CanSat India 2022-23
Critical Design Review (CDR)

#2022ASI-049
Team Kalpana

Presentation Outline

Team Description

Team Kalpana

Ms Shweta Gautam (**Faculty Advisor**)

3rd Year — VANSH KUMAR GOEL (**Student Head**)

2nd Year — MUSKAN (**Alternative Head**)

ELECTRONICS

- 2nd Year — Yash Sharma
- 2nd Year — Arnav Dev

MECHANICAL

- 2nd Year — Yuvraj Dipak Baishya
- 2nd Year — Divya Rawat
- 2nd Year — Vidushi Bhadana

SOFTWARE

- 2nd Year — Khush Ahuja

Acronyms (1/2)

Acronyms	Full Form
AA	Acceleration Accuracy
ABS	Acrylonitrile Butadiene Styrene
AVI	Audio Video Interleave
Pt	Antenna Transmit Power
BOB	Break Out Board
BMS	Battery Management System
COTS	Commercial off the shelf
DS	Datasheet
DOF	Degree of Freedom
EPS	Electrical Power System
ESD	Electrostatic Discharge
EIRP	Equivalent Isotropic Radiated Power
E	Estimate

Acronyms	Full Form
FSW	Flight software Design
GNSS	Global Navigation Satellite System
GUI	Graphical User Interface
GCS	Ground Control System
GSV	GPS Satellites in View
I2C	Inter Integrated Circuit
LED	Light Emitting Diode
LPWAN	Low Power Wide Area Network
LNA	Low Noise Amplifier
MHz	Mega Hertz
Min	Minute
MOI	Moment of Inertia
NA	Not Applicable

Acronyms (2/2)

Acronyms	Full Form
Omni	Omnidirectional
PA	Position Accuracy
PWM	Pulse Width Modulation
RCBL	Rechargeable
SD	Secure Digital
SPI	Serial Peripheral Interface
SW	Solidworks Software
SMT	Surface Mount Device
Temp	Temperature
TH	Through Hole
TTFF	Time To First Fix
Gt	Transmit-Antenna Gain
TX	Transmitter

Acronyms	Full Form
UART	Universal Asynchronous Receiver-Transmitter
VA	Velocity Accuracy
VSWR	Voltage Standing Wave Ratio

System Overview

Brief Summary of Mission

Main objectives

1. Design the cansat having weight of 0.700 kg (+/- 0.050), with dimensions not more than 0.125m diameter and 0.310m height.
2. The cansat will be launched to an altitude of 800 to 900 m from the ground level.
3. The cansat will release the main and drogue chutes at different altitudes during the descent time.
4. First parachute will be released as soon as the CanSat is released from rocket.
5. The descent velocity of Cansat is 20 m/s (+/- 5 m/s) .
6. For the 2nd parachute will be deployed at an altitude of 500m (+/- 10 m).
7. The descent velocity of Cansat will change from 20m/s to 5m/s.

Optional Objectives

1. Novel descent control and Innovative materials.
2. Additional innovative sensor and communication system.
3. Provision of video capture from separation till final touchdown.
4. Innovative recovery techniques viz. HAM radio/ advance beacon.
5. Innovative quality and Reliability analysis methodologies.

External Objectives

1. Greater awareness created amongst educational institutions about CanSats.
2. We are trying to secure an esteemed position in the inaugural Cansat India Competition, 2023.
3. We wish to gain experience and knowledge,make a student satellite, and successfully launch it.
4. We are exploring better manufacturing opportunities.

Changes Since PDR (1/3)

ELECTRONICS	COMPONENT	PDR	CDR	REASON
	Battery	LG INR18650MH1	**Panasonic NCR18650GA**	• Higher charge capacity
	NavIC/GNSS Receiver	SkyTraQ S1216F8 G13	**Quectel L89**	• There was an issue with the availability of **Break Out Board** • **Low form** factor & **lightweight** design
	EPS	• 2 separate power subsystems • 3 batteries used for running the power bus	**Single power subsystem run by 2 batteries**	• Reduction in **weight** • Reduction in **number of boosters** required

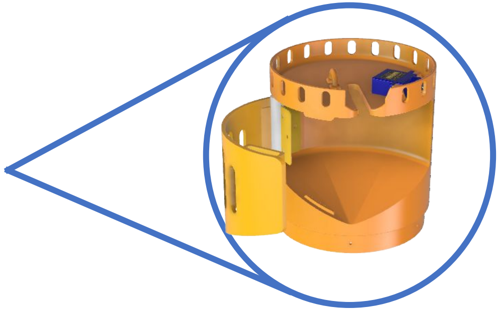
Changes Since PDR (2/3)

SOFTWARE	COMPONENT	PDR	CDR	REASON
	Frames	**Individual frames for each graph** in PDR model of GUI, due to which we had to create multiple figures that was placing **heavy load** over the system	Created **multiple subplots inside a single figure** that **improved** overall **running efficiency** of the GUI	**Decreased overall load** over the system since other tasks were also executing simultaneously
	Widgets	Some **redundant widgets present** that were not required.	GUI upgraded with **no such unnecessary** labels,frames or any Qt **widgets**.	**Improved** the **overall working** of GUI and discard non-usable components to improve the UI.

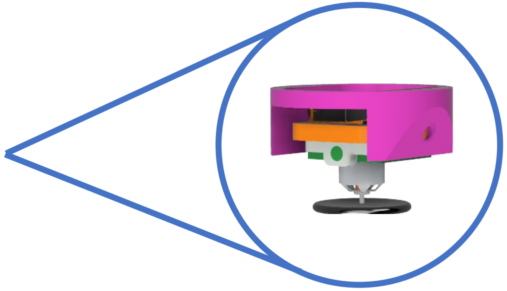
Changes Since PDR (3/3)

MECHANICAL	COMPONENT	PDR	CDR	REASON
	Gyroscope	The Gyroscope model was made with the **flywheel** being connected to a **longer rotating shaft**	The Gyroscope model is connected to a **shorter rotating shaft**	This was done to **increase** the **degree of freedom** of the **flywheel** inside the CanSat container.
	Topology Optimization	The PDR model **did not undergo** any **topology optimization** which led to the CanSat's **increased weight**	The CDR model underwent **topology optimization** which **decreased weight** of the CanSat.	This was done to **increase** the **weight margin** and add or improve important components inside the CanSat.
	Base of gyroscope	There is a **plate between** electronics compartment and gyro model.	The **plate** has been extended **downwards.**	For **better connections** and to **decrease links**.
	Parachute compartment	There were **two o rings** to connect to primary and secondary parachute	There is **one o ring** and a cavity is made in place of another o ring to connect primary parachute directly to the secondary parachute.	To **increase drag** force.

System Level Requirement (1/2)

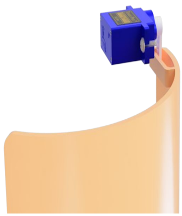


Parachute compartment

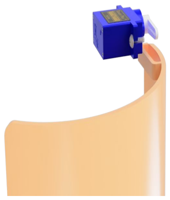


Gyro compartment

1. The shroud lines of the **first parachute** are connected to the second parachute.
2. The **second parachute** is attached to the bigger hook through an o-ring.
3. The **Parachute compartment** gate is kept in place by a servo shaft which locks the compartment gate.



Locked configuration



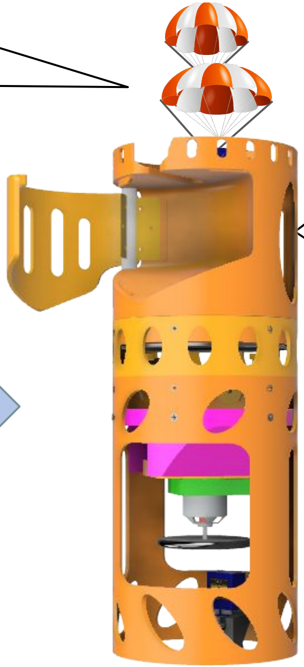
Unlocked configuration

1. The **servo motor** is connected to the shaft.
2. The pitch servo will help to rotate the wheel of gyro.
3. Its working is based on **bias momentum control method.**
4. As the rotor tilts the changing **angular momentum** causes a **gyroscopic torque** that rotates the spacecraft.

System Level Requirement (2/2)

The **first parachute** is deployed as soon as **CanSat releases** from rocket.

The **second parachute** is deployed at an altitude of **500m** (+/-10m) from CanSat.



Servo motor **unlocks** the **parachute** lid.

Stowed Configuration

First Parachute Deployment

Second Parachute Deployment

Program Schedule Overview

S No.	Name	Start Date (DD/MM/YY)	End Date (DD/MM/YY)	Percentage Completion	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN
1	The mission statement was analysed and preparation for the competition started.	13/08/22	16/08/22	100%											
2	Team Member Recruitment	17/08/22	21/08/22	100%											
3	A presentation was prepared based on the CanSat mission requirements and competition guide, and presented to the faculty in-charge	22/08/22	22/08/22	100%											
4	Ideation on several mechanism and sensors selection started	23/08/22	28/08/22	100%											
5	FSW logic was ideated and selected	28/08/22	31/08/22	100%											
6	Class Tests of Team Members	01/09/22	07/09/22	100%											
7	Shortlisted mechanical designs were simulated and electronic components were selected and ordered	08/09/22	15/09/22	100%											
8	Basic GCS requirements were fulfilled and Electronic circuit developed and tested	16/09/22	18/09/22	100%											
9	Mid Semester Exams	19/09/22	24/09/22	100%											
10	PCB design begins. GCS front end development completely designed and started working on PDR .	25/09/22	29/09/22	100%											
11	PDR compiled and mailed	29/09/22	30/09/22	100%											
12	Preparation of PDR Presentation	5/10//22	10/10/22	100%											
13	Preliminary Design Review Completion	10/10/22	31/10/22	100%											
14	PCBs will be soldered	10/10/22	15/10/22	100%											
15	The fabrication of CANSAT shall begin	1/11/22	10/11/22	100%											
16	End Semester Exams	12/11/22	14/12/22	100%											
17	Final testing of software shall be done.Solutions to any failures will be quickly assimilated into our design. Full scale fabrication of the CanSat shall be completed.	16/12/22	15/01/23	100%											
18	Full scale fabrication of the cansat shall be completed	16/01/23	31/01/23	100%											
19	The CDR shall be compiled and mailed.	01/02/23	15/02/23	100%											
20	Preparation of CDR Presentation & Critical Design Review Completion.	16/02/23	31/03/23	0%											
21	Final Models Printed and complete CANSAT assembly is done	01/04/23	14/04/23	0%											
	Environmental Tests Performed & Design is Refined	15/04/23	15/05/23	0%											
22	Flight Readiness Review & Launch Window	15/05/23	15/06/23	0%											
23	Post Flight Review and Results Declaration	15/06/23	30/06/23	0%											

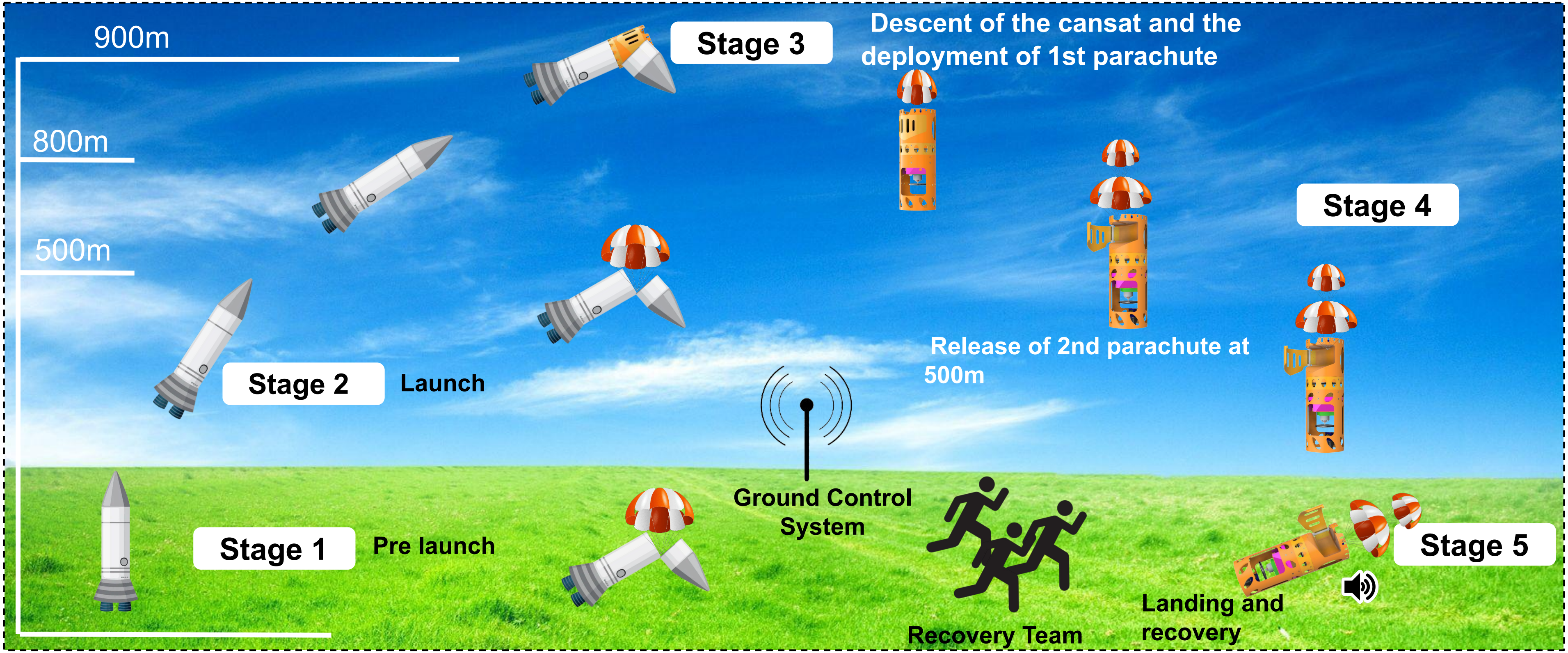
CanSat Work

College Work

CanSat Work To be Done

PFR Work

System Concept of Operation (1/3)



System Concept of Operation (2/3)

PRE- LAUNCH STATE
• CanSat is switched-on. • CanSat is placed in the rocket. • All mechanical systems, sensors, and telemetry facilities are checked for any dysfunctionality. • Ground station is linked with CanSat and CanSat is calibrated. • Telemetry transmission starts.
LAUNCH STATE
• Rocket is Launched. • Altitude increases as rocket ascends. • Apogee reached.
CANSAT DEPLOYMENT STAGE
• CanSat is deployed from the rocket at an altitude of 800m to 900m from ground level. • CanSat immediately deploys the 1st parachute after ejection from the rocket.
CONTAINER DESCENT WITH FIRST PARACHUTE
• The first parachute is deployed after ejection from the rocket, between 800-900 m altitude • The container descends with the first parachute at a speed of 20m/s +/- 5 m/s. • The container shall receive its own telemetry.

System Concept of Operation (3/3)

CONTAINER DESCENT WITH SECOND PARACHUTE

- The Second parachute is deployed.
- The container descent with the second parachute at an altitude of 500m +/- 10m.
- The descent rate of cansat decrease from 20 m/s to (1-3) m/s.

THE MECHANICAL GYRO CONTROL SYSTEM

- The whole cansat is stabilised by active gyro control mechanism.
- We are using bias momentum control method.
- The wheel is rotated and control by BLDC motor and direction of angular momentum is controlled using servo motors.

LANDING

- The Audio Beacon on the container is activated to aid their recovery.
- The container shall relay all telemetry sent from the payload until it lands.

CANSAT RECOVERY AND DATA REDUCTION

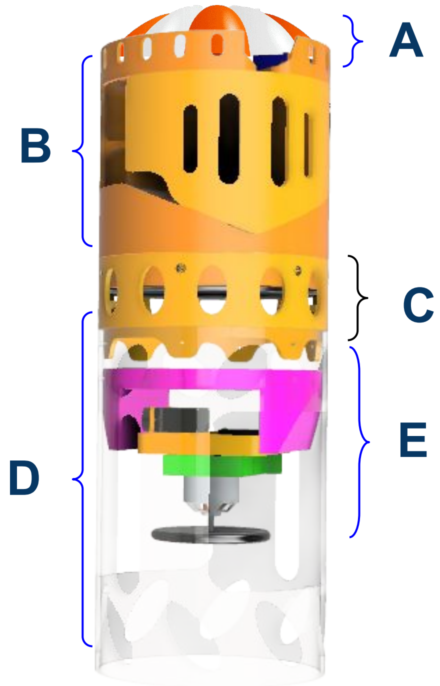
- The Payload is located.
- SD Card is recovered from the CanSat.
- The data is saved in the form of csv files at the GCS (different files for payload and container).
- The PFR is prepared and presented.

Deviations

There are no deviations between specifications in the Mission Guidelines and our CanSat

Physical Layout (1/8)

CANSAT Physical Layout



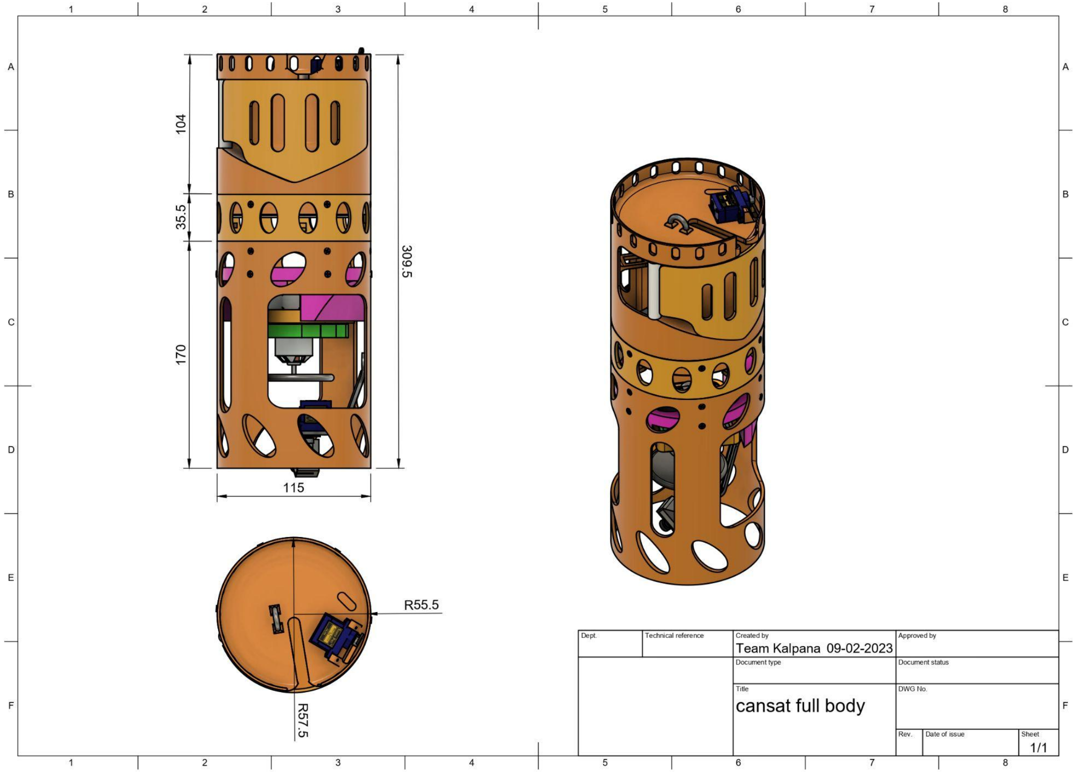
	Components	Dimensions
A	Parachute	Primary Parachute Diameter- **14.74cm** Secondary Parachute Diameter- **143.63cm**
B	Parachute Compartment	Height: **104mm** Inner Diameter: **110mm** Outer Diameter : **115mm**
C	Electronic Compartment	Height: **35.5mm**
D	Gyroscope Compartment	Height: **170mm**
E	Gyro control system	Height: **119.63mm**

Physical Layout (2/8)

Cansat Dimensional Drawing

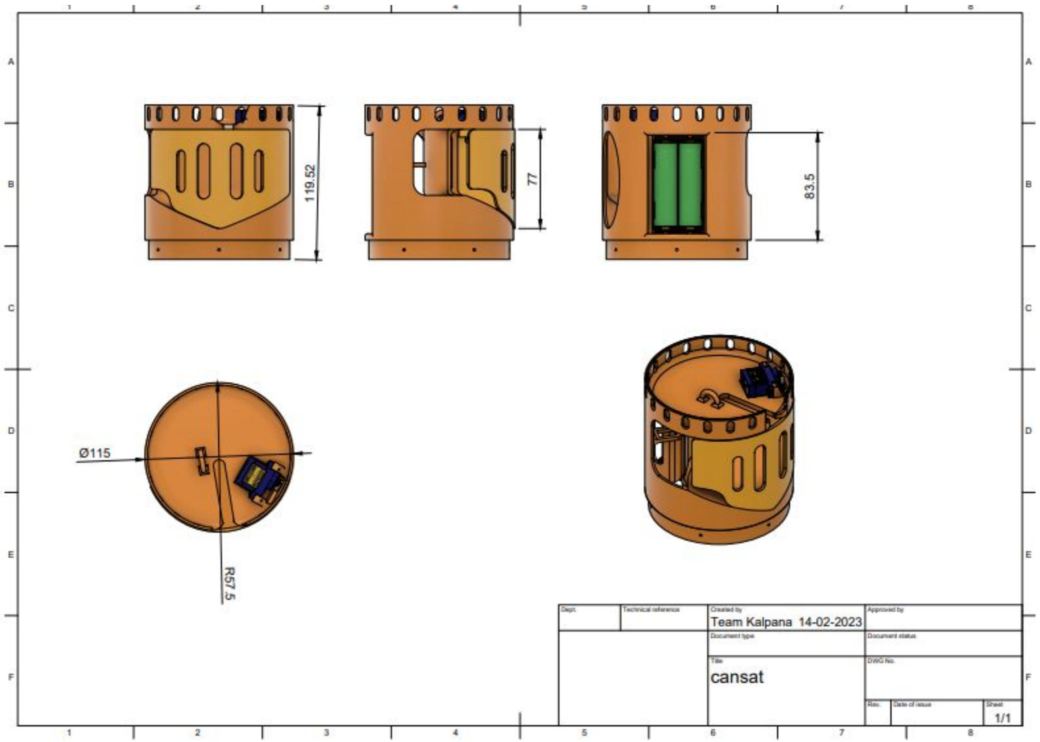
Compartment	Dimension
Parachute	104mm
Electronics	35.5mm
Gyroscope	170mm

Outer Diameter	115mm
Inner Diameter	110mm
Total Height	309.5mm



Parachute Dimensional Drawing

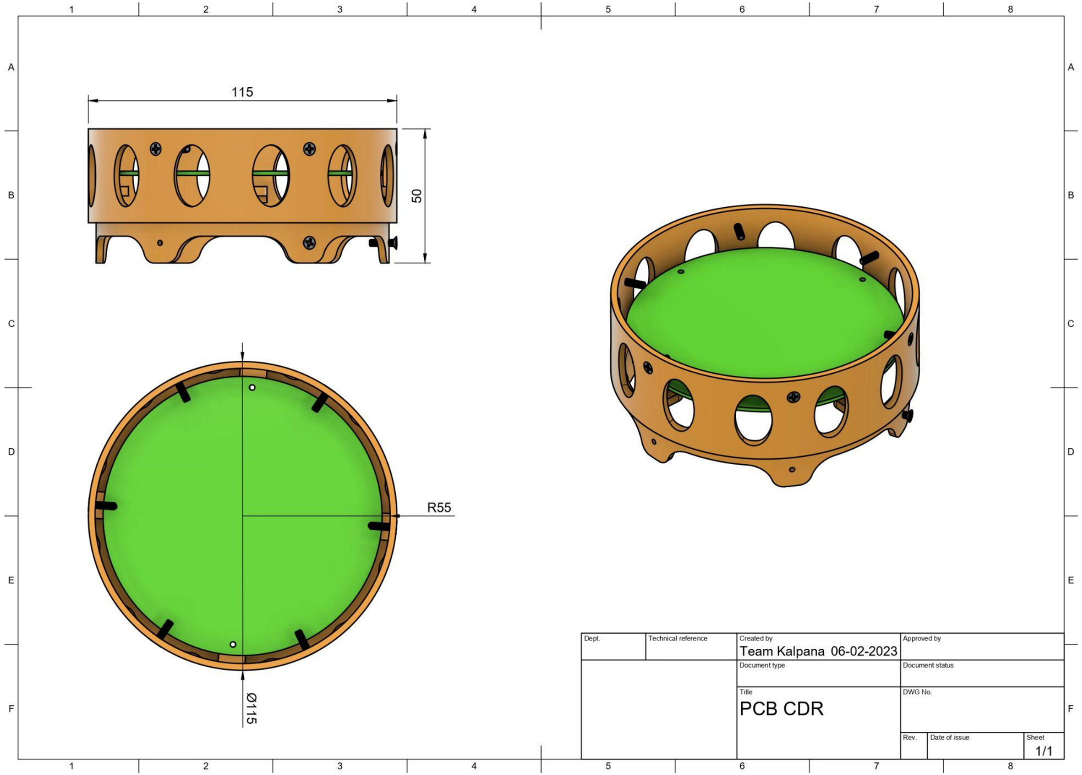
Components	Dimension
Battery Compartment	73.4mm
Parachute Lid	76mm
Parachute Compartment	115.5mm
Outer Diameter	115mm
Inner Diameter	109.2mm



Physical Layout (4/8)

Electronic Compartment Dimensional Drawing

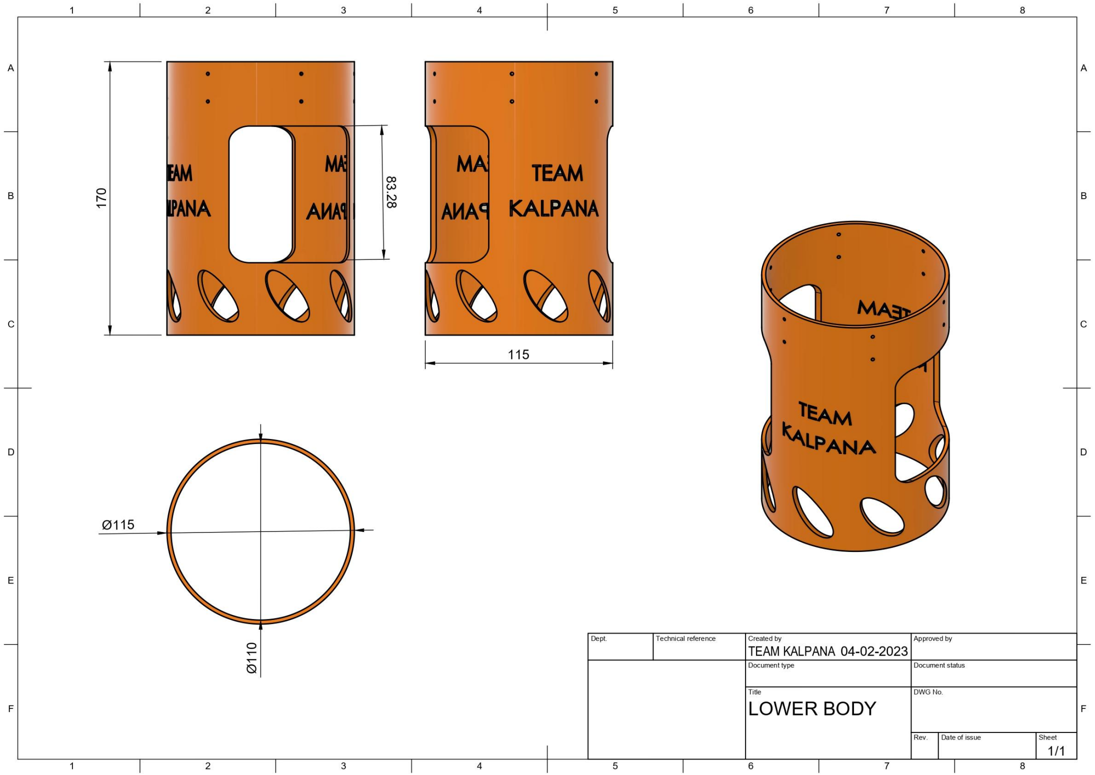
Compartment	Dimension
Height	50mm
Outer Diameter	115mm
Inner Diameter	110mm



Physical Layout (5/8)

