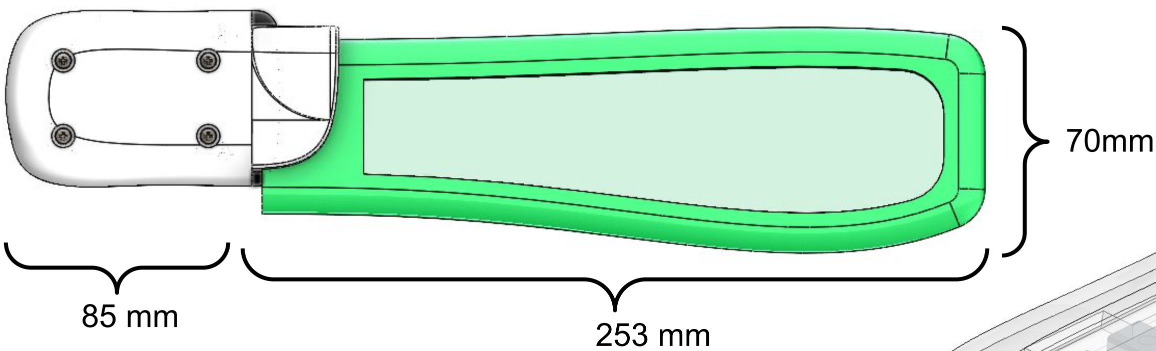
| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| MSR-8 | The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s. | High | | ✓ | | |
| MSR-9 | The container shall release the first payload at 500 meters and second payload at 400 meters (+/- 10 meters). | High | | ✓ | | |
| MSR-10 | The science payloads shall be an auto rotating maple seed. | High | | | | ✓ |
| MSR-11 | All descent control device attachment components shall survive 30 Gs of shock. | High | ✓ | | | |
| MSR-12 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | High | | ✓ | | |
| MSR-13 | All structures shall be built to survive 15 Gs of launch acceleration. | High | ✓ | | | |

# Mechanical Sub-System Requirements (3/3)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| MSR-15 | No lasers allowed. | High | | | | ✓ |
| MSR-16 | An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat. | High | | ✓ | | |
| MSR-17 | Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects. | High | | ✓ | | |
| MSR-18 | Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. | High | | | | ✓ |

# Payload Mechanical Layout of Components (1/4)



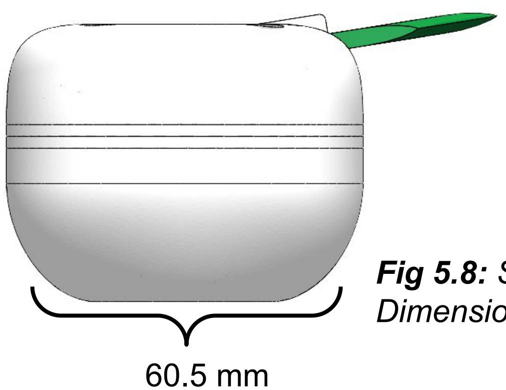
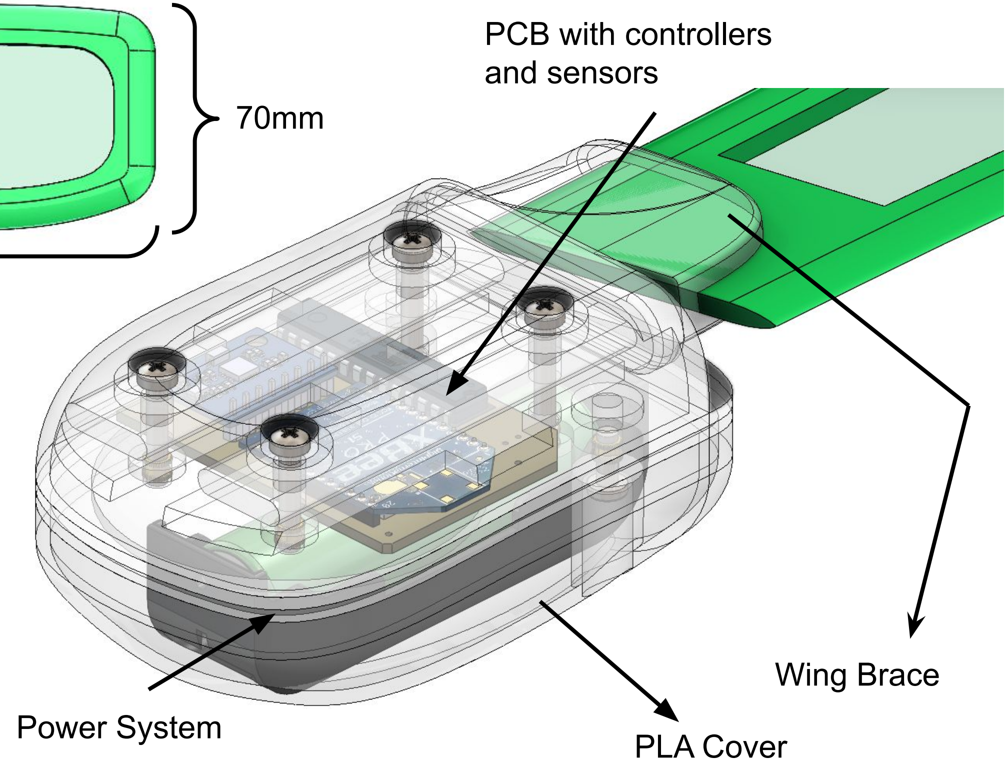




***Fig 5.8:** Science Payload Dimensions*

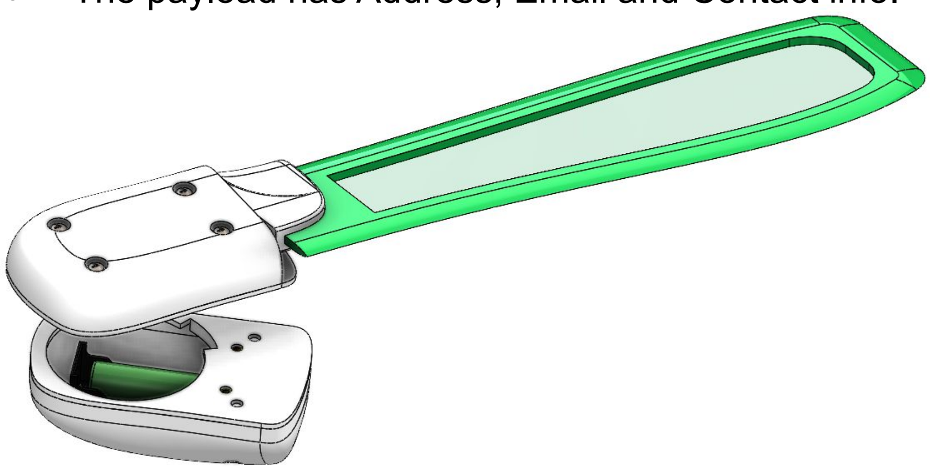
## Dimensions



# Payload Mechanical Layout of Components (2/4)

## Key Features

- Payload Shell is made up of PLA with Modular Wing Brace insertion and covers are held with 4 bolts with brass inserts embedded in the PLA.
- The second section is easily detachable with a twist. **It contains batteries, switch and power electronics which can be easily replaced without major disassembly.**
- Electronics firmly attached in upper and middle section.
- The payload has Address, Email and Contact info.



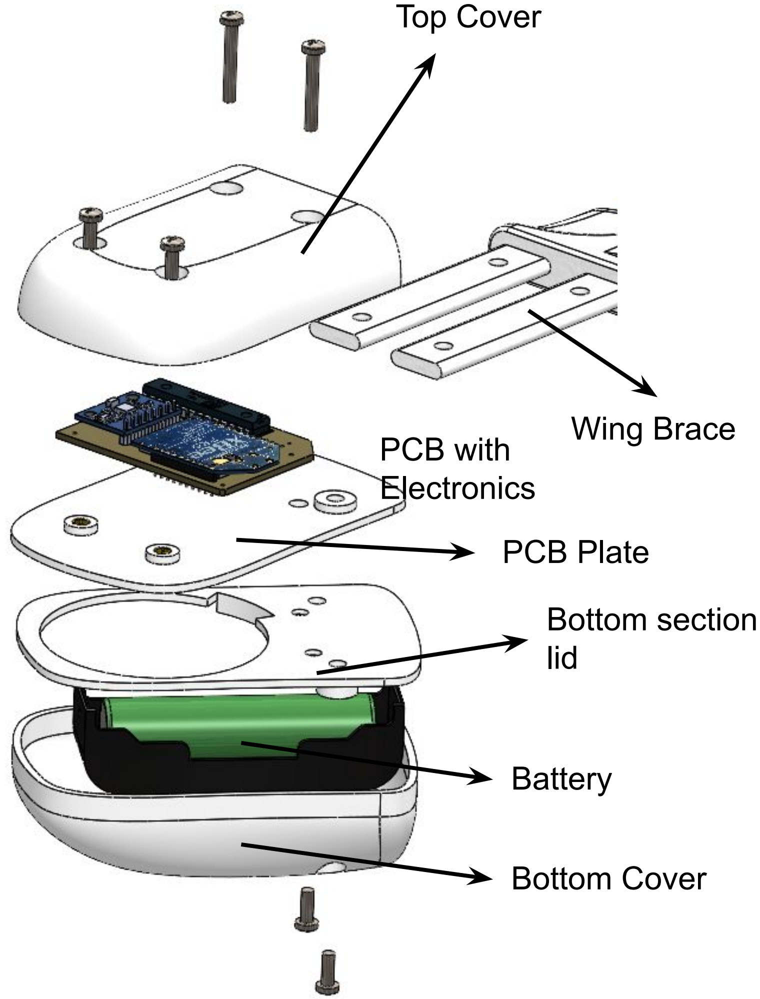
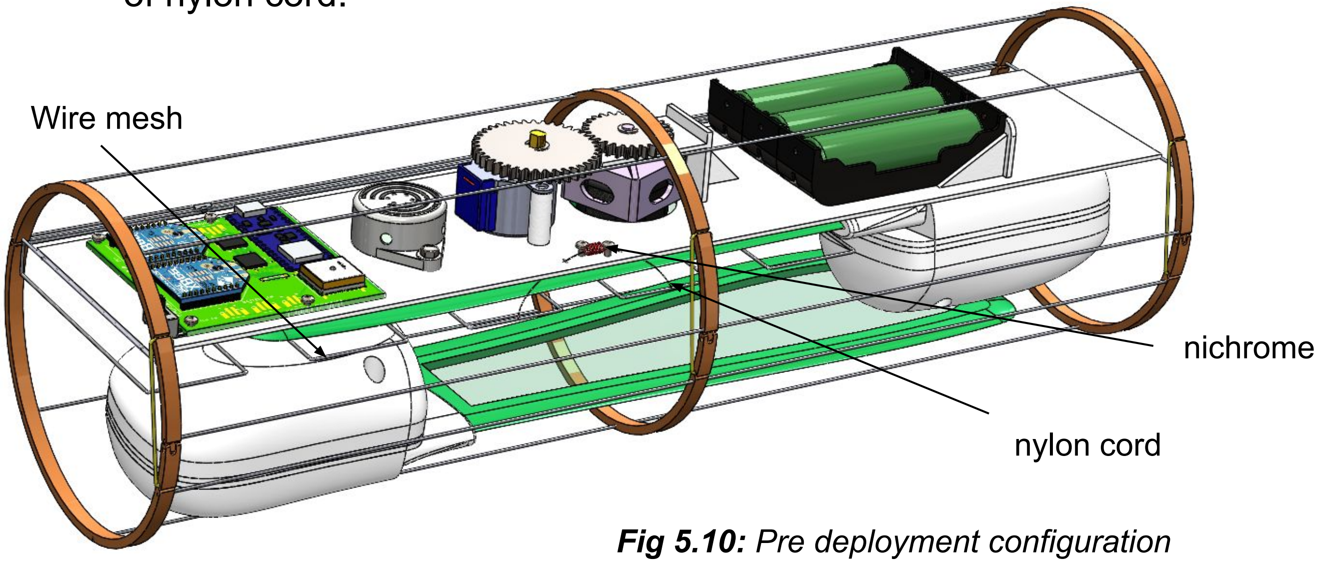



***Fig 5.9:*** *Detailed and exploded view of payload*

## Payload Pre Deployment Configuration

- This Design includes the arrangement of payloads in an alternating fashion.
- The payload which deploys first at 500m is kept directly inside the container and is supported by the rings and linear rails of container
- The payload which deploys second at 400m is supported firmly by a wire mesh structure tied to the electronics plate with the help of nylon cord.



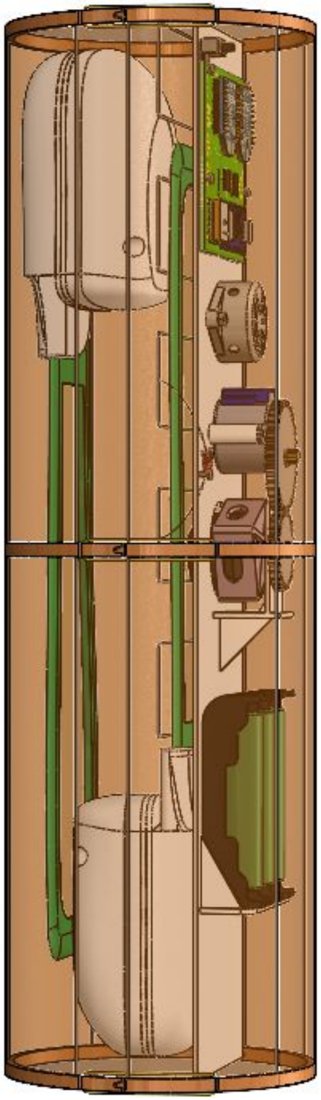



***Fig 5.10:*** *Pre deployment configuration*

## Payload Deployment Configuration

- The payload deployment is achieved through opening of the container's bottom by action of elastic bands after nichrome burns the cords which tied the bottom portion to upper portion of container.
- The wing is a single solid piece. After coming out from the container, the payload starts autorotation and as the lift increases the payload achieves near horizontal configuration

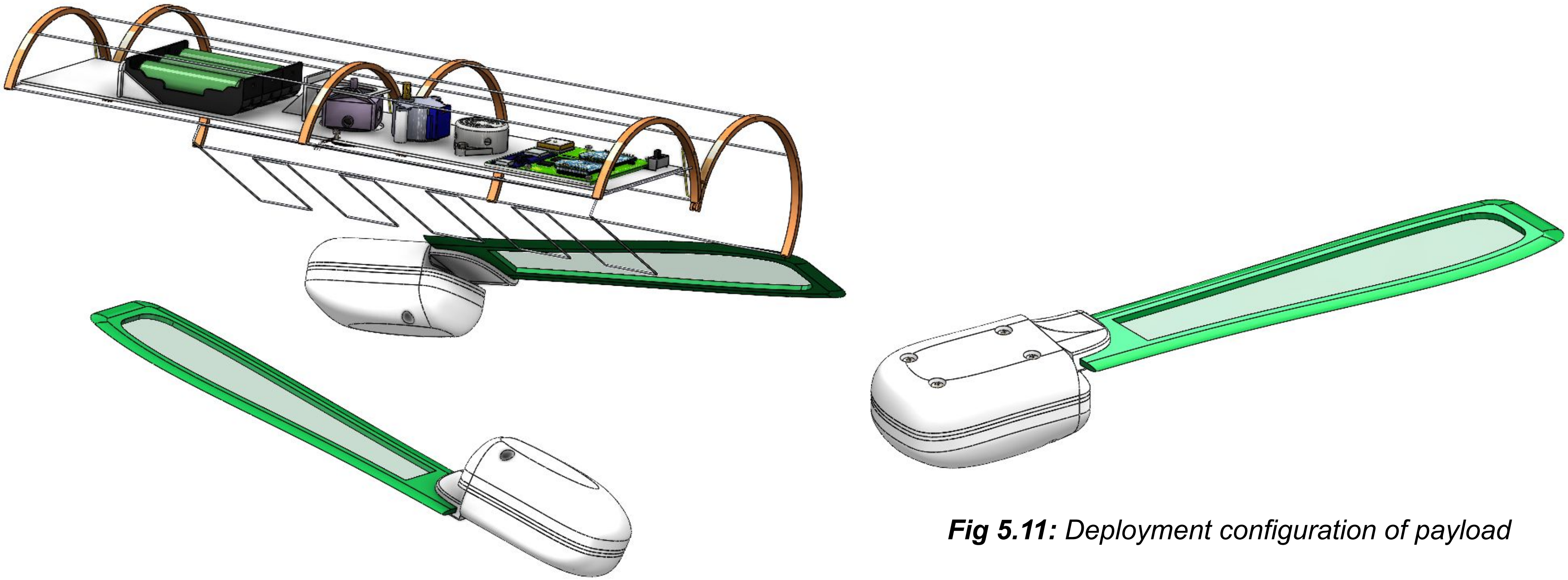


***Fig 5.11:*** *Deployment configuration of payload*

# Container Mechanical Layout of Components (1/3)

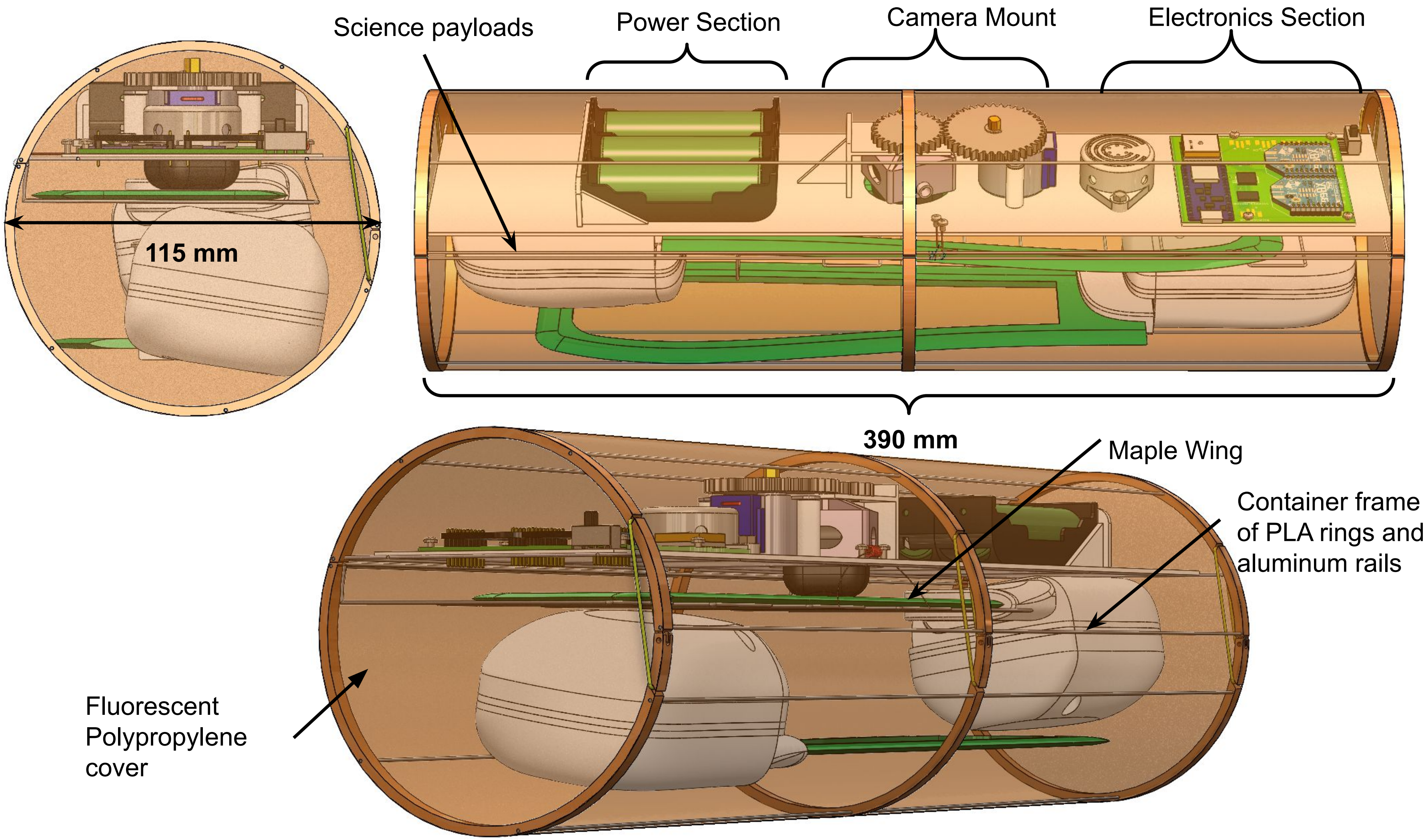



***Fig 5.12:*** *Cansat assembly with container dimensions*

# Container Mechanical Layout of Components (2/3)

## Key features

- The container is a solid hybrid structure of Aluminium linear rails and 3 PLA rings to strengthen the entire container structure.
- **Fluorescent Orange** low density polypropylene cover for easy detection and protection of the electronics.
- Holds the body firmly along with all exterior components.
- Electronics are bolted to the PLA plate which is attached to the rectangular wire frame of container.
- Withstands high G Shocks (15G) .
- Switch on electronics plate accessible through a small opening
- The container has Address, Email and Contact info.

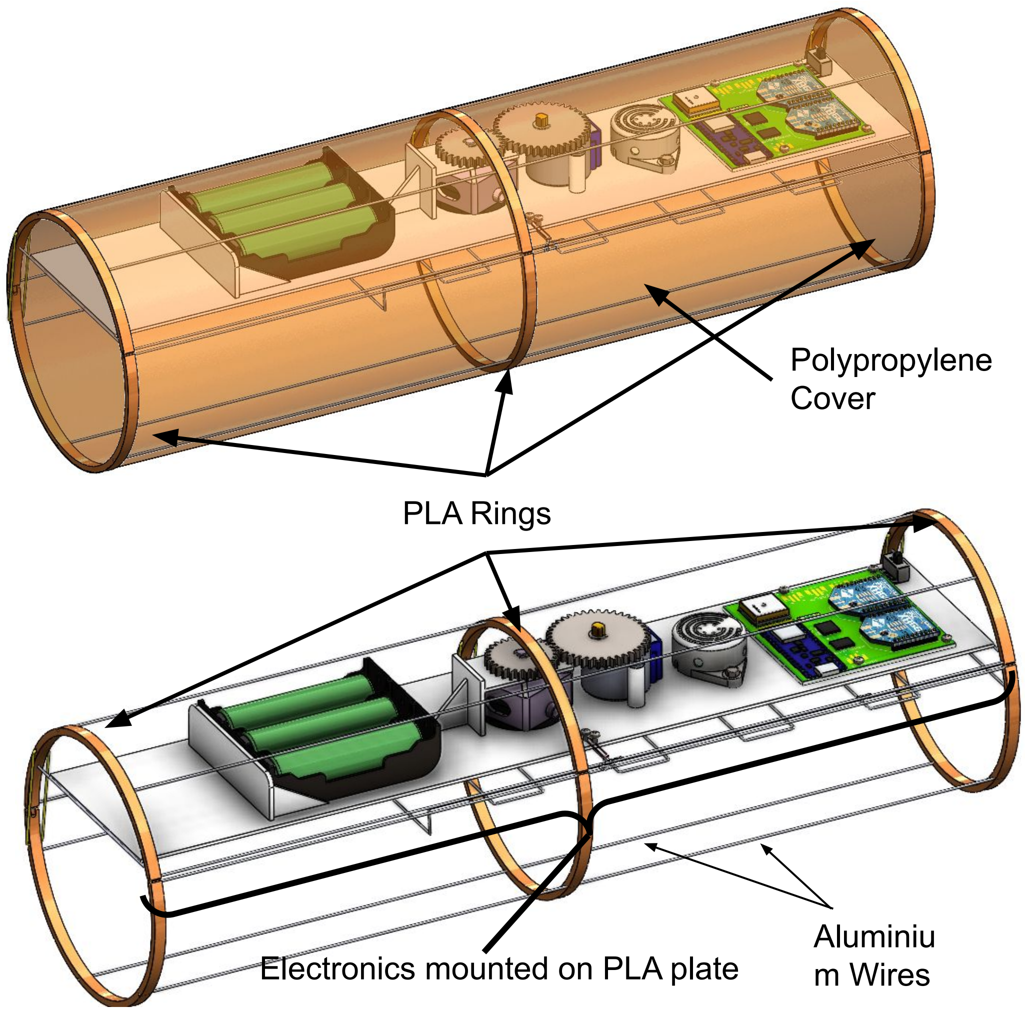
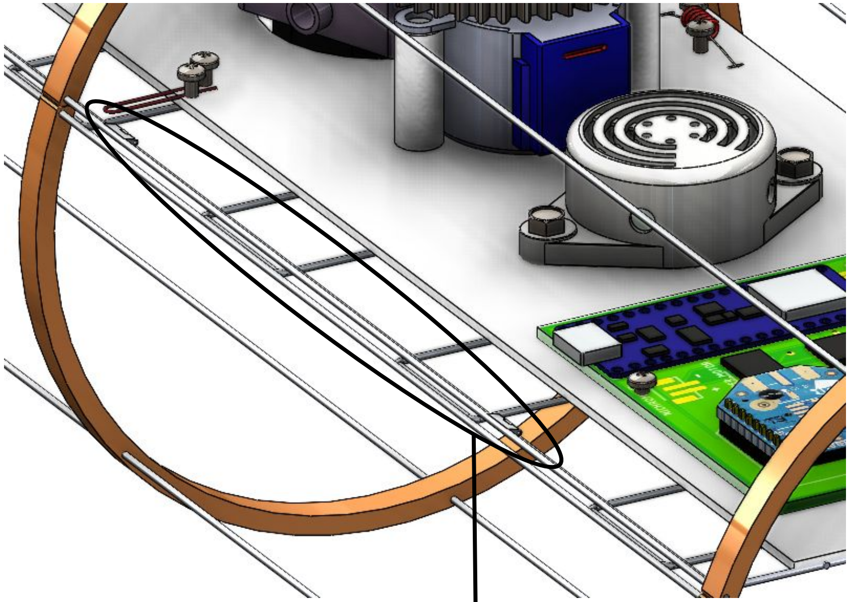



***Fig 5.13:*** *Layout of the components in the container*

# Container Mechanical Layout of Components (3/3)

**Important Components and attachment mechanisms**

- Hinges of the PLA Rings.
- Rubber Bands attachment points.
- Hinges for the Wiremesh.



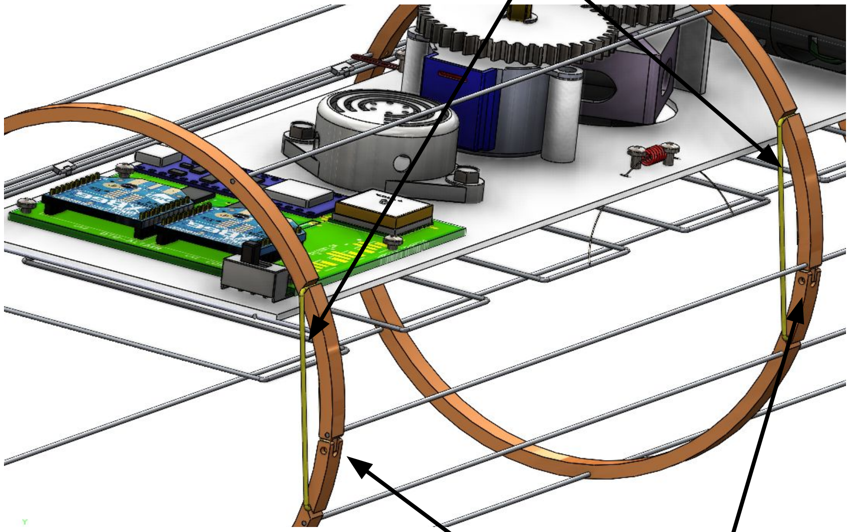




***Fig 5.14:*** *Container Deployment mechanism - Hinge and rubber band system*

# Payload Release Mechanism (1/2)

The PRM is triggered by 2 separate nichrome wires, each rigged to deploy each payload at appropriate altitude.

## Working of PRM

1. Tie lines holding the container door from the container, burns due to the nichrome wire attached to it at 500m.
2. Container Door opens due to the rubber bands placed at the hinges which relax when the tie lines are burnt by nichrome wire inside the container
3. Payload 1 drops down. Payload 2 is still held securely in place by the comb wire mesh.
4. At 400m, another nichrome wire inside the container burns off the tie line that connects the Wiremesh to the electronics plate
5. Wiremesh opens and set the Payload 2 free from the container.