Container Dimensional Drawing

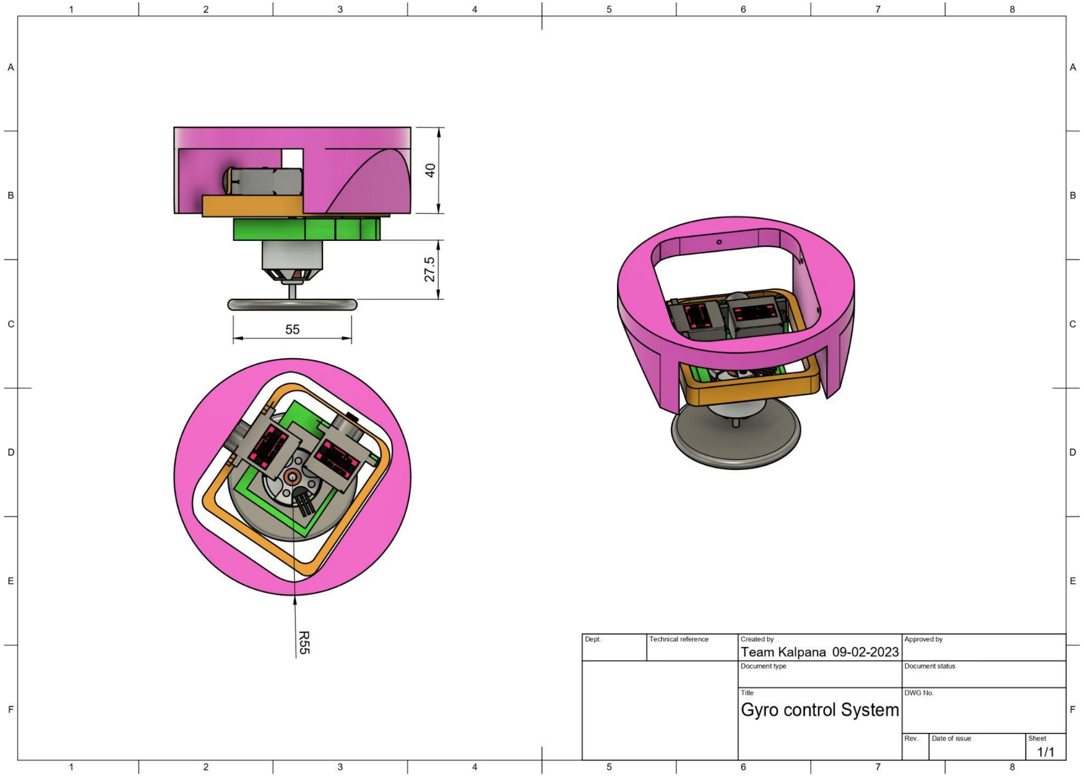
Compartment	Dimension
Height	170 mm
Outer Diameter	115mm
Inner Diameter	110mm



Physical Layout (6/8)

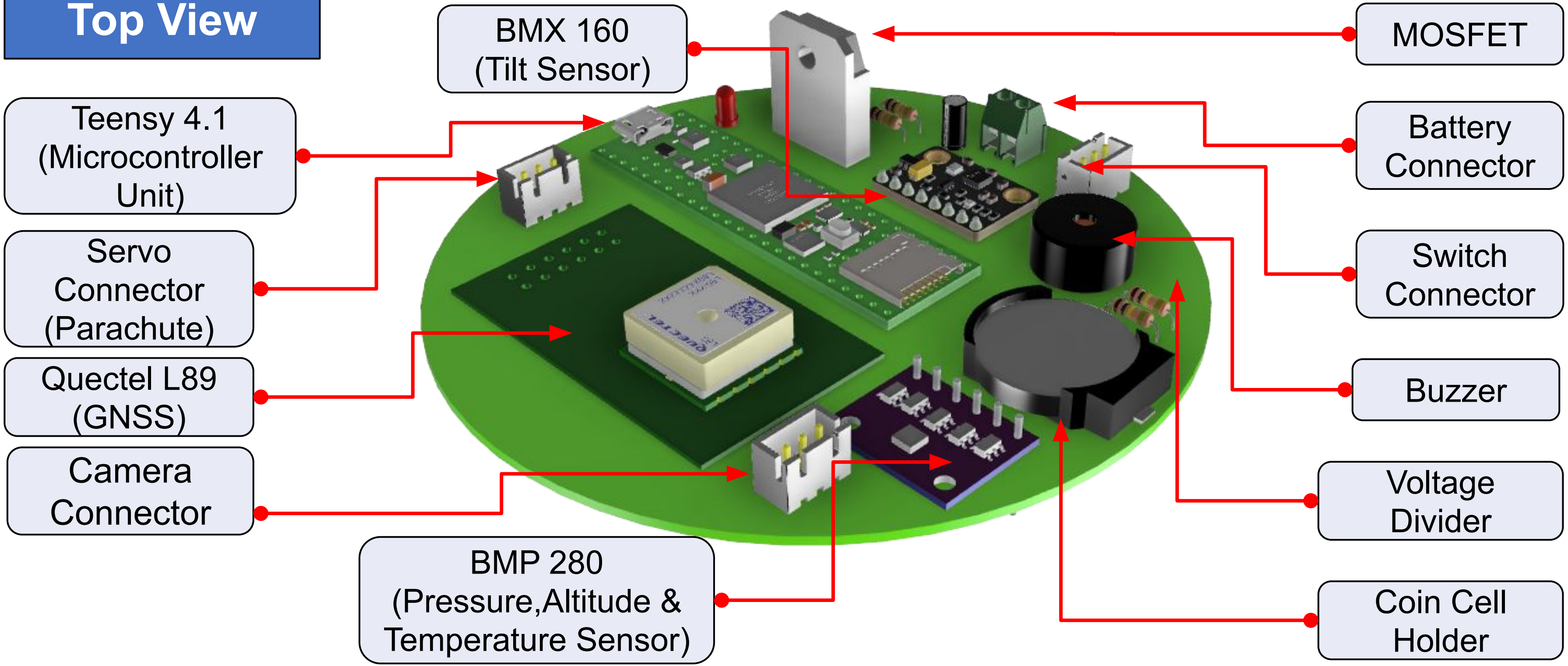
Reaction Wheel Dimensional Drawing

Compartment	Dimension
Wheel Diameter	55 mm
Height	40 mm
Gap between motor base and wheel	27.5 mm



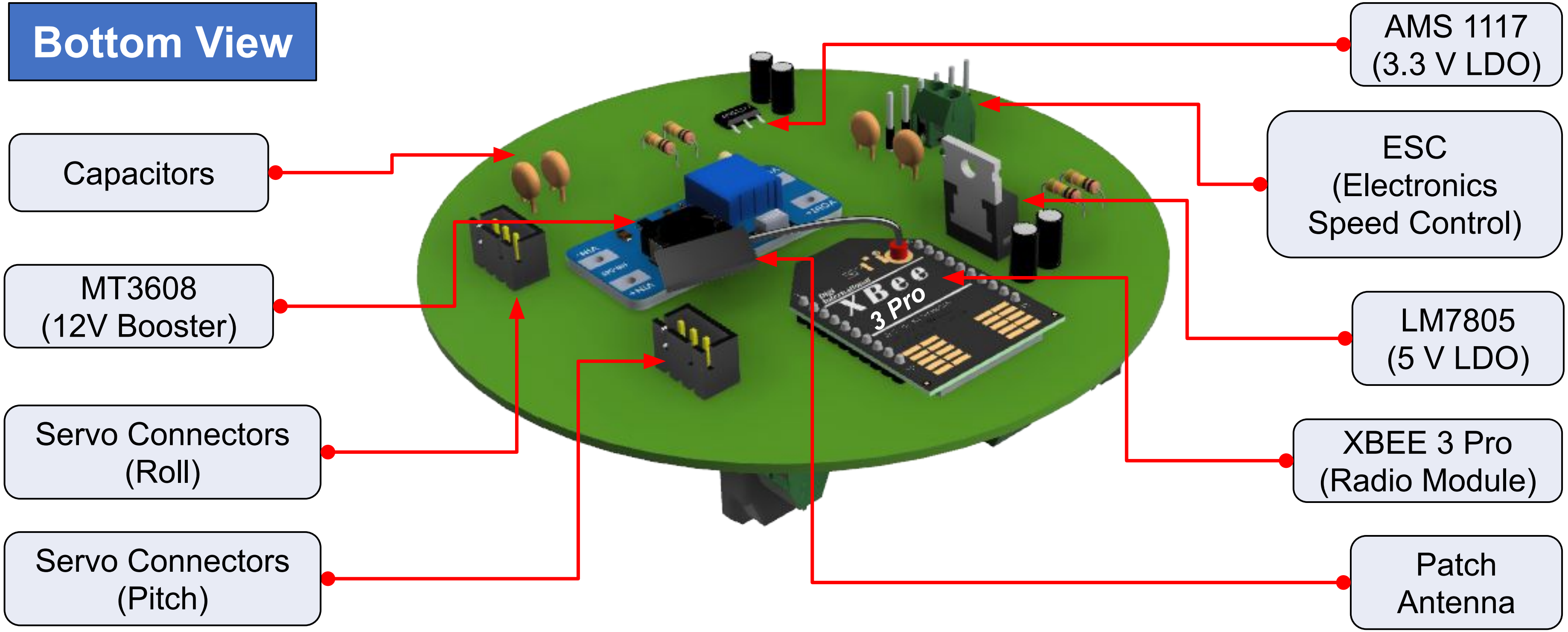
Physical Layout (7/8)

Top View



Physical Layout (8/8)

Bottom View



Material Procurement Details (1/2)

	Component Name	Quantity	Status	Date
ELECTRONICS	BMX 160	1	Received	23/12/22
	MT3608	1	Received	23/12/22
	BMP 280	1	Received	23/12/22
	3.3 V LDO	1	Received	23/12/22
	SG 90	1	Received	23/12/22
	Teensy 4.1	1	Received	23/12/22
	Buzzer	1	Received	20/12/22
	GNSS (Quectel L89)	1	Received	21/12/22
	Battery Case to hold 2 Cells + 2S BMS	1	Received	23/12/22
	18650 Battery Charger	1	Received	23/12/22
	Panasonic NCR18650GA	2	Received	23/12/22
	TAOGLAS FXP 840	1	Received	30/12/22
	XBEE 3 Pro	2	Received	23/12/22

Material Procurement Details (1/2)

	Component Name	Quantity	Status	Expected Date
MECHANICAL	Parachute	2	Has been ordered	17/04/2023
	3D model of parachute compartment	1	Has been printed	15/02/2023
	3D model of gyro control system	5	Has been printed	14/02/2023
	3D model of lower base	1	Has been printed	15/02/2023
	Reaction Wheel	1	Has been machined	14/02/2023
	M2 nut & bolt	18	Ordered	10/02/2023
	Hinge	1	Ordered	14/02/2023
	Teflon pads	4	Ordered	10/03/2023

Flight Readiness Parameters

S. No.	Flight Readiness Parameters
1.	**Mechanical development test** :- It is vital part for us to see the design process to ensure all components work according to specification. To test whether the lid of container will open at the exact time. Both parachute mechanism will be tested.
2.	**Simulation Test** :- We check for GCS software, data transmission, and container functioning. Values are read in the CSV from the server and the data received is then sent to the cansat using XBEE, when the command are received at the container and the simulation commands are sent to CanSat.
3.	**Vibration Test**:- Orbital sander will be used in order to create vibration. Cansat will be placed over the orbital sander in order to test for any failure due to vibration. Also, through this test we can check for possible wear of screws. Ensure that every screw is checked before flight.
4.	**Electronic subsystem development testing** :- A robust connection system was designed to provide power to all flight controller, telemetry imagening ,transmission, gyro system. Connection tested for complete connectivity to avoid high resistance path which caused excessive emission of heat before mission.
5.	**Software development testing** :- Simulate every sensors shutdown or complete shutdowns and ensure that it recovers from last state and not stuck in loops or functions. Accuracy of each sensors tested and with randomly corrupted data in order to check its ability to handle.

Pre Flight Analysis

1

Set up ground station: Everything is configured at the ground station for the feedback system, control, and analysis of real-world data from the cansat. CanSat's **integrity** is examined. **GCS and Cansat** are integrated.

2

Stabilize communication: The **GCS** will be used to **test and validate wireless communication** for consistency.

3

Command Cansat to calibrate:The altitude calibration at the ground station begins. Based on GCS command, the **system** is **calibrated and configured.**

4

System Check: **SD card** and **telemetry data** is provided to judges for scoring. Flight monitoring done on ground station . Dummy telemetry data during mission is collected on system. CanSat is tracked via GNSS coordinates, fluorescent color, and audio beacon.

5

Integrate cansat into Rocket: Before CanSat is integrated into the rocket, **final inspection and clearance** is done. Prior to being mounted onto rocket, **CanSat** is **switched on**, and continuous **wireless communication** with GCS is **confirmed.**

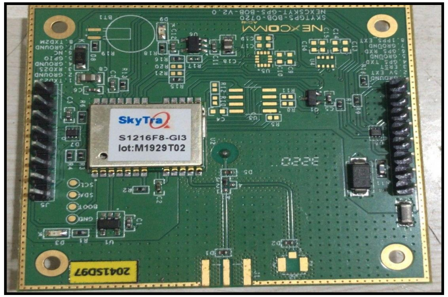
Sensor Subsystems Summary

Sensor Subsystem Summary

Sensor Type	Model Selected	Function	Reason
Gyro/Accelerometer	BMX160 Sensor	Measurement of Acceleration and angular rate (gyroscopic)	• Low power consumption • Low noise • Small form factor
Camera	Adafruit Mini Spy Camera	Capturing the video during descent	• Compact and Lightweight design.
GNSS	Quectel L89	Determining the Location and tracking	• IRNSS enabled GNSS receiver. • Embedded LNA. • Dual antenna present and antenna switch function supported.
Air Pressure/Temperature and Altitude	BMP 280	Measurement of air pressure/ temperature and altitude	• High linearity thus, high accuracy • Supports new filter modes to operate at low noise
Battery Voltage Sensor	Onboard ADC + Voltage Divider	Measurement of battery voltage	• Resistors have small dimensions and are lightweight compared to sensor modules. • Requirement of 1 analog pin over 2 additional I2C pins for sensors.

Sensor Subsystem Changes Since PDR

Sensor Type	PDR	CDR	REASON
GNSS	SkyTraQ S1216F8 G13	**Quectel L89**	• Availability issues in procurement of BOB • Smaller form factor and Lightweight design • It has lower current consumption • It has better tracking sensitivity



SkyTraQ S1216F8 G13

Quectel L89

Air Pressure & Temperature Sensor

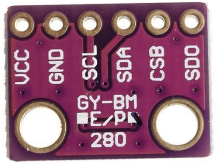
Model	Interface	Voltage (V)	Current (mA)	Accuracy (℃ / hPa)	Resolution (℃ / Pa)	Cost (₹)	Weight (g)	Dimensions (mm³)
BMP280	I2C, SPI	1.71 - 3.6	0.0027	±1.0 / ±0.12	0.10 / 0.16	80	2.0	15.0 x 12.0 x 2.0

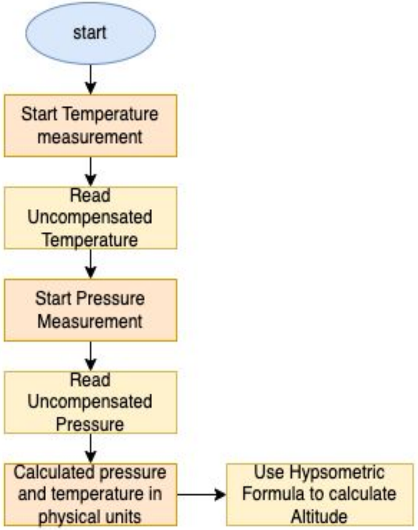
Data Processing

```
#include <Adafruit_BMP280.h>
Adafruit_BMP280 bmp;
void setup(){ bmp.begin(); }
void loop(){
  int p=bmp.readPressure();
  float temp=(bmp.readTemperature(),1);
  Serial.print(F("Temperature = "));
  Serial.print(temp);
  Serial.println(" °C");
  Serial.print(F("Pressure = "));
  Serial.print(p);
  Serial.println(" Pa");
}
```

OUTPUT

```
00:24:19.975 -> Temperature = 17.4 *C
00:24:19.975 -> Pressure = 98932 Pa
00:24:19.975 ->
00:24:20.982 -> Temperature = 17.4 *C
00:24:20.982 -> Pressure = 98928 Pa
00:24:20.982 ->
```





Reasons

- For less noise readings, capability of taking multiple measurements and performing a low pass filter.
- Has high accuracy owing to high linearity

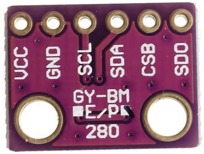
Data Format
xx Pa
xx.x ℃

Altitude Sensor

Model	Interface	Voltage (V)	Current (mA)	Accuracy (℃)	Resolution (℃)	Cost (₹)	Weight (g)	Dimensions (mm³)
BMP280	I2C, SPI	3.3	1.12	±0.10	0.10	80	2.0	15.0 x 12.0 x 2.0

Data Processing

```
#include <Adafruit_BMP280.h>
Adafruit_BMP280 bmp;
float sealevel=1013.25;

void setup(){
bmp.begin();
}
void loop(){
Float
h=bmp.readAltitude(sealevel);
Serial.print(F("Approx altitude =
"));
Serial.print(h);
Serial.println("m");
}
```



OUTPUT

```
Approx altitude = 215.00 m

Approx altitude = 215.13 m

Approx altitude = 214.82 m
```

Reasons

- For less noise readings, capability of taking multiple measurements and performing a low pass filter.
- Has high accuracy owing to high linearity

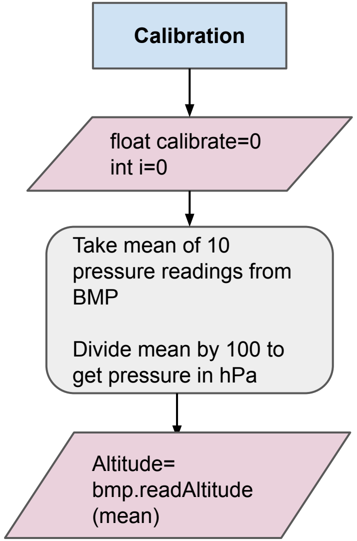
Data Format

xx.xx m

Formula Used

$$h = 44330 \times \left(1 - \left(\frac{P}{P_0}\right)^{\frac{1}{5.255}}\right)$$

h -> altitude
P -> Current pressure value
P_0 -> Pressure at sea level



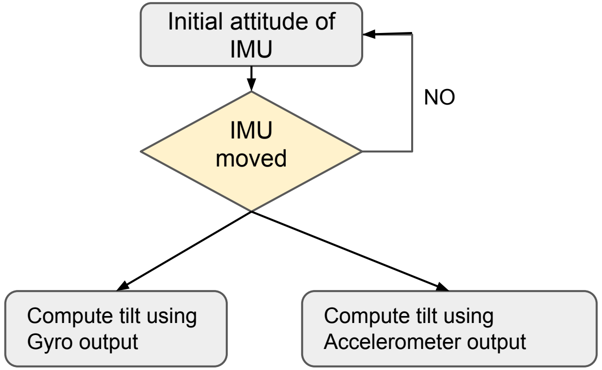
Tilt Sensor

Model	Interface	Voltage (V)	Current (mA)	Resolution			Cost (₹)	DOF	Dimensions (mm³)	Weight (gm)
				g	°/s	µT				
BMX160	I2C	3.3	1.5	2/16	125/16	1150/14	1400	9	20x12x4	3

Data Processing

```
#include <DFRobot_BMX160.h>
DFRobot_BMX160 bmx160;
void setup(){
sBmx160SensorData_t Omagn, Ogyro, Oaccel;
  bmx160.getAllData(&Omagn, &Ogyro, &Oaccel);
bmx160.begin();
}
void loop(){
  /* Display the gyroscope results (gyroscope data is in g) */
  Serial.print("G ");
  Serial.print("X: "); Serial.print(Ogyro.x); Serial.print("  ");
  Serial.print("Y: "); Serial.print(Ogyro.y); Serial.print("  ");
  Serial.print("Z: "); Serial.print(Ogyro.z); Serial.print("  ");
  Serial.println("g");
  /* Display the accelerometer results (accelerometer data is in m/s^2) */
  Serial.print("A ");
  Serial.print("X: "); Serial.print(Oaccel.x     ); Serial.print("  ");
  Serial.print("Y: "); Serial.print(Oaccel.y     ); Serial.print("  ");
  Serial.print("Z: "); Serial.print(Oaccel.z     ); Serial.print("  ");
  Serial.println("m/s^2");
}
```

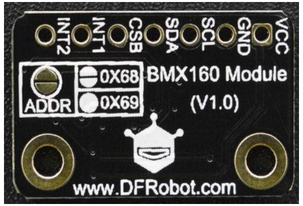
```
A X: -0.49  Y: -4.63  Z: 8.89  m/s^2

G X: 0.25  Y: 0.12  Z: 0.34  g
A X: -0.44  Y: -4.73  Z: 8.83  m/s^2

G X: -0.02  Y: -0.02  Z: 0.09  g
A X: -0.44  Y: -4.57  Z: 8.85  m/s^2
```



Reasons

- Delivers low noise readings by supporting multiple filter modes.
- It has a Small form factor (physical size)

Data Format
xx.xx g
xx.xx m/s²



Camera (1/2)

Model	Voltage (V)	Current (mA)	Resolution (px*px)	Cost (₹)	Weight (g)	Size (mm³)
ADAFRUIT MINI SPY CAMERA	3.7-5	110	1280 x 720	1000	2.8	28.5 x 17 x 4.2

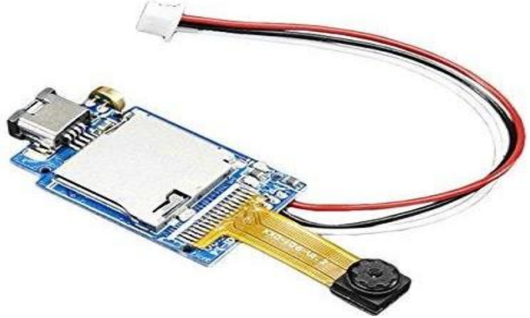
Data Processing

```
int cam=2;
void setup() {
  pinMode(cam,OUTPUT);
  digitalWrite(cam,HIGH);
}
void loop(){
  digitalWrite(cam,LOW);
  delay(50);
  digitalWrite(cam,HIGH);
  delay(60000);
  digitalWrite(cam,LOW);
  delay(600);
  digitalWrite(cam,HIGH);
}
```

To start recording the video we have to touch the trigger pin to GND for less than 100 ms

delay(60000);
Length of recording

To stop recording the video we have to touch the trigger pin to GND for more than 500 ms



Reasons

- It has an integrated driver
- It has a small form factor (physical size and weight)

Data Format
AVI

Video Recorded in above format will be saved onto SD card after we stop recording with the given lines of code.

Camera (2/2)

Inspector

MOVI0000.AVI

General:

Source:	/Volumes/NO NAME/VIDEO/ MOVI0000.AVI
Resolution:	1280 × 720
Data Size:	12.7 MB
Current Size:	2517 × 1416
Video Format:	Motion JPEG OpenDML
Audio Format:	Linear PCM, 16 bit little-endian signed integer, 8000 Hz

Video Details:

Encoded FPS:	30
Aspect Ratio:	16:9
Current Scale:	1.97×
Colour Primaries:	Untagged
Transfer Function:	Untagged
YCbCr Matrix:	Untagged
Code Points:	Untagged
Track ID:	1667510320

Audio Details:

Channels:	Mono
Track ID:	1651978544

Resolution and fps

Specifications of Video Captured using Adafruit 3202 Mini Spy Camera

Picture captured by Adafruit 3202 Mini Spy Camera

Battery Voltage Sensor

Sensor	Interface	Voltage (V)	Resolution (mV)	Cost (₹)	Weight (g)	Dimensions (mm³)
Onboard ADC + Voltage Divider	Analog	0 - 7.4	13.3/1024 = 12.98	N/A	N/A	N/A

Data Processing

```
void setup() {
  Serial.begin(9600);
}
void loop() {
  int sensorValue =
analogRead(A10);
  float voltage = sensorValue * (3.3 /
1024.0);
  float
battery_voltage=voltage*(13.3/3.3);
  Serial.println(battery_voltage);
Serial.println("------");
 delay(1000);
}
```

OUTPUT

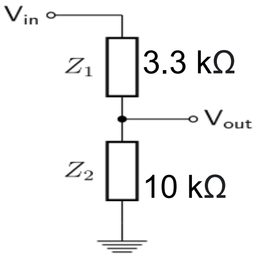
```
20:21:33.245 -> 3.38
20:21:33.245 -> ------
20:21:34.246 -> 3.38
20:21:34.246 -> ------
```

Data Format

xx.xx V

Reasons

- As we do not require external module hence, it is easier to implement.
- In Teensy 4.1 we have onboard Analog to Digital Converter (ADC) through which we can read the battery voltage after Voltage Divider.



Analog read V_{in}

Teensy 4.1 uses onboard ADC to measure voltage divider circuit to measure battery voltage that exceeds its operating range of 3.3V, allowing accurate reading and processing.

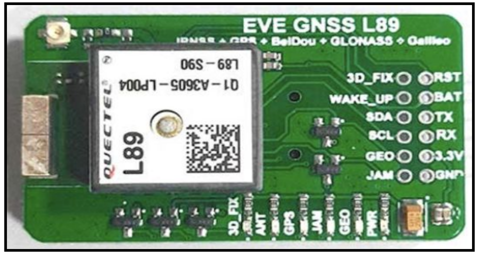
$$V_{out} = V_{in} \times \frac{Z_2}{Z_1 + Z_2}$$

To obtain voltage reading, Analog read is multiplied by a factor of 13.3/3.3

NavIC/GNSS Receiver (1/2)

Model	Interface	Voltage (V)	Current(mA)	Accuracy	Cost (₹)	Weight (g)	Dimensions (mm^3)
QUECTEL L89	I2C,UART	3.3	99.0	VA < 0.1m/s AA < 0.1m/s^2 PA ~ 1.8m CEP	1,410.10	8.2	50 x 30 x 6.8

DATA FORMAT				
<GNSS_TIME>	<GNSS_LATITUDE>	<GNSS_LONGITUDE>	<GNSS_ALTITUDE>	<GNSS_SATS>
xx:xx:xx	xx.xxxx N	xxx.xxxx E	xxx.x m	xx



Reasons

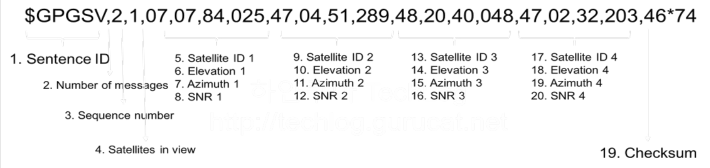
- With **2 embedded antennas**, module works at **L1 and L5 bands** simultaneously - increasing number of visible satellites, reducing TTFF and **enhancing positioning accuracy**, especially in rough urban terrain.
- Great **anti-jamming performance** due to multi-tone active interference canceller

NavIC/GNSS Receiver (2/2)

Output

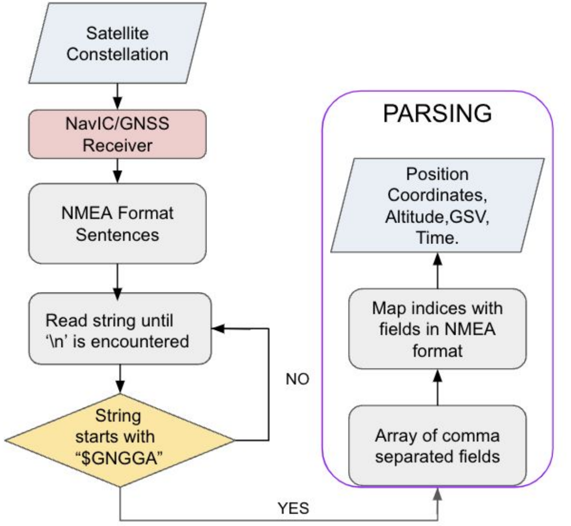
```
11:10:50.094 -> -------------------------
11:10:50.409 -> IRNSS/NavIC SIGNALS: $GIGSV,1,1,02,03,57,167,31,06,,,24,1*4C
11:10:51.062 -> $GNGGA,054051.000,2836.827208,N,07702.294928,E,2,13,1.46,211.597,M,-36.114,M,,*56
11:10:51.062 -> Satellites: 13
11:10:51.062 -> Altitude: 211.597 m
11:10:51.062 -> Latitude: 28.6138 N
11:10:51.062 -> Longitude: 77.0382 E
11:10:51.062 -> Time: 05:40:51.00
11:10:51.062 -> Indian Standard Time: 11:10:51
11:10:51.062 -> -------------------------
```

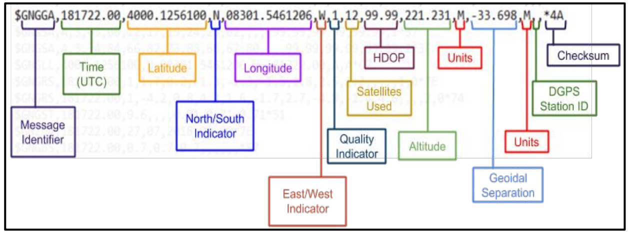
- ➔ An IRNSS enabled GNSS module has been used.
- ➔ Indicated herein are the NavIC/IRNSS NMEA message strings received i.e. GSV sentence with talker ID $GI (for NavIC).
- ➔ The $GNGGA sentence has been parsed for required communication data.



Data Processing

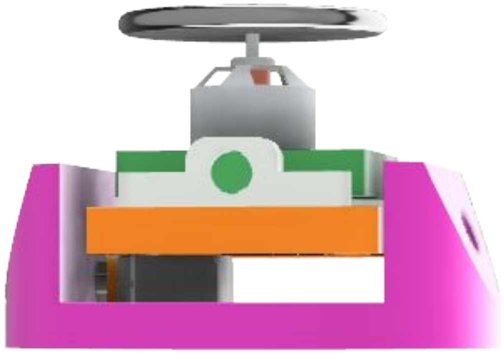
```
String sentence =
mySerial.readStringUntil('\n');
if (sentence.startsWith("$GNGGA")) {
      Serial.println(sentence);
      String parts[15];
      int i = 0;
      char * pch = strtok (sentence.c_str(),",");
      while (pch != NULL) {
        parts[i++] = pch;
        pch = strtok (NULL, ","); }
      String Satellites = parts[7];
      String altitude = parts[9];
      String time = parts[1];
      String latitude_full = parts[2];
      int
latitude_degrees=int((int)(latitude_float)/100);
      String longitude_full = parts[4];
      float longitude_minutes=
((longitude_float-(longitude_degrees*100.0))/
60.0);
      float
longitude_converted=longitude_degrees +
longitude_minutes;
```





Actuator Summary

Control Mechanisms of the Actuator



Unique Mechanism to Control Gyro's Gimbals

Shaft of servo motors fixed to the frame of the gyroscope

SENSOR

- **Sensors -** sense the state of the **surrounding** environment and send data to the **processor**.
- The sensor is an IMU (**Inertial Measurement Unit**), to measure the **tilt** of the CanSat hence, the **deviation along pitch and roll axes.**
- We have chosen **BMX 160** as our IMU.

Processor

Teensy 4.1

ACTUATORS

- Actuator we will be using are the MG90 Servo Motors
- The servo motors themselves will rest on the platforms connected to the gimbals, which will facilitate the movement.

System Level Gyroscope Attitude Control

The **Gyroscopic Attitude control** will be done by following the **Law of Conservation of Angular Momentum.** The formula which will be used is -

$$M_w(r_w)^2(\omega_w) = \frac{1}{2}[(M_c)\{(r_c)^2 + \frac{1}{3}(L_c)^2\}]\omega_w$$

$$\omega_p = \frac{2g}{(r_w) \times (\omega_w)}$$

- Stabilisation is **not done** along **Yaw** axis.We understand that **unlike sensors**, **motors** are **mechanical** devices that will have some **inertia** even after changing PWM signals to vary their speed hence,there'll be some **latency**.

- To **conserve Angular Momentum**, the CanSat may start **rotating opposite** to that of the flywheel owing to this latency. Thus, the Gyroscope will be held in a frame held by **bearings** in order to **prevent tangling** of the Parachutes due to **torsional** inertial movement of the CanSat

Calculations & Formulae

M_W (g)	W_W (RPM)	W_P (rad/sec)	W_C (rad/sec)
100	1500	6075.32	0.087266
100	1500	3037.66	0.174532
100	1500	2025.09	0.261799
100	1500	1012.54	0.523598
100	1300	6075.3206	0.087266
100	1300	3037.66	0.174532
100	1300	2025.09	0.261799
100	1300	1012.54	0.523598
100	1000	6075.32	0.087266
100	1000	2025.09	0.261799
100	1000	1012.5474	0.523598

ASSUMPTIONS	
M_C	600 g
R_W	50mm

ASSUMPTIONS	
R_C	57.5mm
L_c	309.5mm

W_W	angular velocity of wheel
M_W	Mass of wheel
R_W	Radius of wheel
M_C	Mass of CanSat
R_C	Radius of cansat
W_P	Angular Precision of the Gyroscope
W_C	Angular Precision of the Cansat Container
L_C	Length of the cansat

Torque produced in CanSat due to tilt =
MOI of CanSat x Angular velocity of CanSat

$$\frac{1}{2}[(M_c)\{(r_c{}^2)+\frac{1}{3}(L_c)^2\}]\omega_c$$

Torque in reaction wheel(I) =

$$M_w(r_w)^2(\omega_w)$$

CanSat stabilisation:
Torque by CanSat =Torque by reaction wheel

$$M_w(r_w)^2(\omega_w)=\frac{1}{2}[(M_c)\{(r_c{}^2)+\frac{1}{3}(L_c)^2\}]\omega_c$$

Moment of inertia

MOI of wheel= $M_w(r_w)^2$

MOI of cansat= $\frac{1}{2}[(M_c)\{(r_c)^2+\frac{1}{3}(L_c)^2\}]$

Angle of Precision

$$\omega_p=\frac{r_w\times M_w\times g}{\frac{1}{2}\times M_w\times r_w{}^2\times\omega_w}\qquad \omega_p=\frac{r_w\times M_w\times g}{I\times\omega_w}\qquad \omega_p=\frac{2g}{(r_w)\times(\omega_w)}$$

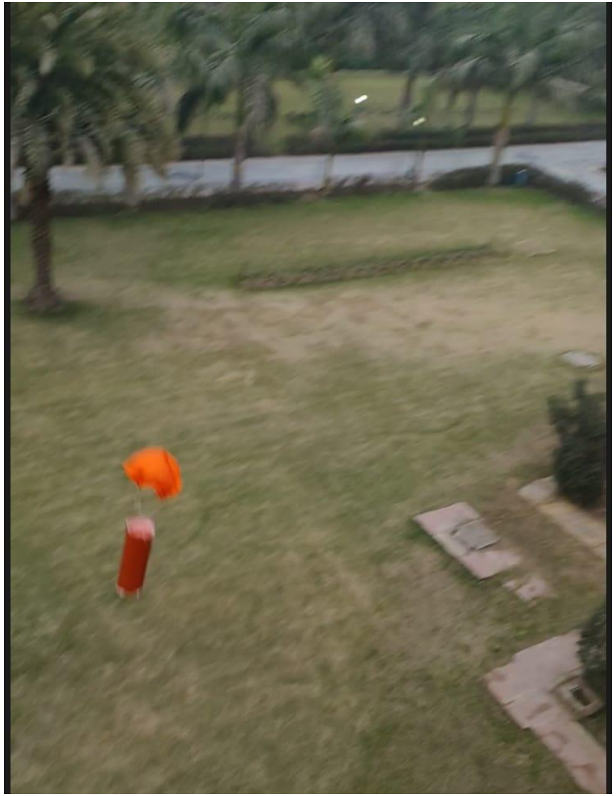
Descent Control Mechanism

Descent Control Changes Since PDR

COMPONENTS	PDR	CDR	REASON
Primary Parachute	Diameter was **20.94cm**	New diameter is **14.74cm**	As parachute with coefficient of drag 2.2 was easily available.
Secondary Parachute	Diameter was **204.15cm**	New diameter is **143.63cm**	
Parachute Compartment	Both parachutes are connected to their respective **o rings.**	One of the O rings has been removed and the middle O ring is placed adjacent to the new cavity made in the parachute compartment.	As both the parachutes are connected to each other in series ,the drag force will be used more efficiently thus achieving the the required descent velocity.

Descent Control Prototype Testing

Objective	Procedure	Observation
To examine CanSat descent rate when the second parachute is deployed	Tie the second parachute to the dummy CanSat and measure the descent time to determine the descent rate	We observed that the Cansat's descent velocity was a bit off from the desired descent velocity by a margin of 2 m/s.



Descent Control Overview

Descent Control System

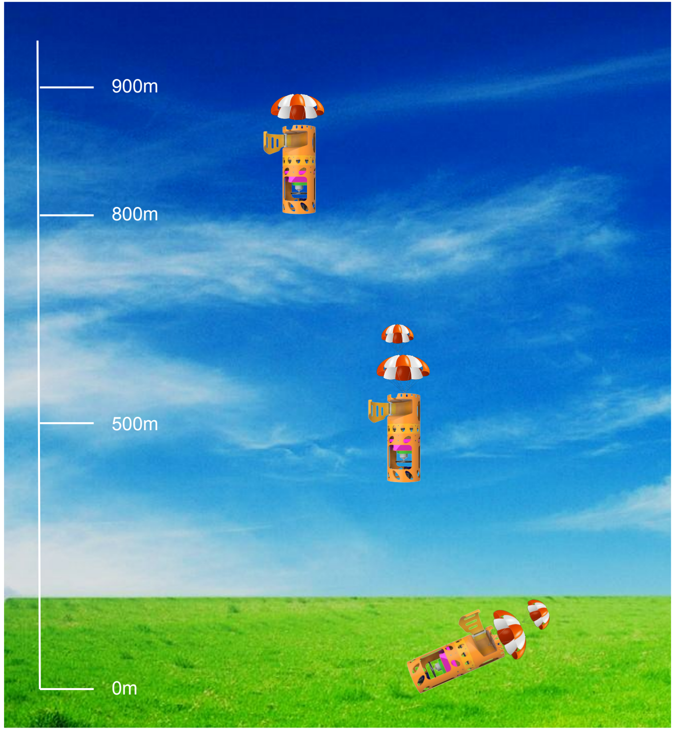
Container Descent: The container descends with the help of a **hexagonal parachute** of **diameter 14.74 cm** at a **descent velocity** of **20(+/-5)m/s**.

At the **altitude** of **500m**, **secondary** hexagonal parachute of **diameter 143.63 cm** is released to decrease the descent rate of the CanSat to **1-3m/s**.

Configuration

Parachute Compartment with an **accessible side lid** used for deployment of the **secondary parachute**.

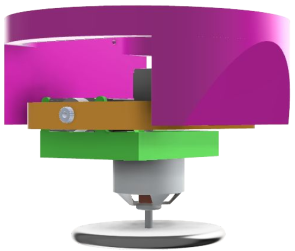
Container Hexagonal Parachutes are made of **ripstop nylon** with **diameters 14.74 cm** and **143.63 cm**, respectively.



Descent Control Overview

Selected Configuration

Two gimbal control mechanisms are used in gyro. Whenever the cansat tilts in pitch or yaw axis while descending, the gyro corrects its orientation by the help of its reaction wheel.



Parachute compartment:

-Secondary parachute is stowed inside the parachute compartment and it's shroud lines is connected to o ring.
-Primary parachute is kept at the top of the parachute compartment and it's shroud lines is connected to secondary parachute spill hole.

Container Descent Control Hardware (1/4)

DESCENT CONTROL HARDWARE

- The CanSat has two parachute for different altitudes.
- Primary parachute is directly connected to the secondary parachute which is connected to the **o ring**.
- First parachute immediately deploys after the CanSat is ejected from the rocket at an altitude **800-900** m from the ground.
- When the CanSat reaches **500** meters, the parachute compartment door will be opened by a servo motor and the secondary parachute will be deployed.

Container Descent Control Hardware (2/4)

Passive Components				
Parachute Type	**Shape**	**Color**	**Material**	**Reason**
First Parachute	Hexagonal	Fluorescent orange	Ripstop nylon	● It is cost efficient ● It has high drag coefficient. ● These are lightweight and easily foldable ● It provide **Stable** descent due to **spill hole** in the parachute design
Second Parachute	Hexagonal	Fluorescent orange	Ripstop nylon	
Slots (oval) in the parachute compartment have been provided for the airflow to passively release the secondary parachute which is stowed inside it.				

Active Components
Servo motor
BMP 280 (Altitude Sensor)

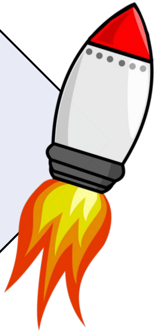
Key Considerations:
- Hexagonal Parachutes with Drag Coefficient 2.2 are used
- BMP 280 is a barometric pressure sensor which detects the height.
- Servo Motor facilitates the release of the parachutes on receiving command from the BMP 280

Container Descent Control

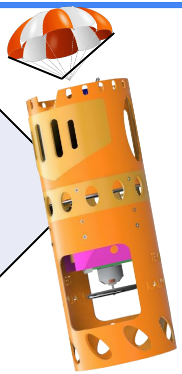
Hardware : Parachutes with Spill Hole

Container Descent Control Hardware(3/4)

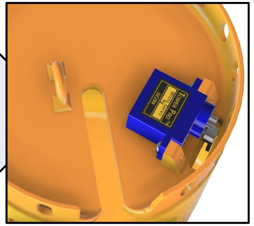
Rocket reaches apogee



Primary parachute is released from the rocket, air will push back and flow into the canopy of the parachute, increasing drag until a terminal velocity of **19.64 m/s** is attained.

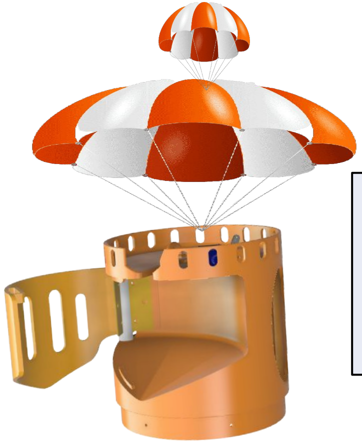


At 500 m servo motor will rotate 180 angle.



The primary parachute reduces the descent rate to 19.64m/s.

After the release of the secondary parachute,the descent rate is reduced to 1.96 m/s.



Second parachute will deploy

Container Descent Control Hardware (4/4)

v	Descent Velocity
$\mathbf{C_d}$	Coefficient of Drag
m	Mass of CanSat
$\mathbf{A_1}$	Area of Primary parachute
$\mathbf{A_2}$	Area of Secondary Parachute

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

Formula used for Calculation of Descent Velocity

Assumptions-

- The effect of crosswind is neglected.
- The value of (g) is taken 9.81 m/s^2
- The force due to gravity will be balanced by the drag force.

Calculation of First Parachute:

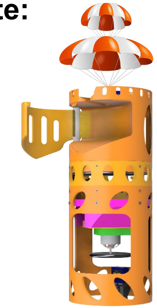
- **m** = 700g
- $\mathbf{C_d}$ = 2.2 (including spill hole)
- $\mathbf{A_1}$ = 0.0135m^2
- ρ = 1.2 kg/m^3

$\boxed{V_1 = \mathbf{19.64\ m/s}}$

Calculation of Second Parachute:

- **m** = 700g
- $\mathbf{C_d}$ = 2.2(including spill hole)
- $\mathbf{A_1}$ = 0.0252 m^2
- $\mathbf{A_2}$ = 2.7077 m^2
- **A** = $A_1 + A_2$ = 2.7329 m^2
- ρ = 1.2 kg/m^3

$\boxed{V_2 = \mathbf{1.96\ m/s}}$

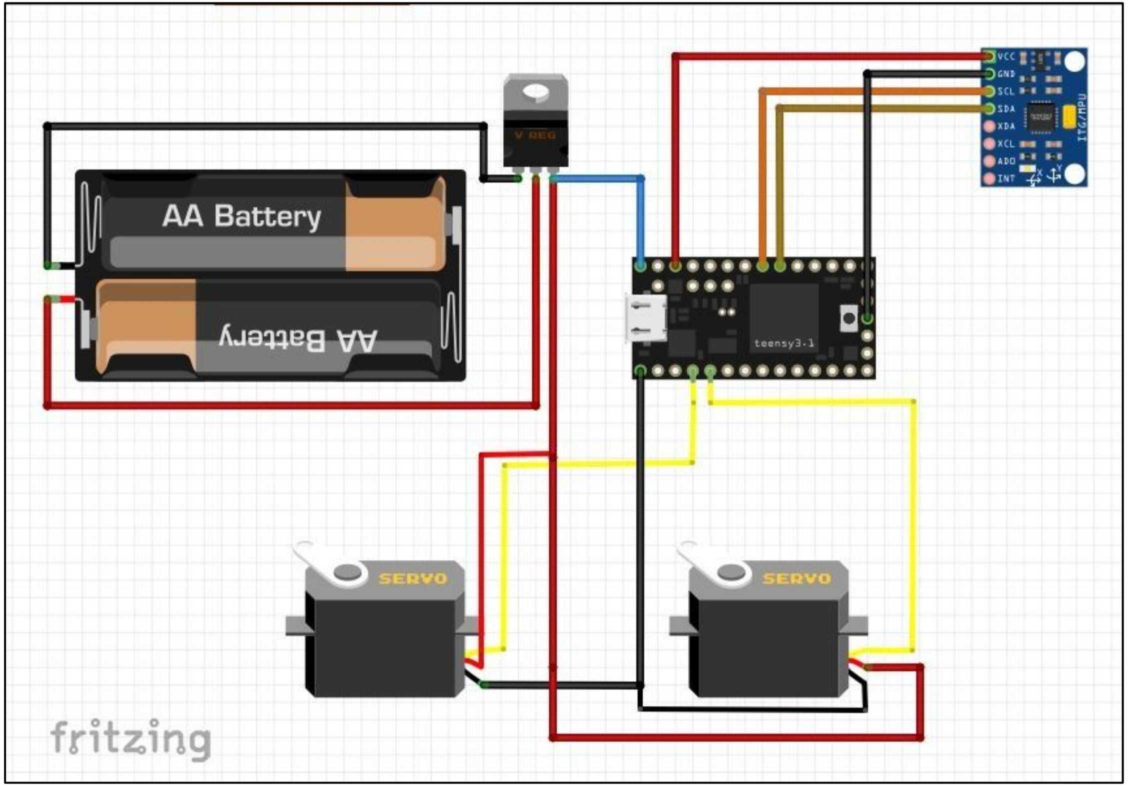


Simulation Analysis

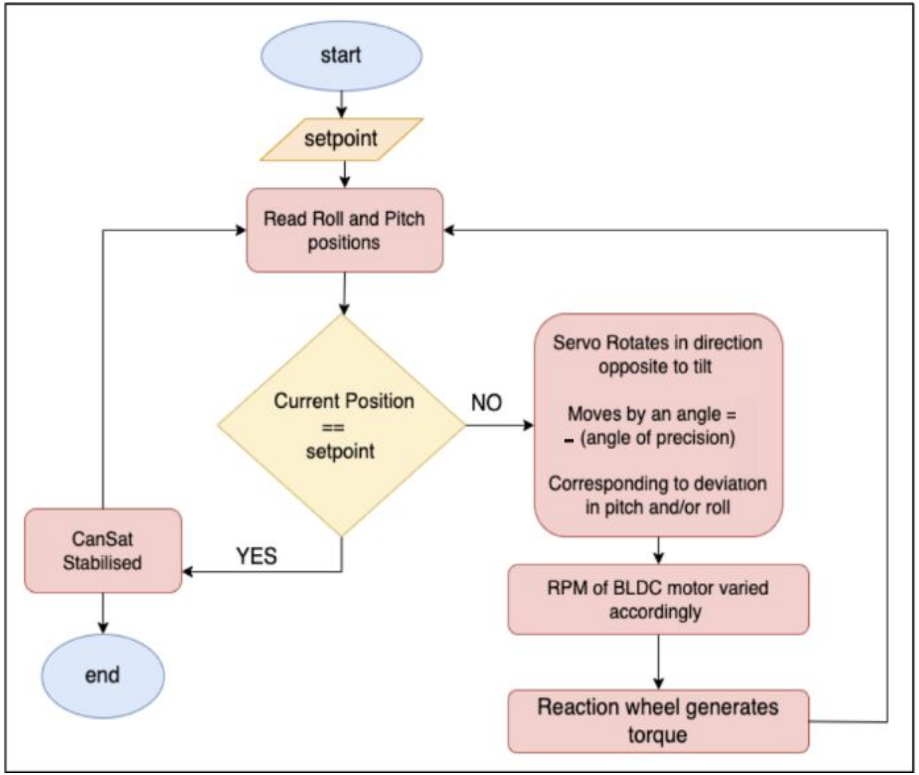
Simulations

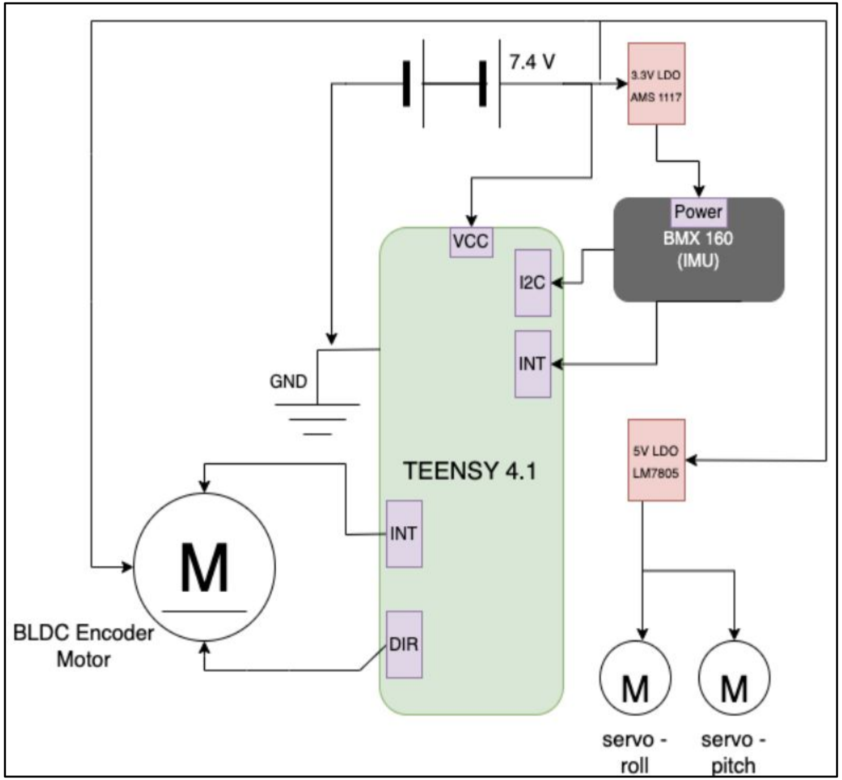
Data Processing

```
DFRobot_BMX160 bmx160;
Servo s_camR;
Servo s_camP;

float dR;
float dP;

void setup() {
  if (!bmx160.begin()  ){
    Serial.println("NO BMX found");
    while(1);
  }
  s_camR.attach(24);
  s_camP.attach(25);
}
void loop() {
  sBmx160SensorData_t Omagn, Ogyro, Oaccel;
  bmx160.getAllData(NULL, NULL, &Oaccel);
  dR=(atan2(Oaccel.x)*4068)/71;
  dP=(atan2(Oaccel.y)*4068)/71;
  s_camR.write(-1*dR);
  s_camP.write(-1*dP);
}
```



Actuator and Attitude Control Loop





Detailed Description of Realized Subsystems

Payload Subsystem

Payload Subsystem Overview (1/2)

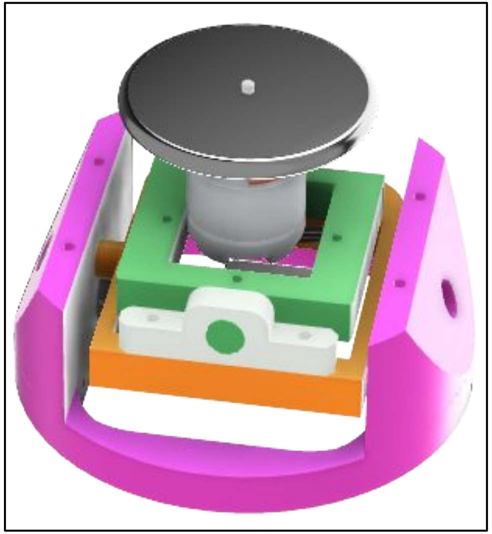
Payload subsystem comprises of an innovative auto mechanical gyro control.

- Flywheels called **reaction/momentum wheels** are employed by any satellite/CanSat to provide stability and attitude control.
- The satellite responds by spinning when torque is applied to one of its axes by adding or subtracting energy from the flywheel.
- This energy is supplied using a motor attached to flywheel.
- **A single axis of the spaceship is stabilised by maintaining flywheel rotation, also known as momentum.**

1. **Reaction Wheel** : The reaction wheel is mounted on a BLDC Motor shaft that controls and produces the desired rpm of the wheel.

2. **BLDC Motor** : The motor is selected over other type of motors because of its less weight and more rpm range. The motor is placed in a pocket formed at inner gimbal.

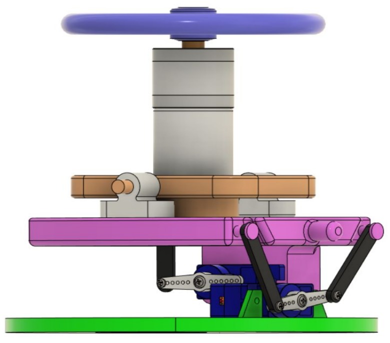
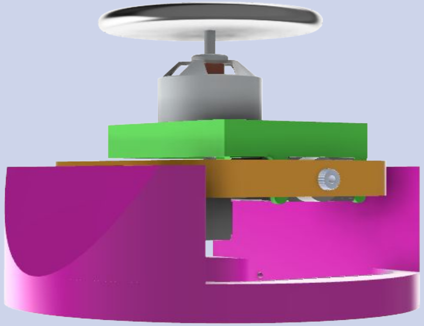
3. **Gimbals** : Two gimbals are incorporated having relative rotational linkage whose axis rotation is controlled by two servo motors.



Gyroscope subsystem

Payload Subsystem Overview (2/2)

Payload subsystem changes since PDR

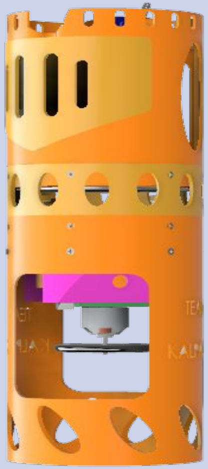
Previous Payload Design	Current Payload Design
	
The Gyroscope model was made with the flywheel being connected to a longer rotating shaft. Dimension are not too accurate. Number of links are greater than new design.	The Gyroscope model is connected to a shorter rotating shaft. Dimension are measured accurately also using less no of links too .Number of links are less due to extended part of base plate.

Mechanical Subsystem Design

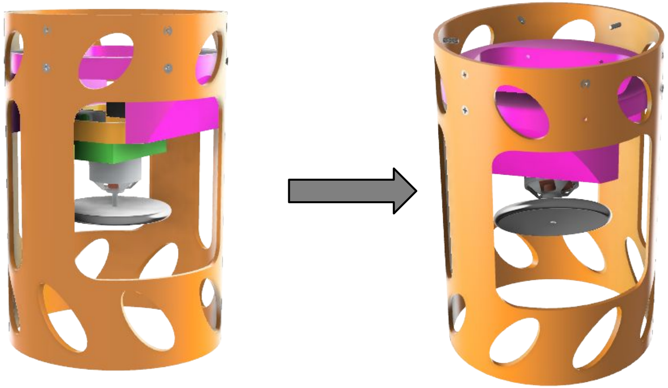
Mechanical Subsystem Changes Since PDR (1/5)

COMPONENT	PDR	CDR	REASON
Gyroscope	The Gyroscope model was made with the **flywheel** being **connected** to a **longer rotating shaft.**	The Gyroscope model is **connected** to a **shorter rotating shaft.**	This was done to **increase the degree of freedom** of the flywheel inside the CanSat container.
Base of gyroscope	There was a **plate between electronics compartment** and **gyro model.**	The **plate** has been **extended** downwards.	This was done to **increase the weight margin** and add or improve important components inside the CanSat.
Parachute compartment	There were **two o rings** to connect two **parachute**	Cavity is made in place of one o ring and **primary** parachute will be **connected to secondary parachute.**	To **increase drag** force

Container Structure changes since PDR

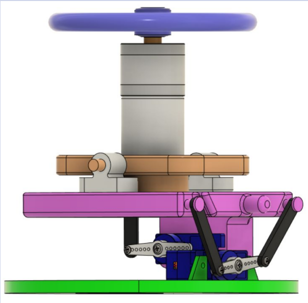
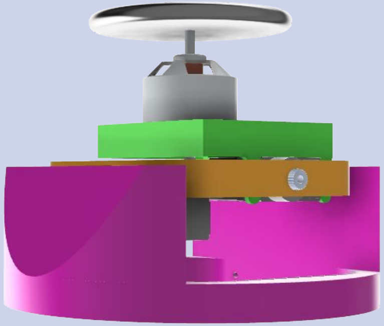
Previous Container Structure	Current Container Structure
	

- The CDR model underwent **topology optimization** which **decreased weight** of the CanSat.
- CanSat Topology Optimization in **lower part** of CanSat is also helping **reaction wheel** to move **freely**.