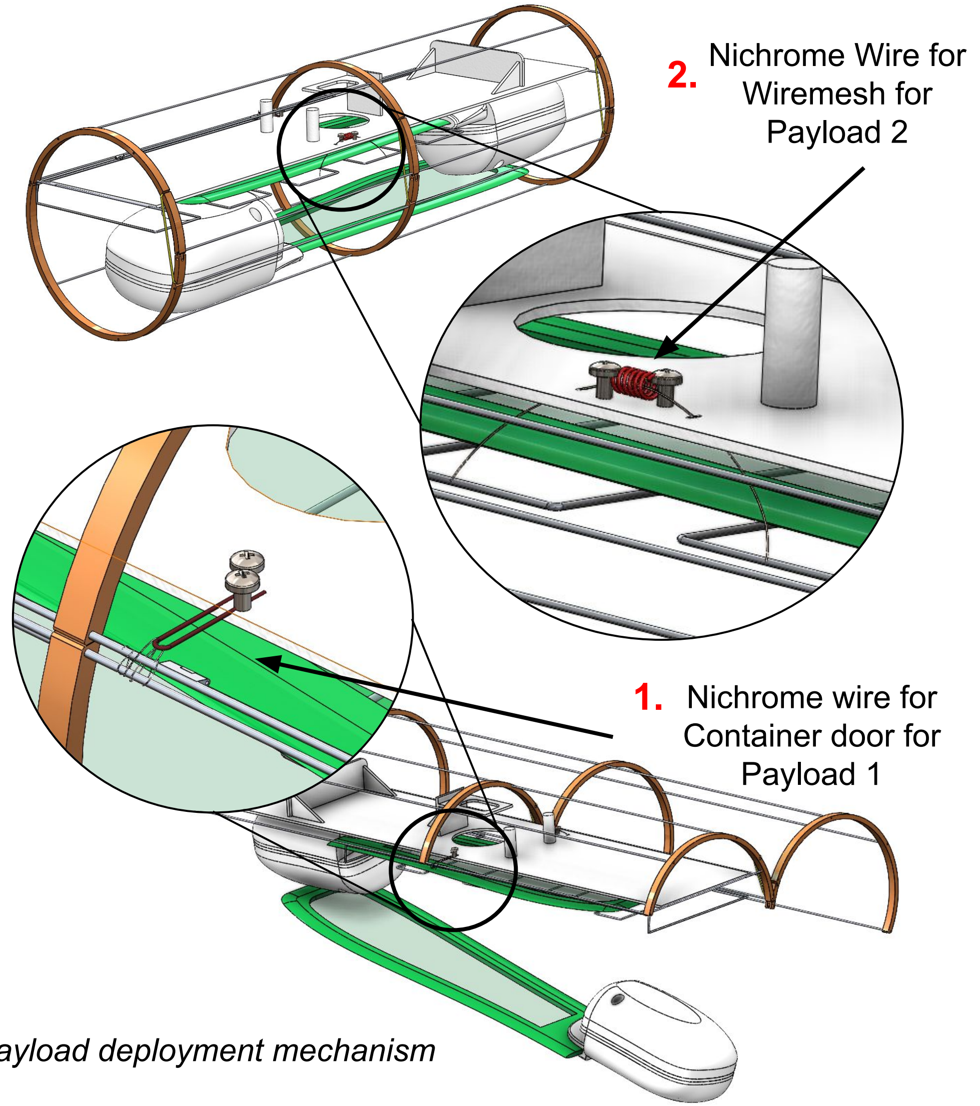



***Fig 5.15:*** *Payload deployment mechanism*

# Payload Release Mechanism (2/2)

Payload 1 Release

Payload 2 Release

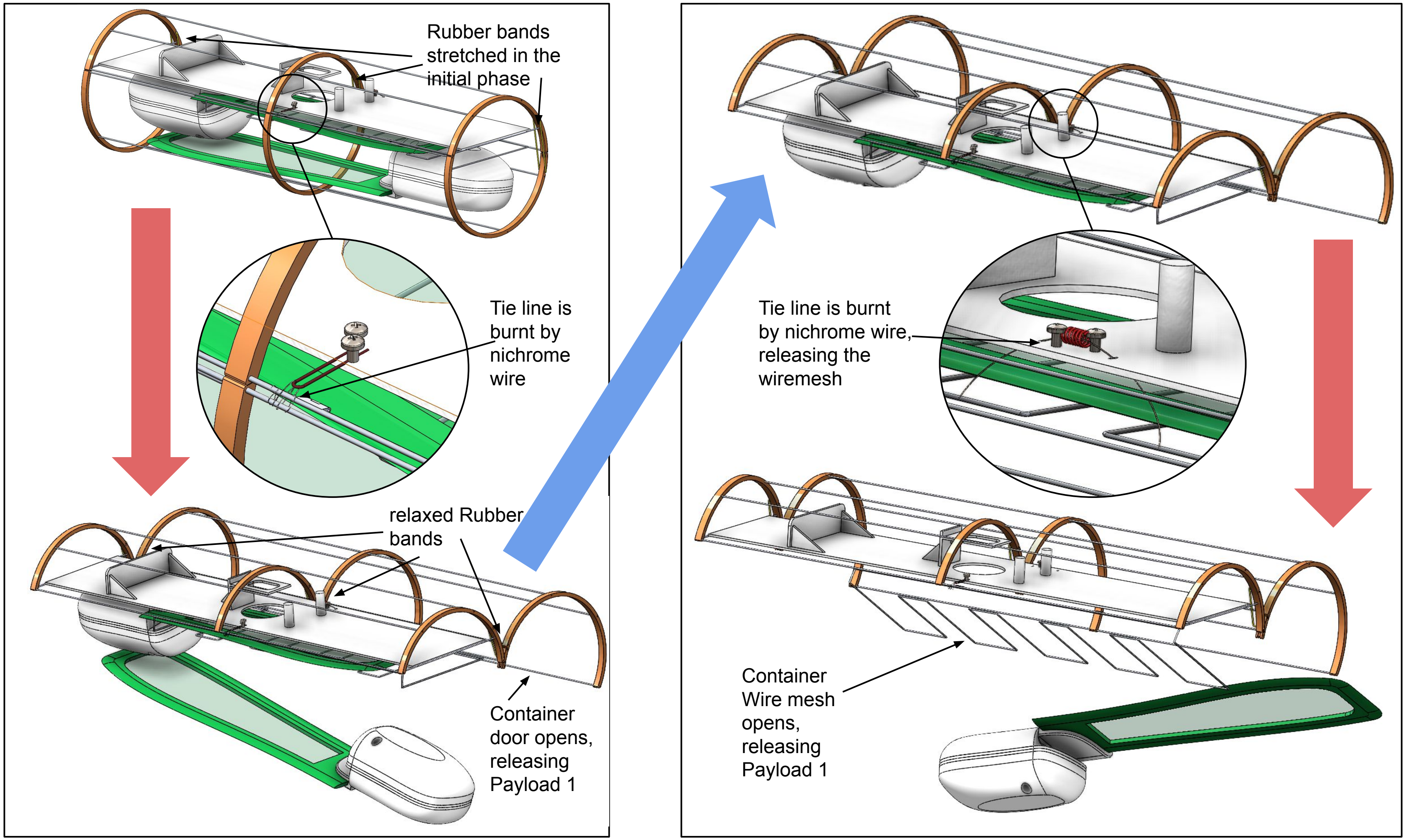



***Fig 5.16:*** *Configuration of payload deployment system*

## Paracord - PLA Ring attachment

- In accordance to the deployment requirements, the container parachute is folded and stowed on the cylindrical face of the container
- The *cross shaped parachute is tied directly to the PLA rings of the container with the help of 12 nylon paracords* for uniform load distribution on all sides .
- The parachute on the container is deployed passively as soon as CANSAT separates from the rocket.

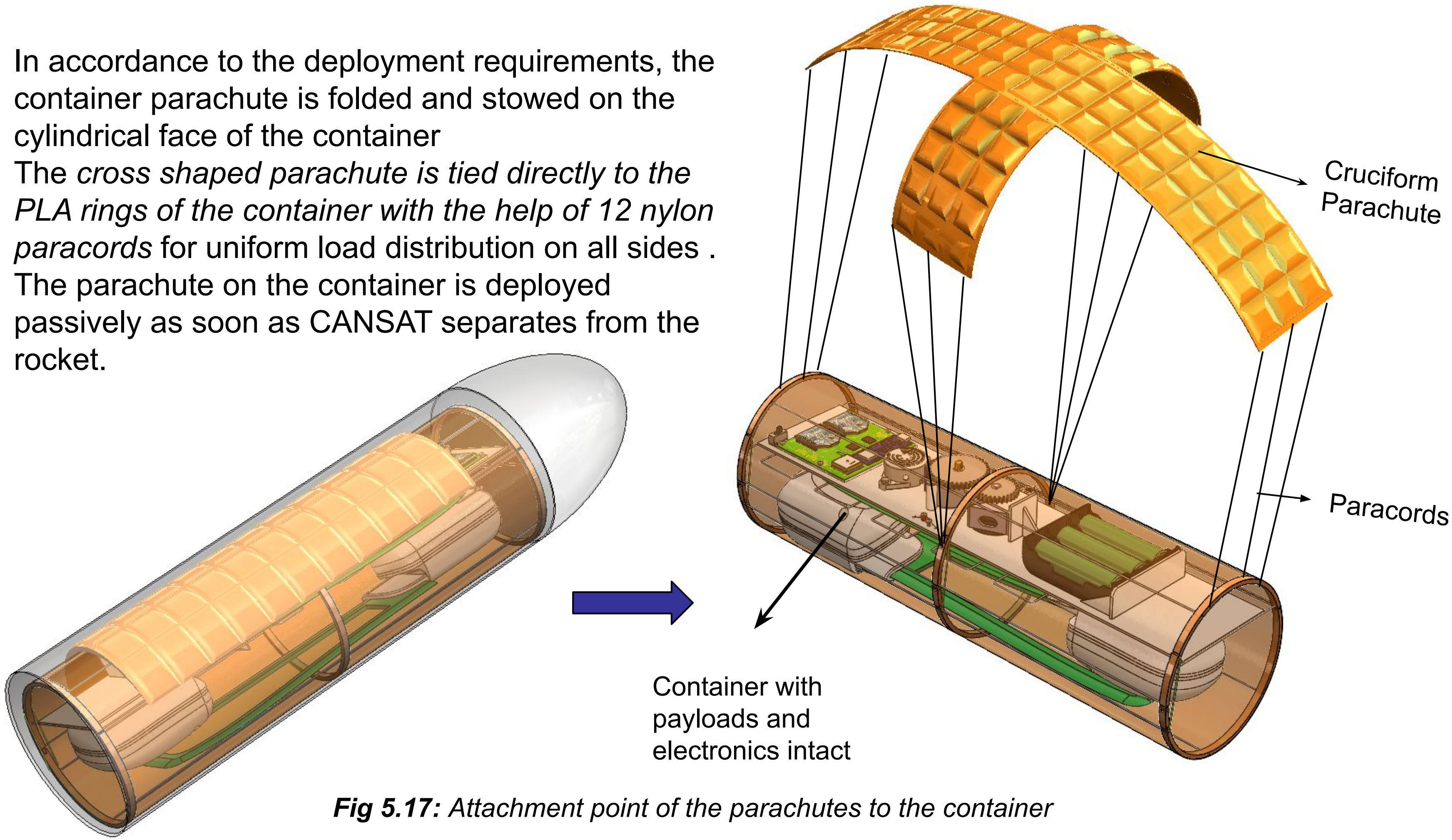
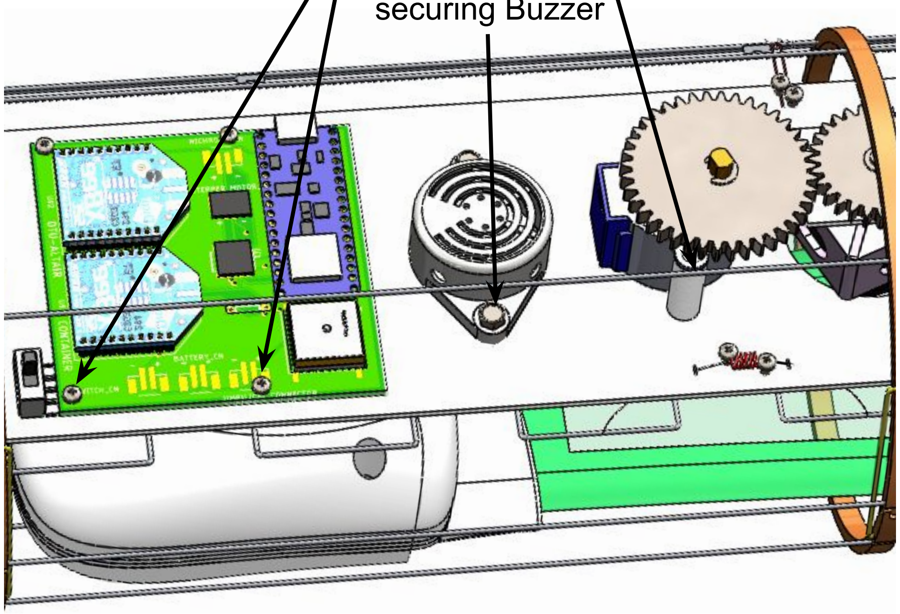



***Fig 5.17:*** *Attachment point of the parachutes to the container*

## Container Electronics Integrity

Electronics on the container are placed on a custom PCB and all the components like microcontroller, XBee, GPS module and all other modules are fixed on the PCB. PCB is secured on a PLA plate on the Container platform. PCB has bolts which are **secured with brass inserts** on the PLA plate.
Big components like Buzzer and Stepper is **fixed with Bolts.**

**Shock absorbant spacers** will be added under sensitive parts such as XBee and GPS Modules.



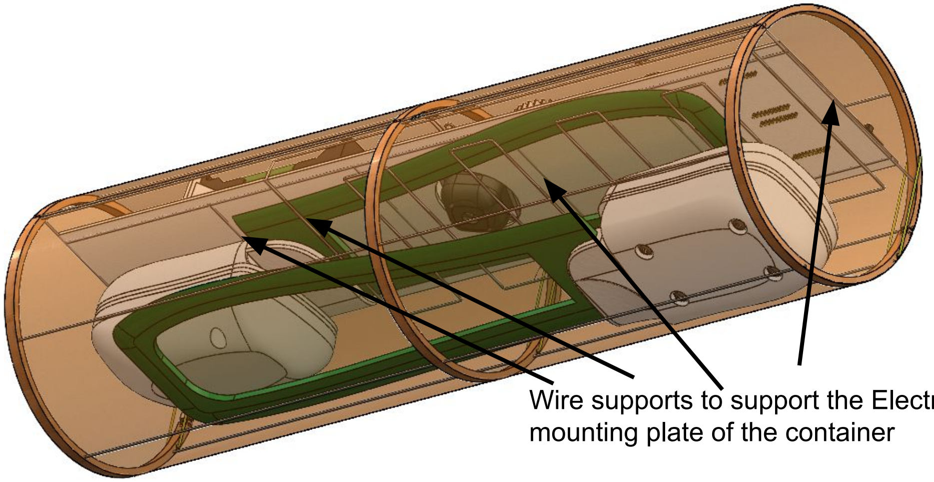




***Fig 5.18:*** *Structural integrity of container electronics is ensured via mounting on PLA plate*

## Payload Electronics Integrity

Payload Shell acts as a protective Cover for the electronics.

Payload Shell is a **Layered structure** secured with M3 bolts going in brass inserts to firmly hold the structure

Custom PCB containing microcontroller, Sensor module and XBee radio is securely **placed between an enclosed space** in the top compartment.

Bottom Compartment contains the Power systems including the Battery and power switches. Battery case is attached to the bottom compartment with resin based glue, **Battery and Power Switch remains accessible** through the hole for easy replacement and reachability. No spring contacts are used in Battery case.

Lid of the Bottom Compartment can be easily closed with the help of M3 Bolts.

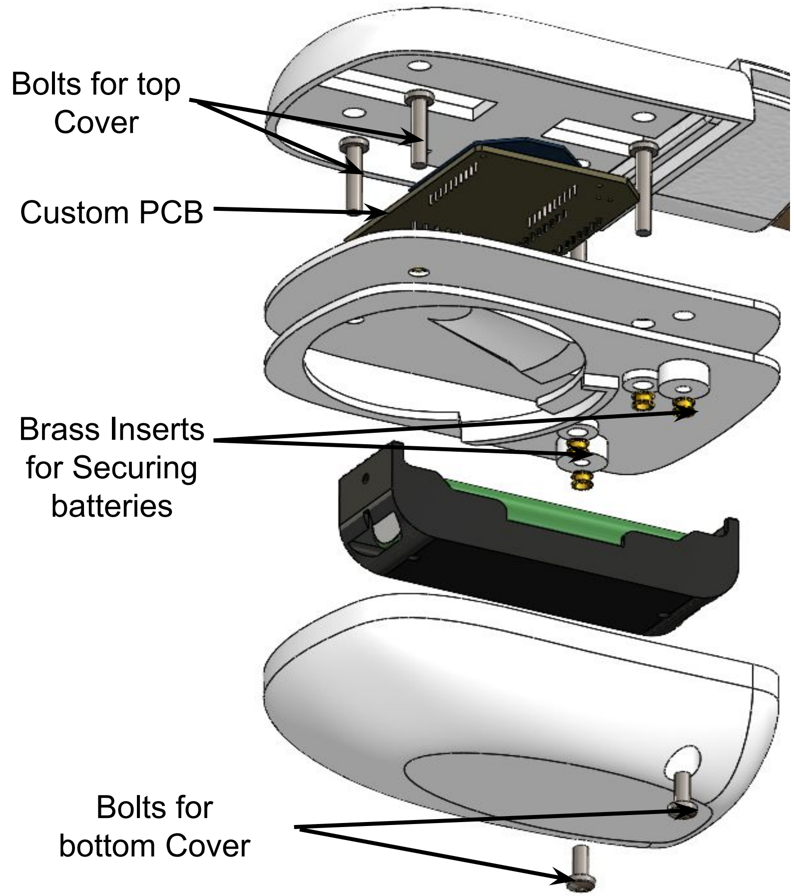



***Fig 5.19:*** *Structural integrity of container electronics is ensured via layered structure*

## Container Structural Integrity

Static simulation was performed on solidworks to simulate the forces acting on the PLA rings due to paracords. A force of **6N** was applied on the rings, keeping the bottom portion fixed. The stress and displacement plots are shown below. The max values for stress(2.6MPa) are well below the tensile strength for PLA(37 MPA) , **assuring that the structure is rigid enough to survive the forces due to paracords**.

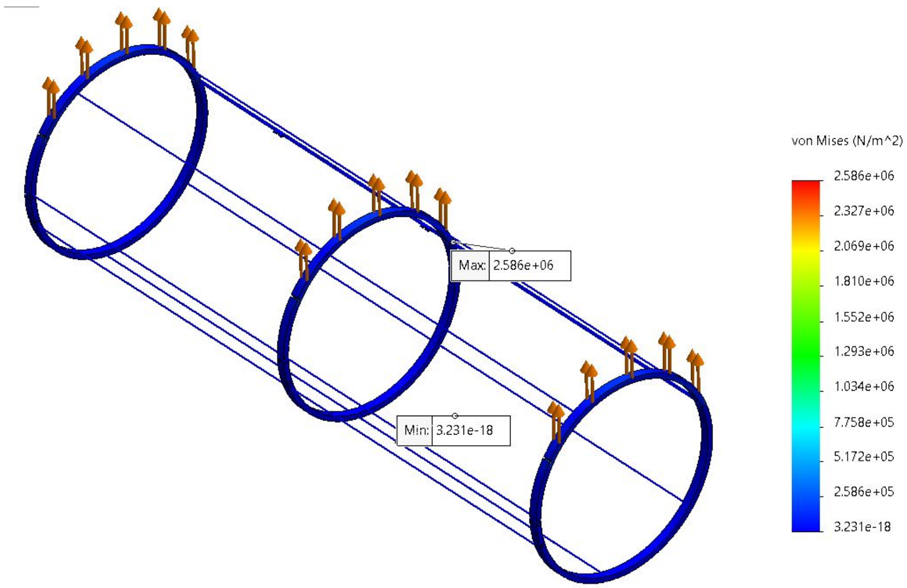



***Fig 5.20:** Static Stress simulation of the container cage*

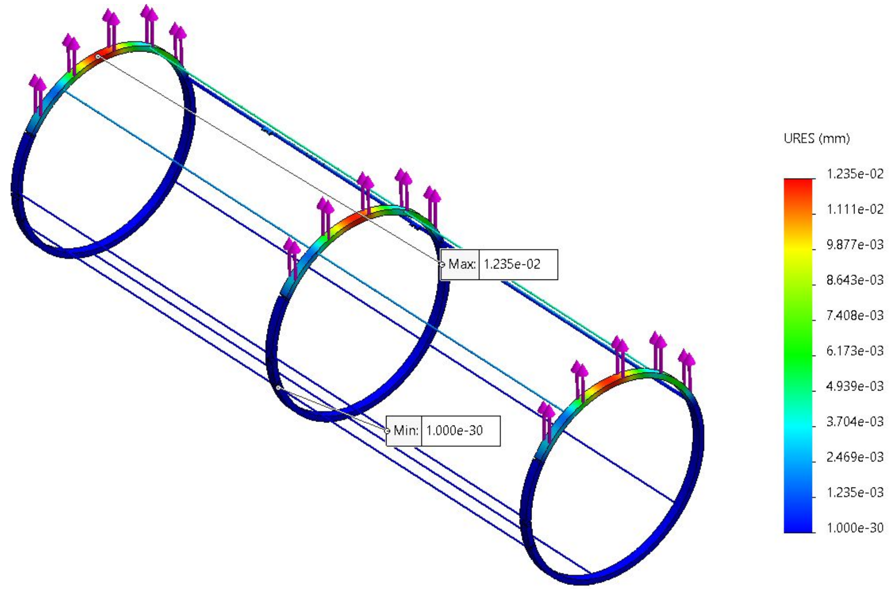


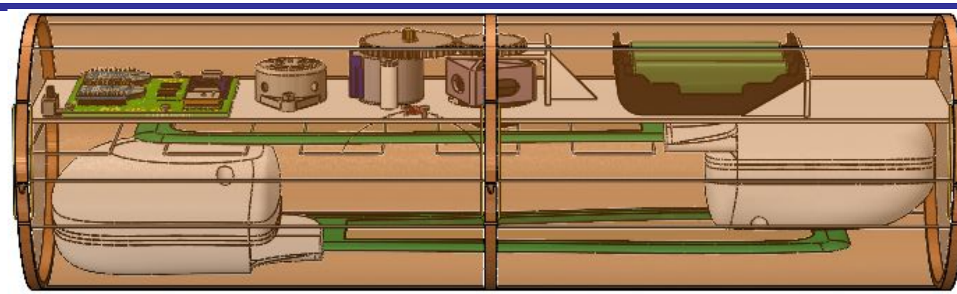

***Fig 5.21:** Static displacement simulation of the container cage*

# Structural Survivability (4/6)

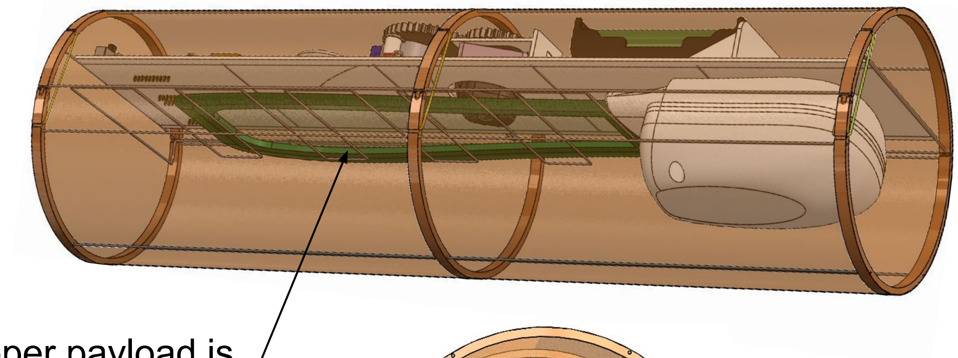
**Payload Structural Integrity**

Payloads are secured inside the container, one rests on the container door and other sits on the wire mesh which keeps the payload from falling after the deployment of the lower payload.

Both the payload holding mechanisms are taught tightly with tie lines and are expected to **withstand 30Gs of shock without breaking.**



Both Payloads fit securely inside the container



upper payload is secured by the wiremesh and is secured from the both side by the container cage

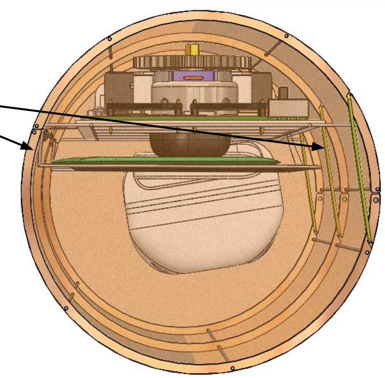
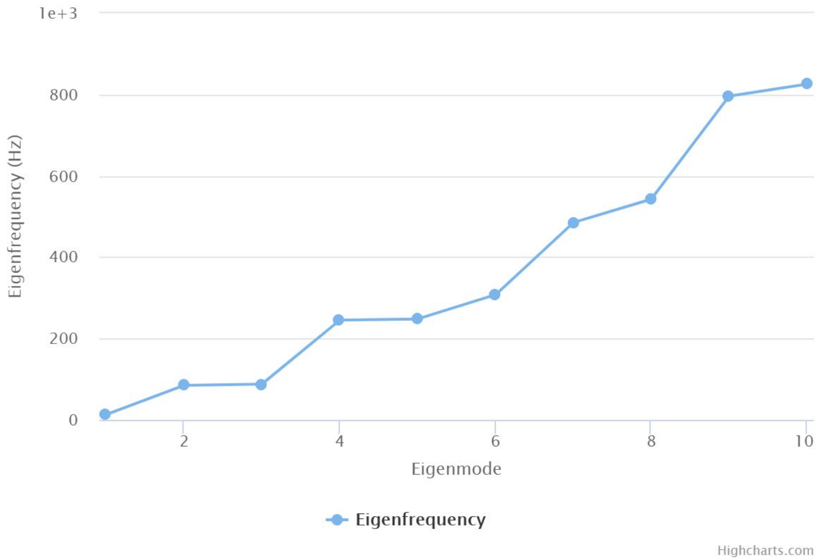


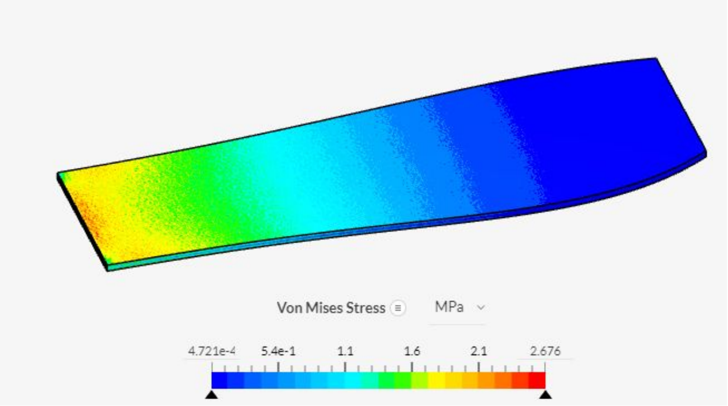
***Fig 5.22:*** *Features present in the design to secure the payloads*

## Wing Structural Integrity

The wing with all the load along with the centrifugal force due to rotation was simulated on SimScale. Minor displacements were noticed near the tip.

The Frequency analysis gives the first eigenfrequency to be 12 Hz. Which is high for the oscillations which are around 1.8Hz due to the rapid pitch and roll shifting therefore no deformation or any abrupt changes should appear on the wings.



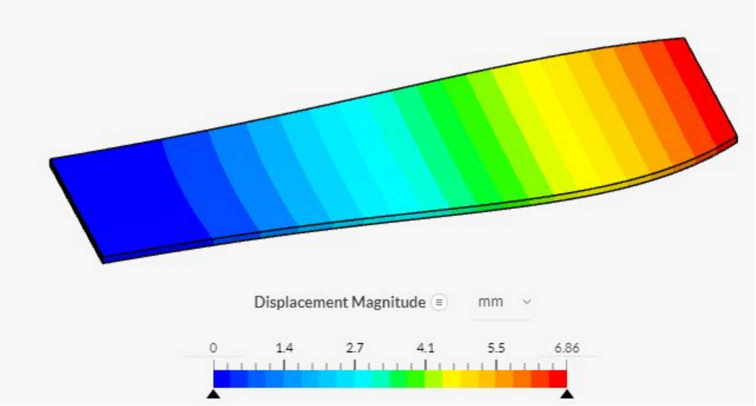
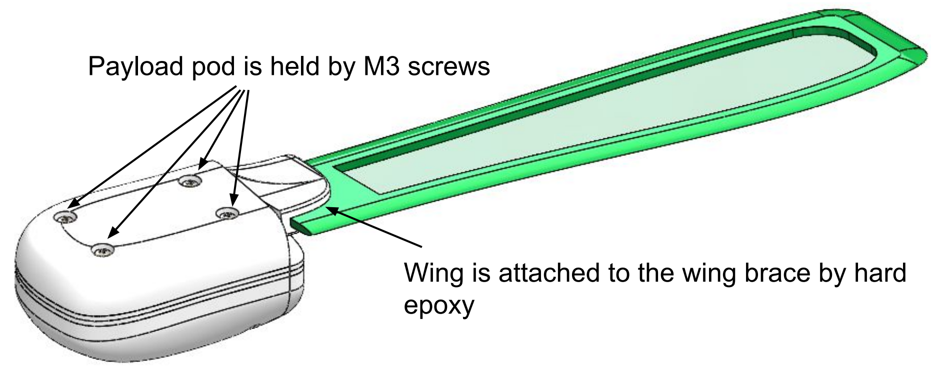



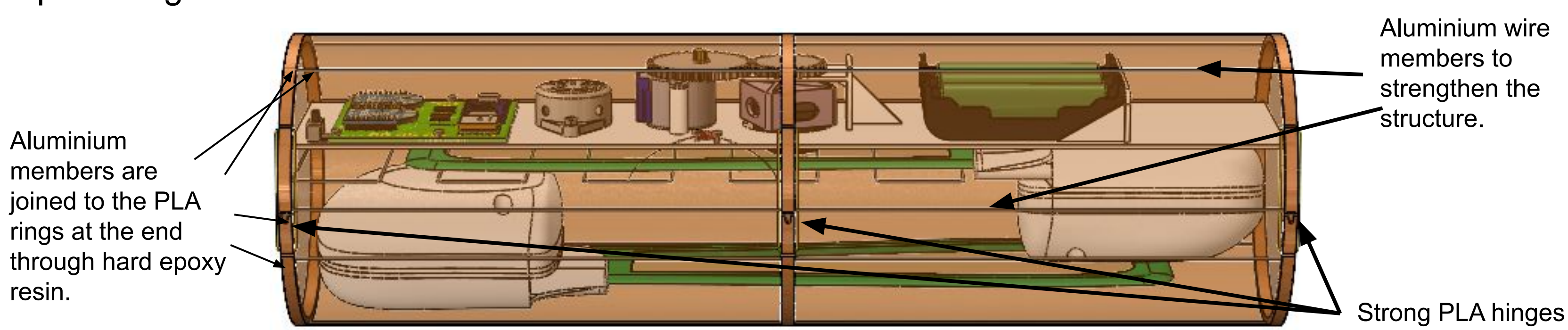

***Fig 5.23:*** *Harmonic and static simulation of science payload's wing*

# Structural Survivability (6/6)

## Overall Attachment Structural Integrity

The structure is supposed to **withstand the 15Gs of acceleration and shock of 30Gs**. Due to multi member linked cage and protective film around the container, the Container electronics are safe from the outside environment. Similarly for the Descent Control Systems, the Payload PLA shell protects it from drop to the ground at 11.8m/s.