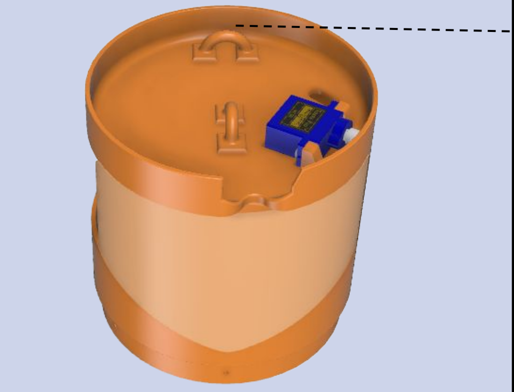
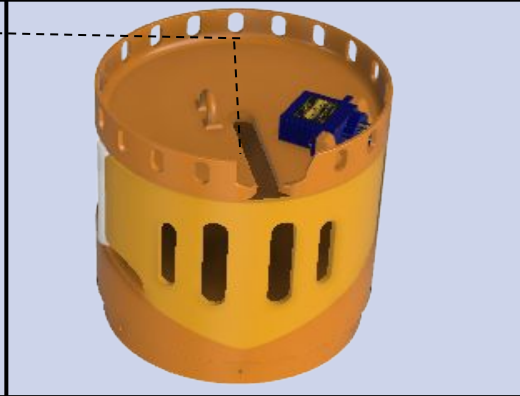
Mechanical Subsystem Changes Since PDR (3/5)

Payload subsystem changes since PDR

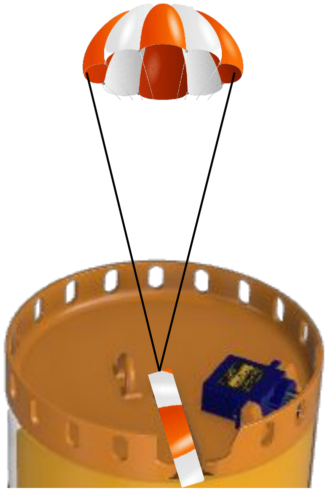
Previous Payload Design	Current Payload Design
	
The **Gyroscope model** was made with the **flywheel** being connected to a longer **rotating shaft**. Dimension are not too accurate.	The Gyroscope model is connected to a shorter rotating shaft. Dimension are measured accurately also using less no of links too .
Number of links are greater than new design.	Number of links are less due to extended part of base plate.

Mechanical Subsystem Changes Since PDR (4/5)

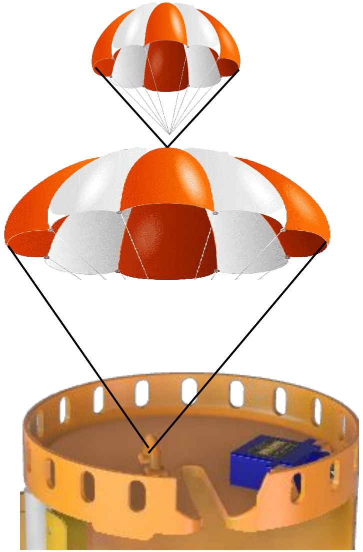
Parachute Compartment changes since PDR

Previous Parachute compartment	Current Parachute compartment
	

This cavity is made in place of o ring in order to connect primary parachute directly to secondary parachute as drag force is greater in this configuration



Primary parachute deployed view



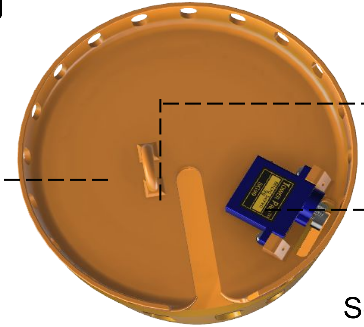
After secondary parachute is deployed

Mechanical Subsystem Changes Since PDR (5/5)

Container Parachute Attachment Mechanism

Cavity is made to connect primary parachute shroud lines directly to secondary parachute

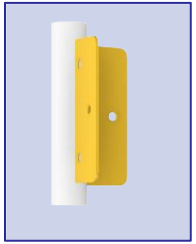
O ring



Cavity

Servo motor

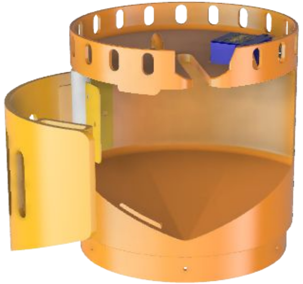
Container Top VIew



Hinge

The shroud lines of secondary parachutes will be connected to a hook via **O rings.**

Container **closed** configuration



Container **open** configuration

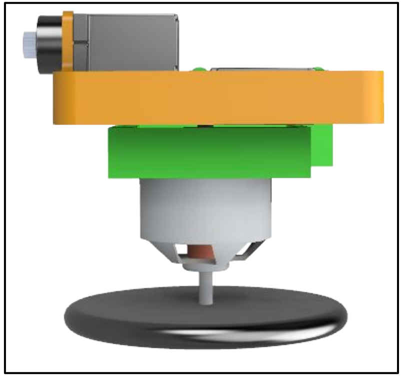
Mechanical Subsystem Changes Since PDR

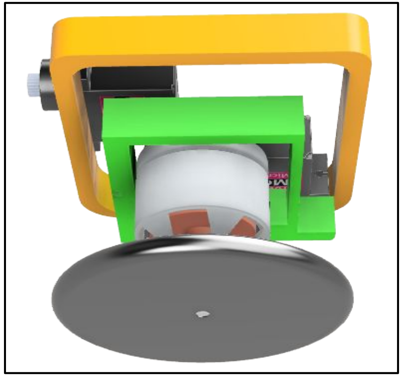
Servo motors are connected to the fixed platform of gyro.

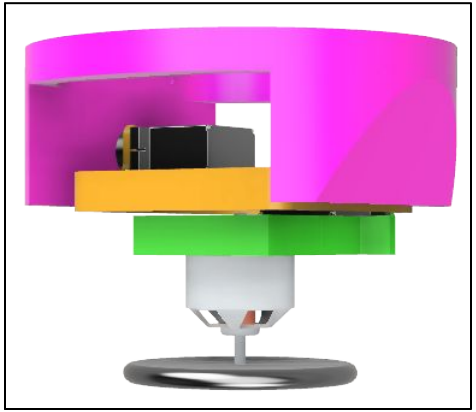
The axis of rotation can be controlled and tilted by using various servo motors and mechanical links.

GYRO CONTROL SYSTEM

When servo motor will rotate, servo motor body will rotate gimbal
Gimbal are used to change the direction of rotating wheel.

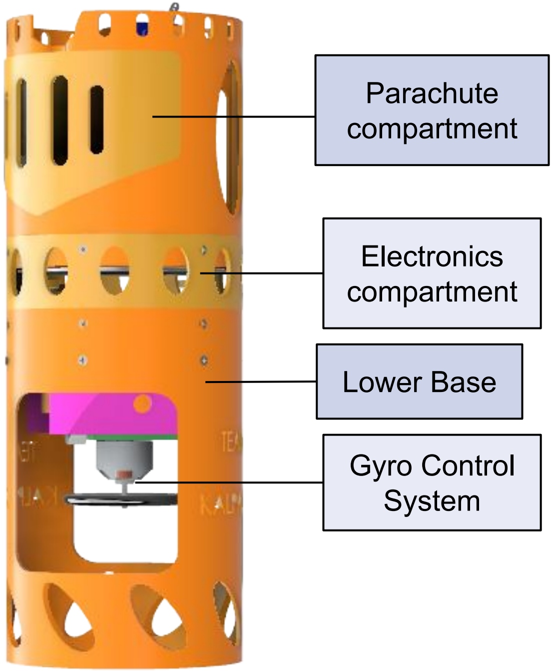


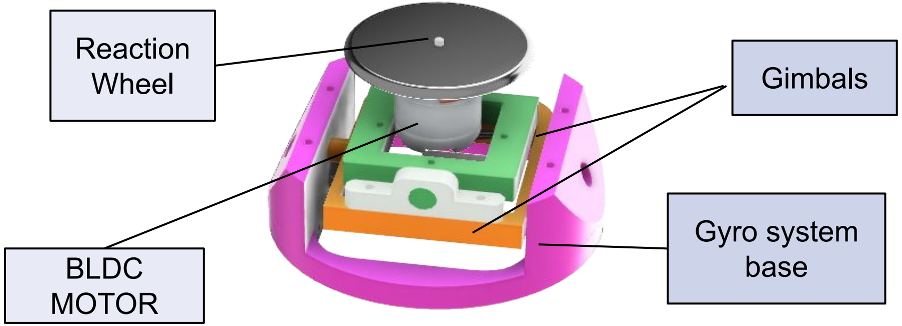




Two MG90S servo motor are used to control gimbal of gyro.
Aluminium wheel is used .
BLDC motor is used to rotate wheel.

Mechanical Subsystem Overview (1/2)





Container	Material
Parachute	Ripstop nylon
Parachute compartment	ABS
Electronic compartment	
Container	

Gyro control system	
Gimbal	ABS
Links	ABS
Reaction wheel	Aluminium

Mechanical Subsystem Overview (2/2)

Interface Definition

Parachute Compartment :

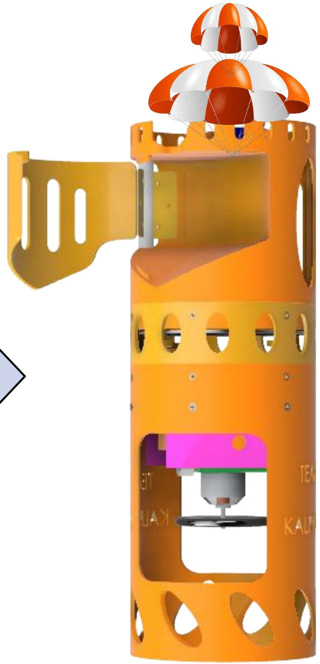
Both parachutes are shown here-

- Primary parachute is kept on the upper surface
- Secondary parachute is stuffed inside a separate compartment.

Gyro Control System :

- We are using bias momentum control method by attaching a momentum wheel that conserves angular momentum inside the satellite hence, stabilises the CanSat.
- The wheel is rotated and controlled by BLDC motor.

Launch Configuration



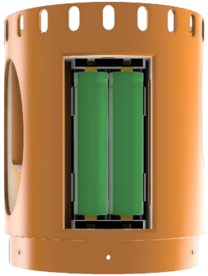
Deployed Configuration

Mechanical Layout of Components

Electronics Compartment: Container PCB is stowed here on the mounts and secured with the help of screws.

Parachute Compartment :
The shroud lines of secondary parachutes is connected to an o ring which is connected to hooks.

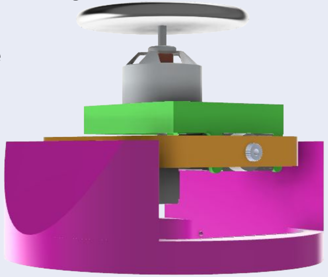
- **First Parachute** is stowed on the top of the compartment.
- **Second parachute** is stowed inside the parachute compartment and with the compartment door kept in place through a servo shaft.



Gyro Control Mechanism:

The **Bias Momentum Control Method** is used for Active Gyro Control by attaching a momentum wheel that conserves angular momentum inside the satellite.

The wheel is rotated and controlled by a **BLDC motor.**



Battery can be easily accessed by the battery enclosure lid present on the side of parachute compartment.

Mass Budget

Mass Budget (1/3)

Component	Model Name	Quantity	Determination	Unit Mass(g)	Mass(g)	Uncertainty (g)
Microcontroller	Teensy 4.1	1	E	10.0	10.0	±0.1
Temperature / Pressure sensor	BMP 280	1	DS	2.0	2.0	0
Radio	Digi Xbee 3 Pro2.4GHz ZB3.0	1	E	10.80	10.80	±0.2
Battery	Panasonic NCR18650GA	2	DS	48.0	2x48.0=96.0	0
GNSS	Quectel L89	1	E	8.2	8.2	0
Coin cell	Energizer CR2032	1	DS	3.0	3.0	0
Container Gyro Sensor	BMX 160	1	DS	3.0	3.0	±0.2
Mosfet	IRF3205	1	DS	2.0	2.0	0
Buzzer	CEP 1112	1	DS	2.0	2.0	0
Camera	Adafruit Mini Spy Camera	1	DS	2.8	2.8	0
Voltage Booster	MT3608	1	E	7.0	7.0	±0.2
PCB	-	1	E	28.0	28.0	±0.3
SD Card	SanDisk Ultra	2	DS	0.5	2x0.5=1.0	0
Antenna	FXP 840.07.0055B	1	E	1.0	1.0	±0.1
Miscellaneous (LEDs ,Switch,etc)	-	-	E	10.0	10.0	±0.6
Total Electronic Mass					**176.8 g**	**±1.7 g**

Mass Budget (2/3)

CanSat system	Component	Material/Specs	Quantity	Determination	Mass (g)	Uncertainty(g)
Container	Container	ABS	1	SW Determination	74.281	±1.2
	Parachute+Battery Compartment	ABS	1+1	SW Determination	57.104	±0.4
	Electronics Compartment	ABS	2	SW Determination	32.77	±0.2
	Nut & Bolts	M2 Pan Head	2	Measured	4.124	±0.1
	Parachute(Both)	Hexagonal	2	Calculated	86.09	±0.01
	Screws	ST4 cross head	12	Measured	5.55	±0.1
	Sorbothane pads	2 mm thickness	1	DS	0.680	±0.01
	SG 90 Servo	-	1	DS	9	-
Gyro Control System	Mechanical Body and links	ABS	1	SW Determination	87.52	±0.2
	Motor(BLDC + Servos)	-	1 + 2	DS	56	-
	Reaction Wheel	Aluminium	1	Calculated	100	±0.5
	Nut & Bolts	M2 Pan Head	3	Measured	6.186	0.01
Total Mechanical Mass (g)					**519.305**	**±2.73**

Mass Budget (3/3)

Sub Division	Total Mass(g)	Uncertainty(g)
Container	289.599g	2.12
Gyro Control System	239.706g	0.71

TOTAL MASS (MECHANICAL+ELECTRONICS) = 519.305g + 176.8g

Total Mass: 696.105 g

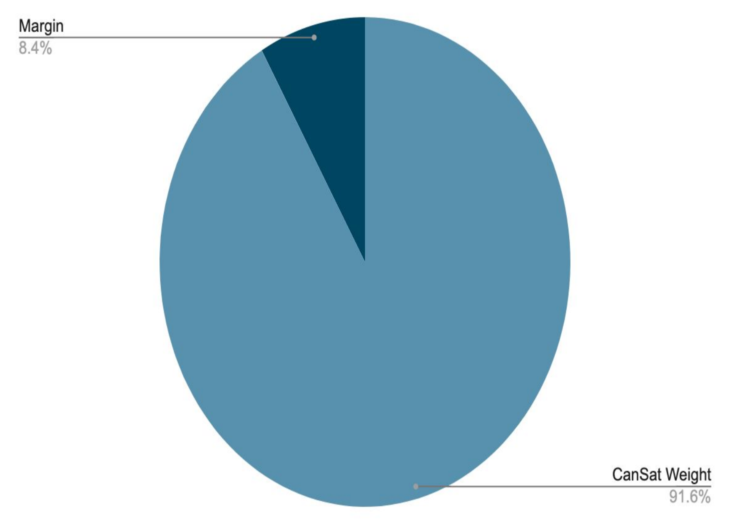
Source of Uncertainty

1. Least count of the weighing scale used is 0.1 g, so an error of ± 0.1 g is introduced in all the components whose weight is measured.
2. SolidWorks provides an estimated mass of the design based on ideal manufacturing and ideal material properties, which is not achievable so an error of 10% of the estimated weight can be considered.

Method of Correction

Two containers which have different wall thickness will be manufactured before the actual launch.

1. MoC 1 - If mass of CanSat < 650g, container with thicker wall will be used. We would also carry dummy mass to add weight to the system if it falls short of the specified lower mass limit.
2. MoC 2 - If mass of CanSat > 750g, container with thinner wall will be used. Moreover, a container of a slightly lower density material will be carried.



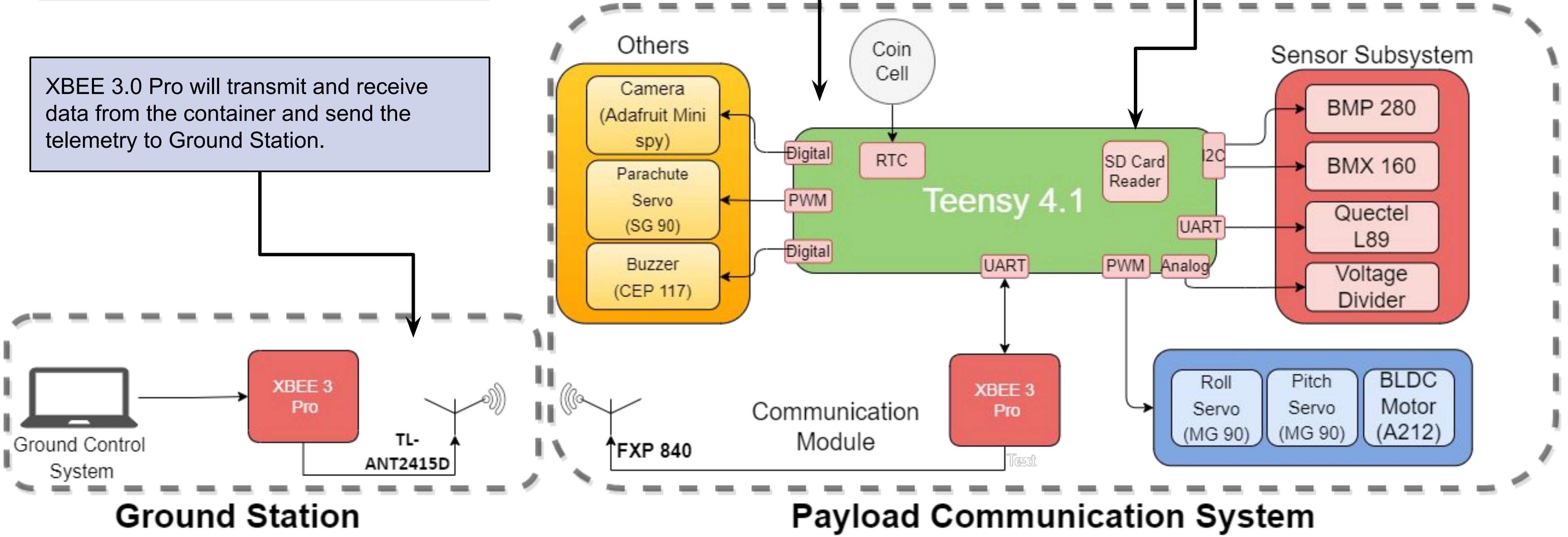
Communication and Data Handling (CDH) Subsystem Design

Command Data Handler (CDH) Overview

Teensy 4.1 is used to perform sensors acquisition, control actuators and arrange packet data to be sent to GCS.

Telemetry Data will be stored in .csv file which will be stored in SD card using in-built in Teensy 4.1.

XBEE 3.0 Pro will transmit and receive data from the container and send the telemetry to Ground Station.



Processor & Memory (1/3)

Model	Boot Time (ms)	Processing Speed (MHz)	Voltage (V)	Current (mA)	Memory (Flash) (RAM)	Pins	Communication Protocols	Cost (₹)	Weight (gm)	Dimensions (mm³)
TEENSY 4.1	5	600	5.0	100	8 MB 1 MB	42 Digital 18 Analog 35 PWM	8x UART, 3x I2C 3x SPI	3241	10	61 x 18 x 4

Selected	Reasons
TEENSY 4.1	● It has faster processing speed which helps us to use in various operations such as controlling Gyroscope Motors. ● It has big **8 MB of Flash Memory** which helps us to store bigger programs like flight software. ● It has **in built SD card slot and RTC**, so that external modules are not required. ● Tightly Coupled Memory which allows us fast single cycle access to memory using a pair of 64 bit Bus. ● The processor-ARM Cortex M7 is a dual-issue superscalar processor, meaning it can execute two instructions per clock cycle.

Performance

ARM Cortex-M7 brings many powerful CPU features to a true real-time microcontroller platform. CPU performance is many times faster than typical 32 bit microcontrollers.

Processor & Memory (2/3)

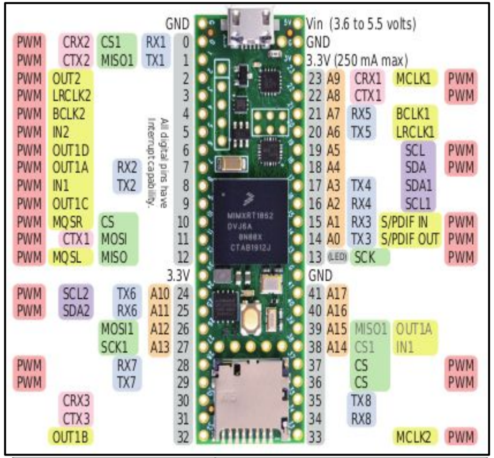
Teensy 4.1 runs off of the NXP iMXRT1062 IC, which is a 32-bit ARM Cortex-M7

- **Dual Issue Superscalar Architecture**
  Cortex-M7 is a dual-issue superscalar processor, meaning M7 can execute 2 instructions per clock cycle, at 600 MHz.
- **Branch Prediction**
  Cortex-M7 is the first ARM microcontroller to use branch prediction. On Cortex-M4 & earlier, loops and other code which much branch take 3 clock cycles. With M7, after a loop has executed a few times, the branch prediction removes that overhead, allowing the branch instruction to run in only a single clock cycle.
- **Tightly Coupled Memory**
  Allows Cortex-M7 fast single cycle access to memory.
  The DTCM bus is actually a pair of 32 bit paths, allowing M7 to perform up to 2 separate memory accesses in the same cycle.

All digital pins have interrupt capability.

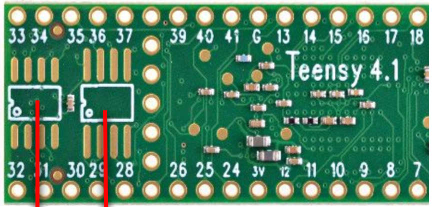
Teensy 4.1 is designed to bring all general purpose I/O pins to breadboard friendly pads on the outside edges.

TEENSY 4.1



Feature	Number of Pins
SDIO (4 bit data)	Micro SD Socket
PWM Pins	35
Analog Inputs	18
Serial Ports	8
Total I/O Pins	55

I2C	3 ports
SPI	3 ports
UART	8 ports



Meant for Flash Memory

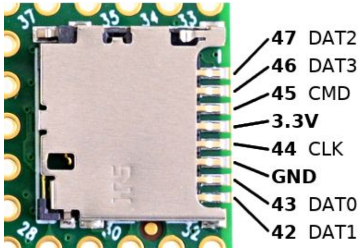
Meant for SRAM

Flash Memory	8 MB
RAM	1 MB
EEPROM	4 KB

Processor & Memory (3/3)

Model	Voltage (V)	Mass (g)	Size of sd card supported (GB)	Interface	Dimensions (mm^3)	Cost (₹)
TEENSY 4.1 Inbuilt SD card Reader	3.3	N/A	32	SPI	N/A	N/A

Model	Memory (GB)	Interface	Data Transfer Rate (Mb/s)	Writing Speed (MB/s)	Reading speed (Mb/s)	Cost (₹)
SanDisk Ultra	16	Mounted on SD Card Shield	98	51.5	99.5	395



Data Processing

```
#include <SD.h>
File Kalpana_Test;
String packet="";
SD.begin(BUILTIN_SDCARD);
void Data_Log(){
  Kalpana_Test =
SD.open("Flight_2022ASI049.csv", FILE_WRITE);
  if (Kalpana_Test)
      {
        Kalpana_Test.println(packet);
        Kalpana_Test.flush();//save recovery
package, flush from buffer
      }
    Kalpana_Test.close();
}
```

Data packet is logged onto a .csv file with the name “Flight_2022AS1049”, which is saved onto the SD card.

Real Time Clock

Model	Voltage (V)	Mass (g)	Current (mA)	Accuracy (s/day)	Interface	Dimensions (mm^3)	Cost (₹)
Teensy 4.1 On board RTC	3	N/A	N/A	±1.0	Analog	On Board	N/A

Data Processing

```
#include <TimeLib.h>
void setup() {
  setTime(0, 0, 0, 24, 1, 2023); // setting power on time as start time }
void loop() {
  digitalClockDisplay();
  delay(1000); }
```

OUTPUT

```
00:44:43.808 -> 0:00:04
00:44:44.804 -> 0:00:05
00:44:45.782 -> 0:00:06
```

REASONS

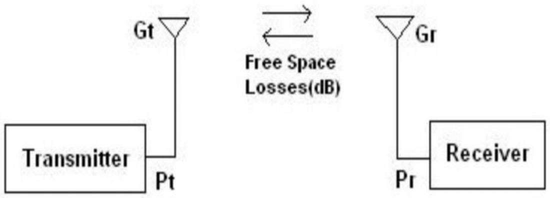
- As we do not require an external RTC module hence it is easier to implement RTC.
- Teensy 4.1 have internal RTC we have to connect a coin cell to provide uninterrupted Date & Time.

Data Format

hh:mm:ss

Container Antenna Summary (1/2)

Model	Frequency Range(GHz)	In Power (W)	Impedance (ohm)	Range (km)	Peak Gain (dBi)	Directivity	Cost (₹)	Weight (g)	Dimension (mm)
FXP 840.07.0055B	2.4 - 2.5	2	50	2.5	3.6	Omni	621.4	1.0	14 x 5 x 0.1



Step-1: EIRP = Pt - Cable_loss + Gt

Step-2: FSL (Free Space Loss) = EIRP - Pr

Step-3: dist = FSL + 20*Log10(Lambda) - 21.98

=>Antenna coverage distance = 10^(dist/20)

Power (W to dBm): P(dBm) = 10 x $\log_{10}$(P(in W)) + 30

ANTENNA RANGE CALCULATION METHODOLOGY

- We've assumed the Receiver and Transmitter to be the same antenna
- Cable Loss = 3 dB
- Sensitivity = -80 dBm

Transmit power = (Efficiency/100)*(input Power)

Reasons
• Made from flexible material thus, tolerant to mechanical deformations.
• Tiny form factor (physical size and shape of component).
• Particular model more easily available in Indian market.

Container Antenna Summary (2/2)

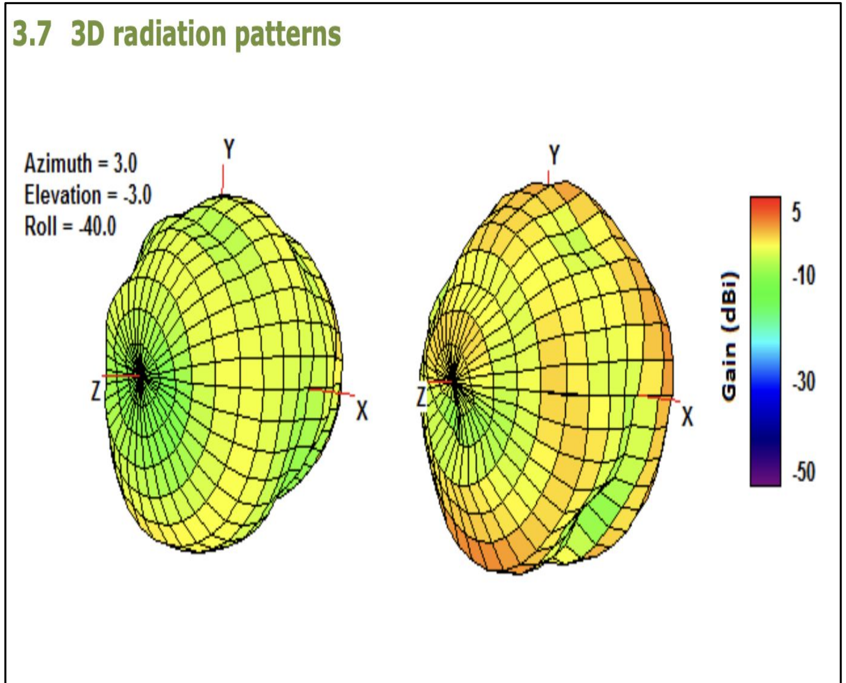
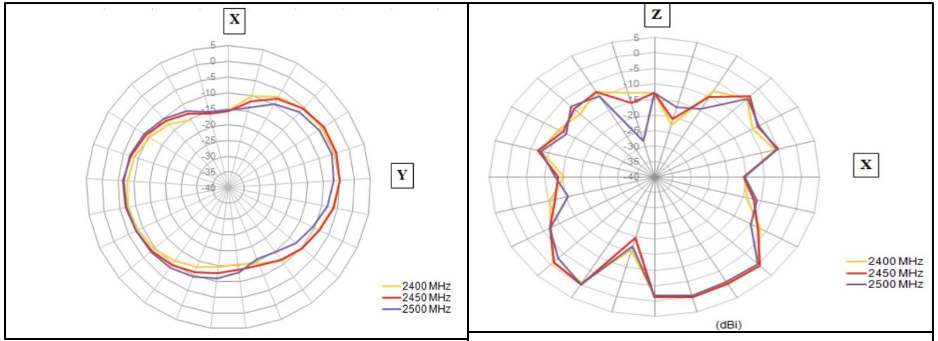
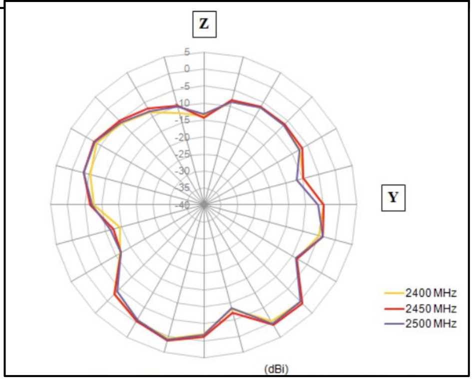


Figure 12. 3D Radiation Pattern at 2450 MHz (left side), Radiation Pattern at 5000 MHz (right side) of the FXP840 Antenna.