**Thorough testing and integration of the Container is kept on hold and is pushed due to sudden increase in COVID-19 virus cases. Testing will continue when the situation gets better.**

***Fig 5.24:*** *Attachment point presents to secure the payload and container.*

# Mass Budget (1/3)

| COMPONENTS | | ESTIMATED WEIGHT (in grams) | SOURCE |
|---|---|---|---|
| CONTAINER | Polypropylene Encase (Fluorescent) | 25.07 | CAD Measurement |
| | Aluminium Wire Rails(1mm) + wiremesh | 11.22 | Measurement |
| | PLA rings x6 | 20.38 | CAD Measurement |
| | Electronics Support Plate | 26.67 | CAD Measurement |
| | Container Electronics | 223.32 | Datasheets |
| | Elastic Bands x 3 | 6 | CAD Measurement |
| | Fishing Lines x 3 | 1 | CAD Measurement |
| | Nichrome Wires x 2 | 1 | CAD Measurement |
| | Bolts and Brass Inserts M3 x 10 | 18 | CAD Measurement |
| | Camera gimbal gears | 6.54 | CAD Measurement |
| PAYLOAD 1 & 2 | Bolts and Brass Inserts M3 x 6 | 10 x 2 | CAD measurement |
| | PLA Wing | 21.5 x 2 | Measurement |
| | PLA Shell | 31.89 x 2 | CAD measurement |
| | Payload Electronics | 60.91 x 2 | Datasheets |
| PARACHUTE AND ITS ATTACHMENTS | Parachutes - Ripstop | 9 | Estimation |
| | Chords - Nylon 66 | 2 | Estimation |
| **TOTAL (in grams)** | **598.8** | | |

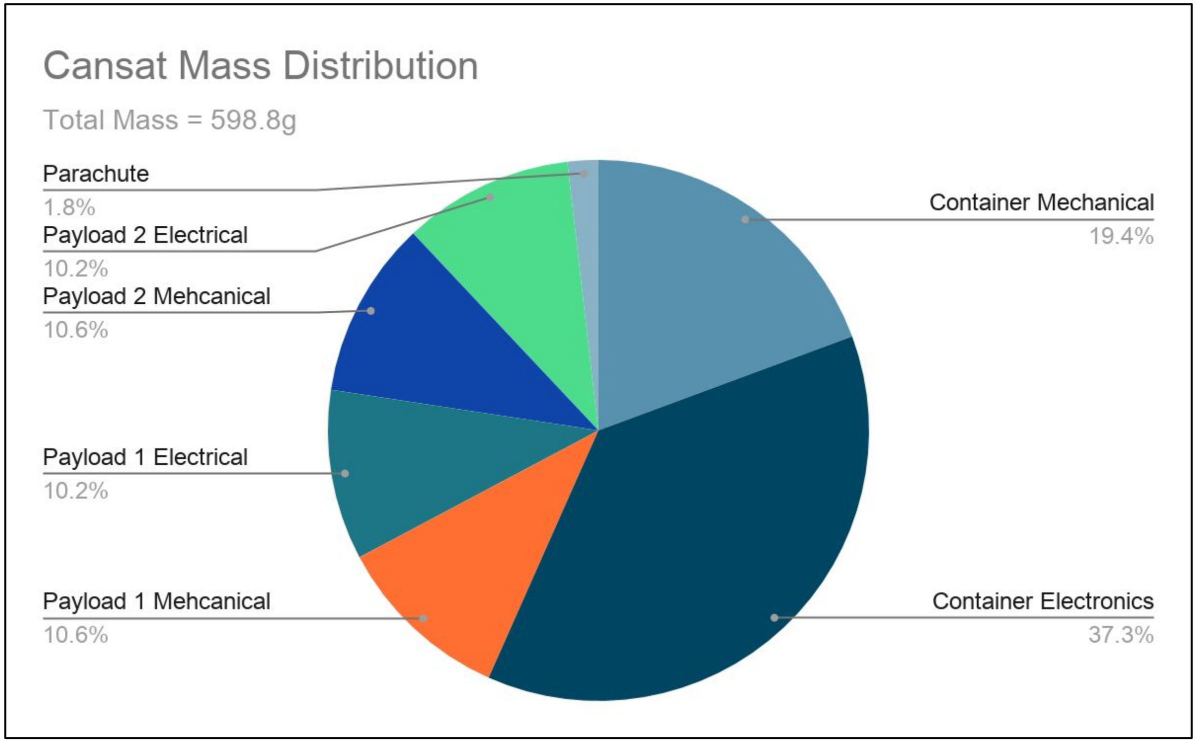
# Mass Budget (2/3)

| Container Electronics | | |
|---|---|---|
| **Electrical Component** | **QTY** | **mass** |
| Arduino Nano Ble 33 sense | 1 | 5g |
| Neo6M | 1 | 12g |
| Mini 1080P FPV Camera | 1 | 8g |
| Xbee S2C | 2 | 9.42g |
| iFlight 5V Buzzer Alarm | 1 | 2.9g |
| Samsung 30Q 3000mah Battery 18650 | 3 | 144g |
| Strontium 32GB SD card | 1 | 1g |
| 28BYJ-48 Stepper motor + ULN2003 motor driver | 1 | 32g |
| micro sd card module | 1 | 6g |
| TB6612FNG motor driver | 1 | 3g |
| **TOTAL** | | **223.32g** |

| Payload Electronics | | |
|---|---|---|
| **Electrical Component** | **QTY** | **mass** |
| Atmega328p | 1 | 2.2g |
| GY-87 | 1 | 6g |
| Samsung 30Q 3000mah Battery 18650 | 1 | 48g |
| Xbee S2C | 1 | 4.71g |
| **TOTAL** | | **60.91g** |

| NET MASS | |
|---|---|
| **Container** | **350.2g** |
| **Payload 1** | **124.3g** |
| **Payload 2** | **124.3g** |

## Mass Distribution




Total Mass of the whole system is **598.8g** (excluding margins) which is well within range of the given requirements. After including **margins of 10 grams**, the total mass becomes 608.8 which is **within requirements** as well.

**To modify the mass**, if need be, we can ***change the infill of the 3D printed parts*** and ***remove extra members of the wireframe as per requirement.***

# Communication and Data Handling (CDH) Subsystem Design

**Kunal Thakur**

# Container CDH Overview

**Overview of Payload Communication Data Handling Subsystem:**

| SNo. | Component Requirement | Selected Component | Function/Properties of the Component |
|---|---|---|---|
| 1. | Container Processor/Microcontroller | Arduino Nano 33 BLE Sense | To acquire and process telemetry data |
| 2. | Memory Storing Device | Strontium Nitro 32GB Micro SDHC Memory Card | To store the telemetry data obtained from sensors so that it can be viewed for reference later. |
| 3. | Real Time Clock | Arduino crystal oscillator | Guidance in Mission time tracking |
| 4. | Container Antenna | Xbee whip Antenna | To act as a transceiver antenna for communication |
| 5. | Radio Communication | XBee S2C – RF Module | To act as a transceiver and hence transmit as well as receive data from the sensors of the payload to the ground station |

# CDH Changes Since PDR

| Component | Change | Rationale |
|---|---|---|
| **MT76813DBI ESP8266 Serial WIFI wireless Gain Antenna** | Replaced by onboard whip antenna | it is space efficient and virtually free. |
| **Radio configuration** | Earlier 4 xbee were used and now 5 xbee are used | helps in easier communication without headache to change pan ID every second |

# CDH Requirements (1/2)

| Base Requirement for Communication Data Handling | | | | | | |
|---|---|---|---|---|---|---|
| **Requirement Number** | **Requirement** | **Priority** | **Process Phase** | | | |
| | | | **R** | **T** | **P** | **C** |
| CDH - 01 | The container shall include electronics to receive sensor payload telemetry. | High | | | ✓ | |
| CDH - 02 | The container shall transmit its telemetry and the payload telemetry received once per second in the format described in the Telemetry Requirements section. | High | | | ✓ | |
| CDH - 03 | Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission. | High | | | ✓ | |
| CDH - 04 | XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed. | High | | | | ✓ |
| CDH - 05 | XBEE radios shall have their NETID/PANID set to their team number. | High | | | | ✓ |
| CDH - 06 | XBEE radios shall not use broadcast mode. | High | | | | ✓ |
| CDH - 07 | The container shall stop transmitting telemetry when it lands. | High | | | | ✓ |
| CDH - 08 | All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) | High | | | | ✓ |

# CDH Requirements (2/2)

| Base Requirement for Communication Data Handling | | | | | | |
|---|---|---|---|---|---|---|
| **Requirement Number** | **Requirement** | **Priority** | **Process Phase** | | | |
| | | | **R** | **T** | **P** | **C** |
| CDH - 09 | Teams shall plot each telemetry data field in real time during flight. | High | | | ✓ | |
| CDH - 10 | The science payload shall transmit all sensor data in the telemetry. | High | | | | ✓ |
| CDH - 11 | The ground system shall command the science vehicle to start transmitting telemetry prior to launch. | High | | | ✓ | |

# Container Processor & Memory Selection (1/3)

| Microcontroller | Manufacturer (Processor) | Clock Speed | Boot Time | Data Interface Pins | Power Required | Flash Memory | RAM | Unit Price (USD) |
|---|---|---|---|---|---|---|---|---|
| Arduino nano 33 BLE Sense | ARM Processor | 64 MHz | 2-3 seconds (with bootloader) | 14-digital pins 2 serial pins 6 PWM pins, 4 SPI pins 12C pins | 3.3V - regulated, 6-20V unregulated external supply, 19 mA | 1Mb | 256Kb | $31 |

**Arduino Nano 33 BLE Sense:**

1. **Familiarity** with Arduino IDE as used in other team projects.
2. **Lower Boot time** compared to Raspberry pi Zero.
3. 64 MHz **Clock Speed** to support quick sensor data processing.
4. **Small Package** with onboard sensors.

***Fig 6.1:****Arduino Nano 33 BLE Sense*

# Container Processor & Memory Selection (2/3)

**The detailed specifications of Arduino Nano 33 BLE sense processor and microcontroller are as follows:**

| | | | |
|---|---|---|---|
| Microcontroller | nRF52840 | EEPROM | none |
| Architecture | ARM | DC Current per I/O Pin | 15 mA |
| Operating Voltage | 3.3V | Input Voltage | 21 Volts (limit) |
| Flash Memory | 1MB (nRF52840) | Digital I/O Pins | 14 |
| S-RAM | 256KB (nRF52840) | Power Consumption | 19 mA |
| Clock Speed | 64MHz | PCB Size | 18 x 45 mm |
| Analog IN Pins | 8 (ADC 12 bit 200 ksamples) | Weight | 5 gr (with headers) |

# Container Processor & Memory Selection (3/3)

**The below chart expresses the trade and selection of memory to store all the data transmitted from sensors:**

| Model | Manufacturer | Memory space available | Transfer Speed | Unit Price (USD) |
|---|---|---|---|---|
| SRN32GTFU1QR | Strontium Nitro | 32gb | 85 mb/s | $4.90 |

**Strontium Nitro 32GB Micro SDHC Memory Card:**

1. The Strontium SD Card has **is of low cost** compared to the SanDisk SD Card ever with **same memory space** available.
2. **Faster transfer speed** of 85 mb/s.
3. **SPI communication interface**, which means more reliability when it comes to data transfer.
4. Easier to **read data** from file.


***Fig 6.2:**32GB Micro SDHC Memory Card*

# Container Real-Time Clock

| Model | Clock Type (hardware or Software) | Communication Interface | Power Consumption | Operational Voltage | Reset Tolerance | Unit Price (USD) |
|---|---|---|---|---|---|---|
| Internal RTC | Software | inbuilt arduino function | 0 mA | -0.5V Min 3.6V Max | After the reset, the arduino requests current time from gps and maintains the clock ticks | $0 |

**Arduino nano 33 BLE sense inbuilt RTC**

1. Very **low power consumption** required
2. Very l**ow operational voltage** required
3. **Cost efficient** as it is inbuilt on the module .

***Fig 6.3:****Arduino nano BLE sense 33*

# Container Antenna Selection (1/3)

## Container-to-Ground link antenna:

| Model | Connector Type | Gain (dBi) | Outdoor Distance (Visual Line-of-Sight) | Indoor Distance (Office Building) | Unit Price (USD) |
|---|---|---|---|---|---|
| **Xbee pro whip antenna** | Attached to the pcb | 1.5 | 1335m | 43m | Nil (Included with the module) |

# Container Antenna Selection (2/3)

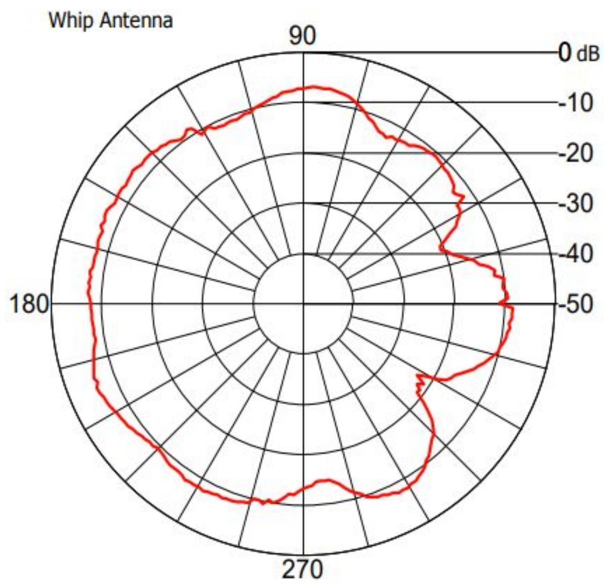



***Fig 6.4:****Whip antenna radiation pattern*

Selected Antenna: **Xbee pro whip antenna**

1. **Longer** Outdoor distance (Visual Line-of-Site)
2. **Better** Radiation Pattern.
3. **Higher gain.**
4. **light weight**

# Container Antenna Selection (3/3)

**Container-to-payload link antenna:**

The same Container-to-Ground link antenna will be used.

# Container Radio Configuration (1/4)

| Name | Manufacturer | Range | Operating Temperature | RF Data Rate | Power Required | Transmit Power | Sensitivity | Unit Price (USD) |
|---|---|---|---|---|---|---|---|---|
| Xbee S2C | Digi International Inc. | Outdoor line-of-sight: up to 1200 m | -40 to 85º C | 250 kbps | 2.1 V-3.6 V | 6.3mW (+8dBm), boost mode 3.1 mW (+5dBm), normal mode | -102 dBm, boost mode -100 dBm, normal mode | $35 |

- **Xbee S2C** is selected because of higher range and high sensitivity.
- **NETID** of the Xbee's - ground station and the container, are set to our Team ID which i **1357.**


***Fig 6.5:****Xbee S2C*

# Container Radio Configuration (2/4)

**Transmission Control during the different mission phases:**

**Launch** **Deployment** **Parachute** **Landing**

Pre Launch → Launch and Release → **Container Landing**

**Communication will be established between the Container, Payloads and the Ground Control Station.**

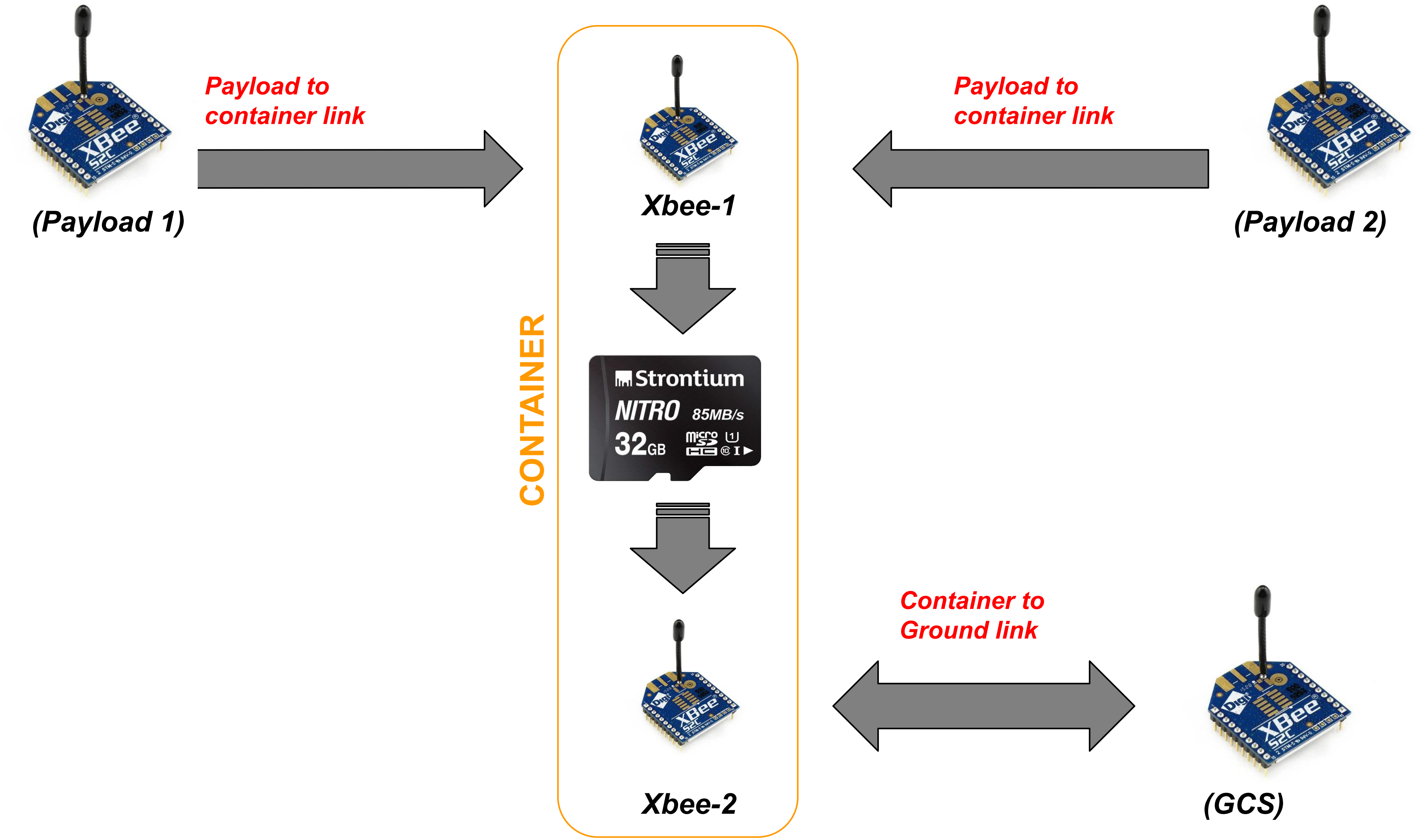
**Upon released from the rocket, the Container and science payloads will establish a serial communication mode with GCS and send the required telemetry. It will continue to do so during their whole flight.**

**Upon Container landing, the sound beacon will be triggered, container will stop sending the telemetry. The communication will terminate when the container lands.**

# Container Radio Configuration (3/4)

- Point to Point (P2P) topology is used.
- Xbees are configured in API mode.
- The Payloads will send data to Xbee-1 of the container.
- This data  is stored in the memory storing device in the container.
- The data is then transmitted by a second Xbee (Xbee-2) present in the container to the GCS.

# Container Radio Configuration (4/4)



# Container Telemetry Format (1/3)

**Included Data:**

Upon powering up, the CanSat probe shall collect the required telemetry at a 1 Hz sample rate.

The telemetry data shall be transmitted with ASCII comma separated fields followed by a carriage return.

**<TEAM_ID> is the assigned team identification.**

**<MISSION TIME> is UTC time in format hh:mm:ss, where hh is hours, mm is minutes, and ss is seconds.**

**<PACKET_COUNT> is the count of transmitted packets, which is to be maintained through processor reset. One count is used for transmission of all packets, regardless of type.**

**<PACKET_TYPE> is the ASCII character 'C' for Container telemetry, characters 'S1' for Science Payload 1 (deployed first) relayed telemetry, and characters 'S2 for Science Payload 2 (deployed second) relayed telemetry.**

**<MODE>= 'F' for flight (the default mode upon system start) and 'S' for simulation**

**<SP1_RELEASED>= 'N' for not released and 'R' for released**

**<SP2_RELEASED>= 'N' for not released and 'R' for released**

**<ALTITUDE> is the altitude in units of meters and must be relative to ground level. The resolution must be 0.1 meters.**

**<TEMP> is the temperature in degrees Celsius with a resolution of 0.1 degrees C. 10.<VOLTAGE> is the voltage of the CanSat power bus. The resolution must be 0.01 volts.**

**<GPS TIME> is the time generated by the GPS receiver. The time must be reported in UTC and have a resolution of a second.**

# Container Telemetry Format (2/3)

<GPS_LATITUDE> is the latitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees.

<GPS_LONGITUDE> is the longitude generated by the GPS receiver in decimal degrees with a resolution of 0.0001 degrees.

<GPS_ALTITUDE> is the altitude generated by the GPS receiver in meters above mean sea level with a resolution of 0.1 meters.

<GPS_SATS> is the number of GPS satellites being tracked by the GPS receiver. This must be an integer number.

<SOFTWARE STATE> is the operating state of the software. (e.g., LAUNCH_WAIT, ASCENT, ROCKET_SEPARATION, DESCENT, SP1_RELEASE, SP2_RELEASE, LANDED, etc.)

<SP1_PACKET_COUNT> is the count of relayed telemetry packets from Science Payload 1

<SP2_PACKET_COUNT> is the count of relayed telemetry packets from Science Payload 2

<CMD ECHO> is the fixed text command id and argument of the last received command with no commas. For example, CXON or SP101325.

Additional comma delimited data fields may be appended after the required fields as determined necessary by the team's design

# Container Telemetry Format (3/3)

**Data rate of Packets:**

- **Burst data transmission mode** would be used for data packet transfer.
- Burst Mode is a temporary **high-speed** data transmission mode used to facilitate **sequential data transfer** at maximum throughput.

**Data Format:**

<TEAM_ID>,<MISSION_TIME>,<PACKET_COUNT>,<PACKET_TYPE>,<MODE>,<SP1_RELEASED>,<SP2_RELEASED>,<ALTITUDE>,<TEMP>,<VOLTAGE>,<GPS_TIME>,<GPS_LATITUDE>,<GPS_LONGITUDE>,<GPS_ALTITUDE>,<GPS_SATS>,<SOFTWARE_STATE>,<SP1_PACKET_COUNT>,<SP2_PACKET_COUNT>,<CMD_ECHO>

**Example Data Frame**:

1357,123,123,C,F,R,R,500,23,3.9,11:27:17,20.5256,23.6552,5001,7,DESCENT,123,123,CXON

***The given example data frame matches the competition requirements and guideline.***

# Container Command Formats (1/3)

The Container shall receive and process the following commands from the Ground Station:

**CX - Container Telemetry On/Off Command**

**CMD,<TEAM_ID>,CX,<ON_OFF>**

Where:

1. CMD and CX are static text.
2. <TEAM ID> is the assigned team identification.
3. <ON OFF> is the string 'ON' to activate the Container telemetry transmissions and 'OFF' to turn off the transmissions.

Example: The command CMD, 1000,CX,ON activates Container telemetry transmission, assuming the team id is 1000.

**ST - Set Time**

**CMD,<TEAM_ID>,ST,<UTC_TIME>**

Where:

1. CMD and ST are static text.
2. <TEAM ID> is the assigned team identification.
3. <UTC_TIME> is UTC time in the format hh:mm:ss where hh is hours, mm is the minutes and ss is the seconds.

Example: The command CMD,1000,ST,13:35:59 sets the mission time to the value given.

It is recommended that the time be set directly from the Ground System time, in UTC, rather than being typed into the command manually.

# Container Command Formats (2/3)

**SIM - Simulation Mode Control Command**

**CMD,<TEAM_ID>,SIM,<MODE>**

Where:

1. CMD and SIM are static text.

2. <TEAM_ID> is the assigned team identification. 3. <MODE> is the string 'ENABLE' to enable the simulation mode, 'ACTIVATE' to activate the simulation mode, or 'DISABLE' which both disables and deactivates the simulation mode.

Example: Both the CMD, 1000,SIM, ENABLE and CMD, 1000,SIM,ACTIVATE commands are required to begin simulation mode.

**PX - Science Payload Transmission On/Off**

**CMD,<TEAM ID>,SP1X,<ON OFF> CMD,<TEAM_ID>,SP2X,<ON_OFF>**

Where:

1. CMD is static text

2. SP1X and SP2X are static text indicating to control telemetry for SP1 and SP2 respectively

3. <TEAM ID> is the assigned team identification. 4. <ON_OFF> is the string 'ON' to activate the Science Payload transmissions and ‘OFF’ to turn off the transmissions

Example: CMD,1000,SP1X,ON will trigger the Container to relay a command to the Science Payload 1 to begin telemetry transmissions.

# Container Command Formats (3/3)

**SIMP - Simulated Pressure Data (to be used in Simulation Mode only)**

**CMD, <TEAM ID>,SIMP,<PRESSURE>**

Where:

1. CMD and SIMP are static text.
2. <TEAM ID> is the assigned team identification.
3. <PRESSURE> is the simulated atmospheric pressure data in units of pascals with a resolution of one Pascal.

Example: CMD, 1000,SIMP, 101325 provides a simulated pressure reading to the Container (101325 Pascals = approximately sea level).

*Note: this command is to be used only in simulation mode.*

# Payload Processor & Memory Selection (1/2)

| Microcontroller | Manufacturer (Processor) | Processor Speed | Boot Time | Data Interfaces | Power Required | Flash Memory | RAM | Unit Price (USD) |
|---|---|---|---|---|---|---|---|---|
| ATmega 328p | Microchip Technology | 0-8MHz at 2.7 to 5.5V 0-16MHz at 4.5 to 5.5V | 500mS | 1-UART, 2-SPI, 1-I2C | 2.7V to 5.5V | 32 KB ISP | 2 KB SRAM | $1.9 |

**ATmega 328p:**

1. **Smaller** in size and **lesser Boot time**
2. **Low power consumption**
3. **Six sleep modes:** Idle, ADC noise reduction, power-save, power-down, standby, and extended standby


***Fig 6.6:****ATmega 328p*

# Payload Processor & Memory Selection (2/2)

**Since the payload need not to store data, so memory storage requirements is not applicable for it.**

# Payload Antenna Selection (1/2)

| Model | Connector Type | Gain (dBi) | Mass (grams) | Outdoor Distance (Visual Line-of-Sight) | Indoor Distance (Office Building) | Unit Price (USD) |
|---|---|---|---|---|---|---|
| **Xbee pro whip antenna** | Attached to the pcb | 1.5 | Nil (Included with the module) | 1335m | 43m | Nil (Included with the module) |

# Payload Antenna Selection (2/2)

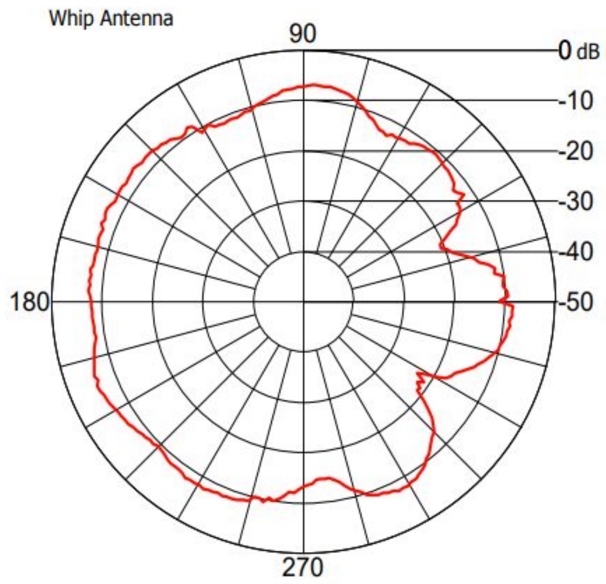



***Fig 6.7:****Whip antenna radiation pattern*

Selected Antenna: **Xbee pro whip antenna**

1. **Longer** Outdoor distance (Visual Line-of-Site)
2. **Better** Radiation Pattern.
3. **Higher gain.**

# Payload Radio Configuration (1/2)

| Name | Manufacturer | Range | Operating Temperature | RF Data Rate | Power Required | Transmit Power | Sensitivity | Unit Price (USD) |
|---|---|---|---|---|---|---|---|---|
| Xbee S2C | Digi International Inc. | Outdoor line-of-sight: up to 1200 m | -40 to 85º C | 250 kbps | 2.1 V-3.6 V | 6.3mW (+8dBm), boost mode 3.1 mW (+5dBm), normal mode | -102 dBm, boost mode -100 dBm, normal mode | $35 |

- **Xbee S2C** is selected because of higher range and high sensitivity.
- **NETID** of the Xbee's - ground station and the container, are set to our Team ID which is **1357** and that of payloads is set to **1362** (1357+5)


***Fig 6.8*** *Xbee S2C*

# Payload Radio Configuration (2/2)

**Transmission Control during the different mission phases:**

**Launch** **Payload 1 Deployment** **Payload 2 Deployment** **Landing**

Pre Launch → Launch and Release → **Payload Landing**

**Communication will be established between the Container, Payloads and the Ground Control Station.**

**Upon release from the Container, the science payloads will send the required telemetry and will continue to do so during their whole flight.**

**Upon Payloads landing, they will continue to send the telemetry until the container lands. The communication will terminate when the container lands.**

# Payload Telemetry Format (1/2)

**Included data:**

Upon powering up, the Payload shall collect the required telemetry at a 1 Hz sample rate.
The telemetry data shall be transmitted with ASCII comma separated fields followed by a carriage return.

**<TEAM_ID> is the assigned team identification.**

**<MISSION TIME> is UTC time in format hh:mm:ss, where hh is hours, mm is minutes, and ss is seconds.**

**<PACKET_COUNT> is the count of transmitted packets, which is to be maintained through processor reset. One count is used for transmission of all packets, regardless of type.**

**<PACKET_TYPE> is the ASCII character characters 'S1' for Science Payload 1 (deployed first) relayed telemetry, and characters 'S2 for Science Payload 2 (deployed second) relayed telemetry.**

**<SP_ALTITUDE> is the altitude in units of meters and must be relative to ground level. The resolution must be 0.1 meters.**

**<SP_ TEMP> is the measured temperature in degrees Celsius with a resolution of 0.1 degrees C.**

**<SP_ROTATION_RATE> is the science payload rotation rate around the axis perpendicular to the center of the rotor in rotations per minute (RPM).**

# Payload Telemetry Format (2/2)

The Container will relay the received Science Payload data as it is received, in the following format:

**<TEAM_ID>,<MISSION_TIME>,<PACKET_COUNT>,<PACKET_TYPE>, <SP_ALTITUDE>,<SP_TEMP>,<SP_ROTATION_RATE>**

**Data rate of Packets:**

- **Burst data transmission mode** would be used for data packet transfer.
- Burst Mode is a temporary **high-speed** data transmission mode used to facilitate **sequential data transfer** at maximum throughput.

**Example Data Frame**:

<1357>,<123>,<123>,<S1>,<1023>,<15>,<5.9>

***The given example data frame matches the competition requirements and guideline.***

# Electrical Power Subsystem Design

**Rishabh Raj Singh**

# EPS Overview (1/3)

| Container | | |
|---|---|---|
| **Component** | **Model** | **Description** |
| Battery | Samsung ICR18650-26H | To power the system |
| Switch | DPDT | To power on the system |
| Audio Beacon | iFlight 2pcs 5V Buzzer Alarm Super Loud FPV Buzz | For recovery of payload after landing |
| Motor Driver | ULN2003 | For controlling the stepper motor present in camera gimbal |
| Motor Driver | TB6612FNG | For timed control of nichrome heating and audio beacon |

# EPS Overview (2/3)

| Payload | | |
|---|---|---|
| **Component** | **Model** | **Description** |
| Battery | Samsung ICR18650-26H | To power the system |
| Switch | SPST | To power on the system |
| LDO | MCP1700 | Regulate voltage |

# EPS Overview (3/3)

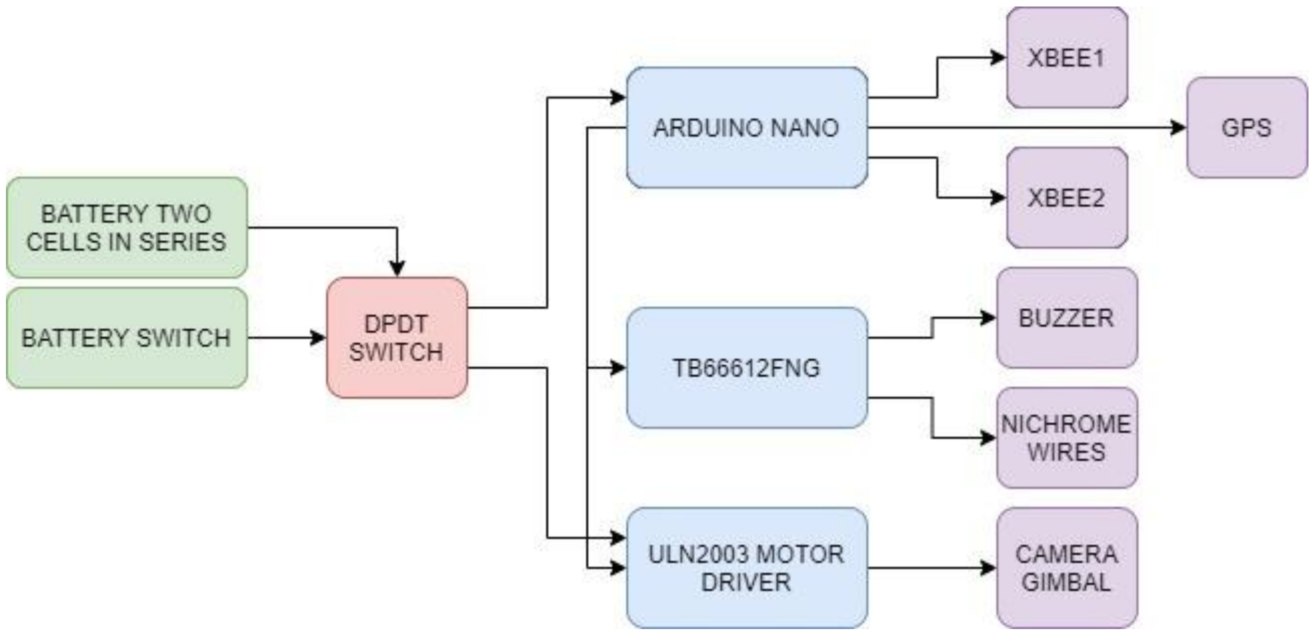



***Fig 7.1: Container EPS overview diagram***

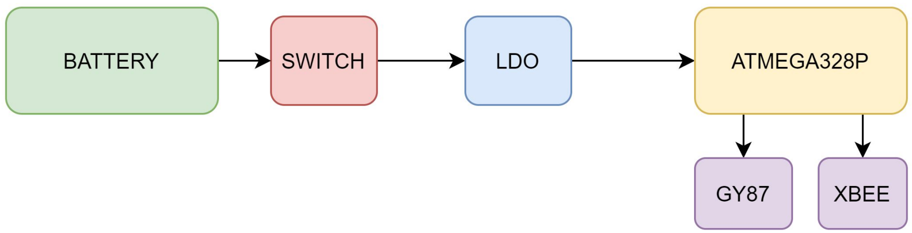



***Fig 7.2: Payload EPS overview diagram***

# EPS Changes Since PDR

| Component | Change | Rationale |
|---|---|---|
| Xbee | An extra Xbee was added | This extra xbee was added to increase the efficiency between the GCS and container. |
| GPS Sensor | GPS sensor was changed | Due to unavailability of sensor. |

# EPS Requirements (1/2)

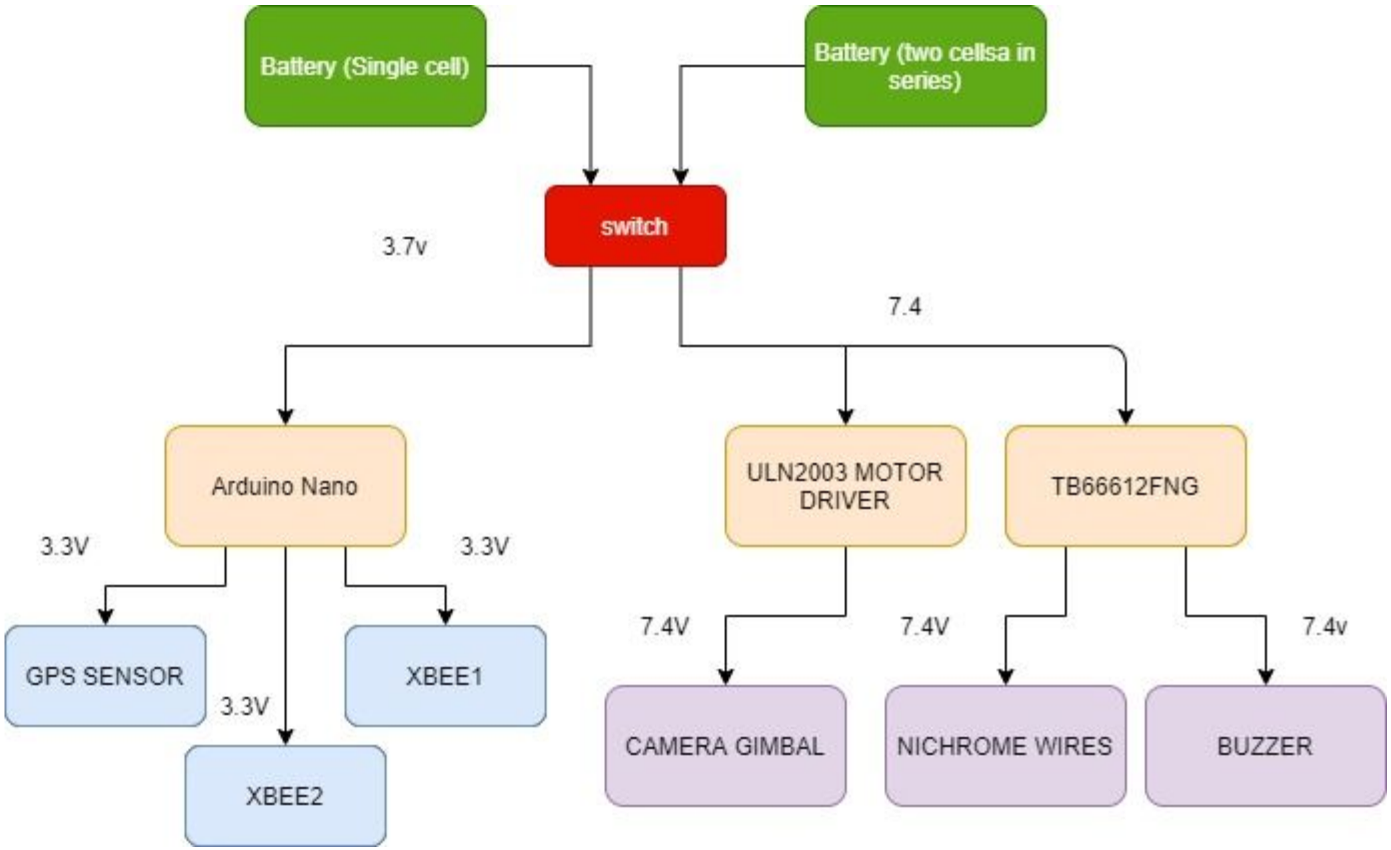
| Base Requirement for Electrical Power Subsystem | | | | | | |
|---|---|---|---|---|---|---|
| Requirement Number | Requirement | Priority | Process Phase | | | |
| | | | R | T | P | C |
| EPS - 01 | Total mass of the CanSat (probe) shall be 600 grams +/- 10 grams. | High | | | ✓ | |
| EPS - 02 | The probe shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing. | High | | | ✓ | |
| EPS - 03 | All electronic components shall be enclosed and shielded from the environment with the exception of sensors. | High | | | ✓ | |
| EPS - 04 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | High | | | ✓ | |
| EPS - 05 | The Cansat shall operate for a minimum of two hours when integrated into the rocket. | High | | | | ✓ |
| EPS - 06 | Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. | High | | | | ✓ |
| EPS - 07 | The probe must include an easily accessible power switch. | High | | | ✓ | |

# EPS Requirements (2/2)

| Base Requirement for Electrical Power Subsystem | | | | | | | |
|---|---|---|---|---|---|---|---|
| Requirement Number | Requirement | Priority | Process Phase | | | |
| | | | R | T | P | C |
| EPS - 08 | An audio beacon is required for the probe. It may be powered after landing or operate continuously. | High | | | ✓ | |
| EPS - 09 | Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. | Medium | | | | ✓ |
| EPS - 10 | An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat. | High | | | ✓ | |
| EPS - 11 | Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects. | High | | | ✓ | |
| EPS - 12 | The CANSAT must operate during the environmental tests laid out in Section 3.5. | Medium | | ✓ | | |

# Container Electrical Block Diagram

***Fig 7.3: Container Electrical Block Diagram***




We will be using mobile adapter of 5 volt output along with buck boost converter as Umbilical power source.

# Container Electrical Circuit Diagram

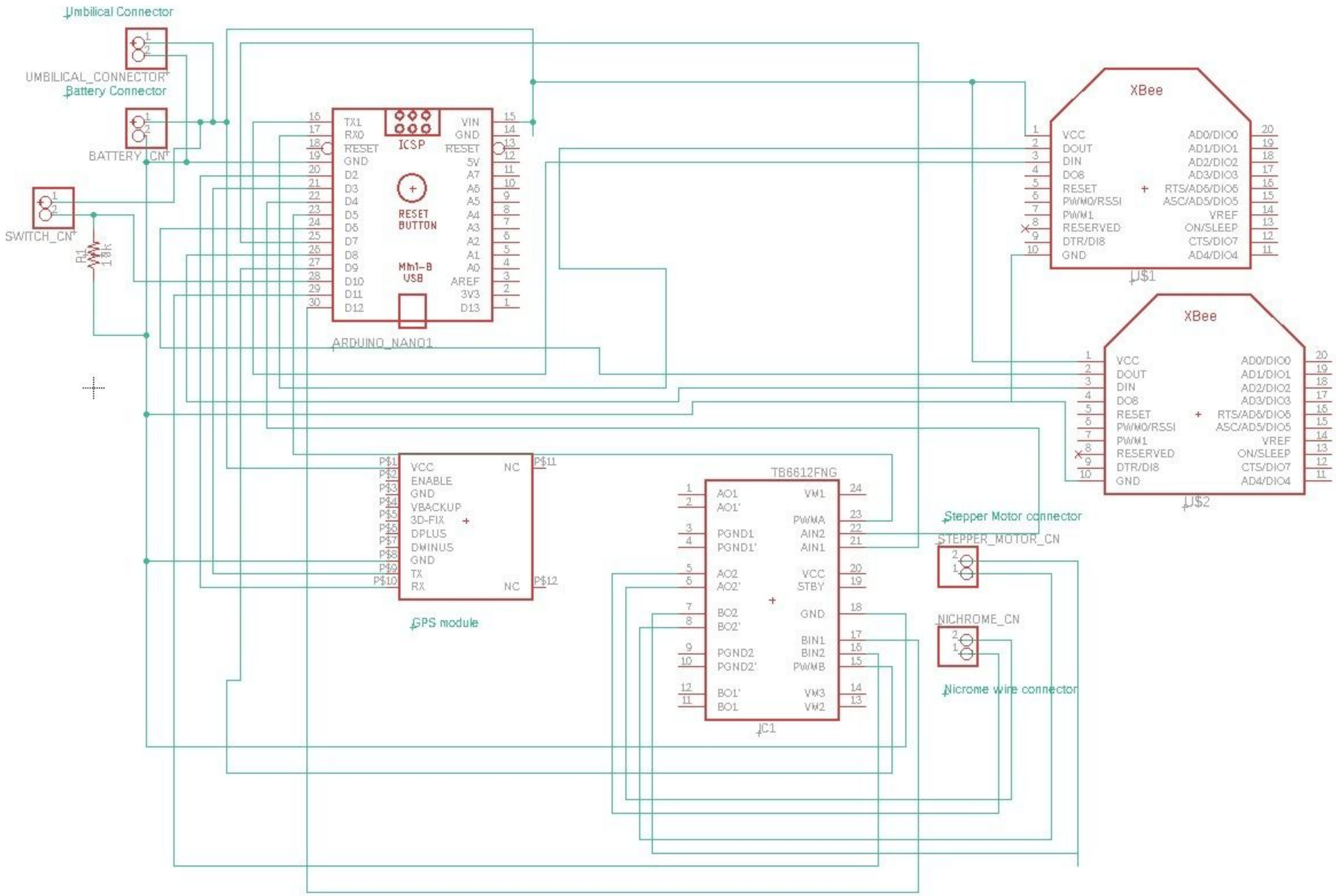



***Fig 7.4:*** *Container Electrical Circuit Diagram with umbilical connector*

# Container Power Source

| Battery | Operating Temperature (°C) | Weight (g) | Type | Voltage | Capacity (mAh) | Energy | Price (USD) |
|---|---|---|---|---|---|---|---|
| Samsung ICR18650-26H | 0°C to 45°C | 45 ± 3 | Li-Ion | 3.7 V | 2600 | 9.36Wh | $17 |


***Fig 7.5:** Samsung ICR18650-26H*

**Samsung ICR18650-26H -**

1. Weight for equivalent capacity is very less.
2. High energy density.
3. Rechargeable
4. Single cell provides with 9.36wH of energy

# Container Power Budget (Logical electronics)

| Component | Voltage (V) | Current (mA) | Power (mW) | Power Consumption | Duty cycle(%) | Source |
|---|---|---|---|---|---|---|
| Ublox NEO-6M Ultimate GPS | 2.7-3.6 | 45 | 162 | 100 mWh | 100 | Datasheet |
| Arduino BLE sense | 3.3 | 15 | 49.5 | 49.5 mWh | 100 | Datasheet |
| Xbee 1 | 3.3 | 50 | 165 | 165 mWh | 100 | Datasheet |
| Xbee 2 | 3.3 | 50 | 165 | 165 mWh | 100 | Datasheet |
| Total Energy required (WH) for 1 hour | | | **541.5 mWh ( approx )** | | | |
| Total Energy required (WH) for 2 hour | | | **1083 mWh ( approx )** | | | |

**Energy available** = 9.36Wh (single 18650 cell)

**Therefore energy available > Energy Required**

**Margin** = 9.36Wh - 1.083Wh = **8.277 Wh**

# Container Power Budget (Power electronics)

| Component | Voltage (V) | Current (mA) | Power (mW) | Power Consumption | Duty cycle(%) | Source |
|---|---|---|---|---|---|---|
| BYJ28 stepper motor (1 axis gimbal) | 5v | 250 | 1250 | 1250mWh | 100 | Datasheet |
| Nichrome wire | 7.2 | 0.245 | 1768 | 4.91mWh | 100 | Estimate |
| Buzzer | 5v | 25 | 125 | 125mWh | 100 | Datasheet |
| Total Energy required (WH) for two hours | | | **1379.91mWh ( approx )** | | | |

**Energy available** = 18.72Wh(2 18650 cells in series)
**Therefore energy available > energy Required**
**Margin** = 18.72Wh - 1.37991Wh = **17.34009Wh**

- **Samsung 18650 cell is used with 2 in series for stepper motor, Nichrome wire,and buzzer and single cell is used separately for Arduino nano, Xbee, and GPS sensor.**
- **The battery selected is capable of providing power to the payload for more than 2 hours**

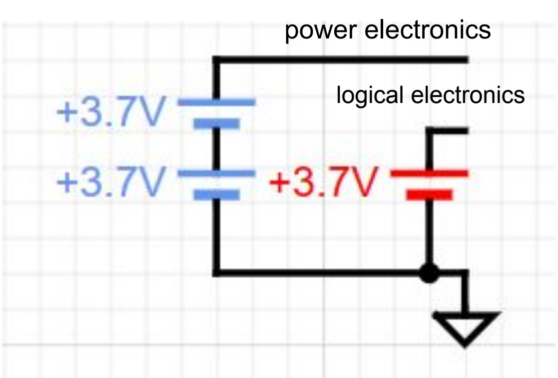



***Fig 7.6:*** *Battery Cell Orientation*

# Payload Electrical Block Diagram

- ***We will be using mobile adapter of 5 volt output along with buck boost converter as Umbilical power source.***

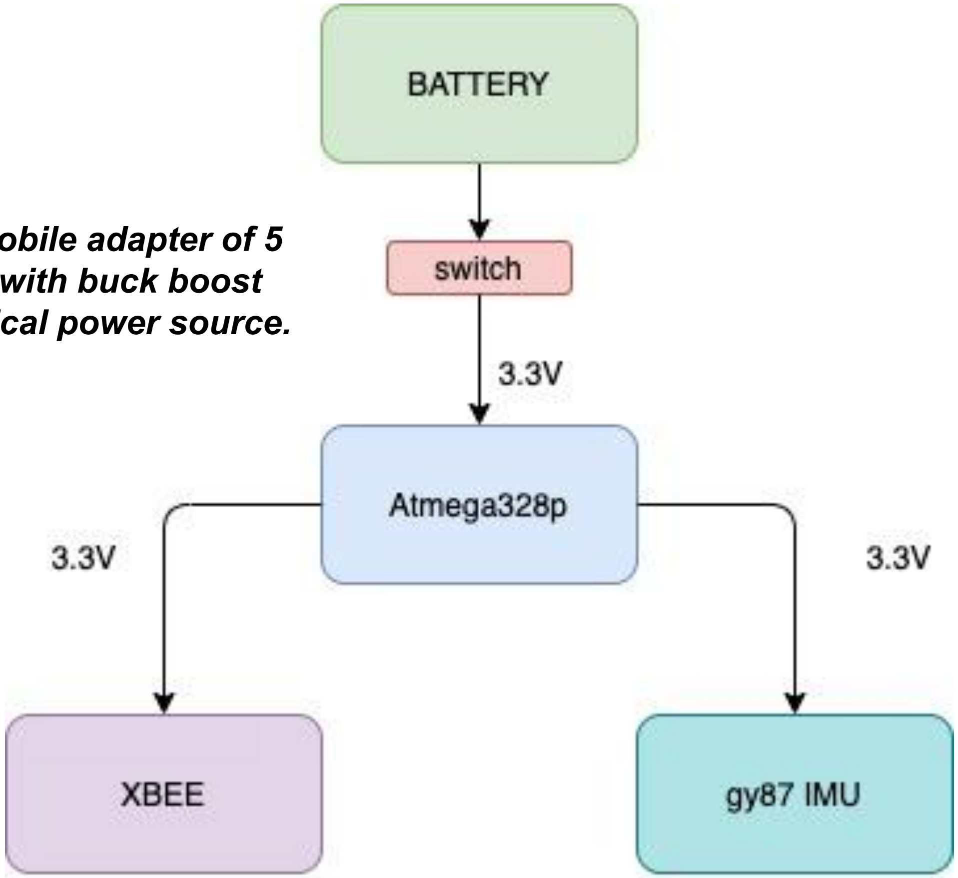



***Fig 7.7:*** PAYLOAD ELECTRICAL BLOCK DIAGRAM

# Payload Electrical Circuit Diagram

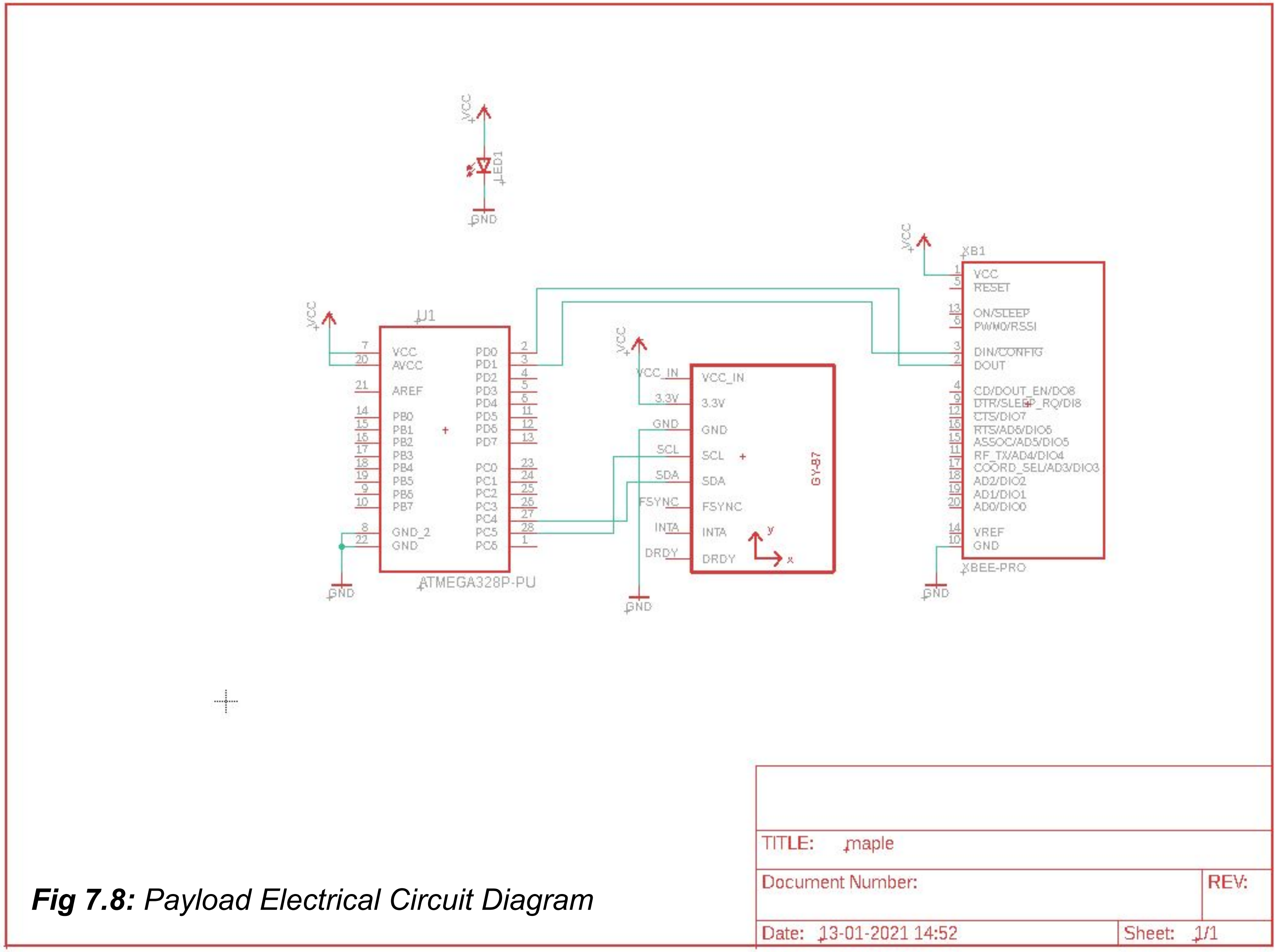



***Fig 7.8:*** *Payload Electrical Circuit Diagram*

# Payload Power Source

| Battery | Operating Temperature (°C) | Weight (g) | Type | Voltage | Capacity (mAh) | Energy | Price (USD) |
|---|---|---|---|---|---|---|---|
| Samsung ICR18650-26 H | 0°C to 45°C | 45 ± 3 | Li-Ion | 3.7 V | 2600 | 9.36Wh | $17 |


***Fig 7.9:*** *Samsung ICR18650-26H*

**Samsung ICR18650-26H -**

1. Weight for equivalent capacity is very less.
2. The smaller size with cylindrical shape is most preferable.
3. High energy density.
4. Rechargeable
5. Single cell provides with 9.36wH of energy

# Payload Power budget

| Component | Voltage (V) | Current (mA) | Power (mW) | Power Consumption | Duty cycle(%) | Source |
|---|---|---|---|---|---|---|
| Atmega328p | 3.0-5.5 | 10 | 33 | 33mWh | 100 | Estimate |
| GY87 IMU | 3.3 | 4.6mA | 15.18 | 15.18mWh | 100 | Datasheet |
| Xbee PRO S2C | 3.3 | 50 | 165 | 165mWh | 100 | Datasheet |
| Total Energy required (WH) for 1 hour | | | **213.18mWh ( approx )** | | | |
| Total Energy required (WH) for 2 hour | | | **426.36mWh ( approx )** | | | |

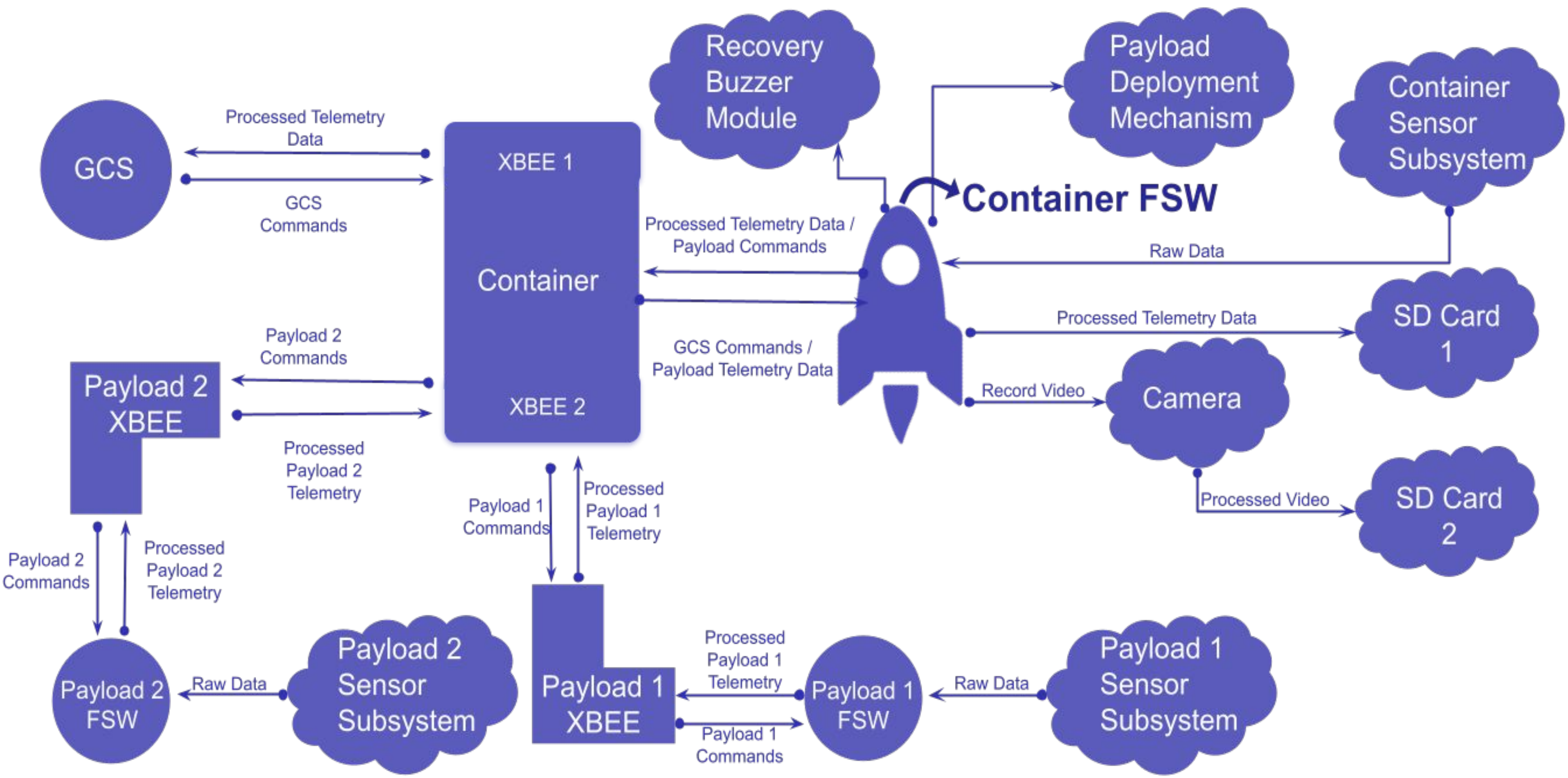
**Energy available** = 9.6Wh (single 18650 cell)
**Therefore energy available > Energy Required**
**Margin** = 9.6Wh - 0.42636Wh = **9.17364Wh**

- **Samsung 18650 single cell is used.**
- **The battery selected is capable of providing power to the payload for more than 2 hours**

# Flight Software (FSW) Design

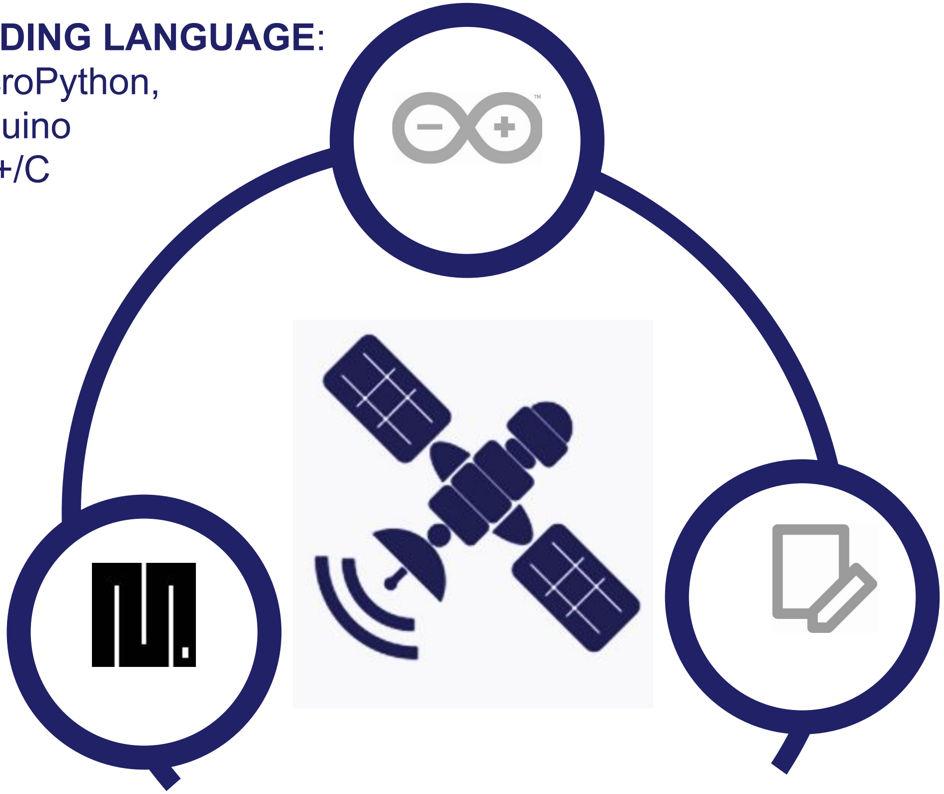
Pranav Bhatnagar

# FSW Overview (1/3)



# FSW Overview (2/3)

**CODING LANGUAGE**:
MicroPython,
Arduino
C++/C



**DEVELOPMENT ENVIRONMENT**:
VS Code
Arduino IDE

**FSW tasks:**

- Recording video.
- Gathering Sensor data ,processing in correct sequence according to CanSat requirements.
- Deploying the Payloads
- Communication b/w Payload and Container
- Communication b/w Container and GCS
- Enable audio beacon for recovery.
- Enable Simulation mode only when received command from GCS.
- maintain a count of packets transmitted, time and configuration state throughout the mission even during processor resets.
- Managing power of system by enabling the buzzer and lighting up the LED on the Arduino when power requirement is not met.