2D Radiation Patterns



FXP 840



Payload Radio Configuration (1/2)

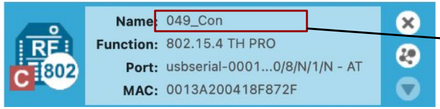
Model	Interface	Data Rate (Kbps)	Line of Sight (m)	Transmit Power (dBm)	Supply Voltage (V)	Supply Current (mA)	Cost (₹)	Dimensions (mm)	Sensitivity (dBm)	Weight (g)
Digi XBEE 3 PRO 2.4GHz ZB3.0	UART, SPI, I2C	250	3200	+19	3.3	Tx : 135 Rx: 17	3,499	TH: 24.38 x 27.61 SMT: 21.99 x34x3.05	-103	10.8

Data Processing

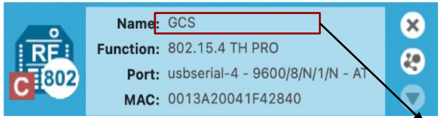
```
void Xbeetx(){
  char dataPacket[packet.length() + 1];
  packet.toCharArray(dataPacket, packet.length() + 1);
  XBee.write(dataPacket, sizeof(dataPacket)); }
```

Reason

Includes Zigbee 3.0 for mesh networking and Digi XBee 3 Cellular with the **latest LTE technologies like LTE-M and NB-IoT.**



Container Xbee



GCS Xbee

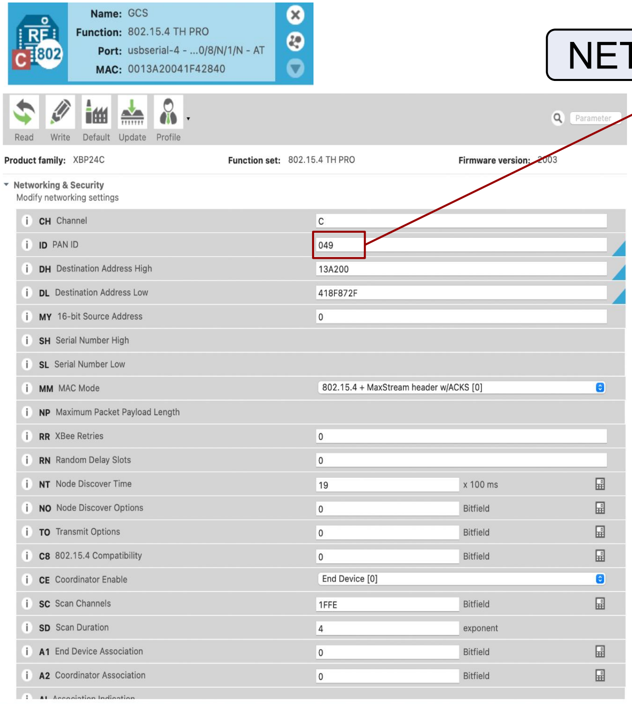
String packet → String converted to array → XBee transmits characters serially

OUTPUT

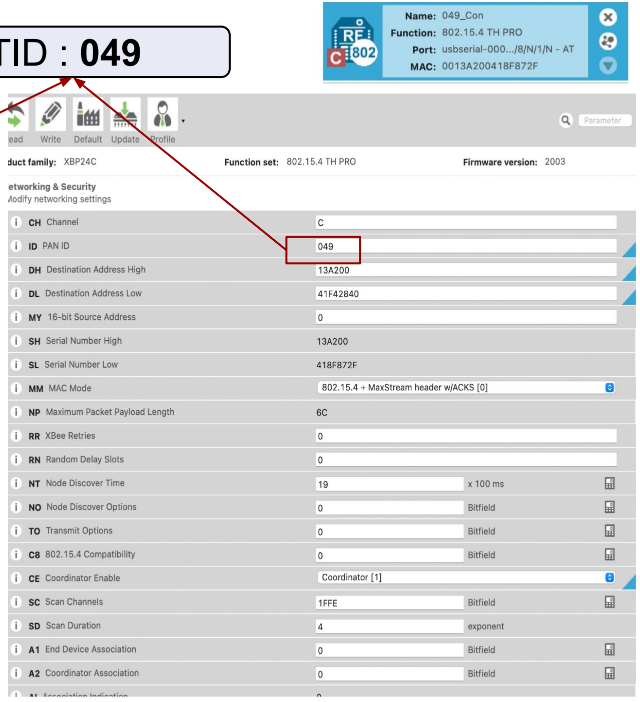
```
test<2022AS1-049,0:00:03,1,0.0,98421,24.6,0.04,00:13:11,0.0000,0.0000
,,V*23
,-0.42,0.16,10.11,-0.10,0.05,0.05,2>
<2022AS1-049,0:00:05,2,-0.0,98422,24.6,0.03,00:13:15,0.0000,0.0000,,,
-0.42,0.14,10.11,-0.11,0.05,0.06,2>
<2022AS1-049,0:00:05,3,0.3,98418,24.6,0.03,00:13:17,0.0000,0.0000,,,-
```

```
6D 75 6E
69 63 61
74 69 6F
6E 20 74
65 73 74
3C 32 30
```

Payload Radio Configuration (2/2)



NETID : **049**



Configuration

Coordinator : GCS Radio
Destination address: 0013A200418F872F
Endpoint : Container Radio
Coordinator address:0013A20041F42840

Transmission Control

- **Transmission begins** when the Cansat is turned ON. The communication is established between the **GNSS** and the Cansat.
- **Transmission stops** on completing the landing stage of the cansat and all the data telemetry is saved in .csv file.

Xbee will communicate in Unicast mode and send data packet to the GCS at a frequency of **1Hz.**

Payload Telemetry Format (1/2)

S.No.	Parameter	Description
1.	<TEAM ID>	The id of the team (2022ASI-xxx)
2.	<TIME STAMPING>	Time count from the state of initial power.
3.	<PACKET COUNT>	Number of packets that have been transmitted.
4.	<ALTITUDE>	Altitude in meters relative to the ground. The resolution must be 0.1 meters.
5.	<PRESSURE>	Atmospheric pressure. The resolution must be 1 Pascal.
6.	<TEMP>	Temperature in degrees Celsius with a resolution of 0.1°C.
7.	<VOLTAGE>	Voltage of the CANSAT power bus. The resolution is 0.01V.
8.	<GNSS TIME>	Time in seconds generated by the GNSS receiver.

S.No.	Parameter	Description
9.	<GNSS LATITUDE>	Latitude coordinates generated by GNSS receiver with a resolution of 0.0001 degrees.
10.	<GNSS LONGITUDE>	Longitude coordinates generated by GNSS receiver with a resolution of 0.0001 degrees.
11.	<GNSS ALTITUDE>	Altitude in meters generated by GNSS receiver. The resolution is 0.1 meters.
12.	<GNSS SATS>	Number of satellites being tracked by GNSS This is an integer number.
13.	<ACCELEROMETER DATA>	Data received from the gyroscopic sensor including acceleration and roll & pitch parameter in m/s^2.
14.	<GYRO SPIN RATE>	Spin rate of Mechanical Gyro wrt CANSAT in degrees per second.
15.	<FLIGHT SOFTWARE STATE>	Operating state of the software (eg. launch wait, ascent, decent).

Payload Telemetry Format (2/2)

Telemetry Data Format

<TEAM ID>,<TIME STAMPING>,<PACKET COUNT>,<ALTITUDE>, <PRESSURE>, <TEMP>,<VOLTAGE>,<GNSS TIME>,<GNSS LATITUDE>,<GNSS LONGITUDE>, <GNSS ALTITUDE>,<GNSS SATS>,<ACCELEROMETER DATA>, <GYRO SPIN RATE>, <FLIGHT SOFTWARE STATE>,<ANY OPTIONAL DATA><\r>

The Data Rate of Packets

The frequency of data transfer rate is **1Hz**.

The CSV file containing our telemetry is named as **FLIGHT_2022ASI049.csv**

Telemetry Sample Data

<2022ASI-049,00:00:16,16,0.2,98436,17.1,0.82,11:42:56,28.6139,77.0385,155.9,5,-0.57,0.10,10.11,-0.08,0.04,0.06,2>

Above data format matches competition guide requirements

Payload Command Format

S.No.	Command Name	Description	Command Format	Example
1.	CX (Telemetry ON/OFF Command)	This command is used to turn on/off the telemetry.	CMD,<Team_ID>,CX,ON/OFF	CMD,049,CX,ON CMD,049,CX,OFF
2.	SET TIME	This command is used to set the mission time.	CMD,<Team_ID>,SET_TIME,<IST_Time>	CMD,049,SET_TIME,10:08:49
3.	CALIBRATE	This command calibrates gyros, barometric altitude, accelerometer.	CMD,<Team_ID>,CALIBRATE,<mode>	CMD,049,CALIBRATE
4.	SIM ENABLE	This command is used to send control status of the simulation mode.	CMD,<Team_ ID>,SIM_ENABLE	CMD,049,SIM_ENABLE
5.	SIM DISABLE	This command is used to send control status of the simulation mode.	CMD,<Team_ID>,SIM_DISABLE	CMD,049,SIM_DISABLE
6.	SIM ACTIVATE	This command is used to send control status of the simulation mode.	CMD,<Team_ID>,SIM_ACTIVATE	CMD,049,SIM_ACTIVATE
7.	ON	To Start FSW Logic.	CMD,<Team_ID>,<ON>	CMD,049,ON
8.	OFF	To Stop FSW Logic.	CMD,<Team_ID>,<OFF>	CMD,049,OFF

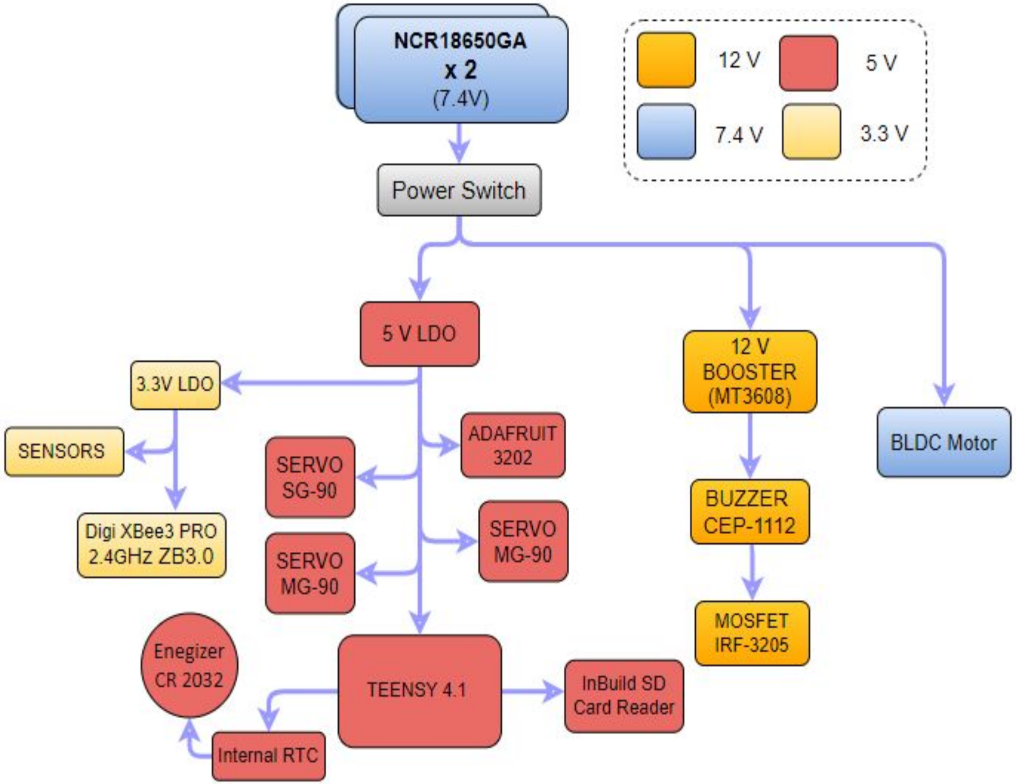
Electrical Power Subsystem Design (EPS)

EPS Changes Since PDR

Component	PDR	CDR	Reason
Battery	LG INR18650MH1	Panasonic NCR18650GA	Higher charge capacity (typical 3450 mAh, rated 3300 mAh) as opposed to 3200 mAh previously.
POWER SETUP	2 separate subsystems; i) Powered by a single cell rated 3.7 V to run sensor subsystem ii) powered by 2 cells in series to run mechanical gyro subsystem	Single power subsystem run by 2 x cells in series to provide 7.4V and 3300mAh capacity	• Reduced weight from 147g to 98g • No requirement of voltage booster for a 5V line or to run the BLDC motor. • Total boosters required brought down to 1 from 3, previously.
	12V line for BLDC motor	BLDC motor will be run directly by the batteries at 7.4V	Voltage booster cannot boost current to > 2A and BLDC motor has high current consumption.

EPS Overview (1/2)

Category	Purpose	Component Used
Battery	Serves as the power source for the EPS circuit	Panasonic NCR18650GA
Coin Cell	To power the RTC of the Teensy 4.1 Microcontroller	Energizer CR2032
Power Switch	Allows/disallows flow of current in the circuit	-
Voltage Regulator (3V LDO)	Will lower voltage from >3.3V (7.4V) to 3.3V for sensors' power line	AMS1117
Voltage Regulator (5V LDO)	Will lower voltage from >5V (7.4V) to 5V for power line that will drive our servo motors and camera	LM7805
Voltage Booster	Will boost voltage from <12V to 12V to run MOSFET and Buzzer	MT3608
LED	Indicates if or not the EPS and its components are functional	-

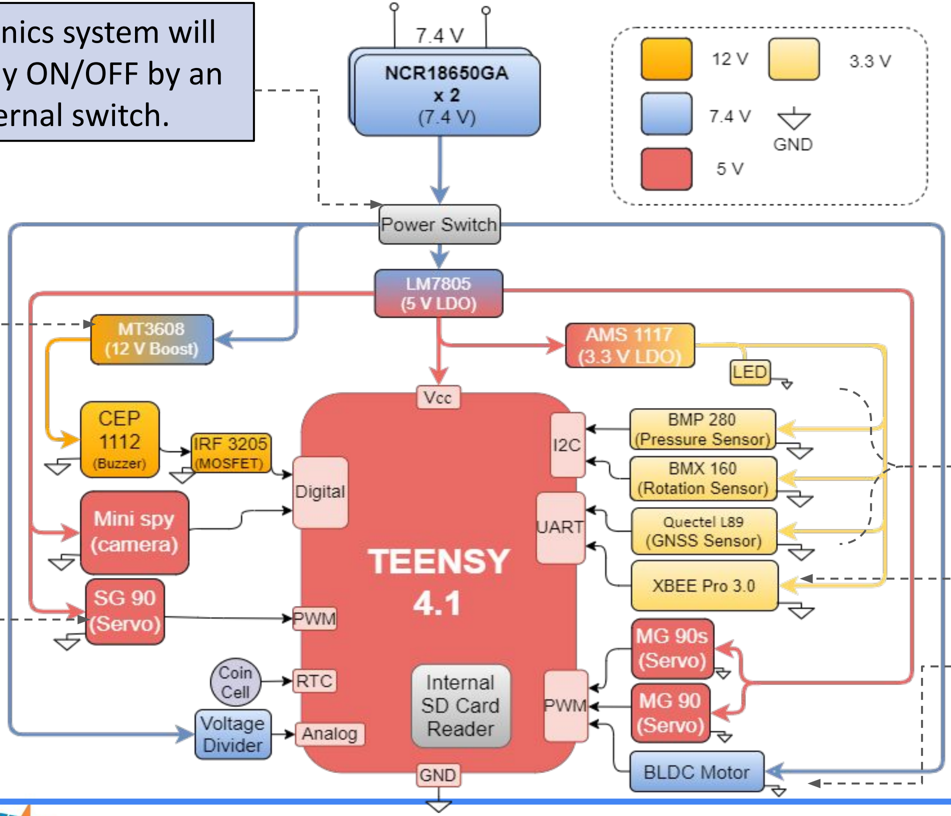


EPS Block Diagram

Electronics system will be easily ON/OFF by an external switch.

Buzzer is powered with 12V from a voltage booster.

A servo is used to deploy the parachute by opening the lid of parachute compartment



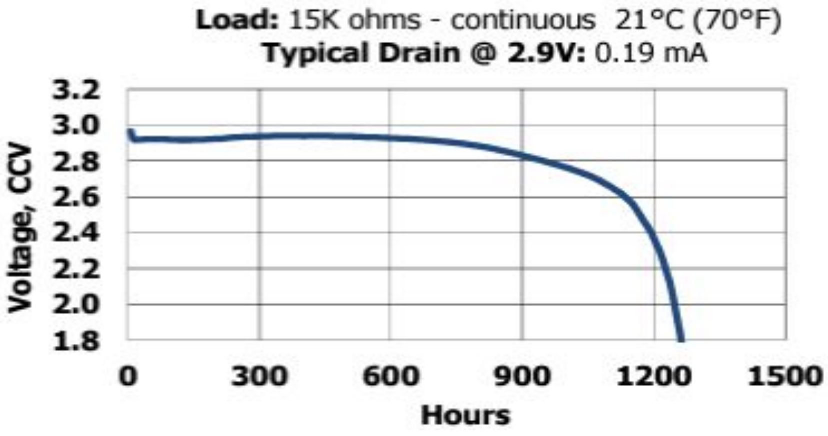
Several sensors to gather the telemetry data.

XBEE Pro 3 will transmit telemetry to Ground Control Station having NETID 049

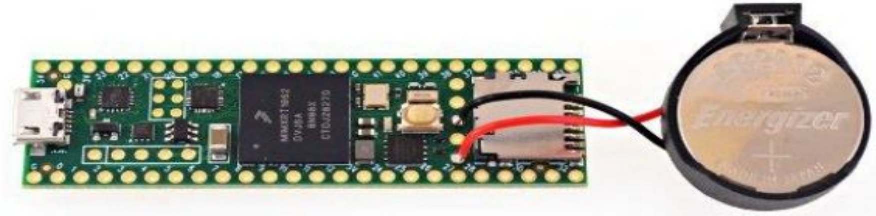
Brushless DC motor will be used in GYRO Control Mechanism

RTC Power Source

Model	Voltage (V)	Type	Capacity (mAh)	Operating Temperature (°C)	Cost (₹)	Weight (g)	Dimensions (Diameter x Height in mm)
CR 2032	3	Lithium	225	-30 to +60	65	3.0	20.0 x 3.2



REASONS
• High Current Capacity so as to complete our requirements of flight timings. • Very Low self Discharge and Very High power to weight ratio.



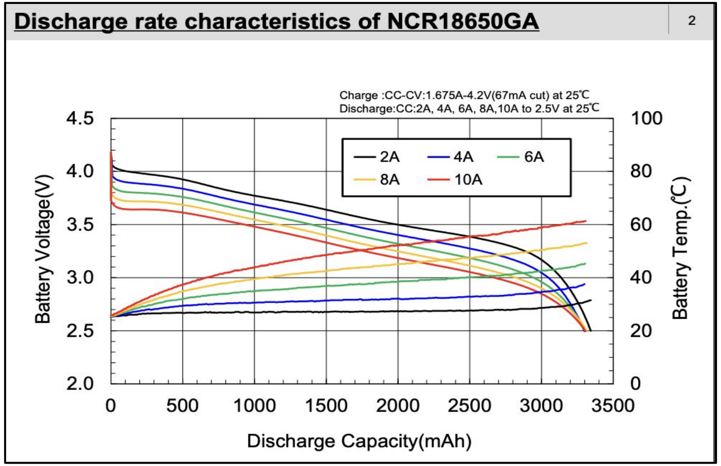
Power Budget

Power Source

Type	Configuration	Voltage (V)	Capacity (mAh)	Maximum Continuous Discharge Current (A)	Cost (₹)	Weight (g)	Dimensions (Diameter X Length in mm)
Li ion RCBL	2 batteries connected in Series	3.7	3450	10	799	48	18x65

Reasons
● High energy density ● Long stable power and long run time ● Long cycle life ● Good consistency and low self discharge

Panasonic NCR18650GA



Calculation Methodology

In - Flight

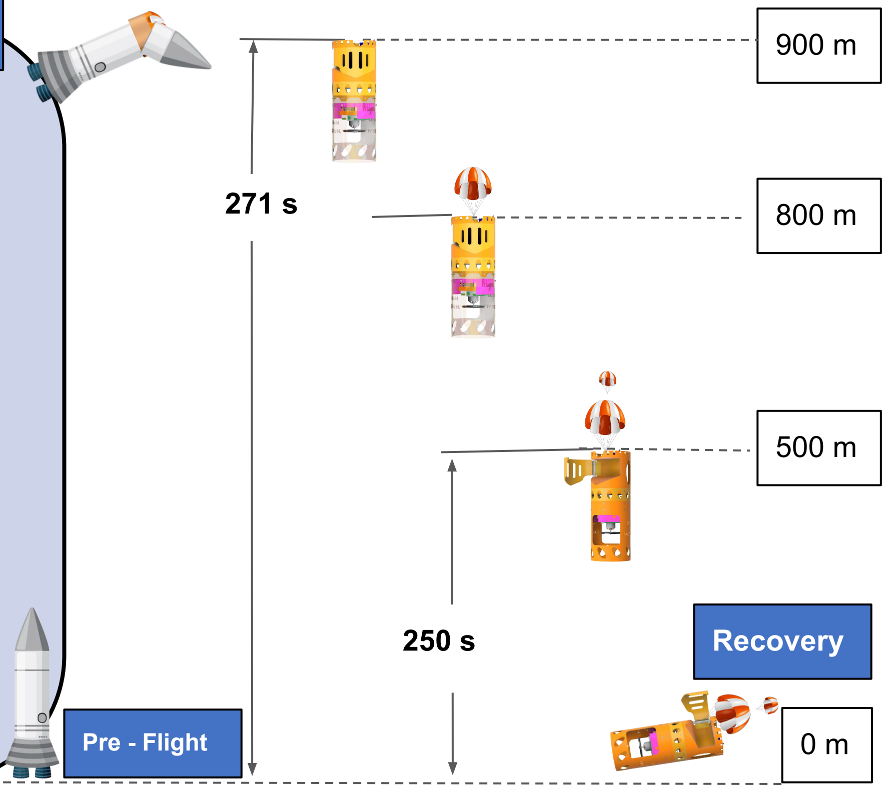
- ➔ Pre Launch Time (T_{PRE}) [Until CanSat is launched] = 120 min.
- ➔ In Flight Time (T_{IN}) [While the CanSat is in air] =

  Airtime after deployment of 1st parachute at 900m (till 500m)

  \+ airtime after deployment of 2nd parachute at 500 m (to ground)

  \+ Time taken by parachute whilst deploying

  = 20.37 + 250 +(⅔) ≈ 271 seconds ≡ 4.52 min.
- ➔ Recovery Stage Time (T_R) = 60 min.
- ➔ Total Time (T_S) = T_{PRE} + T_{IN} + T_R = 120 + 4.52 + 60 = 184.5 min. ≡ 3.075 h
- ➔ Duty Cycle % = (Time for which the component is active / Total time of operation)*100
- ➔ Base Power = Voltage * Current
- ➔ Average Power Consumption = (Base Power) * (Duty Cycle) * (T_S)



Power Budget (1/3)

Component	Current (mA)	Voltage (V)	Source	Duty Cycle (in %)			Average Consumed Energy (Wh) [V*I*t (in hours)]		
	Standard			PreFlight	In Flight	Recovery	Pre Flight	In Flight	Recovery
BMP280 (Altitude, Pressure,and Temperature Sensor)	0.0027	3.30	DS	100.00	100.00	0.00	0.000018	0.000001	0.000000
BMX160 (Rotation Sensor)	1.59	3.30	DS	100.00	100.00	0.00	0.010461	0.000394	0.000000
Quectel L89 (NavIC/GNSS Receiver)	99.00	3.30	DS	100.00	100.00	0.00	0.653400	0.024593	0.000000
ADAFRUIT 3202 (Camera)	110.00	5.00	DS	0.00	100.00	0.00	0.000000	0.041403	0.000000
MOSFET	110.00	10.00	DS	0.00	0.00	100.00	0.000000	0.000000	1.100000
CEP-1112 (Buzzer)	11.00	12.00	DS	0.00	0.00	100.00	0.000000	0.000000	0.132000
SG-90 Servo	200.00	5.00	DS	0.00	2.00	0.00	0.000000	0.001506	0.000000
RTC	0.1000	3.00	E	100.00	100.00	100.00	Inbuilt into Teensy 4.1		

Power Budget (2/3)

Component	Current (mA)	Voltage (V)	Source	Duty Cycle (in %)			Average Consumed Energy (Wh) [V*I*t (in hours)]		
	Standard			PreFlight	In Flight	Recovery	Pre Flight	In Flight	Recovery
SD Card	0.1000	3.00	E	100.00	100.00	0.00	Inbuilt into Teensy 4.1		
MT3608 (Voltage Booster - 12 V)	20.00	7.40	EST	0.00	0.00	100.00	0.0000	0.0000	0.1480
Teensy 4.1 (Microcontroller Unit)	100.00	5.00	DS	100.00	100.00	100.00	1.0000	0.0375	0.5000
XBEE 3 Pro : Tx (RF Module): Rx	135.00	3.30	DS	100.00	100.00	0.00	0.8910	0.0334	0.0000
	17.00	3.30	DS	100.00	100.00	0.00	0.1122	0.0042	0.0000
MG 90 servo motors	400.00	5.00	DS	0.0000	100.00	0.00	0.0000	0.1500	0.0000
BLDC motor	5000.00	7.40	E	0.0000	100.00	0.00	0.0000	2.7750	0.0000
MISCELLANEOUS AND PASSIVE COMPONENTS									**0.7626 Wh**
TOTAL ENERGY CONSUMED									**8.3888 Wh**

Team Kalpana

Power Budget (3/3)

Sources of Uncertainty

- Although switched ON, the components consume some power owing to their **standby currents** whose values have been added in the final power budget with an uncertainty of **10%.**
- **~0.77 Wh** is added to the final total accounting for **miscellaneous power** consumed by LDR,LDO,internal resistances, and passive components.
- **Some data** in the power budget have been **estimated.**

~ 35% of Total Battery Power is consumed in 3.075 Hrs of operation

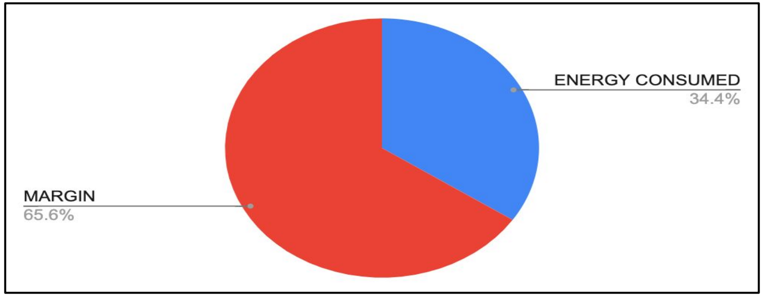
Duration	Battery Operating Time
Pre-flight	3450/352.59 = 9.78 Hr ~ 587.09 mins
In-flight	3450/5866.59 = 0.59 Hr ~ 35.28 mins
Post-flight	3450/241 = 14.3153 Hr ~ 858.92 mins

Battery operating time =
Capacity (mAh) / Current consumed (mA)

Our power bus is capable of running the entire system during each section of flight while leaving behind a significant margin.

Energy of each component = (Power consumed)*(SUM(duty cycle*cycle duration))

- Average Energy consumed in 3.075 Hr ~ **8.3888 Wh**
- Average Energy supplied by battery = **24.42 Wh**
- Power Margin ~ **16.0311 Wh**



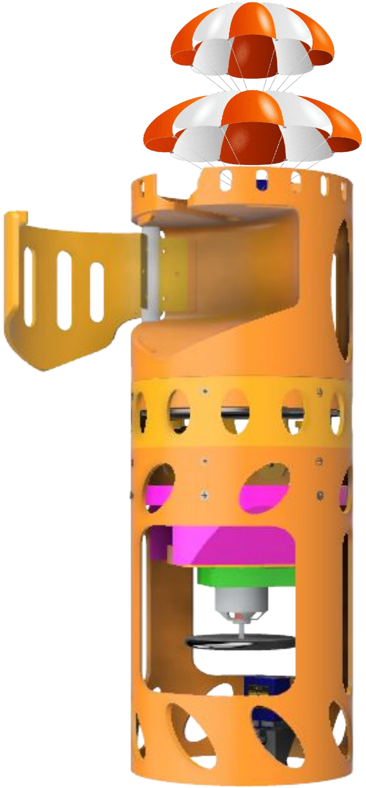
Parachute Deployment and Recovery

Parachute Deployment

The cansat is designed to have two separate parachute systems.

Primary parachute is connected to **secondary parachute** and secondary parachute is connected to **o ring**.

The **first parachute** is attached to the **top** of the **cansat** and is deployed automatically as soon as the cansat is **ejected** from the rocket. This allows the cansat to take on a **vertical orientation**.



The **second parachute** is located in a compartment within the **cansat**, and is released at a specific altitude, as determined by the **CanSat's** altitude sensor (**BMP280**).

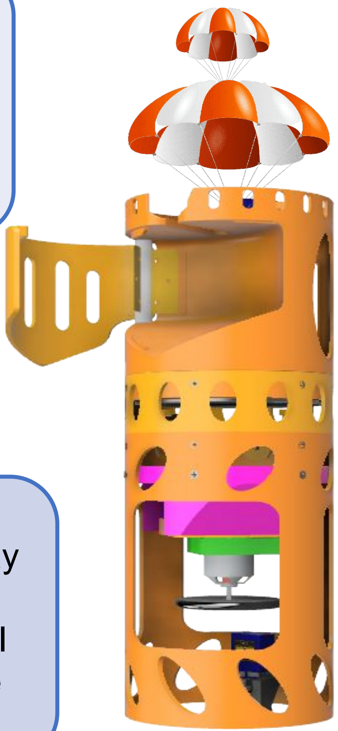
When the **sensor** detects an altitude of **500m**, the shaft of the servo motor (**SG-90**) is rotated which then opens the gate of the **parachute compartment**, releasing the **second parachute**.

The second parachute deploys with the force of a spring and the pressure of the surrounding air, slowing the descent of the cansat and ensuring a safe landing.

CanSat Location and Recovery

Fluorescent Orange colour of the cansat and the Pink colour of the parachutes will help us locate the cansat very easily after landing.

An Audio Beacon which is installed on the Cansat will play a high pitch and loud(92dB+) sound upon landing which will help the recovery team to the Cansat.



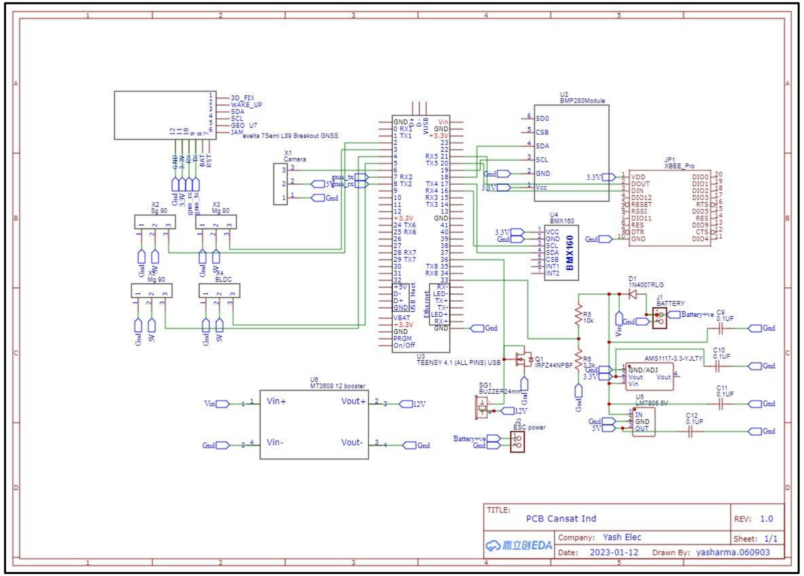
A label will be attached to the CanSat displaying the team ID, contact phone number and Email address in case of failed recovery.

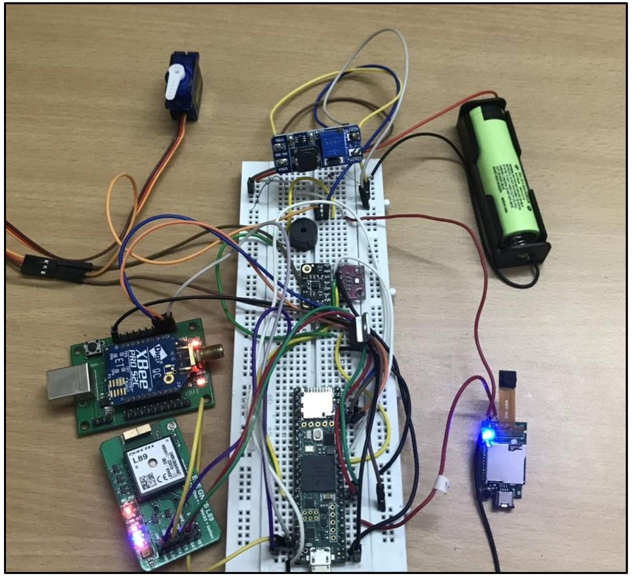
The recovery team will follow the descent trajectory by observing the descent and Payload’s last GNSS location to estimate its position.

The last data/position from GNSS will help estimate the location of the Payload.

Subsystem Level Testing And Results

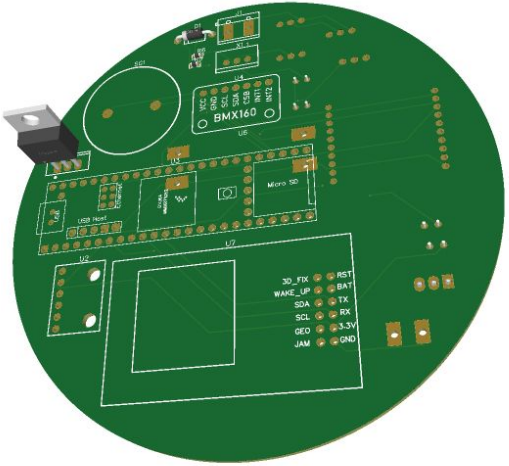
Sensors	**Performance** testing done on **EPS prototype** (**breadboard**). - Prototype was made to **run** under **mission operation time**. - Sensors were **calibrated** until high **accuracy** was achieved. **Software Integration Compliance** was verified.



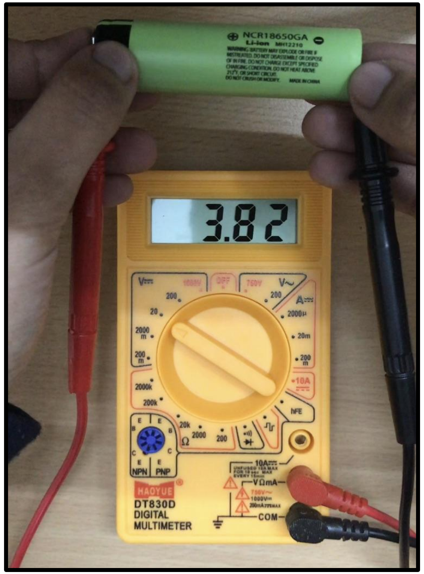


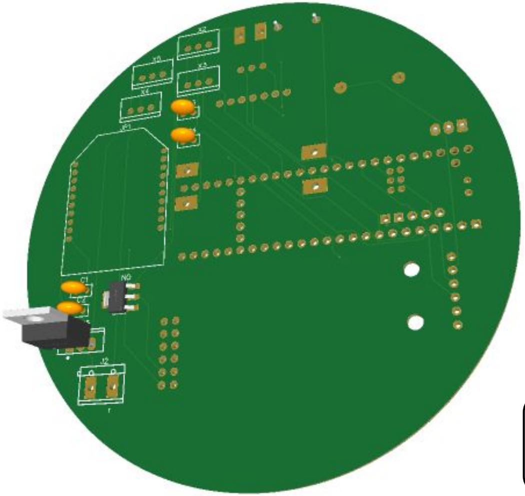
Subsystem Level Testing (2/6)

EPS	
EPS	• Tested for **Voltage regulation and stability** by LDOs. • **Trial run** was carried out for **operation time** with **actual connections** to other subsystems. • **Power bus** was powered by **battery**. • System was driven under **heavy load** of components to ensure **fuse** functionality and system **safety.**



Front View

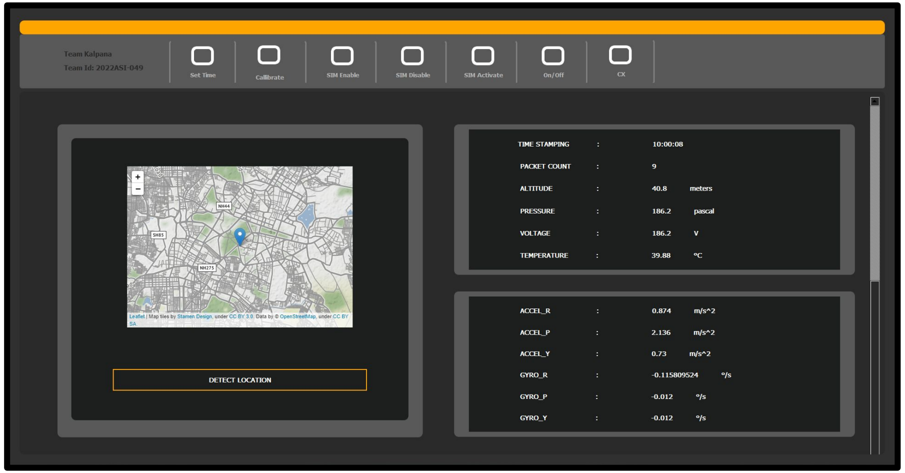


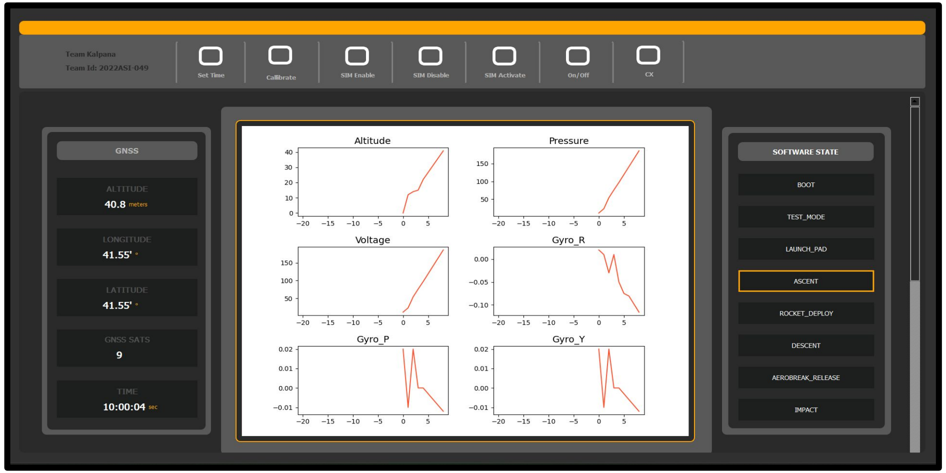


Rear View

Subsystem Level Testing (3/6)

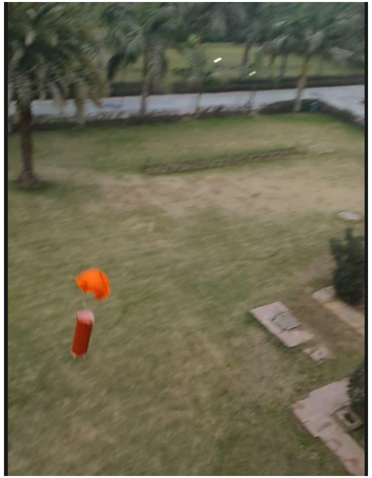
Ground Control Station	• **Simulation** of each **sensors' shutdown** or complete shutdown was done and it was ensured that it **recovers** from last state and is **not stuck** in **loops**. • **Speed** of processing of the **telemetry** was verified. • Random and **false** sensor data/**telemetry** was fed and the ability to handle it was checked, as well as its result. • **Software-hardware integration** with every component like sensors, motors, radio, etc. was checked.





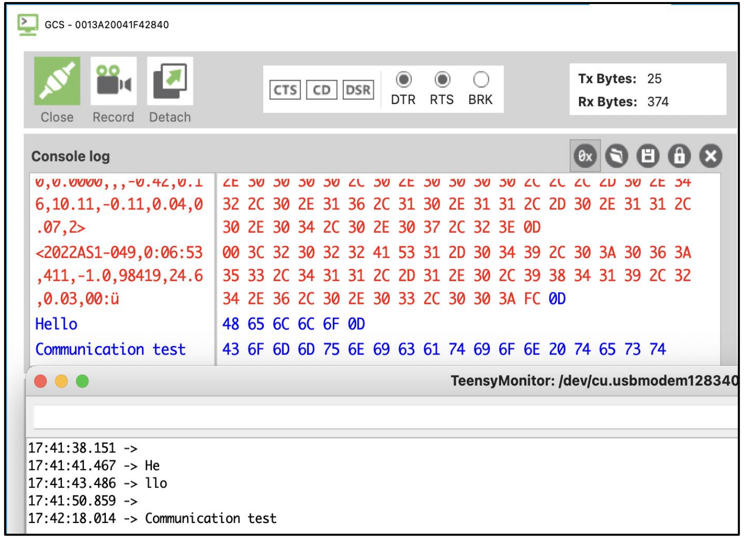
Subsystem Level Testing (4/6)

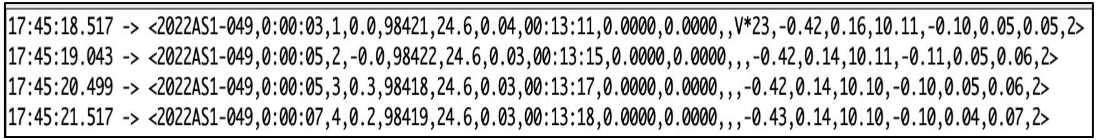
Mechanical & Descent Control Testing	• CanSat was dropped from the tallest building in our college campus, and it was checked if Descent Control Subsystem was functional. • The overall descent of CanSat was tested to **make sure** that **system functioned** at corresponding altitude levels. • Tested whether the **parachute** was able **eject** from Container (immediately after **deployment** from **simulated rocke**t). • **3D printed model of gyro system** was tested by tilting the CanSat container in a controlled manner.

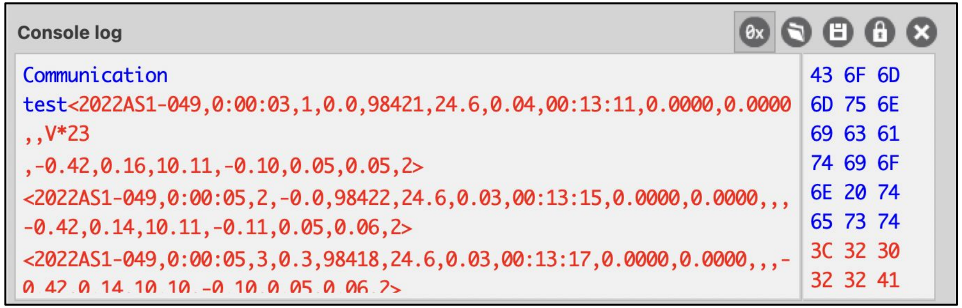


Subsystem Level Testing (5/6)

Radio Communication	
	• Tested **data communication** between **XBee radios** at different distances. • Checked radio communications at **ranges greater than required.** • Communications were tested at **various times** to ensure correct data. • **Open air and ground level range testing** was done to make sure the range maintained required standards.







Blue- Transmitted message from GCS XBee to Coordinator XBee
Red- Telemetry Received by GCS XBee from Coordinator XBee

Subsystem Level Testing (6/6)

CDH	
	• Tested **receiving, transmitting and processing** of **data** of processors and execution of **calculations.** • It was verified that the **video** recorded by camera is stored in **micro SD Card.** • All **antenna gain and range** were tested. • It was verified that the **measured numerical data** is stored in **micro SD card** connected to Teensy 4.1. • Ensured **accuracy** of the data transmitted at huge distances. • Testing of **command systems** were done **multiple times** to ensure **speed and accuracy.**

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
182	TEAM_ID	TIME_STA	PACKET_(	ALTITUDE	PRESSUR	TEMP	VOLTAGE	GNSS_TIN	GNSS_LA	GNSS_LO	GNSS_AL	GNSS_SA	ACC_R	ACC_P	ACC_Y	GYRO_R	GYRO_P	GYRO_Y	FLIGHT_SOFTWARE_STATE		
183	<2022AS1	0:00:00	1	-0.2	98440	17.2	0.81	17:28:36	28.6139	77.0385	155.9	5	-0.56	0.1	10.09	-0.09	0.05	0.06	2>		
184																					
185	<2022AS1	0:00:02	2	-0.1	98440	17.2	0.82	17:28:37	28.6139	77.0385	155.9	6	-0.57	0.09	10.08	-0.09	0.04	0.07	2>		
186																					
187	<2022AS1	0:00:03	3	0	98438	17.2	0.82	17:28:38	28.6139	77.0385	155.9	6	-0.56	0.11	10.07	-0.08	0.05	0.07	2>		
188																					
189	<2022AS1	0:00:04	4	0.3	98435	17.1	0.82	17:28:39	28.6139	77.0385	155.9	6	-0.58	0.09	10.15	-0.08	0.05	0.06	2>		
190																					
191	<2022AS1	0:00:05	5	0	98437	17.2	0.82	17:28:40	28.6139	77.0385	155.9	6	-0.58	0.11	10.09	-0.1	0.05	0.06	2>		
192																					
193	<2022AS1	0:00:06	6	0.3	98435	17.2	0.82	17:28:41	28.6139	77.0385	155.9	6	-0.57	0.14	10.09	-0.08	0.05	0.06	2>		
194																					
195	<2022AS1	0:00:07	7	0.4	98434	17.2	0.82	17:28:42	28.6139	77.0385	155.9	6	-0.55	0.09	10.09	-0.09	0.03	0.06	2>		
196																					
197	<2022AS1	0:00:08	8	0.5	98432	17.1	0.82	17:28:43	28.6139	77.0385	155.9	6	-0.6	0.11	10.11	-0.09	0.04	0.07	2>		
198																					
199	<2022AS1	0:00:09	9	0	98438	17.1	0.82	17:28:44	28.6139	77.0385	155.9	6	-0.57	0.12	10.08	-0.09	0.04	0.06	2>		
200																					
201	<2022AS1	0:00:10	10	0.1	98437	17.1	0.82	17:28:45	28.6139	77.0385	155.9	6	-0.57	0.11	10.09	-0.08	0.05	0.07	2>		
202																					
203	<2022AS1	0:00:11	11	0	98439	17.1	0.82	17:28:46	28.6139	77.0385	155.9	6	-0.57	0.1	10.06	-0.08	0.05	0.07	2>		
204																					
205	<2022AS1	0:00:12	12	0.3	98435	17.1	0.82	17:28:47	28.6139	77.0385	155.9	6	-0.58	0.11	10.09	-0.08	0.04	0.05	2>		

Data packets transmitted get stored as a CSV file in micro SD card on the Teensy 4.1

Antenna Testing

Cansat Integrated Module Simulated Test

Cansat Integrated Module Simulated Test (1/2)

TTLC Fit Check

- This test is to verify the CanSat will properly fit in the rocket payload section and slide out at deployment time.
- We will use measuring tape to measure the dimensions of cansat to ensure whether it is able to fit in rocket or not .
- A measuring tool will be designed as a diameter of envelope in **CAD program** and printed using a 3D printer.
- The accuracy of hole will be checked using **measuring tape**. If the cansat can fit the tool and drop out easily, it will be considered as a success.

Vibration Test

- This test is used to verify the **mounting integrity** of all the **components**, **connections**, **structural integrity**, and **battery connection**.
- it helps to verify whether the cansat can function normally after bearing such vibrations, and also helps to verify designs and analysis of the CanSat structure meet the vibration requirements.
- It is casually performed using the random orbit sander. The rate will be set to around 12,000- 14,000 rpm. The machine will be repeated in 2-3 min duration. Any mechanical and electrical damage will be checked after the test.

Cansat Integrated Module Simulated Test (2/2)

RF Jamming within Structure

- This test is used to check ability of the device to handle any interference that it might receive from other devices.
- It involves subjecting the device to interference and measuring its performance under those conditions.
- We determine location of electrical interference by using a portable battery-powered AM radio tuned to a quiet frequency at the lower end of the dial.
- A static or a buzzing sound is heard when we get close to the source of the interference.

Stress Strain

- This test is used to check for prediction of **plastic, elastic and fluid behaviour**. By this test we can check how the cansat behave against external force and pressure.
- This can be done by **gradually applying load** to sample of cansat and measuring the **deformation** from which the stress and strain can be obtained
- We can draw a stress strain curve for the different value of load and by thus we can analyse the behaviour of the cansat.

Environmental Test Results

Environmental Test Results (1/5)

Drop Test

Purpose	Setup
To check if the system is able to **withstand a shock of 30Gs**.	One end of a **non-stretching cord** is tied with a parachute and the other end is attached to the cansat firmly.

Procedure

- Switch on all the systems of cansat and check if telemetry is being received.
- **Raise the cansat with sufficient elevation and position it such that point of attachment of cansat with the cord points upwards and drop it.**
- Check the cansat for any damage and confirm if the telemetry is still being received.

Result The test was performed and our CanSat **PASSED.**

Environmental Test Results (2/5)

Fit Check

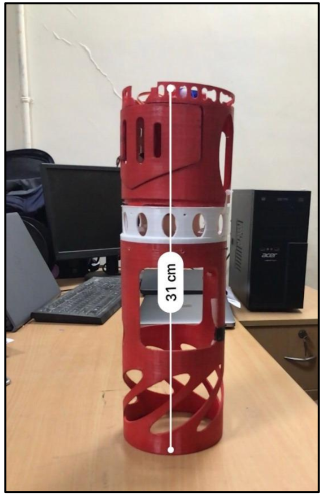
Purpose	Setup
We make sure that our cansat would be **dispatched properly at the time** it is detached from the rocket and the parachute deployment would be smooth.	The cansat is **fitted properly in the payload region** of the container.

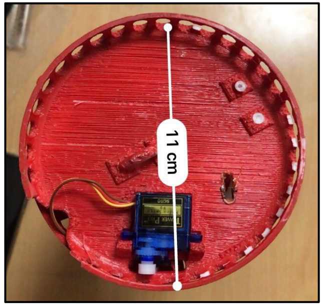
Procedure

- **Fix in the cansat such that it would be fixed in with the payload and at the time it is detached from the rocket the parachute time will not have any crashes.**
- The sat must be fitted properly in the payload section of the rocket and checked for deployability.

Result

The test was performed and our CanSat **PASSED.**





Environmental Test Results (3/5)

Vibration Test

Purpose

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

Setup

Sanding head of sander moves in a random pattern. Secure the sander, upside down, via a bench vise; the CanSat should be secured where the sandpaper is installed. The vise cannot be allowed to move freely and the sandpaper cannot be handheld.

Procedure

- Power on the CanSat and verify accelerometer data is being collected.
- **Power up the sander. Once the sander is up to full speed, wait 5 seconds. Power down the sander to a full stop.**
- Repeat step 2 four more times to inspect the CanSat for damage and functionality.
- Verify accelerometer data is still being collected and then power down CanSat.

Result

Will be performed after CDR.

Environmental Test Results (4/5)

Vacuum Test

Purpose

This test is designed to **verify deployment operation** of the payload.

Setup

A lid can be used or thick sheet of polycarbonate can be placed on top of the bucket. A vacuum cleaner can be used to pull out air and simulate vacuum environment.

Procedure

- Suspend the fully configured and powered CanSat in the vacuum chamber.
- Turn on the vacuum to start pulling a vacuum.
- **Monitor the telemetry and stop the vacuum when the peak altitude has been reached.**
- Let the air enter the vacuum chamber slowly and monitor the operation of the CanSat.
- Collect and save telemetry.

Result

Will be performed after CDR.

Thermal Test

Purpose

To check if the cansat changes characteristics or **fails to withstand high temperature**

Setup

Place the cansat **inside the thermal chamber** making sure that the heat is not directly blown on the cansat.

Procedure

- Turn on the cansat and place it in the thermal chamber.
- **Check if telemetry is being received from cansat and turn on the thermal chamber, raise the temperature and maintain it for some time**.
- Turn off the heating chamber and check for any structural damages while the canast is still hot while taking precautions.
- Check if the telemetry is still being received and if there is any change in the data being received.

Result

Will be performed after CDR.

Design Details

Design Details (1/4)

Parameters Considered for Design and Simulation

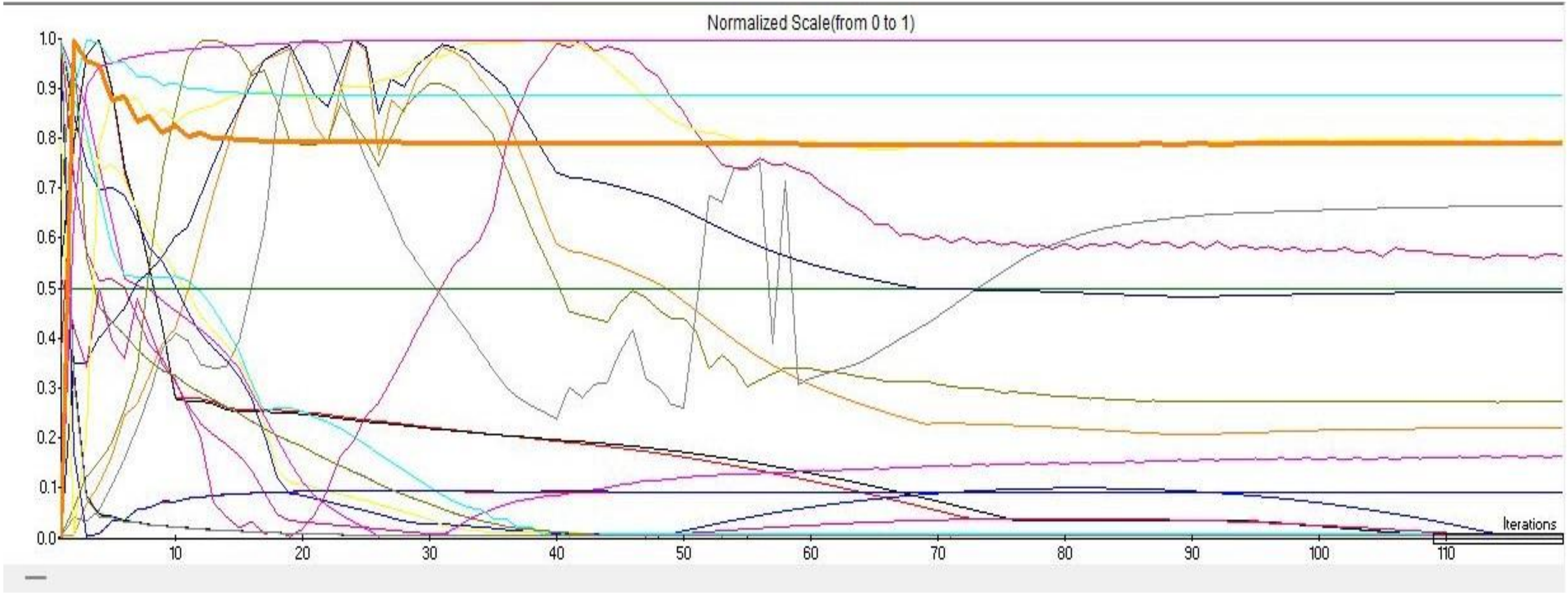
Name	Current Value	Progress	Criterion	Averaged Value
GG Force (X) 21	-0.0376241 N	Achieved (IT = 126)	0.0590598 N	-0.0388325 N
GG Force (Y) 22	2.00589 N	Achieved (IT = 126)	1.0219 N	2.00535 N
GG Force (Z) 23	-0.124442 N	Achieved (IT = 126)	0.153919 N	-0.125738 N
GG Force 20	2.0101 N	Achieved (IT = 126)	1.0337 N	2.00967 N
GG Friction Force (X) 25	0.000243548 N	Achieved (IT = 155)	0.000213981 N	0.000212659 N
GG Friction Force (Y) 26	0.0748023 N	Achieved (IT = 126)	0.00801084 N	0.0746994 N
GG Friction Force (Z) 27	-0.00244609 N	Achieved (IT = 126)	0.00056484 N	-0.00243926 N
GG Friction Force 24	0.0748427 N	Achieved (IT = 126)	0.0080214 N	0.0747395 N
GG Maximum Dynamic Pressure 3	337.19 Pa	Achieved (IT = 165)	144.999 Pa	337.99 Pa
GG Maximum Dynamic Viscosity 10	1.81568e-05 Pa*s	Achieved (IT = 131)	5.66559e-11 Pa*	1.81568e-05 Pa*s
GG Maximum Heat Flux 13	-0 W/m^2	Achieved (IT = 126)	0 W/m^2	0 W/m^2
GG Maximum Heat Transfer Coefficient 12	0 W/m^2/K	Achieved (IT = 126)	0 W/m^2/K	0 W/m^2/K
GG Maximum Static Pressure 1	102695 Pa	Achieved (IT = 158)	755.737 Pa	102711 Pa
GG Maximum Surface Heat Flux (Convective) 14	-0 W/m^2	Achieved (IT = 126)	0 W/m^2	0 W/m^2
GG Maximum Temperature (Fluid) 4	293.4 K	Achieved (IT = 131)	0.00108954 K	293.4 K
GG Maximum Total Pressure 2	102813 Pa	Achieved (IT = 157)	755.65 Pa	102832 Pa
GG Maximum Total Temperature 5	293.405 K	Achieved (IT = 136)	0.00124661 K	293.405 K
GG Maximum Turbulent Viscosity 11	0.0193952 Pa*s	Achieved (IT = 150)	0.000770467 Pa*	0.0193597 Pa*s
GG Maximum Velocity (X) 7	21.5638 m/s	Achieved (IT = 127)	0.843829 m/s	21.5238 m/s
GG Maximum Velocity (Y) 8	21.6774 m/s	Achieved (IT = 126)	2.09875 m/s	21.563 m/s
GG Maximum Velocity (Z) 9	16.6658 m/s	Achieved (IT = 126)	0.674228 m/s	16.6494 m/s
GG Maximum Velocity 6	23.6219 m/s	Achieved (IT = 172)	2.07222 m/s	23.6782 m/s
GG Maximum Wall Temperature 15	293.4 K	Achieved (IT = 130)	0.00116315 K	293.4 K
GG Normal Force (X) 17	-0.0378677 N	Achieved (IT = 126)	0.0591213 N	-0.0390451 N
GG Normal Force (Y) 18	1.93109 N	Achieved (IT = 126)	1.0139 N	1.93065 N
GG Normal Force (Z) 19	-0.121996 N	Achieved (IT = 126)	0.153421 N	-0.123299 N
GG Normal Force 16	1.93531 N	Achieved (IT = 126)	1.02575 N	1.93498 N
GG Torque (X) 28	-0.22271 N*m	Achieved (IT = 126)	0.115052 N*m	-0.222685 N*m
GG Torque (Y) 29	0.00720989 N*m	Achieved (IT = 126)	0.0160025 N*m	0.00717467 N*m
GG Torque (Z) 30	0.115798 N*m	Achieved (IT = 126)	0.0590744 N*m	0.115731 N*m

First Deployment Stage

Boundary condition for first parachute deployment stage is that velocity of airflow is in positive y-axis with a velocity of 19.64 m/s.