# FSW Overview (3/3)

## Container

1. Communicates with both the GCS and the Payloads.
2. Sends Altitude, Temperature, Voltage, GPS Time, GPS Coordinates, GPS Altitude, GPS Satellites, Software State,Voltage to the GCS per second.
3. Monitor altitude changes to trigger payload release.
4. Maintain mission time,packet count and configuration state such as if commanded to transmit telemetry  throughout the whole mission even with processor resets or momentary power loss.(if required)
5. Takes video footage of descent.
6. Enables an audio beacon on landing.

## Payloads

1. Communicates with only the Container.
2. Sends Altitude, Temperature and Rotation Rate of itself to the Container per second.

# FSW Changes Since PDR

| S.no | Change | Rationale |
|---|---|---|
| 1. | We have implemented a **Transition Counter[TC]** in the FSW software. | The Transition Counter will use multiple measurements to check whether altitude or acceleration have changed, which will trigger it to move on to the next stage of the container FSW state.<br>We do not want to take major decisions based on a single measurement, as sensors can read garbage values on accident, so using multiple measurements ensures an erroneous reading doesn't ruin the flight. |
| 2. | We are now using two XBees instead of one. | We need to switch the netid and this process is taking longer than 1 second with a single XBee, which cannot be used reliably for the Cansat. |
| 3. | We will be using the **FlashAsEeprom.h** in the **FlashStorage** library. | **FlashAsEeprom.h** in the **FlashStorage** library is an EEPROM like API that uses Arduino Nano's Flash memory. |
| 4. | We have replaced XBee-PRO with XBee S2C. | Cost saving measure. |

# FSW Requirements (1/3)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| FSW - 01 | The container shall transmit its telemetry and the payload telemetry received once per second in the format described in the Telemetry Requirements section. | High | | ✓ | | |
| FSW - 02 | The container shall stop transmitting telemetry when it lands. | Low | | | | ✓ |
| FSW - 03 | The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets. | High | | | ✓ | |
| FSW - 04 | The container must maintain mission time throughout the whole mission even with processor resets or momentary power loss | High | | | ✓ | |

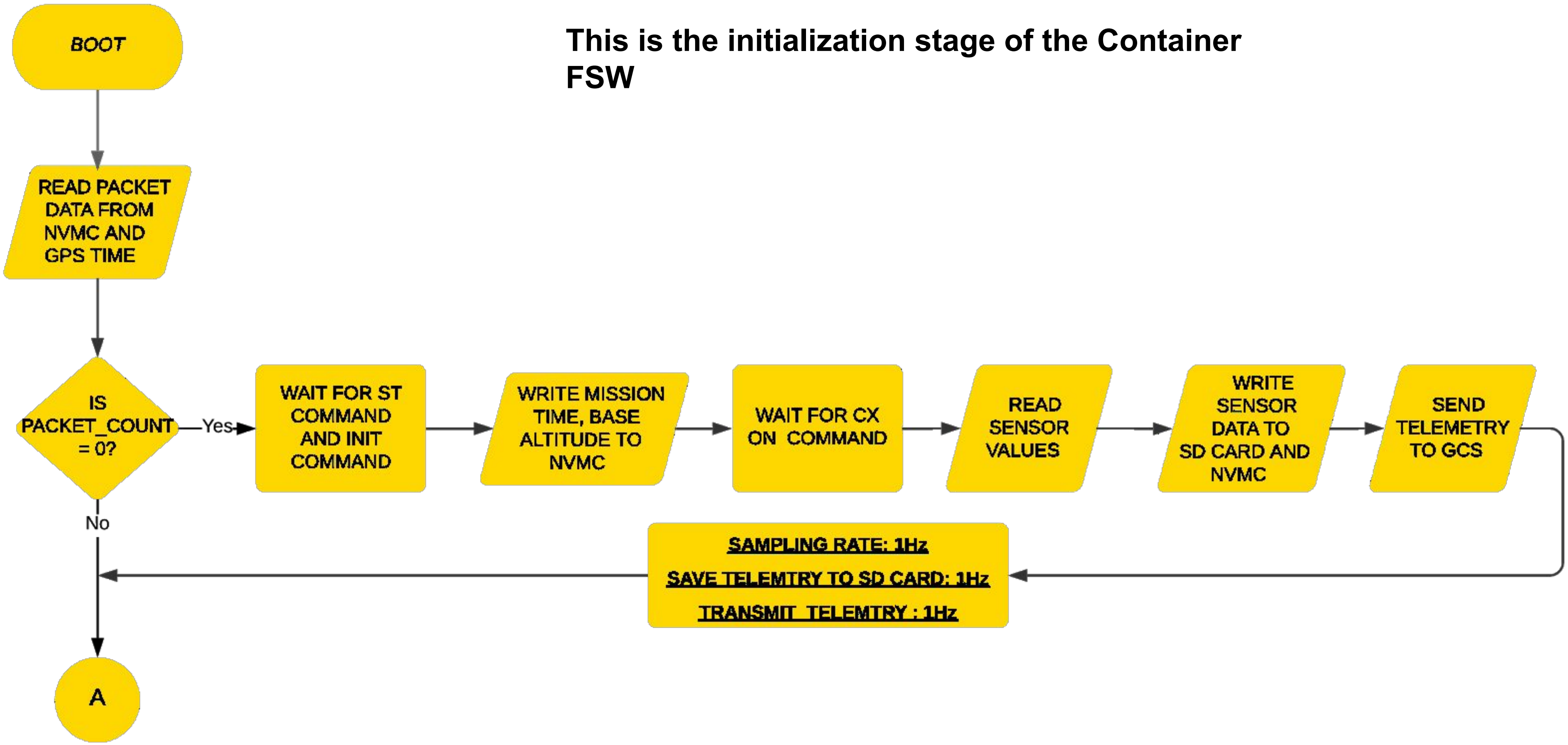
# FSW Requirements (2/3)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| FSW - 05 | The container shall have its time set to UTC time to within one second before launch. | High | | | | ✓ |
| FSW - 06 | The container flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file. | High | | | ✓ | |
| FSW - 07 | In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the container altitude. | High | | | ✓ | |
| FSW - 08 | The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands. | High | | | ✓ | |

# FSW Requirements (3/3)

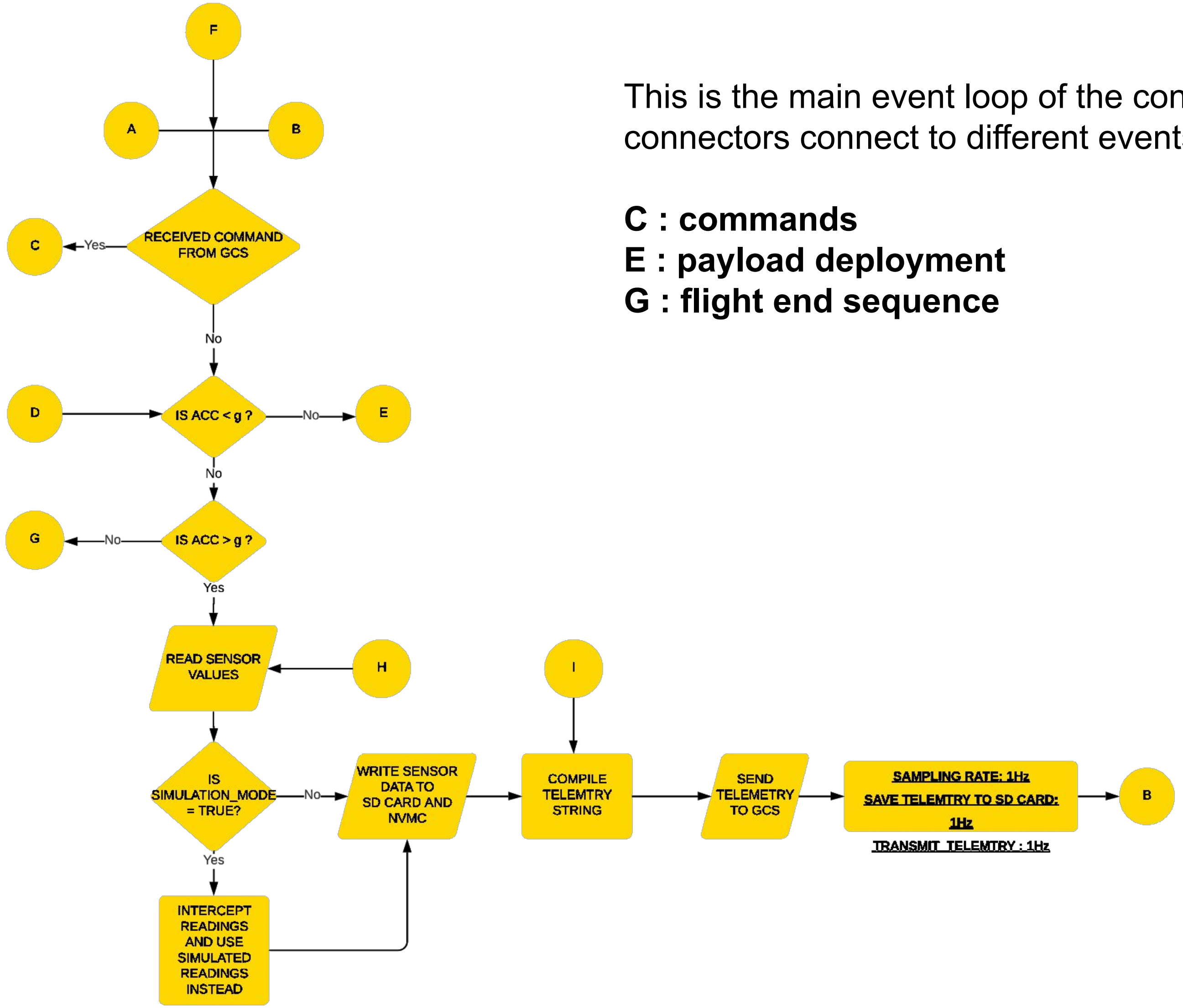
| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| FSW - 09 | Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission. | High | | | | ✓ |
| FSW - 10 | The science payloads shall not transmit telemetry during the launch, and the container shall command the science payloads to begin telemetry transmission upon release from the container. | Medium | | | | ✓ |

# Container FSW State Diagram (1/5)




**This is the initialization stage of the Container FSW**

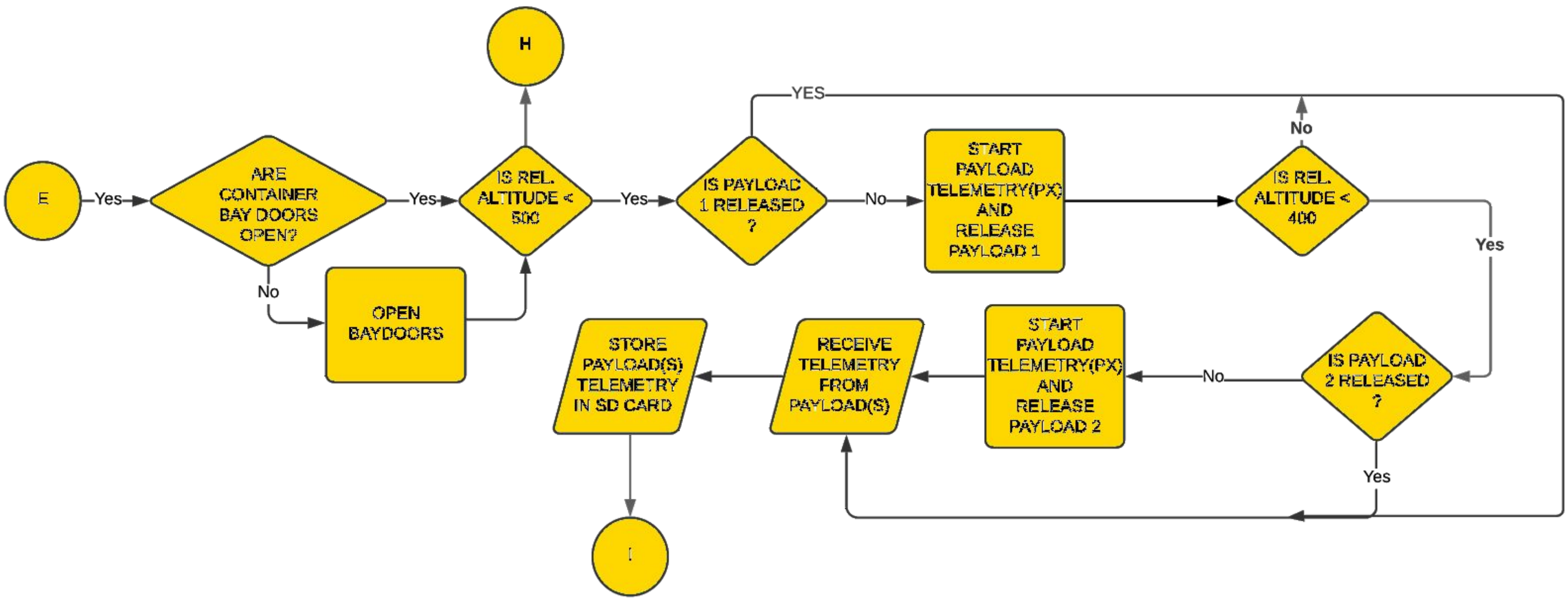
# Container FSW State Diagram (2/5)



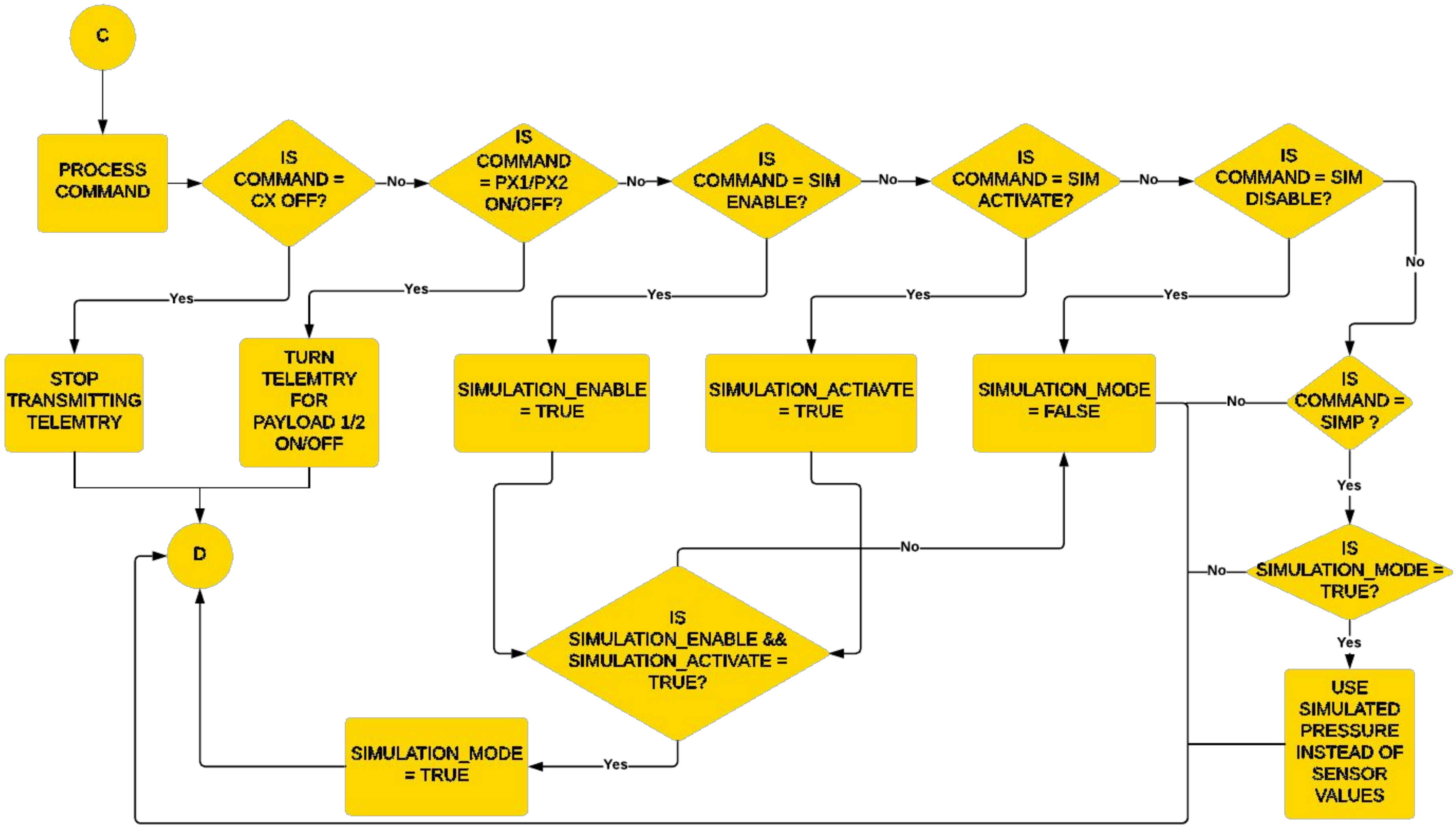

This is the main event loop of the container. All the connectors connect to different events.

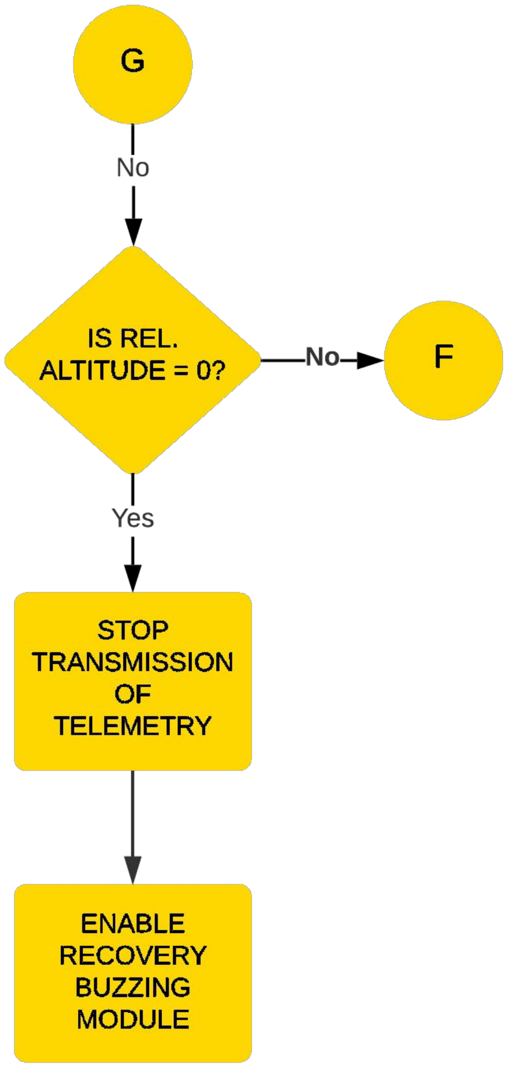
**C : commands**
**E : payload deployment**
**G : flight end sequence**

# Container FSW State Diagram (3/5)



# Container FSW State Diagram (4/5)






## FSW RECOVERY TO CORRECT STATE AFTER PROCESSOR RESET DURING FLIGHT.

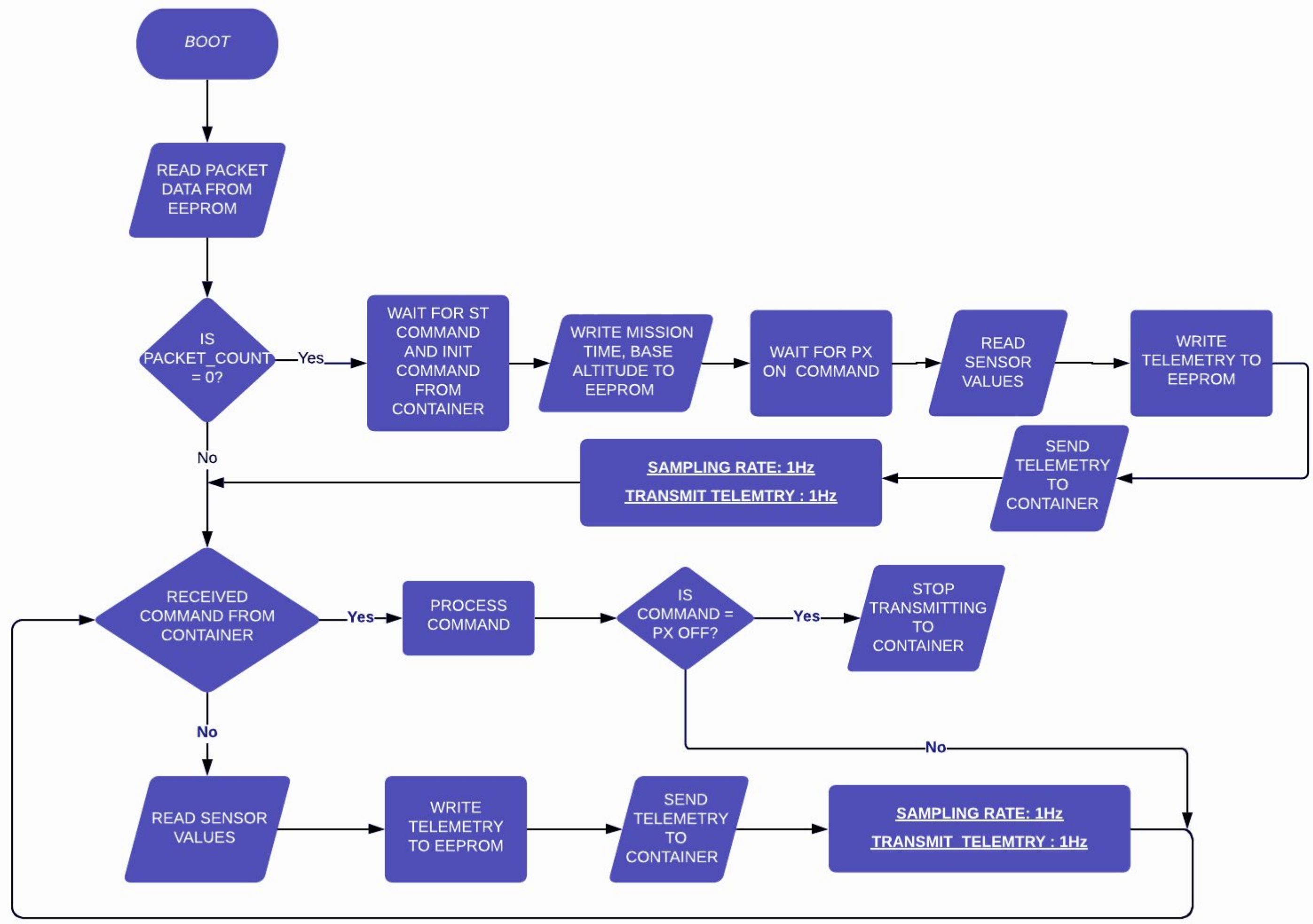
We store the last transmitted packet in the NVMC of the Arduino Nano 33 BLE, which include packet count, mission time.

**Mission time is updated from GPS time for consistency**, and **software state is regained from acceleration readings and altitude.**

## REASONS FOR POWER RESET INCLUDE:

- Power loss.
- Accidental reset button press.
- Low voltage in power bus.

# Payload FSW State Diagram(1/2)



# Payload FSW State Diagram (2/2)

**FSW recovery to correct state after processor reset during flight**

We store the last transmitted packet in the EEPROM of the ATmega328p, which includes **the packet count**.

The packet count determines whether the payload needs to be transmitting telemetry to the container, and the container itself keeps track of mission time, so the payload doesn't have to.

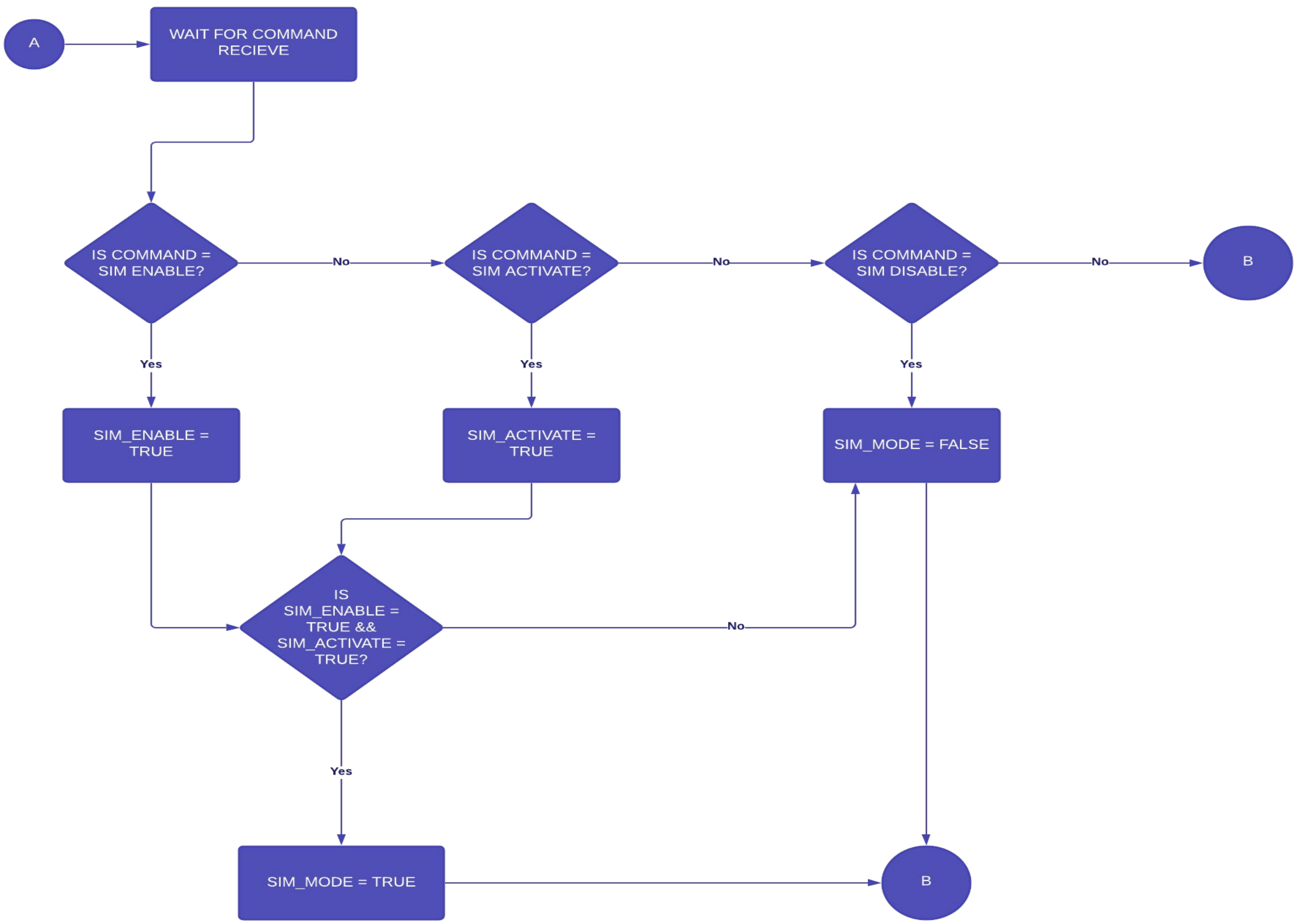
**REASONS FOR POWER RESET INCLUDE:**

- Power Loss
- accidental reset button press
- low voltage in power bus

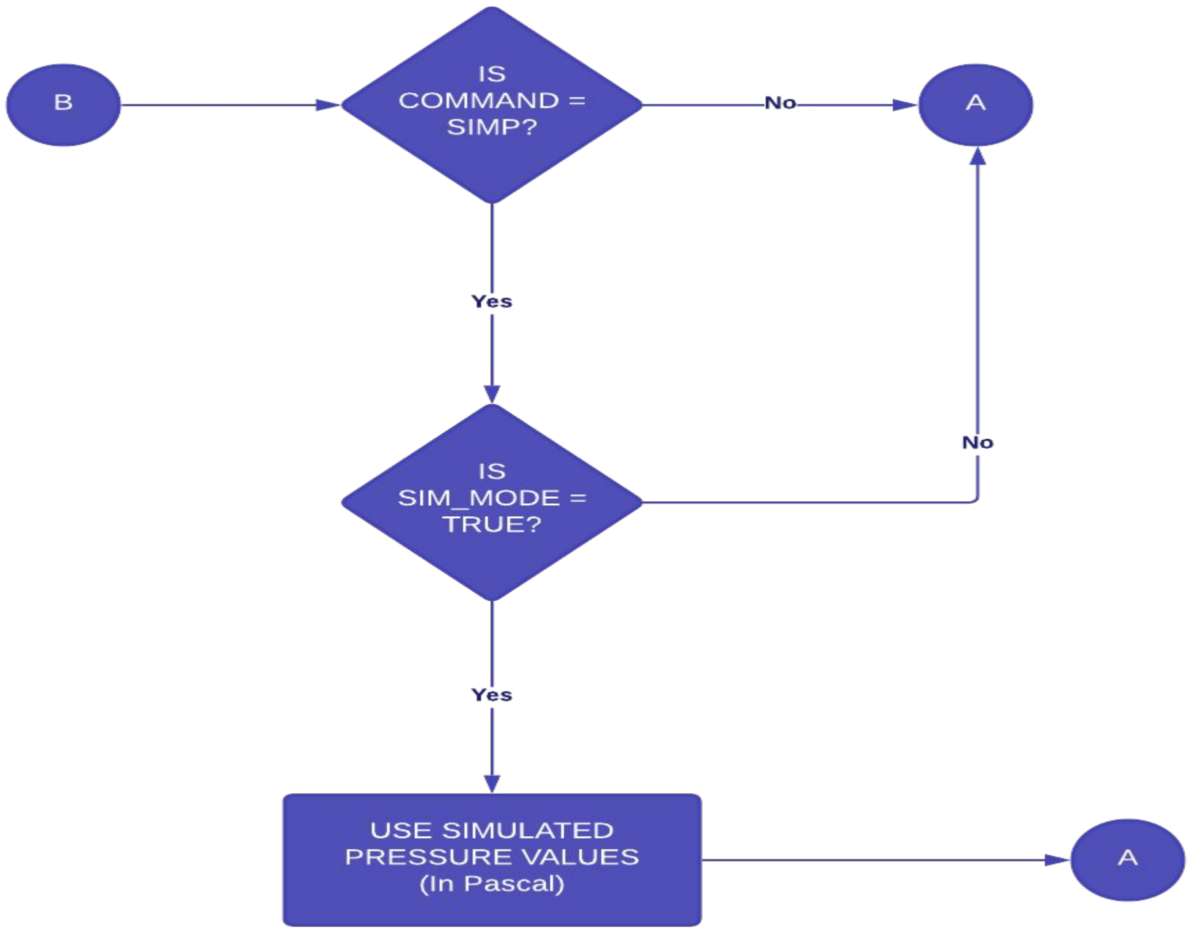
# Simulation Mode(1/3)

- To enable Simulation Mode, two commands **SIM ENABLE** and **SIM ACTIVATE** have to be sent to the GCS. *Two commands are required to ensure Simulation Mode isn't activated accidentally.*
- In Simulation Mode, the Container is waiting for **SIMP** command from the GCS, for Simulated Pressure readings.
- These readings will substitute actual pressure readings, which are used to calculate altitude.
- Acceleration values are also substituted, to ensure Container deploys the Payloads.