Design Details (2/4)

GRAPH



Design Details (3/4)

Parameters Considered for Design and Simulation

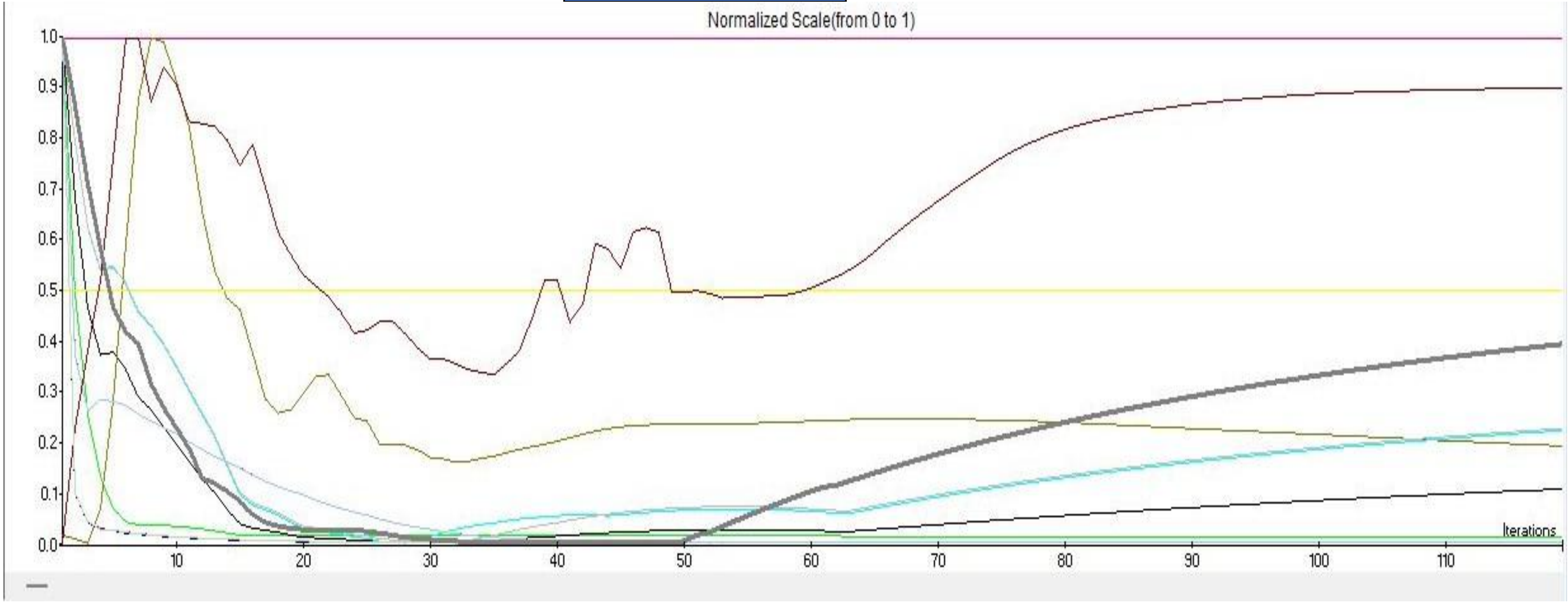
Name	Current Value	Progress	Criterion	Averaged Value
GG Force (Y) 18	0.0268088 N	Achieved (IT = 119)	0.00816367 N	0.026807 N
GG Force 17	0.026836 N	Achieved (IT = 119)	0.00831343 N	0.0268342 N
GG Friction Force (Y) 20	0.00230117 N	Achieved (IT = 119)	0.000242561 N	0.00229727 N
GG Friction Force 19	0.00230176 N	Achieved (IT = 119)	0.000242568 N	0.00229789 N
GG Mass (Fluid) 7	0.0277224 kg	Achieved (IT = 119)	0.000277222 kg	0.0277224 kg
GG Maximum Circumferential Velocity 11	3.03333 m/s	17%	0.1318 m/s	3.44955 m/s
GG Maximum Dynamic Pressure 3	5.63711 Pa	38%	1.31719 Pa	7.32538 Pa
GG Maximum Dynamic Viscosity 13	1.81465e-05 Pa*s	Achieved (IT = 471)	4.90094e-13 Pa*	1.81465e-05 Pa*s
GG Maximum Mach Number 12	0.00891792	26%	0.000566805	0.0101416
GG Maximum Static Pressure 1	101486 Pa	Achieved (IT = 119)	14.3747 Pa	101488 Pa
GG Maximum Total Pressure 2	101486 Pa	Achieved (IT = 119)	14.3743 Pa	101488 Pa
GG Maximum Total Temperature 4	293.202 K	Achieved (IT = 187)	2.90496e-05 K	293.202 K
GG Maximum Turbulent Viscosity 14	0.00207924 Pa*s	Achieved (IT = 155)	4.62567e-05 Pa*	0.00207993 Pa*s
GG Maximum Velocity 10	3.06034 m/s	26%	0.192923 m/s	3.48027 m/s
GG Normal Force (Y) 16	0.0245077 N	Achieved (IT = 119)	0.00794032 N	0.0245097 N
GG Normal Force 15	0.0245371 N	Achieved (IT = 119)	0.00809401 N	0.0245392 N

Second Deployment Stage

Boundary condition for second parachute deployment stage is that velocity of airflow is in positive y-axis with a velocity of 1.96 m/s.

Design Details (4/4)

GRAPH



CanSat Algorithm

Cansat Algorithm Changes Since PDR

There are no changes made in the CanSat Algorithm since PDR.

CanSat Algorithm Overview

Overview

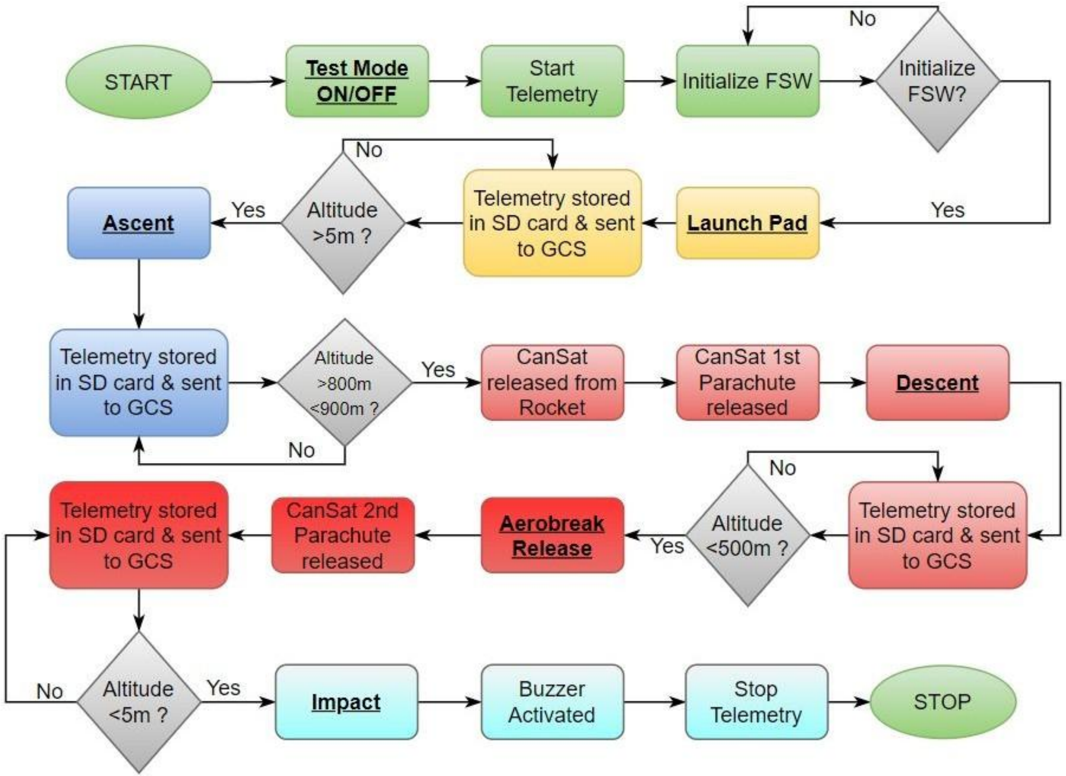
- The CanSat will collect sensor data, store in SD card and send to the Ground Control Station via XBEE.
- Ground Control Station will send the various commands like CX,SET TIME,Calibrate etc.

Programming Languages

- C++ is used for CanSat data processing and Transmission of Telemetry.
- GUI of Ground Control Station is made using Python with PyQt5 libraries.

Development Environment

- Arduino IDE is used for CanSat MCU.
- VSCode is used for GUI development.
- XCTU for XBEE 3 Pro Configuration.



CanSat Algorithm State Diagram (1/4)

BOOT

All the sensors and actuators got the power and are detected by MCU

- PCB gets power.
- Sensors are determined by Teensy 4.1 and are ready for SIMULATION & TEST_MODE

TEST_MODE

This mode is used to calibrate and set all the sensors for the flight.

- Sensors are calibrated and checked.
- Set Time for flight.
- Simulation Mode is enabled by commands form GCS.

LAUNCH_PAD

Telemetry is storing in .csv file and sending to GCS has been started.

- Payload Activation commands will be received.
- Sensors data saved to SD card and sent to GCS via XBEE.

ASCENT

Payload ascents till 900m in the rocket.

- If Altitude is between 800m to 900m, move to next state.
- Sensors data saved to SD card and sent to GCS via XBEE.

ROCKET_DEPLOY

At the apogee the payload is released from the rocket and descent starts.

- Payload is deployed from the rocket.
- Sensors data saved to SD card and sent to GCS via XBEE.

DESCENT

1st Parachute is released to descent at 20m/s.

- If Altitude is less than 500m, move to next state.
- Sensors data saved to SD card and sent to GCS via XBEE.

AEROBREAK_RELEASE

2nd Parachute is released to decrease descent rate to 3m/s

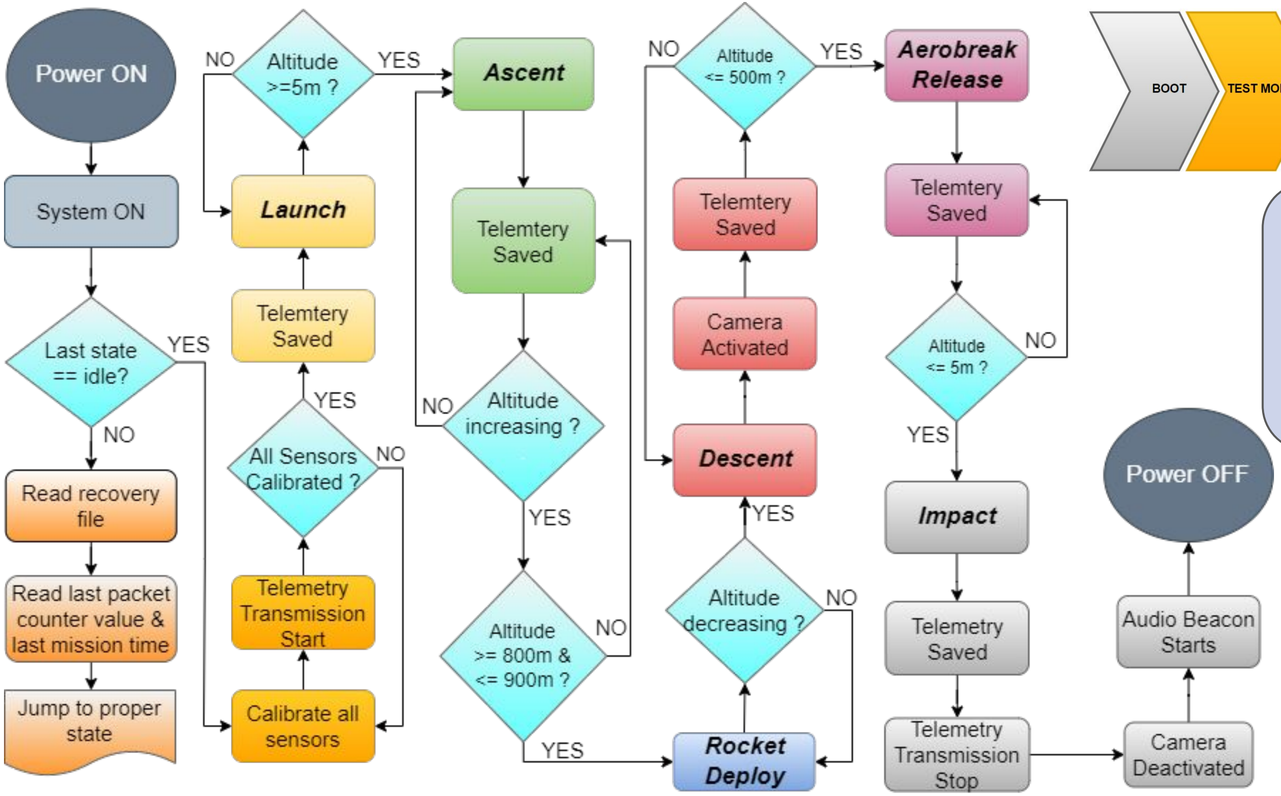
- If Altitude is less than 5m, move to next state.
- Sensors data saved to SD card and sent to GCS via XBEE.

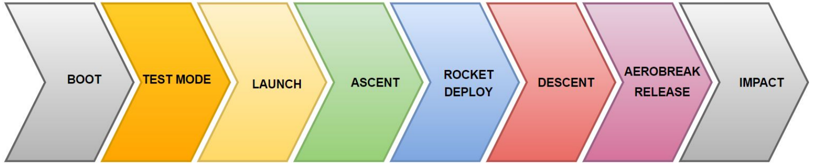
IMPACT

Payload will be on the ground and Audio Beacon

- Audio Beacon is Activated.
- Sensors data saved to SD card and sent to GCS via XBEE have been stopped.
- Power OFF.

CanSat Algorithm State Diagram (2/4)



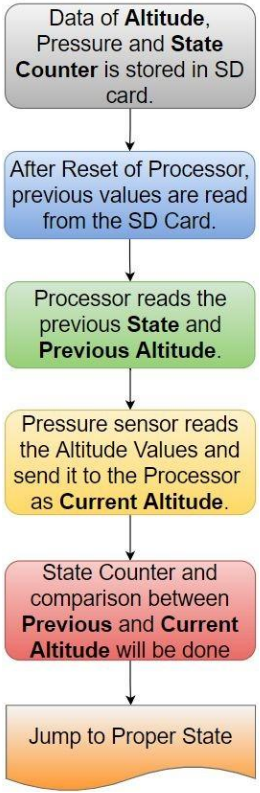


Telemetry Data

- Payload Telemetry Data is stored in the SD card @1Hz.
- Payload will start transmitting telemetry @1Hz after the activation is received from the GCS.

- Two variables **Present Altitude** & **Previous Altitude** have been made to check if the altitude is increasing or decreasing.
- The communication between Payload and GCS takes place via XBEE 3 Pro.

CanSat Algorithm State Diagram (3/4)



Reset Reasons

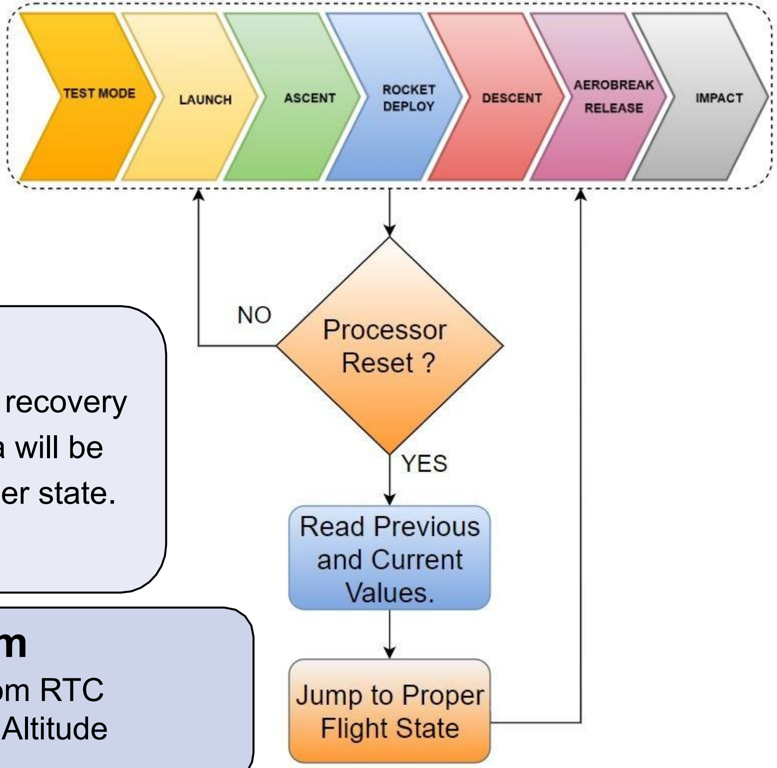
- ❑ Shock Impact in the rocket while Ascent.
- ❑ Voltage Drop due to any glitch in Power Transmission.
- ❑ High Temperature affecting the Processor.

Method

To recover state after restart, microcontroller will read recovery file and check if it was unwanted restart. If it was, data will be saved to variables and state selector will jump to proper state. In other case, state selector jumps to state Idle.

Data used to Recover System

- ❑ State Counter
- ❑ Previous Altitude
- ❑ Time from RTC
- ❑ Current Altitude



CanSat Algorithm State Diagram (4/4)

Processes	Description
Sampling Of Sensors	The Sampling of Sensors starts when the Payloads gets the command of SIM Enable to start simulation in the Launch_Pad mode.
Communications	The communications between Payload and Ground Control Station is done via XBEE 3 having NETID 049.
Data Storage	The Data from all the sensors is saved in the SD card with the help of In-built SD card reader in Teensy 4.1.
Mechanisms Activations	At 500m, Second Parachute is released to decrease the descent rate to 1 - 3 m/s. After landing (altitude < 5m), Audio Beacon is started and Telemetry Transmission stops.
Major Decision Points	During the flight, unwanted resets occur due to various reasons hence a backup of data is made so that processor can read and jump to proper state.
Power Management	When some of the components are not in use then those components are switched into standby mode which help us to conserve power.

Simulation Mode Software

To enter simulation mode Ground Station should send two commands (**SIM ENABLE** and **SIM ACTIVATE**) to container. Two commands are required to prevent accidental initiation. Then GS will start sending air pressure values at **@ 1Hz** to payload via XBEE 3 Pro. FSW will use received values in place of real data from pressure sensor. It will let FSW calculate simulated altitude used by software logic.

Ground Control Station

CMD,049,SIM_ENABLE & **CMD,049,SIM_ACTIVATE** are sent to start the simulation mode. <Pressure> readings are sent from GCS.

<Pressure>

Data with substituted altitude calculated from given Pressure. Looping will be continued until the **SIM DISABLE** command is received from GCS.

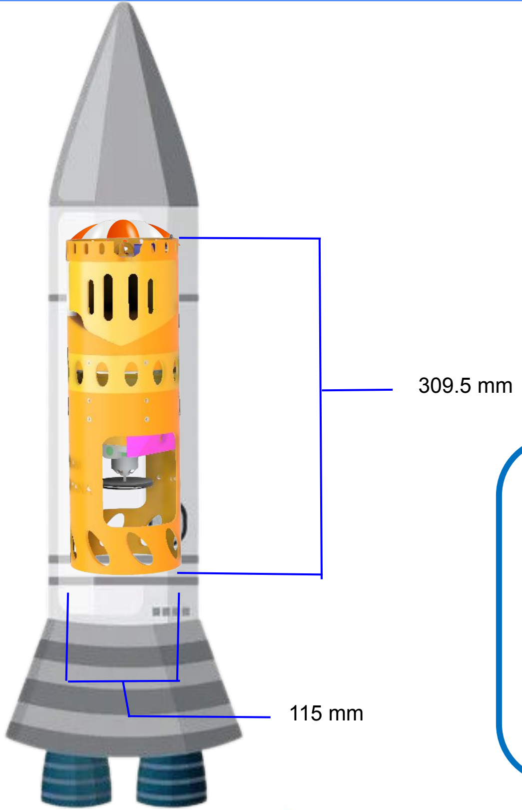
<Altitude>

CMD,049,SIM_DISABLE command is sent to stop the simulation mode.

—

TTLC Margin Realized

TTLC Margin Realised

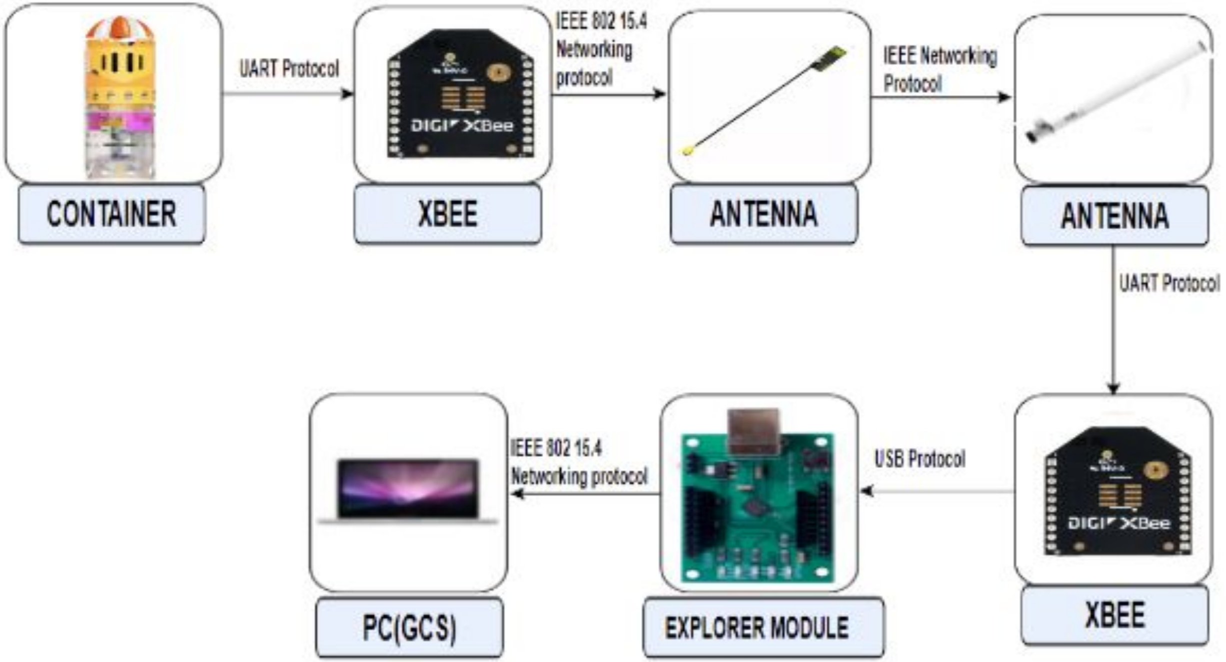


	Height (mm)	Width (mm)
Cylindrical Envelope	310	125
CanSat	309.5	115
Margin	**0.5**	**10**

- For easy integration of the CanSat into the rocket, height of cansat is **309.5mm** and width **115mm**.
- Descent rate is controlled by **dual deployment parachute** mechanism.
- There are **no sharp edges** on the surface of the cansat container as required for the competition.
- **Fit check** will be done to make sure it meets launch vehicle compatibility.
- The Container is **not dependent** on the **rocket airframe** for any support to any component.

Ground Control System (GCS) Design

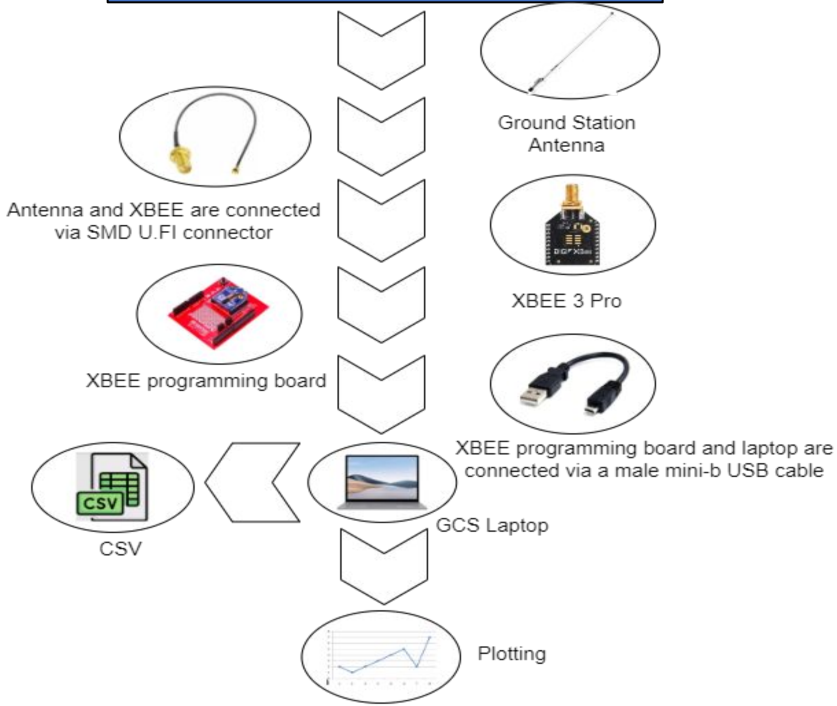
GCS Overview



- The calibration, CX, Set Time, SIM commands are transmitted from the ground station to the Container via XBEE Pro 3 Module, explorer module and antenna.
- The calibration command will be transmitted from the ground station to the container.

GCS Design

GCS DESIGN DIAGRAM



SPECIFICATIONS

BATTERY

Battery backup will be greater than 3 hours.

OVERHEATING

An external cooler with its own battery will be there and to prevent the direct exposure to sunlight an umbrella will be installed.

AUTO-UPDATE

The auto update feature will be disabled on Windows OS before the launch.

BACKUP

The ground system software will also be downloaded as a backup.