# Simulation Mode(2/3)



# Simulation Mode(3/3)



# Software Development Plan

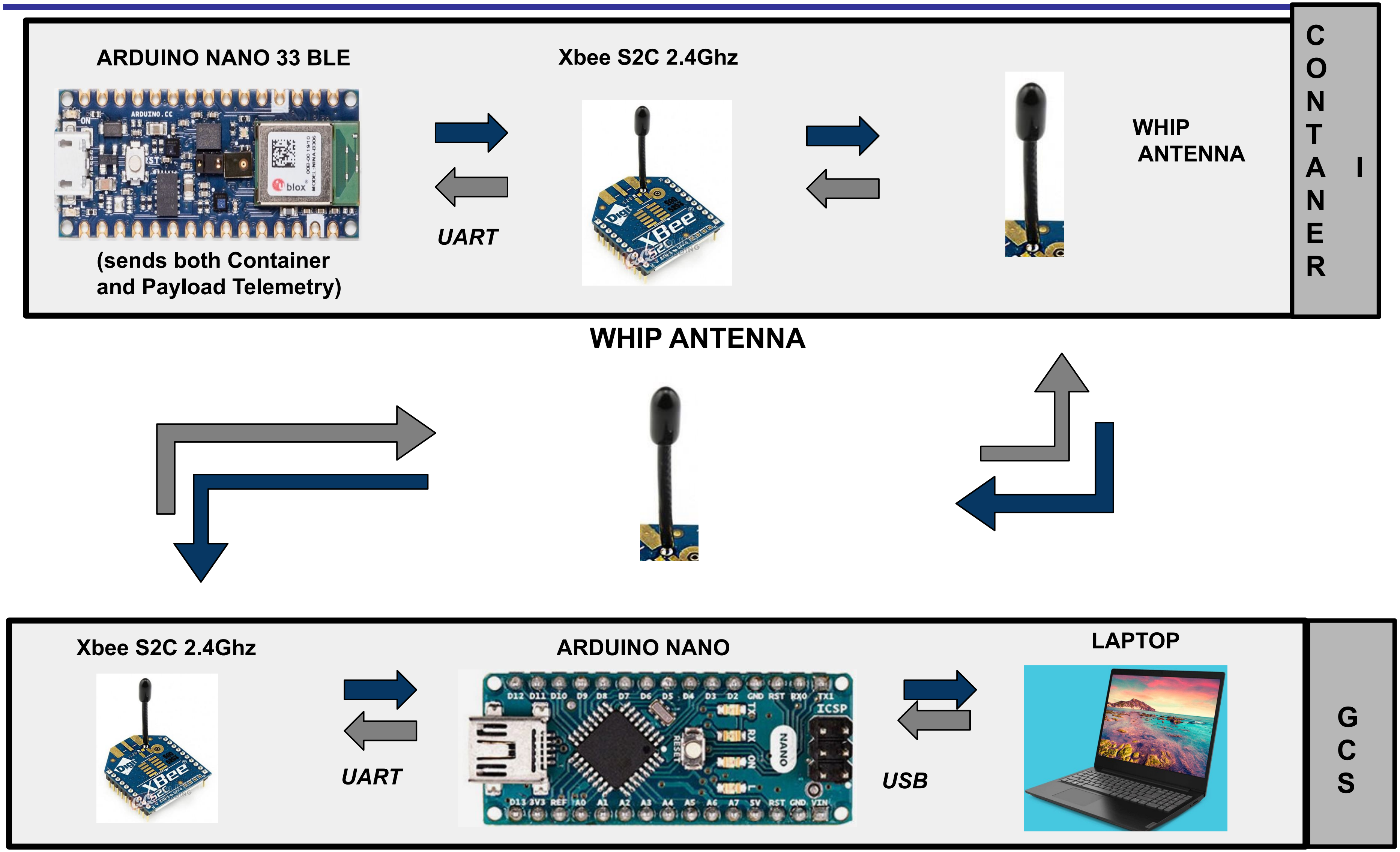
- To prevent late software development we decided to develop the software parallely with hardware component mounting.
- The Container and Payload FSW code is written in **Arduino** to test sensors and prototype the payload deployment mechanisms. The prototype was primarily focussed on testing sensor capabilities.
- We are using **Git** as our Version Control Software. We use **GitHub** for easy online collaboration within the team. The software development is split between :
  - FSW
    - Container
    - Payload
  - GCS

- The GCS code had been developed for CANSAT 2020, changes to telemetry display have been made as well command buttons and Simulation Mode.

# Ground Control System (GCS) Design

**Yash Mudgal**

# GCS Overview



# GCS Changes Since PDR

| Component | Change | Rationale |
|---|---|---|
| XBee Pro s2c | Replaced by xbee s2c | Due to cost consideration |
| XBee 2.4 ghz antenna | Replaced by onboard whip antenna | Comes onboard with xbee s2c |

# GCS Requirements (1/4)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| GCS - 01 | XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed. | High | | | | ✓ |
| GCS - 02 | XBEE radios shall have their NETID/PANID set to their team number. | Medium | | | | ✓ |
| GCS - 03 | The science payload shall have their NETID/PANID set to their team number plus five. If team number is 1000, sensor payload NETID is 1005. | Medium | | | | ✓ |
| GCS - 04 | XBEE radios shall not use broadcast mode. | High | | | | ✓ |
| GCS - 05 | The ground station shall command the Cansat to start transmitting telemetry prior to launch. | High | | | ✓ | |

# GCS Requirements (2/4)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| GCS - 06 | The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section. | High | | | ✓ | |
| GCS - 07 | Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission. | High | | | ✓ | |
| GCS - 08 | Each team shall develop their own ground station. | High | | | | ✓ |
| GCS - 09 | All telemetry shall be displayed in real time during descent on the ground station. | High | | | ✓ | |

# GCS Requirements (3/4)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| GCS - 10 | All telemetry shall be displayed in engineering units (meters, meters/sec,Celsius, etc.) | Low | | | | ✓ |
| GCS - 11 | Teams shall plot each telemetry data field in real time during flight. | High | | | | ✓ |
| GCS - 12 | The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna. | High | | | | ✓ |
| GCS - 13 | The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site. | High | | | | ✓ |

# GCS Requirements (4/4)

| Requirement Number | Requirement | Priority | Process Phase | | | |
|---|---|---|---|---|---|---|
| | | | R | T | P | C |
| GCS - 14 | The ground station software shall be able to command the container to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE | High | | | ✓ | |
| GCS - 15 | When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the container. | High | | | ✓ | |

# GCS Antenna (1/2)

## Container-to-Ground link antenna:

| Model | Connector Type | Gain (dBi) | Outdoor Distance (Visual Line-of-Sight) | Indoor Distance (Office Building) | Unit Price (USD) |
|---|---|---|---|---|---|
| **Xbee pro whip antenna** | Attached to the pcb | 1.5 | 1335m | 43m | Nil (Included with the module) |

This antenna comes pre soldered with xbee s2c
Since the size of antenna is very small, it is easily portable and satisfies range criteria by having tested range of 980m
The antenna is used in table-top configuration since it is omnidirectional

# GCS Antenna (2/2)

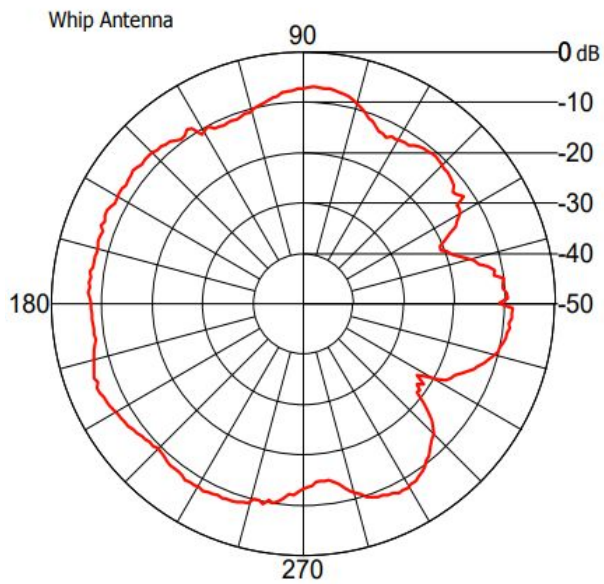
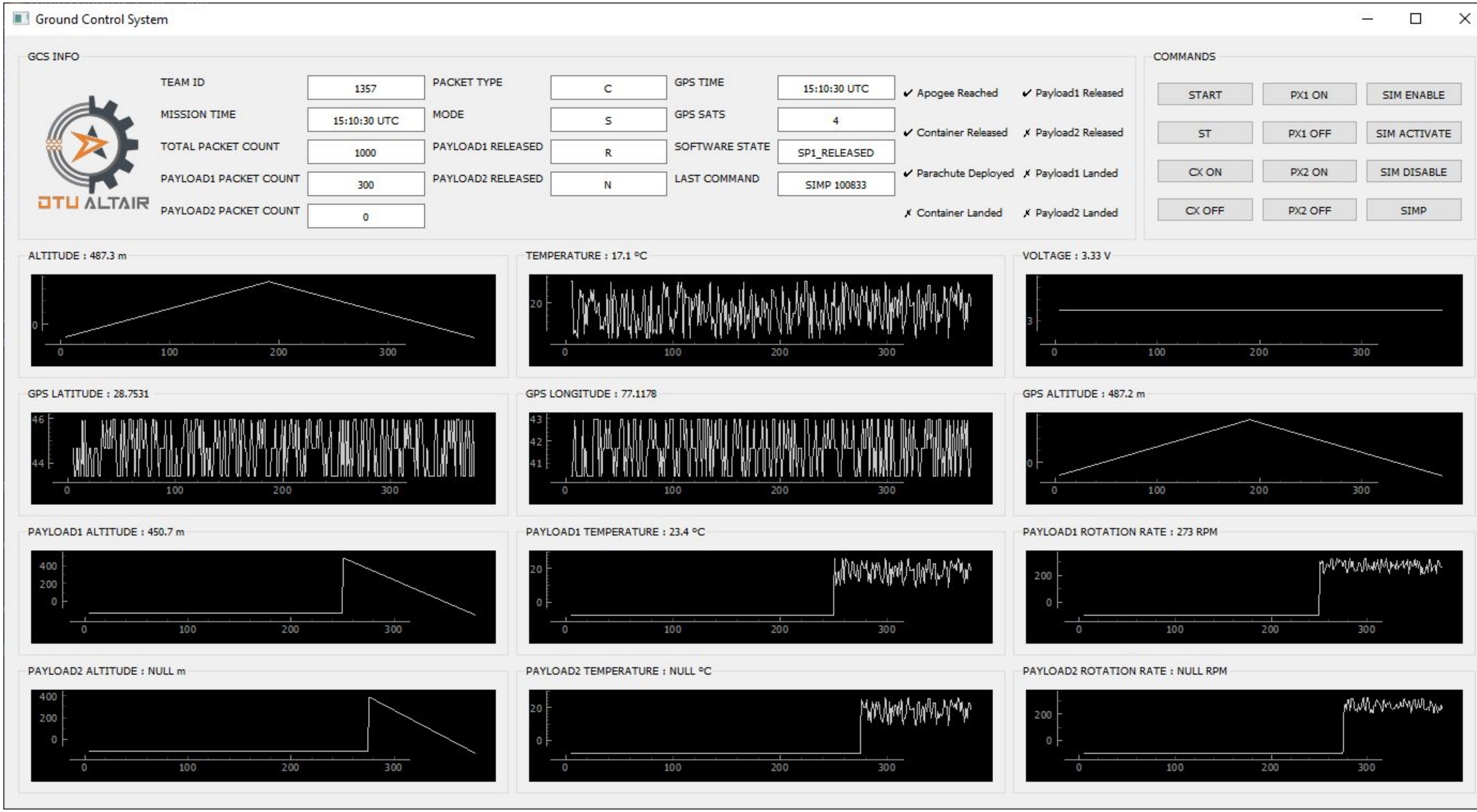



***Fig 6.8:****Whip antenna radiation pattern*

Selected Antenna: **Xbee pro whip antenna**

1. **Longer** Outdoor distance (Visual Line-of-Site)
2. **Better** Radiation Pattern.
3. **Higher gain.**

## Telemetry Display



# GCS Software(2/6)

- **Commercial off the shelf softwares used**

  - Python : GUI to display real time-plots, generate CSV files, communicate with MQTT broker
  - PyQt5 : Library to create the GUI
  - PyQtGraph : Adds a graphing widget to PyQt5
  - XCTU : To configure the XBEE
  - Arduino IDE : Programming our Arduino

- **Real-time plotting software design**

- PyQtGraph will be used in coherence with PyQt5 library in Python to plot real-time values.
- The library will help us in adding graphing widgets to plot real-time values

# GCS Software(3/6)

- The telemetry data that is received and stored into a .csv file, will be read at an interval of 1 second.
- These values will be read and plotted using the PyQtGraph library.

- **Command Software Interface**

- The command software interface is the part of the GUI of the GCS that is responsible for sending all commands to the Container.

# GCS Software(4/6)

- **.csv file generation**

- We use the csv library in Python to aid us in creating a .csv file.
- We will store the telemetry values in these .csv files.
- There will be a total of 3 .csv files, one for the container, two for the payloads (one for each payload)
- these values will be picked up with the help of another method that is developed to read the values and feed it into the graph generated using the PyQtGraph library.

# GCS Software(5/6)

- **Simulation Mode**

- We will use the given sample Test file for initial testing, and generate our own sample files for further testing.
- The GCS software will need access to a sample file and the MQTT broker, else Simulation mode will not be allowed to be enabled.
- The GCS will send the required commands to the Container to enable Simulation mode, then it will read the sample csv file line by line, and transmit SIMP command to the Container at the rate of 1 command per second.
- It will await a response from the container, and then display all the telemetry data.
- It will also send the data to the MQTT broker(cansat.info port 1883) via a pub request under the topic team/1357, with the provided username and password. The data format will be followed as specified by the updated MQTT documentation.

# GCS Software(6/6)

- **Since the Preliminary Design Round**

- The graphing widget has evolved into a functioning element tested against dummy .csv values.
- the graphing widget is designed to read values at a regular time interval.
- XBEE configuration and setup using XCTU software.
- developed methods to establish serial communication.
- developed functionalities to send commands.
- developed functionalities to receive telemetry.

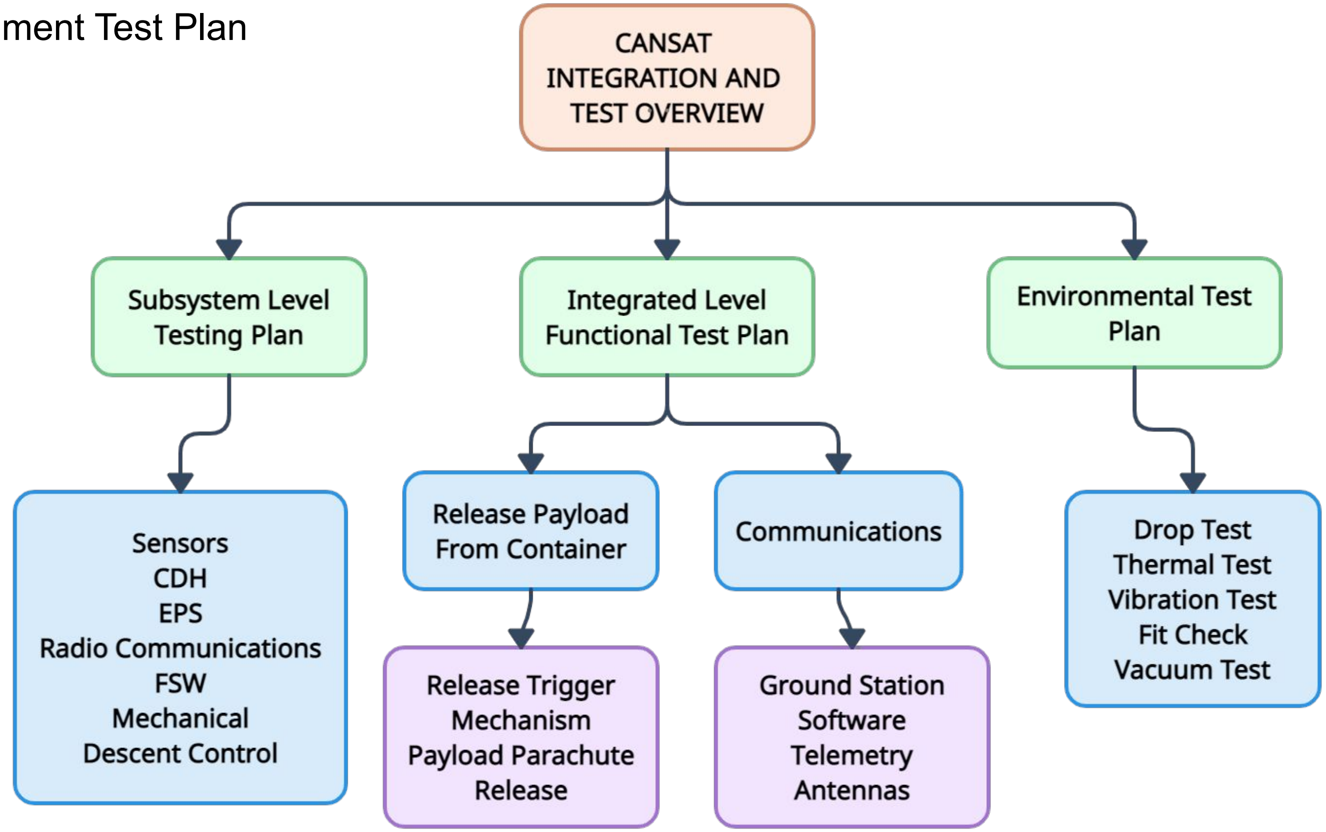
# CanSat Integration and Test

**Kiran**

# CanSat Integration and Test Overview

We will separate the CanSat integration and test overview into 3 parts. They are the followings:

1. Subsystem Level Test Plan
2. Integrated System Level Test Plan
3. Environment Test Plan



# Subsystem Level Testing Plan (1/9)

| SENSORS SUBSYSTEM TEST | CDH SUBSYSTEM TEST | EPS SUBSYSTEM TEST | COMMUNICATION TEST | DESCENT CONTROL SUBSYSTEM TEST | MECHANICAL SUBSYSTEM TEST | FSW SUBSYSTEM TEST |
|---|---|---|---|---|---|---|
| Checking for any faults in the sensor and whether they are in working condition.<br><br>Setting up and calibrating as required. | Verifying data communication occurring at long ranges through radio. | Doing necessary calculations and measurements for power, current etc.(using the help of devices such as multimeters). | Checking Adequacy of antennae.<br><br>Range testing from long distance from XBEE module | Ensuring the deployment of the parachute and its working.<br><br>Testing the flight characteristics of the science payload assembly and its descent velocity .<br><br>Also checking the separation of outer shell and science payload. | Verifying the total mass of the assembly.<br><br>Testing the stability of the science Payload.<br><br>Doing ensure that structure can withstand the required stress/strain | Testing and controlling all the algorithms.<br><br>Verifying the compatibility of programming languages, functions and libraries with the hardwares. |

# Subsystem Level Testing Plan (2/9)

| S.No | Sensors Testing Requirements | Status |
|---|---|---|
| 1 | Sensors are connected to a microprocessor, are tested and calibrated. | To be Procured |
| 2 | Sensors, not linear over the measurement range shall require multi point curve-fitting to achieve accurate measurements. | To be Procured |
| 3 | Structural errors in the sensor outputs shall be eliminated. | To be Procured |
| 4 | The faulty data transmitted by the sensors are rectified and calibrated. | To be Procured |
| 5 | Two point calibration technique shall be used to increase the precision of the temperature sensor. | To be Procured |
| 6 | Toughness and fragility of sensors shall be tested. | To be Procured |

# Subsystem Level Testing Plan (3/9)

| S.No | Communication Handling Subsystem Testing Requirements | Status |
|---|---|---|
| 1 | By using XCTU program, we shall test the communication between XBEE modules. | In Testing Phase |
| 2 | Accuracy of data received and transmitted will be checked. | ✓ |
| 3 | The serial link between the microprocessor and the sensors is verified and corrected. | ✓ |
| 4 | The faulty data transmitted by the sensors are rectified and calibrated. | ✓ |
| 5 | Verified live data transmission sensitivity with no effect of external conditions. | ✓ |
| 6 | Communication at the required range shall be verified. | To be Tested |

# Subsystem Level Testing Plan (4/9)

| S.No | Radio Communication Testing Requirements | Status |
|---|---|---|
| 1 | Checking continuity of loop antenna for any line breaks. | ✓ |
| 2 | XBEE is configured and signal level test are inspected through XCTU software. | ✓ |
| 3 | Long range testing for XBEE modules. | To be Tested |

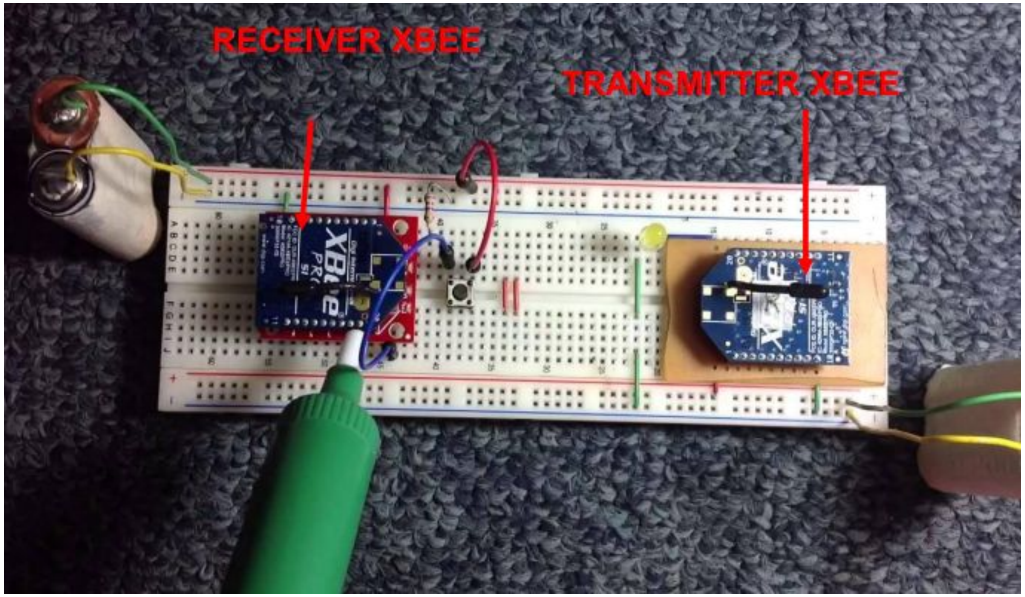



***Fig 10.1:*** *Configuration of XBEEs and signal level test inspected through XCTU software.*

# Subsystem Level Testing Plan (5/9)

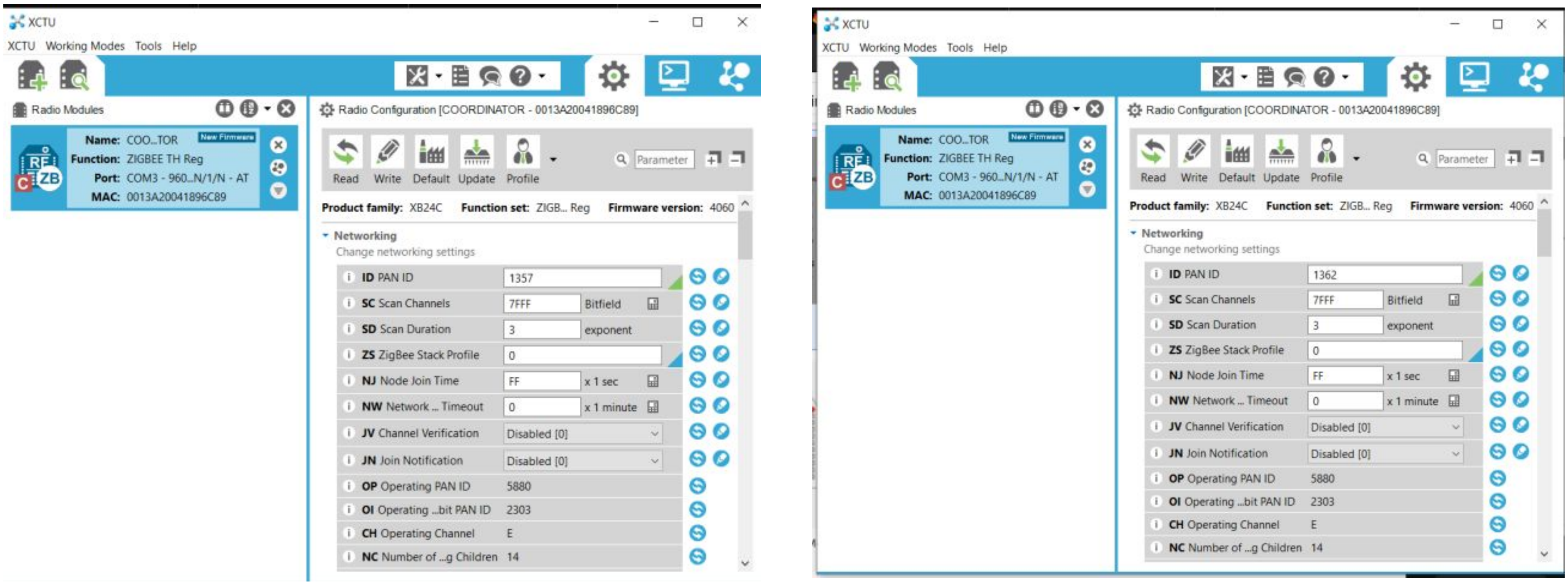



***Fig 10.2:*** *XCTU used for Xbee configuration*

# Subsystem Level Testing Plan (6/9)

| S.No | Electrical Power Subsystem Testing Requirements | Status |
|---|---|---|
| 1 | Inspection for external dents and damages on the battery (18650 cells). | To be Procured |
| 2 | Verified that power source provides adequate power without any effect of external conditions. | - |
| 3 | The stability of every connection, all sensors and soldered parts shall be tested, at every position, the probe. | - |
| 4 | The battery is tested for voltage and current ratings by using multimeter and its probe. | - |

# Subsystem Level Testing Plan (7/9)

| S.No | Flight Software Testing Requirements | Status |
|---|---|---|
| 1 | Verifying that software is valid at every point of competition in sequence. | ✓ |
| 2 | Checked the combination and configuration of the software thread. | In Testing Phase |
| 3 | Data verification is tested with standard and analog high accuracy sensors at sea level. | To be Tested |
| 4 | Time keeping algorithm is tested in case of microcontroller reset. | ✓ |
| 5 | The science payload is threw with parachute from different altitudes and data is transferred to the control system. | To be Tested |

# Subsystem Level Testing Plan (8/9)

| S.No | Descent Control Testing Requirements | Status |
|---|---|---|
| 1 | CanSat with parachute is released vertically from a small height to test flight pattern without payload. | To be Tested |
| 2 | Descent of CanSat with parachute is tested including the science payload. | To be Tested |
| 3 | Descent of CanSat including the science payload is tested from various heights using drone and tall building roofs. | To be Tested |
| 4 | Stability of the “maple seed” science payload and its descent velocity is tested from required heights. | To be Tested |

# Subsystem Level Testing Plan (9/9)

| S.No | Mechanical Testing | Status |
|---|---|---|
| 1 | Total mass of CanSat including all assembly is checked to ensure that it is coming within the specified range. | To be Tested |
| 2 | Deployment mechanism of “maple seed” science payload is tested with the complete mass of CanSat. | To be Tested |
| 3 | Payload deployment mechanism(PDM) is tested and also its time duration is checked | To be Tested |
| 4 | The assembled structure of CanSat is tested to withstand the stresses/strains equivalent to required specified integration. | To be Tested |

## Descent Testing:

• The parachute release and impact test will be tested and we have some options such as releasing from a drone and deploying it from high altitudes. Timing will be measure during the course of the deployment.

• To test the ability of the “maple seed” payload to remain stable in various weather condition.

• The total time of flight, descent rate and vibration and survivability test of the structure and electronics will be tested practically and recorded.

## Communications:

• XBEE Radios will be tested for their range capabilities.

• Communication using XCTU interface will tested. Signal strength of communication will tested from various distance.

# Integrated Level Functional Test Plan (2/2)

## Deployment

- CanSat will be raised to a height of 250 meters using an in-house made drone. Parachute will be deployed at the same height and the two science payload will be separated from the container shell at a height of 200 meters and 150 meters .

## Mechanisms

- Stability and flight characteristics of “maple seed” Science Payload will be tested from various heights.
- Payload deployment will tested by clamping the CanSat and providing current to nichrome wire. It is to ensure fishing chord will snip allowing the Science payload to deploy and timing will be also measured.

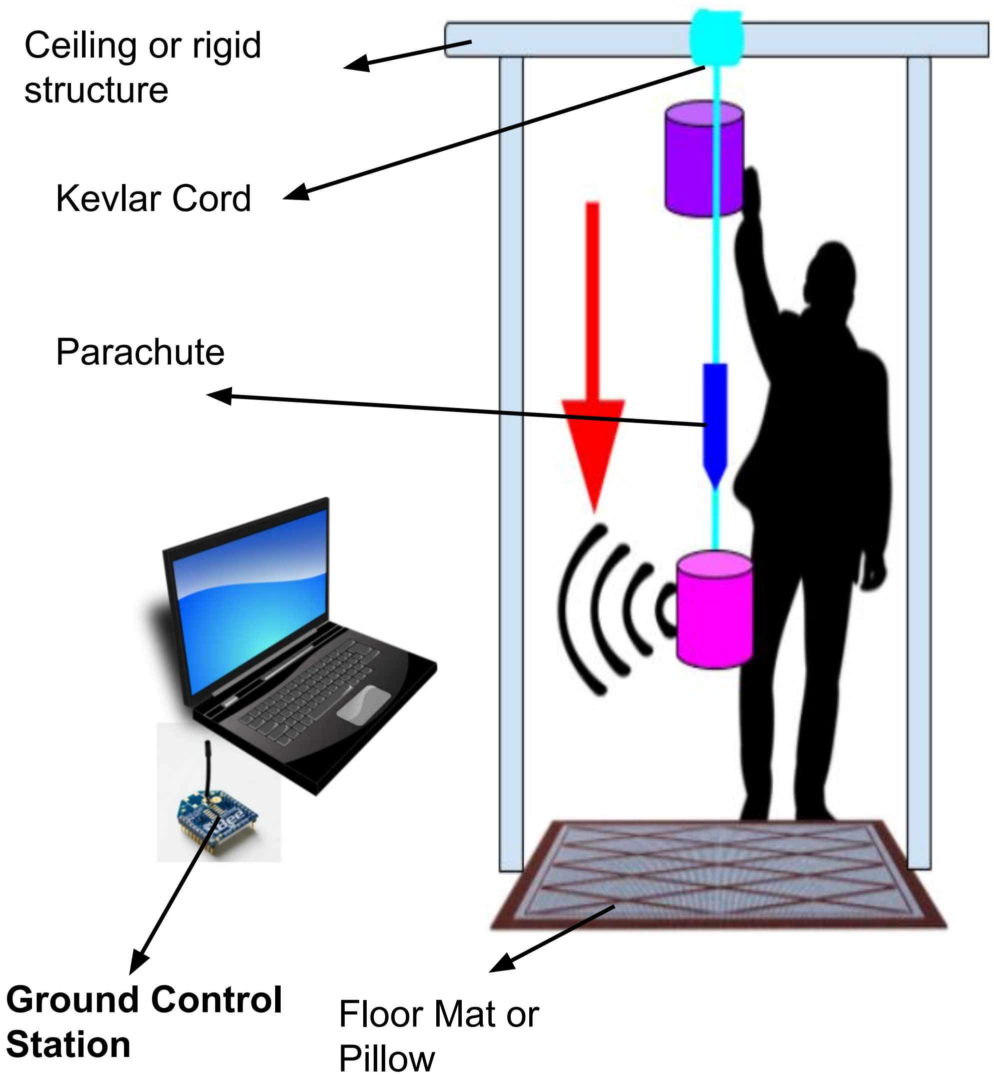
**Drop Test** is designed to verify that the container parachute and attachment point will survive the deployment from the rocket payload section which can be very violent. The goal is to generate about 30 Gs of shock to the system.

**Setup**

A 61 cm non-stretching 1/8 thick kevlar cord, one of its end is secure to an eyebolt attache to fixed point, such as ceiling and the other end is tie to the parachute.

**Objective**

CanSat along with the science payload will be subject to a drop resulting in about 30G shock acceleration, to simulate rocket body separation forces verifying with accelerometer present within the sensors subsystem.



# Environmental Test Plan (2/5)

**Thermal Test** is to verify the CanSat and container can operate in a hot environment. This test will determine if any materials warp, weaken, change characteristics, or fail to function at temperatures up to 35ºC.

**Setup -**

Fully assembled CanSat will be place in controlled thermal chamber (A thermocol container is used as thermal chamber whose temperature is regulated by hairdryers controlled by relays.Relays are operated via a feedback loop controlled by an Arduino and a thermistor. Thermistor will be present inside the chamber to get the real time temperature readings) and heated to ~60ºC while systems are active.

**Objective -**

All components will be examined under this specified thermal condition to ensure functionality within the operation range of temperature as per the requirements of the CANSAT competition.

# Environmental Test Plan (3/5)

**Vibration Tests** will be conducted on payload to test structure stability to survive launch. This is also used to ensure survivability of the science payload inside the CanSat.

**Objective**

This test is designed to verify the mounting integrity of all components, mounting connections, structural integrity, and battery connections.

**Setup**

CanSat will be fix to an orbit sander (present in the mechanical vibrations laboratory of our university) to provide up to 12,000 rpm of rotation equivalent to 233 Hz of vibration, to expose failure of CanSat structures/components if they vibrate at resonance

## FIT TEST

This test is designed to ensure that CanSat fits into the rocket without any obstruction.

To control the dimension of CanSat, a 125 mm diameter hole is cut from a plywood. The accuracy of the diameter of the generated circle will be controlled by a micrometer calliper.

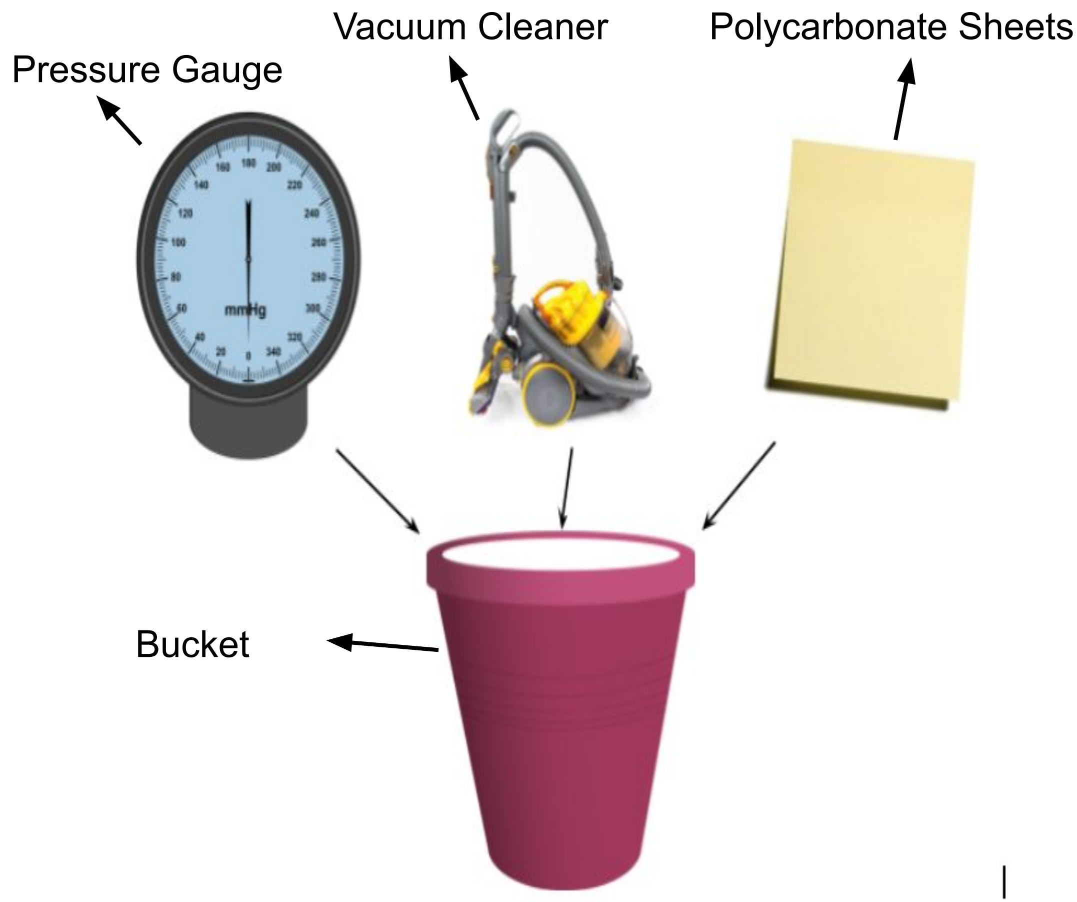
The accuracy of CanSat's diameter will be be tested with formed hole by ensuring it pass through it.

# Environmental Test Plan (5/5)

**Vacuum Test** is designed to verify the deployment operation of the two “maple seed” science payloads.

**Setup -** A bucket is used as a vacuum chamber which is sealed using 6mm thick sheet of polycarbonate. Vacuum is created using a vacuum cleaner and a pressure gauge is attached to verify the effectiveness of the components.

**Objective -** CanSat when fully powered is suspended inside a vacuum chamber, where its telemetry data is collected to verify the integrity of the deployment operation.



# Test Procedures Descriptions

| TEST | PROCEDURE | REQUIREMENTS | PASS FAIL CRITERIA | STATUS |
|---|---|---|---|---|
| Sensors Subsystem Test | All the sensors are installed on the PCB. The accuracy of the sensor data was checked. The accuracy of the results obtained was assessed. | | Incoming data must be accurate, continuous and stable. | ✓ |
| Communication and Data Handling | To verify transmission of data between XBees on XCTU. | | Verify that data transmission is provided. | ✓ |
| Communication and Data Handling | To test connection from different ranges. | | If data transmitted to GCS from 1 km. | ✓ |
| Electrical Power Subsystem | Battery is connected to PCB and voltmeter is connected in parallel | | Read voltage must be equal to Volts as calculated. | ✓ |
| Electrical Power Subsystem | Voltmeter is connected at the power connected points. | | Read voltage must be zero at these neutral points. | ✓ |

# Test Procedures Descriptions

| TEST | PROCEDURE | REQUIREMENTS | PASS / FAIL CRITERIA | STATUS |
|---|---|---|---|---|
| Flight Software Testing | To test burn of wire mechanism on PCB control via Microcontroller | | If the wire mechanism breaks when power is applied. | ✓ |
| Flight Software Testing | To observe transmission speed on ground station interface. | | if the data comes appropriate sequence and speed to the ground station. | ✓ |
| Ground Control System | To check whether the payload is able to switch from real time to SIMULATION Mode and vice versa | | If the time taken to switch to simulation mode or vice versa | To be tested |
| Wireless Communication Test | Flight controller is connected to Xbee and data transfer is started. | | Despite the forced resets RTC must keep the time and continue from where it reset. | ✓ |
| Payload Deployment Test | | | Fins should not get stuck in the container and the deployment has to be smooth. | ✓ |
| Parachute Release Test | Parachute release will be tested by drop tests from the drone. | | Parachute must be released smoothly. | To be tested |

# Test Procedures Descriptions

| TEST | PROCEDURE | REQUIREMENTS | PASS/FAIL CRITERIA | STATUS |
|---|---|---|---|---|
| Drop Test | Cansat will be connected to a 61 cm kevlar cord and released from 2 meters. Component assemblies and parachute attachment points will be tested. | | If CanSat still transfers telemetry after several drop tests<br>If all the mechanism present in CanSat performs adequately | To be tested |
| Vibration Test | Cansat will be placed on orbit sander,and orbit sander will be operated at different frequencies.. | | If mechanical and electrical connections remain intact | To be tested |
| Thermal Test | CanSat will be on power and placed in the foam-insulated thermal box. The system will be tested for 2 hours. Its temperature durability to 60°C will be tested. | | If CanSat still transfers telemetry after maximum temperature. | To be tested |

# Test Procedures Descriptions

| TEST | PROCEDURE | REQUIREMENTS | PASS/FAIL CRITERIA | STATUS |
|---|---|---|---|---|
| Fit Check | CanSat will be passed through a metal cylindrical envelope of 125 mm x 310 mm and the suitability of the dimensions will be verified. | | If CanSat is within the tolerances and all components fit correctly | To be tested |
| Vacuum Test | Full powered CanSat is tested for telemetry data collection in a vacuum chamber for testing the integrity. | | If the CanSat is successfully operate the deployment commands | To be tested |
| Release Mechanism Test | The CanSat will be elevated to a height of 500m with the help of quadcopter. Cansat should trigger the release mechanism at 400 m. | | If the payload is released at the desired height then the release mechanism is working correctly. | To be tested |
| Decent Control Test | The payload and container will be released from a height of 25 m. | | If the container and payload are falling at the desired speed. | To be Tested |

# Test Procedures Descriptions

| TEST | PROCEDURE | REQUIREMENTS | PASS/FAIL CRITERIA | STATUS |
|---|---|---|---|---|
| Visual Inspection and Dimension Verification | The components and the individual parts are tested by naked eye and with the help of different measuring tools the dimensions are finalized | N/A | The dimensions must be under the tolerance and the components must be proper | Partially tested |
| Structural Integrity | All the sub-assemblies, metal plates, and balsa wood to be tested individually against any failure , first on simulation software then on mechanical equipments. | N/A | All of them must be able to handle maximum amount of stress and loads. | To be tested |
| Joints | Joints must be strong enough to bear stresses as there are maximum chances of failure | N/A | Must not fail under static and dynamic loading both | To be tested |
| Parachute folding | The area covered after folding of the parachute is tested by storing the whole assembly in the same container | N/A | Must be within tolerances | To be tested |

# Test Procedures Descriptions

| TEST | PROCEDURE | REQUIREMENTS | PASS/FAIL CRITERIA | STATUS |
|---|---|---|---|---|
| Parachute attachments | Attachment of the parachute will be tested against extreme conditions to ensure safe landing | N/A | The attachments must not break | To be tested |
| Material test of parachute | Parachute material must withstand the air resistance which will be tested by throwing the parachute from similar height by attaching same weight. | N/A | Parachute must not tear | To be tested |
| Payload deployment | Simulating in software and also physically testing the ease with which the payload drops | N/A | Minimum time and least hindrance along with proper deployment | To be tested |
| Payload Attachment | Maintaining both the payloads to be independent of each other which will be tested manually first the with the integration of software | N/A | One payload must be deployed at a time and the strings must not entangle | To be tested |

# Mission Operations & Analysis

**Shashwat Patnaik**

# Overview of Mission Sequence of Events (1/4)

| ARRIVAL | PRE-LAUNCH | DEPLOYMENT |
| --- | --- | --- |

**ARRIVAL**

- ★ Arrival at the launch location
- ★ “Maple Seed” payload is assembled and integrated with CanSat.
- ★ The Cansat integrity will be checked and final testing would be done.
- ★ The GCS and antenna will be set up.

**PRE-LAUNCH**

- ★ Sensor Subsystem and separation mechanism will be tested
- ★ Weight and fit check control will be performed
- ★ Cansat powered and stored until launch
- ★ Integrating CanSat to rocket for launch

**DEPLOYMENT**

- ★ CanSat will be deployed at 670 - 725 meters
- ★ CanSat shall descend using a parachute at a decent rate of 15 m/s
- ★ GCS will be made operational.
- ★ At 500 meters, the container shall release the first science payload and the second science payload at 400 meters .

# Overview of Mission Sequence of Events (2/4)

| MAIN MISSION | RECOVERY | PRESENTATION |
| --- | --- | --- |

**MAIN MISSION**

★ Parachute will open after complete separation from the rocket.

★ Both the science payloads autorotate to decent at the rate of less than 20m/s, concurrently collecting all data from sensor and transmitting the same to CanSat Container which will then transmit to GCS.

**RECOVERY**

★ Both science payloads will be recovered.

★ Audio beacon activated and telemetry transmission stopped.

★ The recovery team locates the CanSat when all launches are completed.

**PRESENTATION**

★ Transmitted data will be analysed and presented.

★ Flight data will be delivered to the jury.

★ The team will clear the area and move on to the PFR work.

# Overview of Mission Sequence of Events (3/4)

## Team Member Roles and Responsibilities:

**1. Mission Control Officer** (This is a single person who is responsible for informing the Flight Coordinator when the team and their CanSat is ready to be launched.)

★ **Kanishk**

**2. Ground Station Crew** (This is one or more persons who is responsible for monitoring the ground station for telemetry reception and issuing commands to the CanSat.)

★ **Pranav Bhatnagar**
★ **Nischit Poojari**
★ **Yash Mudgal**

**3. Recovery Crew** (This is one or more persons responsible for tracking the CanSat and going out into the field for recovery and interacting with the field judges. This crew is responsible for making sure all field scores are filled in or loss of points will occur.)

★ **Aman Dadheech**
★ **Rishabh Raj Singh**
★ **Shashwat Patnaik**

**4. CanSat Crew** (This is one or more persons responsible for preparing the CanSat ,integrating it into the rocket, and verifying its status.)

★ **Kiran**
★ **Sampreet**
★ **Kunal Thakur**

# Overview of Mission Sequence of Events (4/4)

## Antenna Construction and GCS Setup:

The antenna consist of round loop of wire which is held in place on a stand.

The GCS setup consists of mounting umbrella on a stand, placing laptop under it, placing the table fan such that it blows air towards laptop and connecting adaptor to the laptop using USB cable.

**2nd STEP**

**1st STEP**

**3rd STEP**

It is then tethered to the adapter which is the main transceiver unit.

## CANSAT Assembly and Test:

To assemble the CanSat, the battery compartment will be opened

The system will be tested by powering it on and checking the telemetry data.

**2nd STEP**

**1st STEP**

**3rd STEP**

Battery will be inserted in the container and payloads, final assembly will be done after the insertion of battery.

# Overview of Mission Sequence of Events (5/5)

**Delivery of telemetry data file:**

The GCS will generate 3 .csv files for the flight telemetry data :

1. Flight_1357_C.csv for the Container Telemetry
2. Flight_1357_SP1.csv for Science Payload 1
3. Flight_1357_SP2.csv for Science Payload 2

These will be uploaded to the thumb drive provided and submitted to the judges.

**In case of simulated flight:**

The .csv files will be emailed to the judges. The GCS will also be sending telemetry to the MQTT broker at cansat.info, port 1883 under topic teams/1357, using the username and password provided to us. The data format for sending the telemetry is specified in the updated MQTT documentation.

# Field Safety Rules Compliance

- All the Field Safety Rules mentioned in the mission guide will be strictly observed by all team members.

- Mission operations manual comprises of 6 sub-points as appeared in mission guide. Preparing mission guide will help team members to understand safety procedures.

- Indicated manual will likewise be utilized in launch rehearsals before competition day.

- Two copies of the Manual in three ring binders will be present at Flight Readiness. Review the day before launch.


**Development status:**

- The draft of the document is made. It is being updated as we progress towards the launch day. The document will be finalized before Flight readiness review.

# CanSat Location and Recovery

- **Container Recovery**
  A audio beacon - iFly 5V buzzer is placed over the payload. It is capable of producing peak of about 115dB. Moreover, the position of the container can be estimated by examining the footage from the camera onboard. Furthermore, the color of the case of the container is kept fluorescent to easily spot the container.

- **Payload Recovery**

  An external GPS or a buzzer was unfeasible because of the limited amount of space and hinder the stability of the payload. Hence, the color of the case and the wing of the science payload is kept fluorescent to easily spot it.

- **Color Selection**
  The color of the parachute and science payload is kept fluorescent to easily track the container & payload. The rest of the parts are kept white to avoid heating due to radiation from sun.

- **Recovery Address**

  Contact details of the team lead and address will be written on the science payload and container.

# Mission Rehearsal Activities (1/2)

| | Activity | Procedure | Rehearsal Time |
|---|---|---|---|
| 01 | Ground system radio link check | • Ground Station and Xbee are communicating as required.<br>• Telemetry data is taken for controlling accurate data.<br>• Accuracy of telemetry in a certain range is ensured. | 8th April 2021-15th April 2021 |
| 02 | Powering on/off the CanSat | • CanSat gets powered on by an external switch.<br>• System can be rebooted by wireless GCS command. | 8th April 2021-10th April 2021 |
| 03 | Launch configuration preparations | • Final integration and component placing tests will be done.<br>• Ground Station will be ready to take data. | A month before the final launch |

# Mission Rehearsal Activities(2/2)

| | Activity | Procedure | Rehearsal Time |
|---|---|---|---|
| 04 | Loading the CanSat in the launch vehicle | • The Final integrated CanSat will be loaded into a model rocket frame to detect any possible problems. | A month before the final launch |
| 05 | Telemetry processing, archiving, and analysis | • All telemetry data is analyzed in the ground station interface and stored on SD card. Its correctness and stability are checked. | 20th April 2021-30th April 2021 |
| 06 | Recovery | • CanSat science probe will be recovered with the help of GPS, buzzer and recovery crew.<br>• Container wii be recovered with the help of GPS. | A month before the final launch |

*The purpose of this section is to summarize and cross reference the compliance to the CanSat Competition Mission Guide requirements.*

# Requirements Compliance

**Kanishk**

# Requirements Compliance (1/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 1 | Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams. | **Complies** | 98,97 | |
| 2 | CanSat shall fit in a cylindrical envelope of 125 mm diameter x 400 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing. | **Complies** | 29 | |
| 3 | The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard. | **Complies** | 29 | |
| 4 | The container shall be a fluorescent color; pink, red or orange. | **Complies** | 22,70,84,85 | |
| 5 | The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open. | **Complies** | 85 | |

# Requirements Compliance (2/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 6 | The rocket airframe shall not be used to restrain any deployable parts of the CanSat. | Complies | 29 | |
| 7 | The rocket airframe shall not be used as part of the CanSat operations | Complies | 29 | |
| 8 | The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket. | Complies | 29,57 | |
| 9 | The Parachute shall be fluorescent Pink or Orange | Complies | 56 | |
| 10 | The descent rate of the CanSat (container and science payload) shall be 15 meters/second +/- 5m/s. | Complies | 59,60 | |

# Requirements Compliance (3/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 11 | All structures shall be built to survive 15 Gs of launch acceleration. | **Partial** | 95 | To be tested |
| 12 | All structures shall be built to survive 30 Gs of shock. | **Partial** | 95 | To be tested |
| 13 | All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives. | **Complies** | 90,91 | |
| 14 | All mechanisms shall be capable of maintaining their configuration or states under all forces. | **Partial** | 90,94,95 | To be tested |
| 15 | Mechanisms shall not use pyrotechnics or chemicals | **Complies** | 87,88 | |
| 16 | Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire. | **Complies** | 87,88 | |

# Requirements Compliance (4/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 17 | Both the container and payloads shall be labeled with team contact information including email address. | **Complies** | 81,85,210 | |
| 18 | Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost. | **Complies** | 234,235 | |
| 19 | XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE radios are also allowed. | **Complies** | 111 | |
| 20 | XBEE radios shall have their NETID/PANID set to their team number. | **Complies** | 185 | |
| 21 | XBEE radios shall not use broadcast mode | **Complies** | 185 | |
| 22 | The science payload shall descend spinning passively like a maple seed with no propulsion. | **Complies** | 47,48 | |

# Requirements Compliance (6/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 23 | The science payload shall have a maximum descent rate of 20 m/s. | **Complies** | 65 | |
| 24 | The wing of the science payload shall be colored fluorescent orange, pink or green. | **Complies** | 53 | |
| 25 | The science payload shall measure altitude using an air pressure sensor. | **Complies** | 34 | |
| 26 | The science payload shall measure air temperature. | **Complies** | 34 | |
| 27 | The science payload shall measure rotation rate as it descends. | **Complies** | 35 | |
| 28 | The science payload shall transmit all sensor data once per second. | **Complies** | 148 | |

# Requirements Compliance (7/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 29 | The science payload telemetry shall be transmitted to the container only. | Complies | 158 | |
| 30 | The science payload shall have their NETID/PANID set to their team number plus five. | Complies | 185 | |
| 31 | The container shall include electronics to receive sensor payload telemetry. | Complies | 109,111 | |
| 32 | The container shall include electronics and mechanisms to release the science payloads. | Complies | 87,88 | |
| 33 | The container shall include a GPS sensor to track its position. | Complies | 37 | |
| 34 | The container shall include a pressure sensor to measure altitude. | Complies | 36 | |

# Requirements Compliance (8/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 35 | The container shall measure its battery voltage. | Complies | 38 | |
| 36 | The container shall transmit its telemetry and the payload telemetry received once per second in the format described in the Telemetry Requirements section. | Complies | 115,116,117 | |
| 37 | The container shall stop transmitting telemetry when it lands. | Complies | 126 | |
| 38 | The container and science payloads must include an easily accessible power switch that can be accessed without disassembling the cansat and science payloads and in the stowed configuration. | Complies | 81,85 | |
| 39 | The container must include a power indicator such as an LED or sound generating device that can be easily seen or heard without disassembling the cansat and in the stowed state. | Complies | 130 | |

# Requirements Compliance (9/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 40 | An audio beacon is required for the container. It may be powered after landing or operate continuously. | **Complies** | 210 | |
| 41 | The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed. | **Complies** | 210 | |
| 42 | Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells. Coin cells are allowed. | **Complies** | 138 | |
| 43 | An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat. | **Complies** | 81 | |
| 44 | An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat. | **Complies** | 81 | |

# Requirements Compliance (10/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 45 | Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects. | **Complies** | 91 | |
| 46 | The Cansat must operate during the environmental tests laid out in Section 3.5. | **Partial** | 192-196 | To be tested |
| 47 | The Cansat shall operate for a minimum of two hours when integrated into the rocket. | **Complies** | 130,131,135 | |
| 48 | The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets. | **Complies** | 157 | |
| 49 | The container must maintain mission time throughout the whole mission even with processor resets or momentary power loss. | **Complies** | 107,157 | |

# Requirements Compliance (11/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 50 | The container shall have its time set to UTC time to within one second before launch. | **Complies** | 119, 143 | |
| 51 | The container flight software shall support simulated flight mode where the ground station sends air pressure values at a one second interval using a provided flight profile csv file. | **Complies** | 160 | |
| 52 | In simulation mode, the flight software shall use the radio uplink pressure values in place of the pressure sensor for determining the container altitude. | **Complies** | 160 | |
| 53 | The container flight software shall only enter simulation mode after it receives the SIMULATION ENABLE and SIMULATION ACTIVATE commands. | **Complies** | 175 | |
| 54 | The ground station shall command the Cansat to start transmitting telemetry prior to launch. | **Complies** | 175 | |

# Requirements Compliance (12/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 55 | The ground station shall generate csv files of all sensor data as specified in the Telemetry Requirements section. | **Complies** | 176 | |
| 56 | Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission. | **Complies** | 107 | |
| 57 | Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission. | **Complies** | 174 | |
| 58 | Each team shall develop their own ground station. | **Complies** | 165 | |
| 59 | All telemetry shall be displayed in real time during descent on the ground station. | **Complies** | 174 | |
| 60 | All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.) | **Complies** | 173 | |

# Requirements Compliance (13/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 61 | Teams shall plot each telemetry data field in real time during flight | **Complies** | 173 | |
| 62 | The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna. | **Complies** | 165 | |
| 63 | The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site | **Complies** | 165 | |
| 64 | The ground station software shall be able to command the container to operate in simulation mode by sending two commands, SIMULATION ENABLE and SIMULATION ACTIVATE. | **Complies** | 175 | |

# Requirements Compliance (14/14)

| Rqmt num | Requirement | Comply / No Comply / Partial | X-Ref Slide(s) Demonstrating Compliance | Team Comments or Notes |
|---|---|---|---|---|
| 65 | When in simulation mode, the ground station shall transmit pressure data from a csv file provided by the competition at a 1 Hz interval to the container. | **Complies** | 176 | |
| 66 | The science payloads shall not transmit telemetry during the launch, and the container shall command the science payloads to begin telemetry transmission upon release from the container. | **Complies** | 154 | |

# Management

**Shashwat Patnaik**

# Status of Procurements (1/2)

| Components | Quantity | Order Date | Received Date | Status |
|---|---|---|---|---|
| Arduino Nano Ble 33 sense | 1 | 20 dec | 18 feb | Received |
| Payload - IMU - GY-87 | 2 | 20 dec | 13 feb | Received |
| Payload - Atmega328p | 2 | 20 dec | 13 feb | Received |
| Adafruit 746 GPS | 1 | 20 dec | 13 feb | Received |
| Mini 1920*1080P FPV Camera | 1 | 24 dec | 8 feb | Received |
| Xbee Pro S2C RPSMA | 3 | 20 dec | 13 feb | Received |
| Payload Antenna - Xbee Pro S2C Whip antenna | 2 | 20 dec | 13 feb | Received |
| Samsung 30Q 3000mah Battery 18650 | 5 | 5 jan | 8 feb | Received |
| Strontium 32GB SD card | 1 | 10 jan | 12 feb | Received |
| Audio Beacon - iFlight 5V Buzzer Alarm | 1 | 10 jan | 12 feb | Received |

***Many shipments were delayed due to pandemic***

# Status of Procurements (2/2)

| Components | Quantity | Order Date | Received Date | Status |
|---|---|---|---|---|
| 3D printing mechanical framework<br>-Container<br>-Science payload | - | 20 Jan | 23 Jan | Received |
| Stepper motor - 28BYJ | 1 | 10 Feb | 19 feb | Received |
| Parachute Material | 1 | 10 Feb | 20 feb | Received |
| Epoxy and Hot glue | 1 | 20 Jan | 25 Jan | Received |
| Nichrome Wires - Nichrome Wires | 1 | 10 Feb | 14 feb | Received |
| Torsion Spring | 4 | 10 Feb | 14 feb | Received |
| Fishing Chord | 3 | 10 Feb | 16 feb | Received |
| 12 Gauge aluminium wire | 1 | 10 Feb | 16 feb | Received |
| Balsa Wood - 5mm | 1 | 15 Feb | 16 feb | Received |
| Miscellaneous (nuts, bolt) | - | re-used | | |
| Motor Driver - TB6612FNG | 1 | 10 Feb | 19 feb | Received |
| Laptop (Mac or Windows) | 1 | personal | | |

***Many shipments were delayed due to pandemic***

# CanSat Budget – Hardware (Electrical)

| Components | Status | Quantity | Cost (in USD) | Type |
|---|---|---|---|---|
| Arduino Nano Ble 33 sense | New | 1 | 31 | Exact |
| Payload - IMU - GY-87 | New | 2 | 30 | Exact |
| Payload - Atmega328p | New | 2 | 11 | Exact |
| Ublox NEO-6M | New | 1 | 40 | Exact |
| Mini 1920*1080P FPV Camera | New | 1 | 14 | Exact |
| Xbee S2C | New | 4 | 140 | Exact |
| Samsung 30Q 3000mah Battery 18650 | New | 5 | 30 | Exact |
| Strontium 32GB SD card | New | 1 | 5 | Exact |
| Audio Beacon - iFlight 5V Buzzer Alarm | New | 1 | 9 | Exact |
| Sub Total | $310 | | | |

# CanSat Budget – Hardware (Mechanical)

| Components | Status | Quantity | Cost (in USD) | Type |
|---|---|---|---|---|
| 3D printing mechanical framework<br>-Container<br>-Science payload | New | 1 | 60 | Estimate |
| Stepper motor - 28BYJ | New | 1 | 5 | Exact |
| Parachute | New | 1 | 20 | Estimate |
| Epoxy and Hot glue | New | 1 | 30 | Estimate |
| Nichrome Wires - Nichrome Wires | New | 1 | 5 | Exact |
| Torsion Spring | New | 4 | 20 | Exact |
| Fishing Chord | New | 3 | 18 | Exact |
| 12 Gauge aluminium wire | New | 1 | 10 | Exact |
| Miscellaneous (nuts, bolt) | New | - | 5 | Estimate |
| Motor Driver - TB6612FNG | New | 1 | 3 | Exact |
| Sub Total | $176 | | | |

# CanSat Budget – Ground Control Station

| Components | Status | Quantity | Cost (in USD) | Type |
|---|---|---|---|---|
| Laptop (MAC and Windows) | - | 1 | - | Personal |
| Xbee Pro S2C | New | 1 | $35 | Exact |
| Microcontroller - Arduino Nano | New | 1 | $20 | Exact |
| Sub Total | $55 | | | |

# CanSat Budget – Other Costs

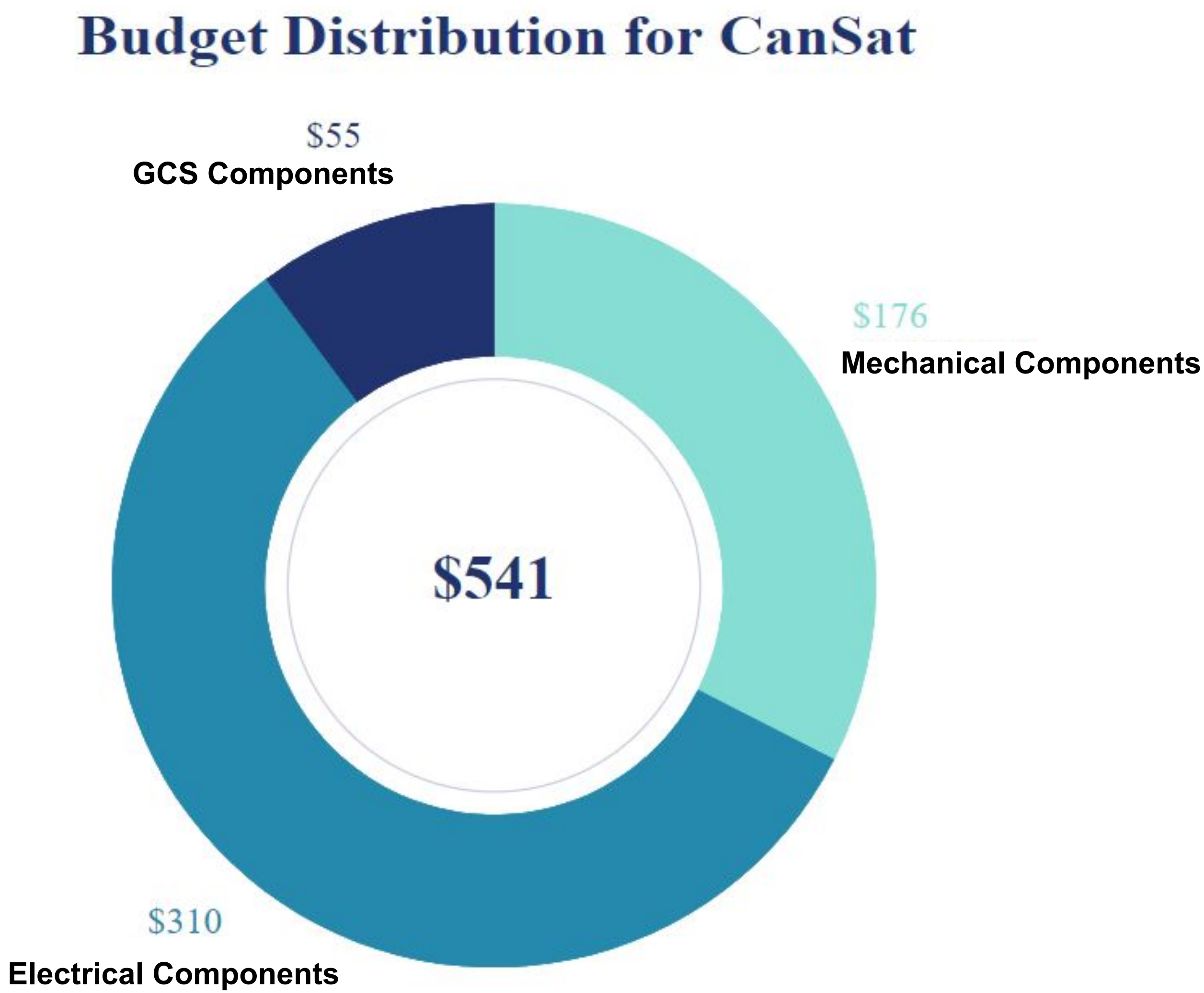
| Components | Quantity | Cost (in USD) | Type |
|---|---|---|---|
| Application Fee | 1 | 50 | Exact |
| Prototyping and Testing | 1 | 220 | Estimate |
| Travelling and Mobility | - | 420 | Estimate |
| Team Attire | 10 | 110 | Estimate |
| Sub Total | $800 | | |

# Final Budget Analysis

| Monetary Budget | |
|---|---|
| University Funding | $2000 |
| Remaining Past Sponsorships | $1254 |
| Individual Contribution from Team Members | $130 |
| Funds from Current Sponsorships | $5469 |

| Total Expenses | |
|---|---|
| CanSat Expenses | $541 |
| Other Costs | $800 |

# CanSat Budget



# Program Schedule Overview

| Task name | Start date | End date | Duration |
|---|---|---|---|
| | **01/08/2020** | **12/06/2021** | **315d 2...** |
| **CanSat Major Milestone** | **01/08/2020** | **12/06/2021** | **315d 2...** |
| 1st Semester | 01/08/2020 | 26/11/2020 | 117d 9h |
| Team Formation And Finalization | 23/08/2020 | 01/09/2020 | 9d |
| Preliminary Design Stage | 27/08/2020 | 30/01/2021 | 156d |
| University Examinations 1 | 07/09/2020 | 18/09/2020 | 11d |
| CanSat Registration | 20/09/2020 | 20/09/2020 | 23h 59m |
| University Examinations 2 | 12/10/2020 | 23/10/2020 | 11d |
| University Examinations 3 | 16/11/2020 | 27/11/2020 | 11d |
| Components Procurement | 20/11/2020 | 20/12/2020 | 30d |
| Winter Break | 01/12/2020 | 06/01/2021 | 36d |
| Prototype Testing | 20/12/2020 | 22/02/2021 | 64d |
| 2nd Semester | 07/01/2021 | 07/05/2021 | 120d |
| PDR Submission | 02/02/2021 | 02/02/2021 | 23h 59m |
| University Examinations 1 | 05/02/2021 | 19/02/2021 | 14d |
| Critical Design Stage | 09/02/2021 | 01/04/2021 | 51d |
| Telecom For PDR | 26/02/2021 | 26/02/2021 | 23h 59m |
| University Examinations 2 | 19/03/2021 | 02/04/2021 | 14d |
| CDR Submission | 02/04/2021 | 02/04/2021 | 23h 59m |
| Telecom For CDR | 12/04/2021 | 12/04/2021 | 23h 59m |
| University Examinations 3 | 23/04/2021 | 07/05/2021 | 14d |
| Environmental Test Document | 28/05/2021 | 28/05/2021 | 23h 59m |
| Competition And PFR Present... | 12/06/2021 | 12/06/2021 | 23h 59m |

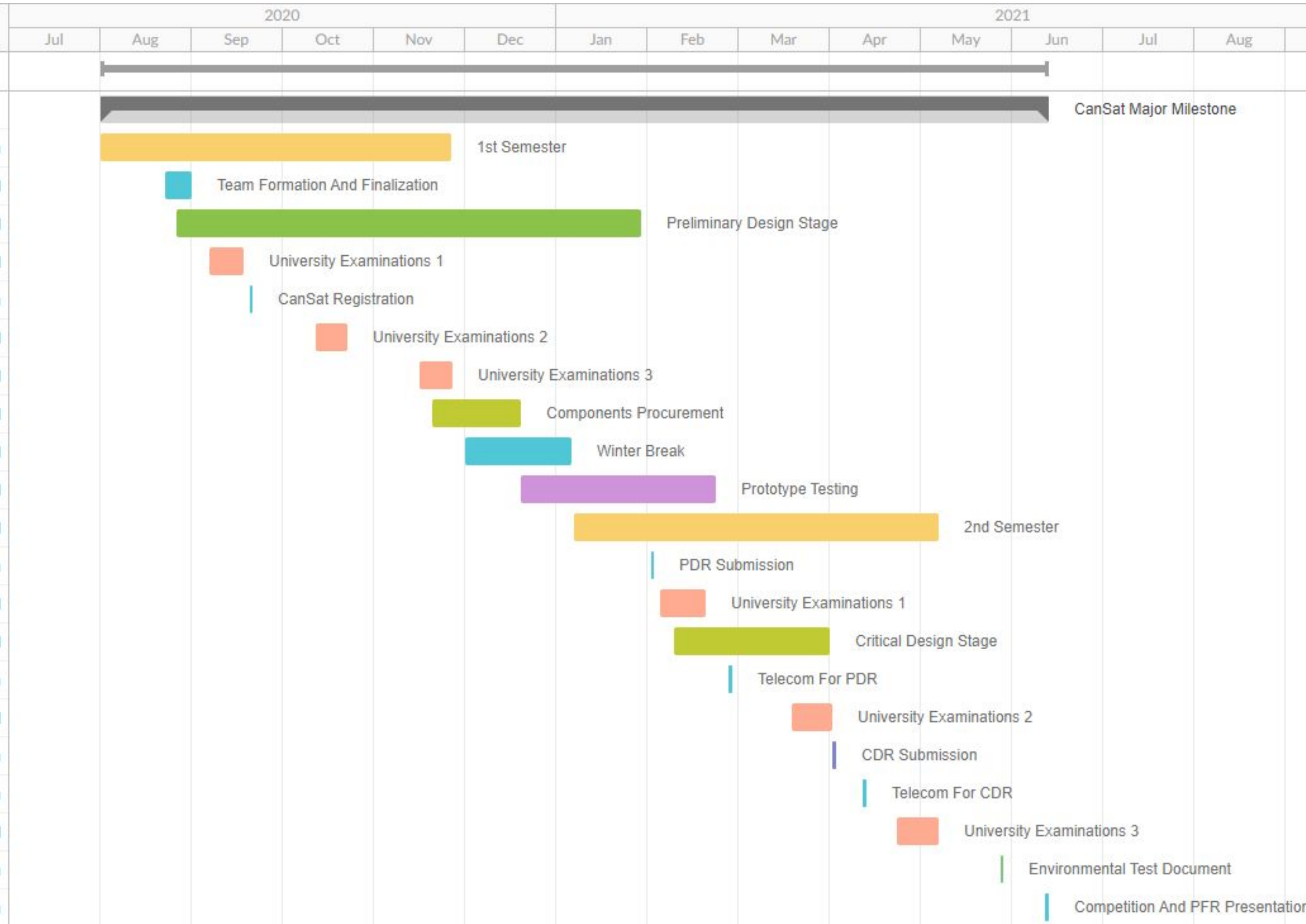



***Fig 13.1:*** *Gantt Chart representing the overall program schedule for CanSat 2021*

# Program Schedule Overview

| Task name | Start date | End date | Duration |
|---|---|---|---|
| | **01/08/2020** | **12/06/2021** | **315d 2...** |
| **CanSat Major Milestone** | **01/08/2020** | **12/06/2021** | **315d 2...** |
| 1st Semester | 01/08/2020 | 26/11/2020 | 117d 9h |
| Team Formation And Finalization | 23/08/2020 | 01/09/2020 | 9d |
| Preliminary Design Stage | 27/08/2020 | 30/01/2021 | 156d |
| University Examinations 1 | 07/09/2020 | 18/09/2020 | 11d |
| CanSat Registration | 20/09/2020 | 20/09/2020 | 23h 59m |
| University Examinations 2 | 12/10/2020 | 23/10/2020 | 11d |
| University Examinations 3 | 16/11/2020 | 27/11/2020 | 11d |
| Components Procurement | 20/11/2020 | 20/12/2020 | 30d |
| Winter Break | 01/12/2020 | 06/01/2021 | 36d |
| Prototype Testing | 20/12/2020 | 22/02/2021 | 64d |
| 2nd Semester | 07/01/2021 | 07/05/2021 | 120d |
| PDR Submission | 02/02/2021 | 02/02/2021 | 23h 59m |
| University Examinations 1 | 05/02/2021 | 19/02/2021 | 14d |
| Critical Design Stage | 09/02/2021 | 01/04/2021 | 51d |
| Telecom For PDR | 26/02/2021 | 26/02/2021 | 23h 59m |
| University Examinations 2 | 19/03/2021 | 02/04/2021 | 14d |
| CDR Submission | 02/04/2021 | 02/04/2021 | 23h 59m |
| Telecom For CDR | 12/04/2021 | 12/04/2021 | 23h 59m |
| University Examinations 3 | 23/04/2021 | 07/05/2021 | 14d |
| Environmental Test Document | 28/05/2021 | 28/05/2021 | 23h 59m |
| Competition And PFR Present... | 12/06/2021 | 12/06/2021 | 23h 59m |

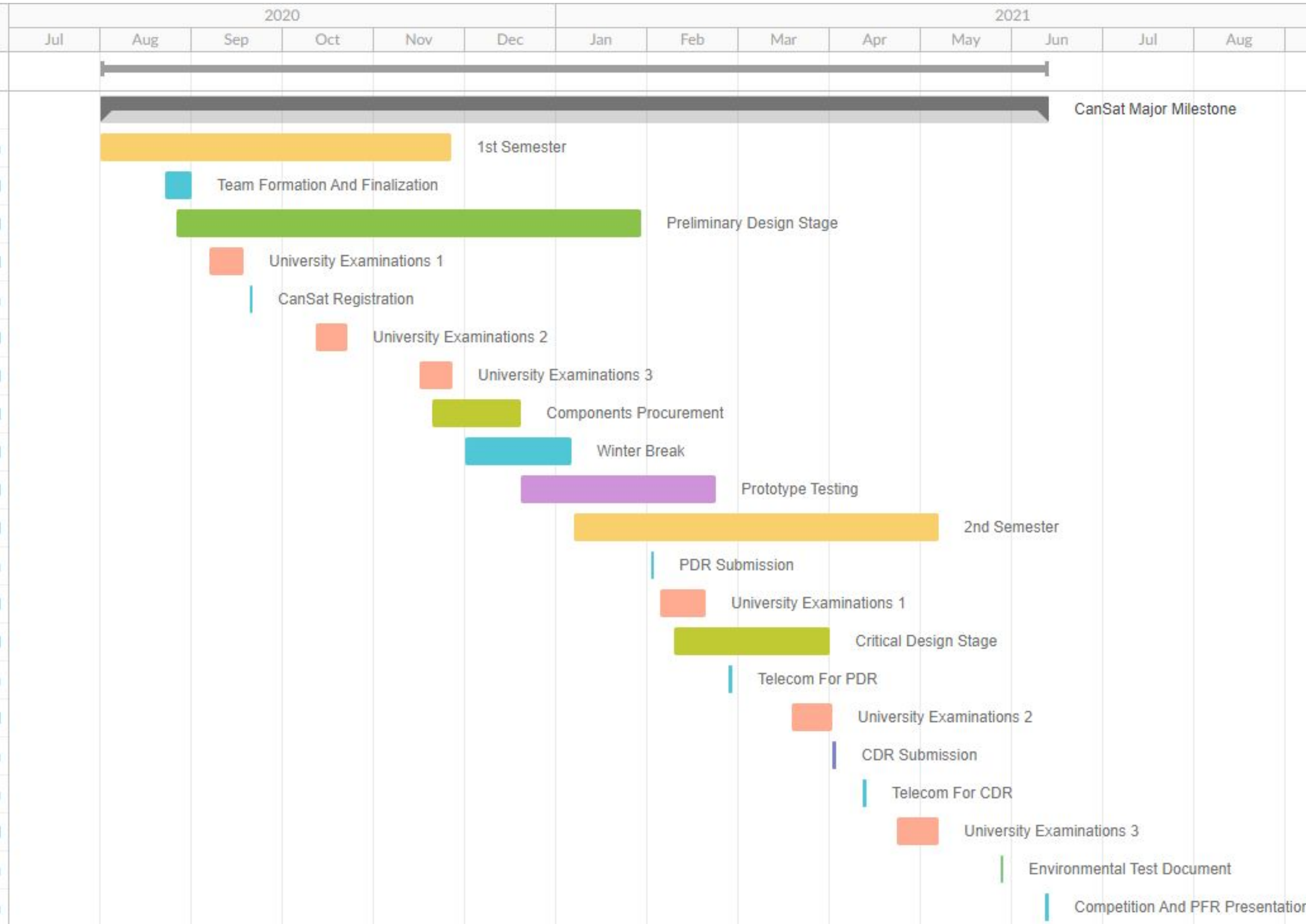



***Fig 13.2:*** *Gantt Chart representing the overall program schedule for CanSat 2021*

# Detailed Program Schedule (1/6)

| COMPETITION MILESTONES | | | |
|---|---|---|---|
| TASK | BEGINNING DATE | ENDING DATE | DURATION (DAYS) |
| CanSat competition | 21 Aug | 14 June | 285 |
| Team recruitment and formation | 23 Aug | 1 Sep | 10 |
| Team Registration application | 20 Sept | 20 Sept | 1 |
| Application fees payment | 5 Dec | 5 Dec | 1 |
| PDR Submission | 2 Feb | 2 Feb | 1 |
| Telecom for PDR | 26 Feb | 26 Feb | 1 |
| CDR Submission | 2 Apr | 2 Apr | 1 |
| Telecom for CDR | 12 Apr | 30 Apr | 1 |
| Environmental Test Document | 28 May | 28 May | 1 |

# Detailed Program Schedule (2/6)

| ACADEMIC MILESTONES | | | |
|---|---|---|---|
| TASK | BEGINNING DATE | ENDING DATE | DURATION (DAYS) |
| 1st Semester | 2 Aug | 27 Nov | 118 |
| University Examinations 1 | 7 Sep | 18 Sep | 11 |
| University Examinations 2 | 12 Oct | 23 Oct | 11 |
| University Examinations 3 | 16 Nov | 27 Nov | 11 |
| Winter Break | 1 Dec | 6 Jan | 16 |
| 2nd Semester | 7 Jan | 7 May | 120 |
| University Examinations 1 | 5 Feb | 19 Feb | 14 |
| University Examinations 2 | -19 Mar | 2 Apr- | 14 |
| University Examinations 3 | 23 Apr | 7 May | 14 |

# Detailed Program Schedule (3/6)

| MECHANICAL DEPARTMENT | | | | |
|---|---|---|---|---|
| TASK | BEGINNING DATE | ENDING DATE | DURATION (DAYS) | ASSIGNED TO |
| Understanding Competition Requirement | 23 Aug | 18 Sep | 27 | Whole Team |
| Preliminary Research | 26 Aug | 30 Sep | 35 | |
| Conceptualizing Design Ideas of Maple Seed Payload | 7 Oct | 30 Oct | 23 | Shashwat Patnaik |
| CAD Modeling of Maple Seed Payload and Container | 29 Oct | 23 Nov | 25 | Sampreet |
| Designing of parachutes | 26 Nov | 1 Dec | 5 | Sampreet |
| Material Selection | 2 Dec | 18 Dec | 16 | Aman Dadheech |
| Simulation and Analysis with CAE and MATLAB | 24 Dec | 31 Jan | 38 | Kanishk |
| Prototyping of CanSat | 31 Jan | 10 Mar | 38 | Shashwat Patnaik |
| Integration and Testing | 17 Mar | 7 Apr | 21 | Kiran |
| Testing of Parachutes | 7 Apr | 14 Apr | 7 | Kiran |
| Freezing of Mechanical Design | 15 Mar | 27 Apr | 12 | Kanishk |

**Team incurred few delays regarding the shipment of components due to the current pandemic, delaying integration and testing of CANSAT.**

# Detailed Program Schedule (4/6)

## Mechanical Milestones

| Task name | Start date | End date |
|---|---|---|
| | **23/08/2020** | **27/04/2021** |
| **Mechanical Department** | **23/08/2020** | **27/04/2021** |
| Understanding Competition Requirement | 23/08/2020 | 18/09/2020 |
| Preliminary Research | 26/08/2020 | 30/09/2020 |
| Conceptualizing Design Ideas of Maple Seed Payload | 07/10/2020 | 30/10/2020 |
| CAD Modeling of Mapple Seed Payload and Container | 29/10/2020 | 23/11/2020 |
| Design of parachutes | 26/11/2020 | 01/12/2020 |
| Material Selection | 02/12/2020 | 18/12/2020 |
| Simulation and Analysis with CAE and MATLAB | 24/12/2020 | 31/01/2021 |
| Prototyping of CanSat | 05/02/2021 | 15/03/2021 |
| Intergration and Testing | 17/03/2021 | 07/04/2021 |
| Testing of Parachutes | 07/04/2021 | 14/04/2021 |
| Optimization and Freezing of Mechanical Design | 15/04/2021 | 27/04/2021 |

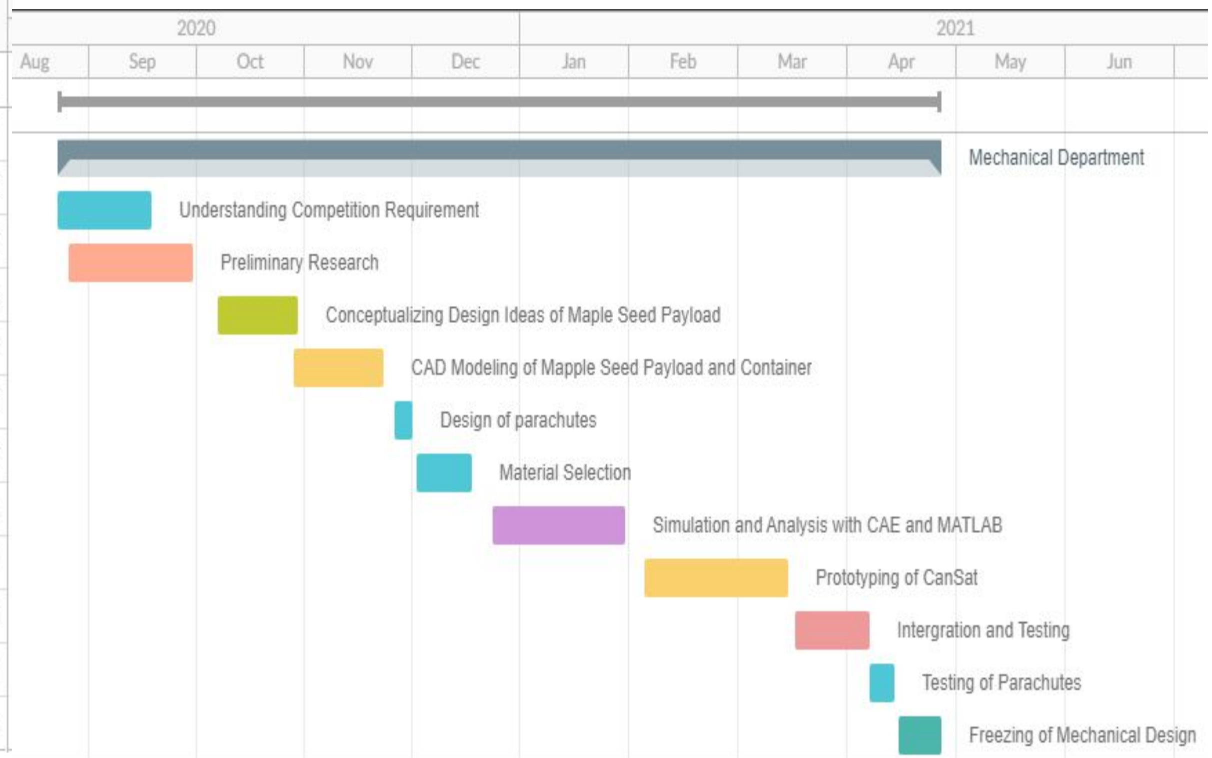



***Fig 13.3:*** *Gantt Chart representing the mechanical program schedule for CanSat 2021*

# Detailed Program Schedule (5/6)

| ELECTRICAL DEPARTMENT | | | | |
|---|---|---|---|---|
| TASK | BEGINNING DATE | ENDING DATE | DURATION (DAYS) | ASSIGNED TO |
| Understanding Requirement | 17 Oct | 30 Oct | 14 | Whole Team |
| Preliminary Research | 20 Oct | 30 Oct | 10 | |
| Trade and Selection of Sensors and Microcontroller | 12 Dec | 6 Jan | 25 | NIschit Nagesh Poojari |
| Hardware Component Selection and Other | 14 Dec | 20 Dec | 6 | Yash Mudgal |
| Real-Time Communication Testing With Xbee | 4 Jan | 9 Jan | 5 | Yash Mudgal |
| Design Of Ground Control System Interface | 7 Jan | 8 Feb | 32 | Pranav Bhatnagar |
| Procurement of Sensors and Microcontroller | 10 Jan | 31 Jan | 21 | Nischit Nagesh Poojari |
| Coding Of Flight Software | 10 Jan | 14 Feb | 35 | Pranav Bhatnagar |
| Pcb Prototype Design And Fabrication | 11 Jan | 14 Jan | 3 | Yash Mudgal |
| Developing Map On Gps | 14 Jan | 28Jan | 14 | Yash Mudgal |
| Testing Of Our Sensor | 3 Feb | 10 Feb | 7 | Nischit Nagesh Poojari |
| Simulation Of All Sensors | 3 Feb | 10 Feb | 7 | Nischit Nagesh Poojari |
| Optimization And Improvisation Of Software | 10 Feb | 28 Feb | 18 | Rishabh Raj Singh |
| Testing Of Electronic Subsystem With On-Board Power | 14 Feb | 18 Feb | 4 | Rishabh Raj Singh |
| Analysis And Development Of Eps | 20 Feb | 10 Mar | 18 | Rishabh Raj Singh |
| Final Testing | 8 Feb | 20 Mar | 12 | Yash Mudgal |

# Detailed Program Schedule (6/6)

## Electrical Milestones

| Task name | Start date | End date |
|---|---|---|
| | **17/10/2020** | **20/03/2021** |
| **Electrical Department** | **17/10/2020** | **20/03/2021** |
| Understanding Requir... | 17/10/2020 | 30/10/2020 |
| Preliminary Research | 20/10/2020 | 30/10/2020 |
| Trade And Selection O... | 12/12/2020 | 06/01/2021 |
| Hardware Component ... | 14/12/2020 | 20/12/2020 |
| Real-Time Communica... | 04/01/2021 | 09/01/2021 |
| Design Of Ground Con... | 07/01/2021 | 08/02/2021 |
| Procurement of Senso... | 10/01/2021 | 31/01/2021 |
| Coding Of Flight Softw... | 10/01/2021 | 14/02/2021 |
| Pcb Prototype Design ... | 11/01/2021 | 14/01/2021 |
| Developing Map On Gps | 14/01/2021 | 28/01/2021 |
| Testing Of Our Sensor | 03/02/2021 | 10/02/2021 |
| Simulation Of All Sens... | 03/02/2021 | 10/02/2021 |
| Optimization And Impr... | 10/02/2021 | 28/02/2021 |
| Testing Of Electronic S... | 14/02/2021 | 18/02/2021 |
| Analysis And Develop... | 20/02/2021 | 10/03/2021 |
| Final Testing | 08/03/2021 | 20/03/2021 |

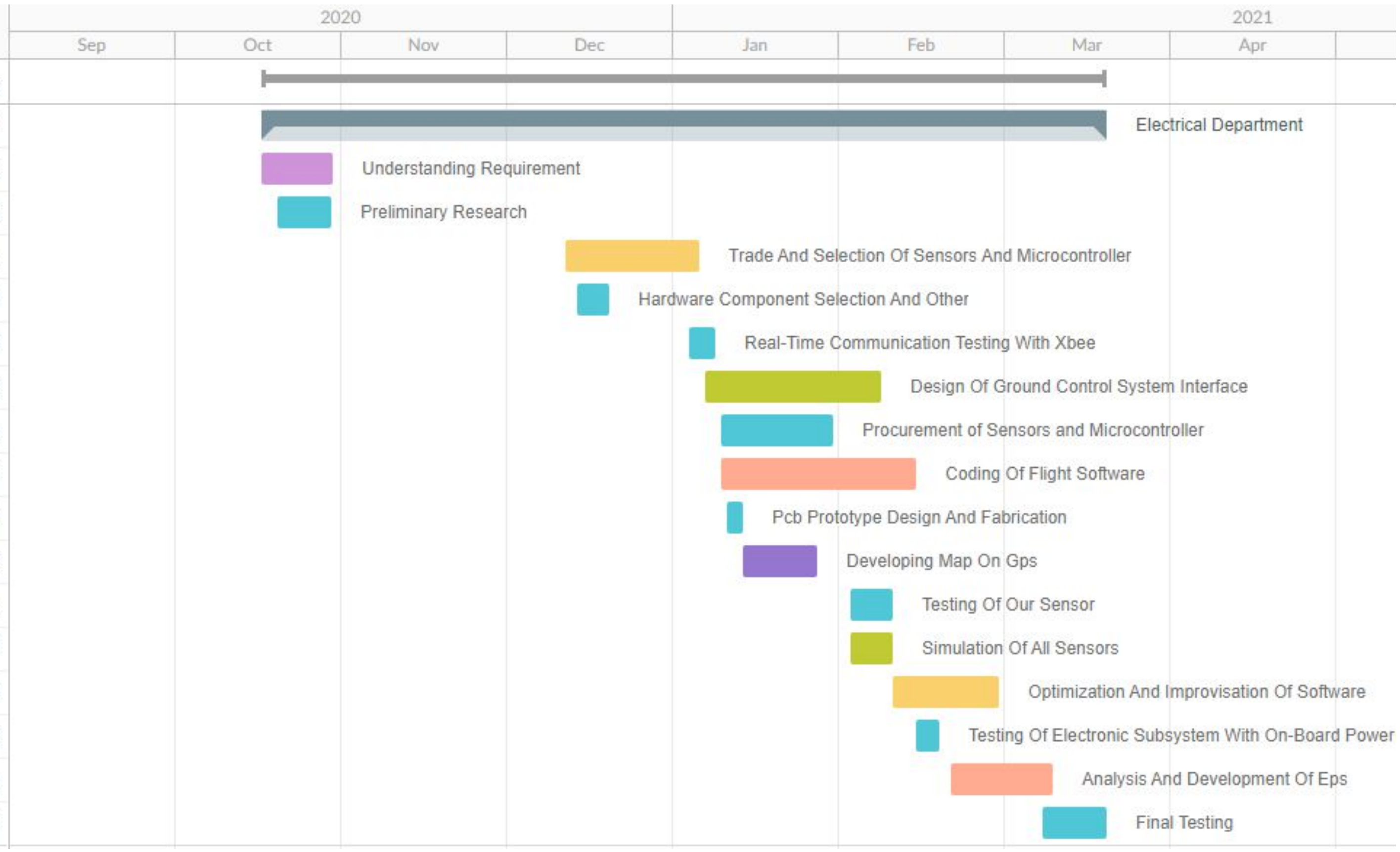



***Fig 13.4:*** *Gantt Chart representing the electrical program schedule for CanSat 2021*

# Shipping and Transportation

*****As the CanSat competition format was changed to conduct the entire process remotely, shipping and transportation is not required*****

However, a detailed outline has been provided for shipping and transportation of our CanSat hardware and tool if the competition were to happen at the launch site.

- CanSat hardware: We would hire a cargo shipping company to ship our CanSat to the launch site from our college in India.
- Tools and Other equipments: We had acquired permission from Indian Airport authorities and other appropriate personal. To carry our equipment with our luggage inside a appropriate container considering all safety precaution.
- Team Members: We would arrange a car from the airport to launch site with a travel agency or though various online taxi service.

# Conclusions

## Electronics and Software Design

**Major Accomplishment**

1. Calibration and testing of sensor completed
2. PCB design completed
3. GCS GUI completed
4. Radio communication system tested
5. FSW states simulated on Proteus
6. CSV file created
7. Toughness and fragility of sensors has been tested

**Major Unfinished Work**

1. PCB not ordered yet
2. Full Electronics integration into Cansat is still pending due to current Covid-19 lockdown restrictions.

## Mechanical System

**Major Accomplishment**

1. Geometry of the wing has been optimized.
2. CAD models and Wing Computational models have been successfully developed.
3. Dynamic model of payload has been created in SIMULINK.
4. Stability and required descent velocity have been verified.
5. Prototype of payload is completed

**Major Unfinished Work**

1. Integrated environmental tests not performed due to current Covid-19 lockdown restrictions.
2. Major fabrication work is not completed due to delays in shipments of component due to current pandemic.
3. Physical Tests cannot be performed due to current Covid-19 lockdown restrictions.