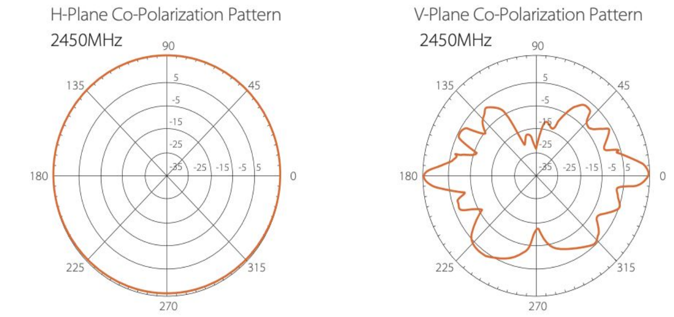
GCS Antenna (1/2)

Model	Frequency (GHz)	Gain (dBi)	Polarization	Impedance (Ohms)	Directivity	VSWR	Range (Km)	Cost (₹)	Weight (g)
TL-ANT2415D	2.4 ~ 2.5	15	Linear, Vertical	50	Omni-Directional	< 2.0	11.2	3500	600

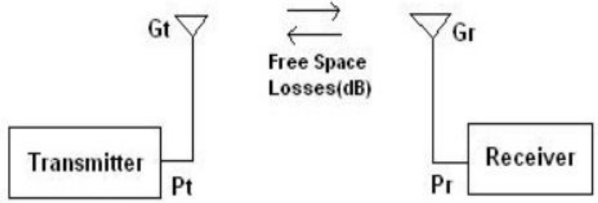
Reasons

- High gain of 15dBi.
- Omnidirectional so no need to reorient continuously.
- Range of more than 11 Km which is much longer compared to others.
- Weatherproof design ideal for ground station.

Radiation Patterns:



GCS Antenna (2/2)



Step-1: EIRP = Pt - Cable_loss + Gt

Step-2: FSL (Free Space Loss) = EIRP - Pr

Step-3: dist = FSL + 20*Log10(Lambda) - 21.98

=>Antenna coverage distance = 10^(dist/20)

Assumptions; The given ranges are calculated taking -
Receiver sensitivity = -100 dBm
Operating Frequency = 2.4Ghz
Cable loss = 3dB

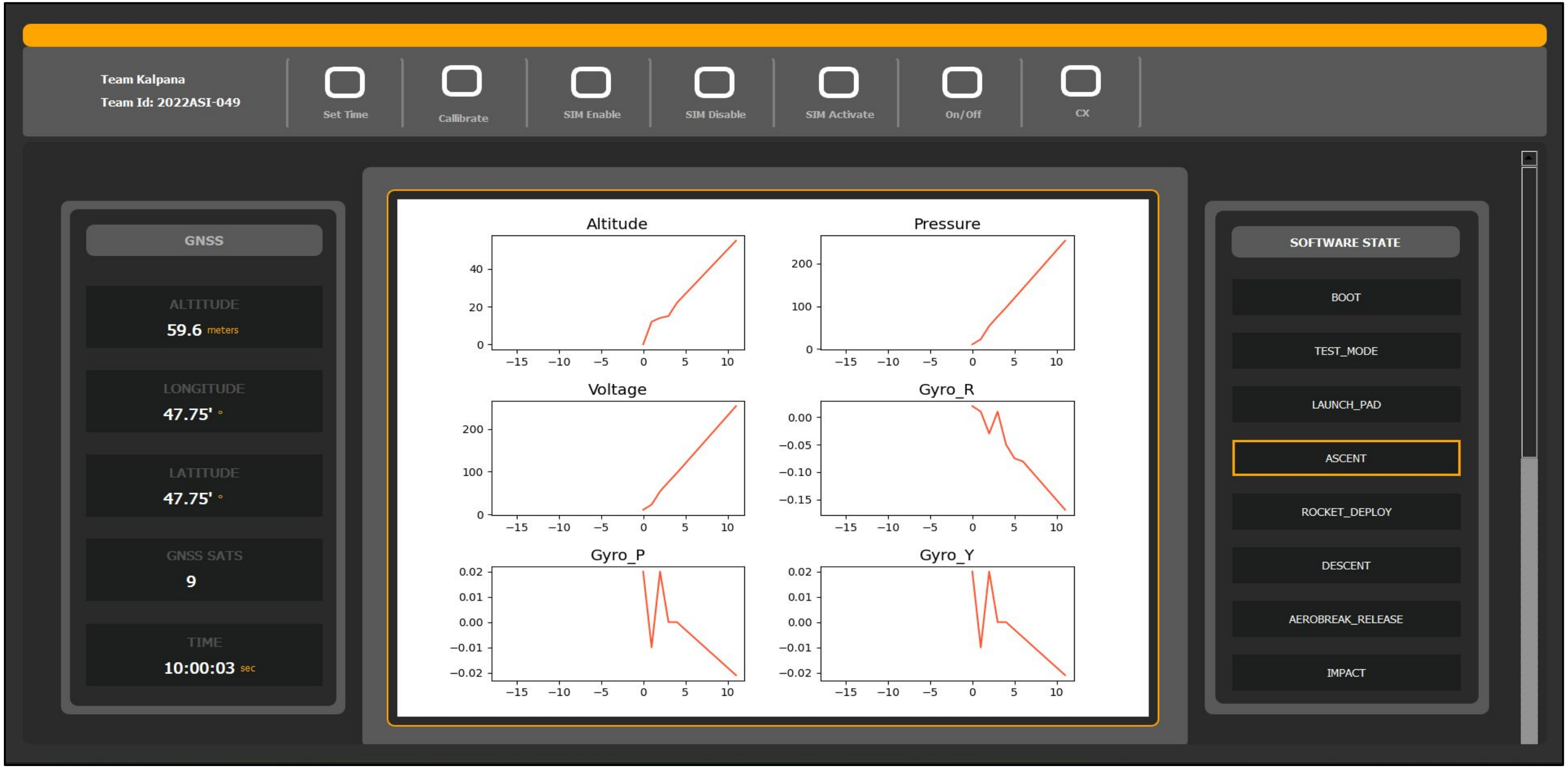
Transmit power = (Efficiency/100)*(input Power)
Power (W to dBm): P(dBm) = 10 x Log_{10}(P(in W)) + 30

INPUT PARAMETERS					PARAMETERS DETERMINED	
Transmit Antenna Gain (dBi)	**Transmit Power (dBm)**	**Operating Frequency (MHz)**	**Cable loss (dB)**	**Receiver Sensitivity (dBm)**	**Free Space Path Loss (dB)**	**Antenna coverage distance (km)**
15	29.03	2400	3	-100	141.03	11.2

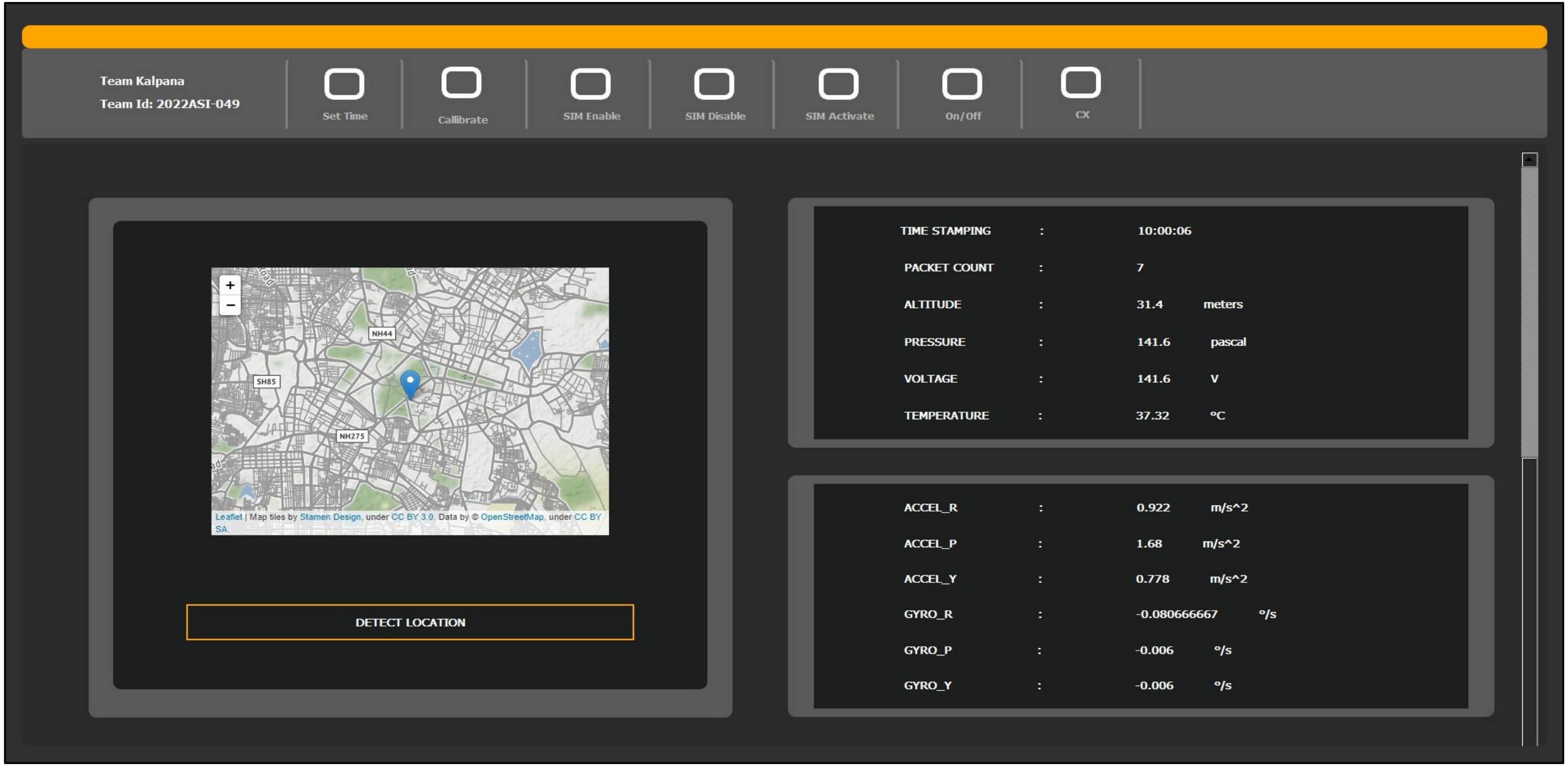
GCS Software (1/3)

DATA VISUALISATION	REAL TIME PLOTTING SOFTWARE DESIGN	COMMERCIAL OFF THE SHELL (COTS)	DESCRIBE .csv FILE CREATION FOR JUDGES	COMMAND SOFTWARE AND INTERFACE
We are using **graphs** and **labels** for Data visualisation.	The **Ground Control Software** reads the data from Serial Port and plots Real Time graphs for Payload in the GUI.	**Python**, **Arduino** and **XBEE Program Module** is used for GCS Development.	The telemetry data is taken from Serial Ports and is diverted into **Flight_2022ASI049.csv** . These files are first created and then the values are stored.	Various commands have been included in the interface according to mission guidelines and use during mission.

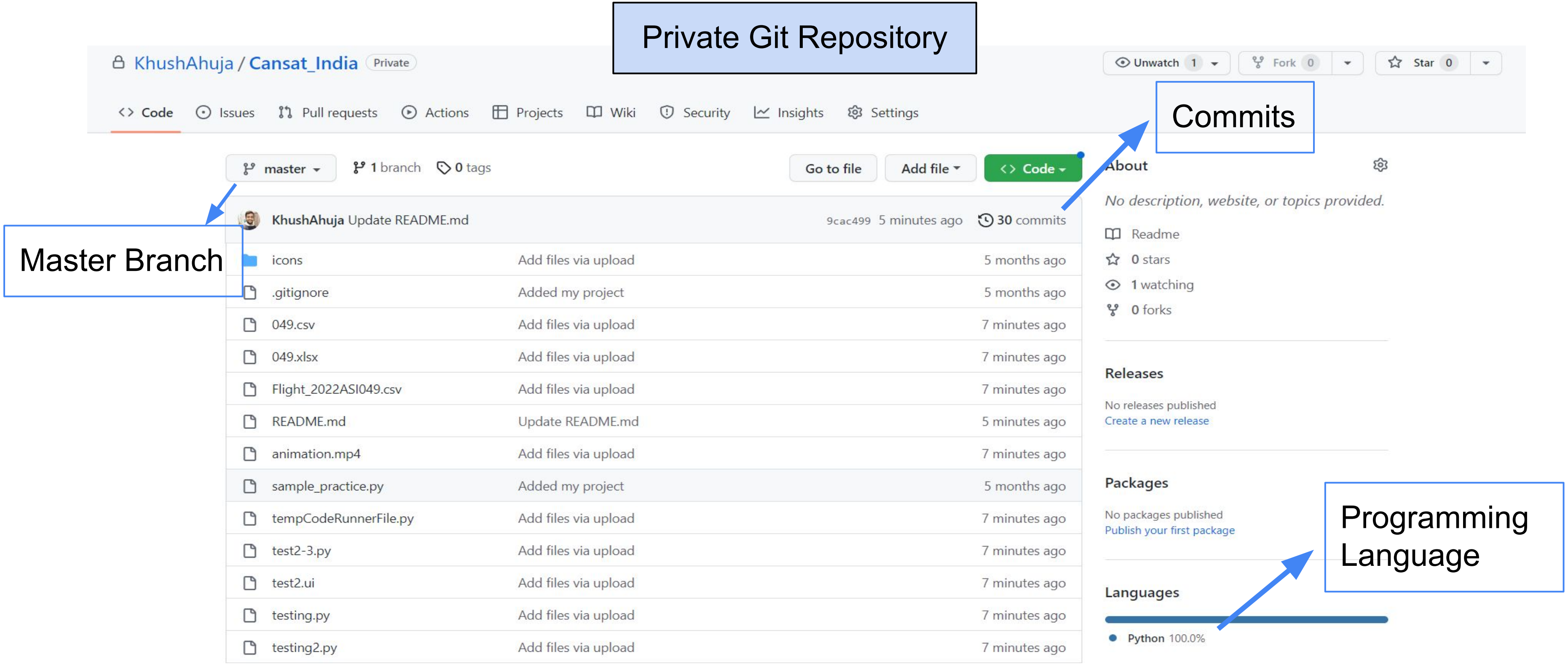
GCS Software (2/3)



GCS Software (3/3)



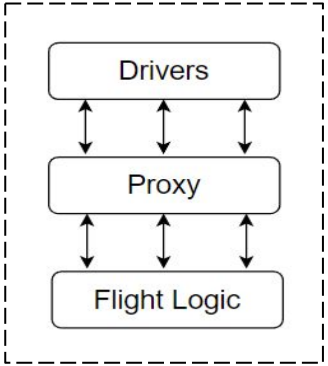
Software Development Plan (1/4)



Software Development Plan (2/4)

Late software development problem

In order to mitigate risk, we initiated preparations well in advance. Our approach involves the development of a three-layer software system. The first layer encompasses drivers for sensors and peripherals, the second layer serves as a connector between the first and third layers, and the third layer is exclusively dedicated to flight logic utilizing a state machine. This solution enables us to independently test the software before integrating it with the hardware. The final step is to program the proxy layer to seamlessly connect all layers.



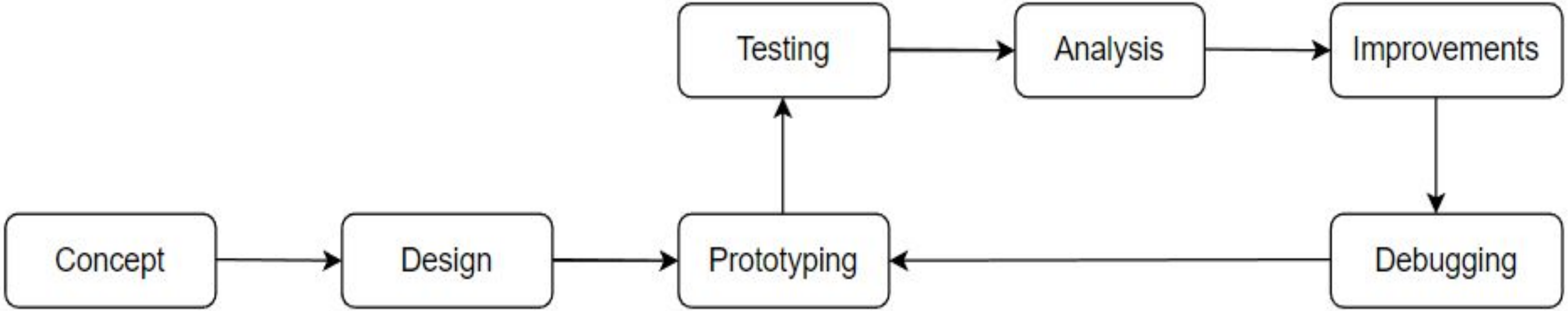
Prototyping and prototyping environments

Each step includes **parallel verification and validation**, noting requirements and conducting a problem analysis, with each module being developed, **constructed**, and **tested with the integration and its integration tests**.
Figma was used for prototyping the GUI, which was utilised to create wireframes for the GUI, which were then included into the **VSCode** using **Python (PyQt5)**.

Software Development Plan (3/4)

Software Developing

We utilised Git as our primary tool for storing and managing our codebase. This software allows for seamless team collaboration and facilitates tracking of issues, as well as conducting code reviews. To maintain continuity in our development efforts, we conduct weekly meetings to discuss any challenges or problems that may arise and to ensure that our progress is on track.

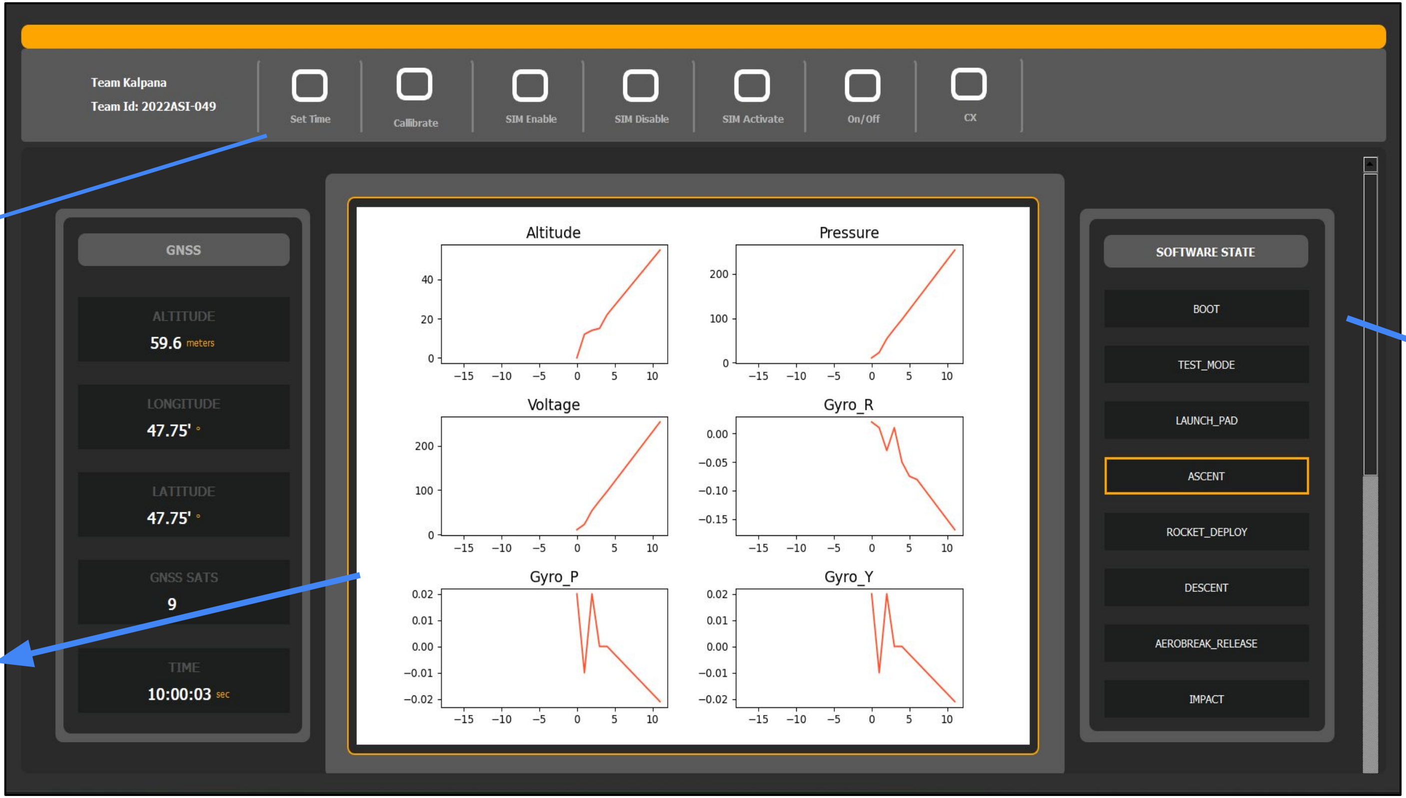


Software Development Plan (4/4)

Progress since PDR	
Real-time telemetry data update	Done
Software state detection	Done
Unwanted restart mechanism implementation	Done
Live container location detection	Done
Data visualization	Done
State machine logic implementation	Done
Sensor programming	Done
Calibration command processing	In progress
Memory card logging	In progress
Deployment mechanism support	In progress
Integrations of all systems	In progress

GCS Final Test Results

GCS Final Test Results (1/2)



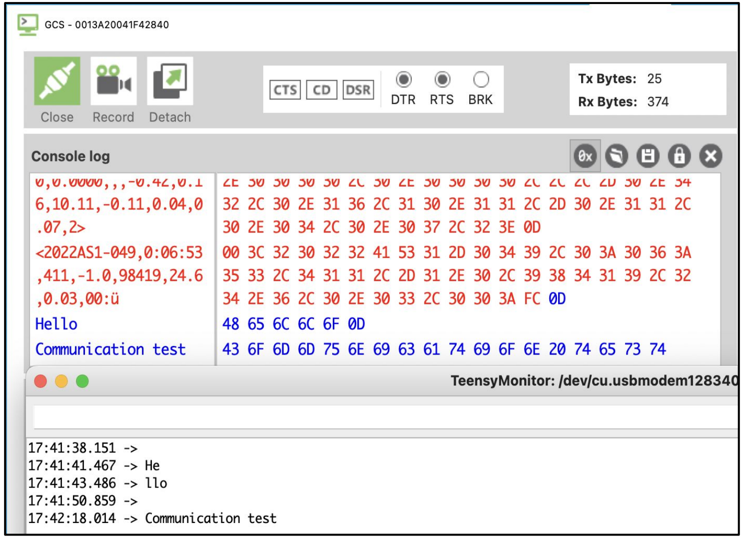
Command palette

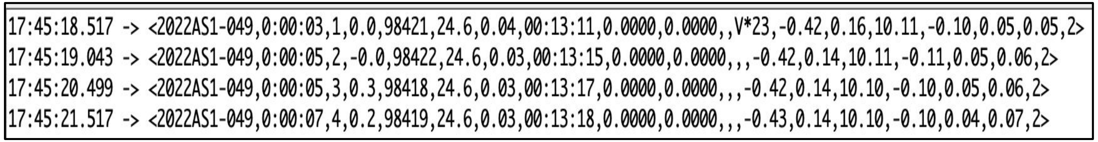
Data Visualization

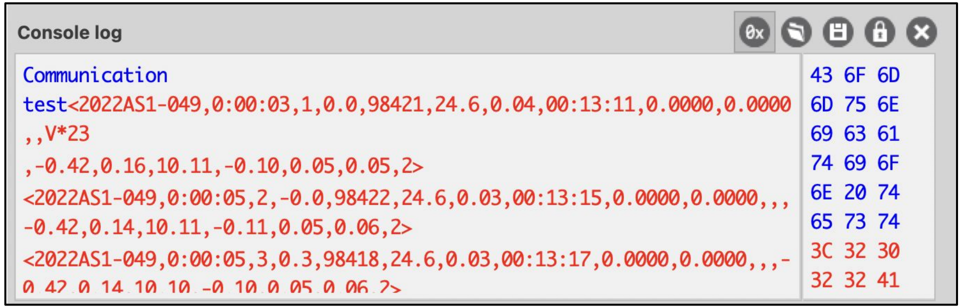
Software states

GCS Final Test Results (2/2)

- Performed multiple communication tests to assess the quality of **data communication** between **XBee radios** over varying distances.
- To ensure that the range of the radios met the necessary standards **open-air** and **ground level** range testing were conducted.
- Checked radio communications at **ranges greater than required.**







Blue- Transmitted message from GCS XBee to Coordinator XBee
Red- Telemetry Received by GCS XBee from Coordinator XBee

CanSat Integration and Testing

CanSat Integration and Test Overview

CDH And FSW Testing
- Receiving and transmission of data through antenna has been tested.
- Speed of processing of data is verified (1Hz).

Communication Testing
- Radio Communication through XBee is verified for different ranges.
- Tested communication various times to ensure correct data.

Mechanical Testing
- Total mass of Cansat is calculated and verified which is 700±50 g
- Parachute, servo and mechanical gyro will be checked.

Integrated Level Testing
- Complete Sensor Subsystem with battery will be tested.
- Container drop test will be verified using drone along with sensor mechanism.
- Radio and Antenna shall be tested.
- The polarisation of antenna will be checked and verified.

Environmental Testing
- Thermal test will be done to check if cansat changes characteristics or fails to withstand high temperature
- Fit test will be done to check whether it's good to launch.
- Drop test, vacuum test and vibration test will be performed.

Decent Control Testing
- Parachute release of Cansat will be verified using drone test.
- Descent rate of the Cansat is checked and verified.

Simulation Testing
- FSW switching is verified.
- GCS switching is tested to verify whether the software is inconsistent.

Sensor Testing
- Sensors will be calibrated until high accuracy is achieved.
- Software Integration compliance shall be verified.

Mission Operation & Analysis

Overview of mission sequence of events (1/3)

Arrival, Checks and GCS Setup

1. Team arrives at the launch site. All team members have assigned roles to follow upon arrival.
2. The CanSat, Laptop and Antenna are checked for any damage and repaired.
3. GCS Software is booted up.
4. Antenna is assembled and connected to the XBEE, which is connected to the laptop to interface with the Software.

Pre Launch

1. The CanSat weight and size are checked.
2. All internal mechanisms are verified.
3. GCS Software is primed for connection.

Final Preparation

1. Parachute is folded and placed in the designated compartment, the release mechanism is checked.
2. CanSat electronics are switched on.
3. CanSat is connected to the GCS Software and communication is verified.
4. CanSat is placed into the rocket payload section.

Delivery of telemetry

Telemetry is published to judges via MQ Telemetry Transport server.

Antenna construction and ground system set up

- Antenna is shipped in parts and inspected for damage when unboxed.
- Then it is assembled using wrench, nuts and bolts and then it is connected to XBEE and ground station.

Overview of mission sequence of events (2/3)

Launch

1. Data transmission begins. Rocket liftoff, telemetry continues during ascent.
2. CanSat is released from rocket between 800-900m.
3. Both the parachutes are connected to O ring. The first parachute is deployed passively.
4. Telemetry continues during descent.
5. For second parachute Cavity is made in place of o ring will be directly connected to the first parachute.
6. Parachute 2 is deployed at 500m (+/- 10 m).

Cansat Recovery

1. The Container buzzer activates for audio cues.
2. Received Telemetry helps locate the CanSat using GPS data.
3. Recovery crew begins hunting for the Cansat and accompanies the field judge during scoring .
4. The Container and payload are colored in fluorescent orange ensuring they are visible clearly from afar.
5. Container and payload are recovered and examine for any damages on impact.

Data Analysis and PFR Preparation

1. SD Card is extracted and the data is analysed. This includes camera recordings.
2. Received telemetry is analysed.
3. Telemetry is backed up and CSV files are submitted for assessment.
4. Telemetry is used in PFR presentation.

Overview of mission sequence of events (3/3)

Team Roles and Responsibility

Name	Role/Responsibility	Role Description
Vansh Kumar Goel	Mission Control Officer	Supervision of all CanSat tasks. This is the person in charge of informing the Flight Coordinator when the crew and their CanSat is ready to launch.
Muskan	CanSat Crew	It is their responsibility to prepare the CanSat, integrate it into the rocket, and verify its status.
Vidushi	CanSat Crew	
Divya Rawat	CanSat Crew	
Khush Ahuja	Ground Station Crew	They are in charge of monitoring telemetry reception at the ground station and issuing commands to the CanSat. They will transmit calibration commands and execute other responsibilities as directed by the Mission Officer.
Arnav Dev	Ground Station Crew	
Yuvraj	Recovery Crew	Responsible for tracking and going out into the field for recovery and interacting with the field officer.
Yash	Recovery Crew	

Pre Flight Requirement-Analysis and Test

Pre Flight Requirement- Analysis and Test (1/6)

Req No.	Requirement	Compliance	Team comments
1.	Total mass of the CANSAT shall be under 0.700 kg (+/- 0.050 kg).	Comply	Mass Budget
2.	CANSAT shall fit in a cylindrical body of 0.125m diameter x 0.310m height. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Comply	TTLC Margin Realized
3.	Any sharp edges on the container body shall be avoided as it can cause interfere during the CANSAT ejection from the rocket.	Comply	TTLC Margin Realized
4.	Color of the CANSAT body shall be fluorescent i.e., pink, red or orange, and shall embody the Indian flag.	Comply	Cansat Recovery
5.	Rocket Airframe will not be allowed to be used as a part of any CANSAT operation.	Comply	TTLC Margin Realized
6.	The CANSAT shall consist of necessary sensors to provide the following mandatory Real-time datasets: Position data, altitude, pressure, temperature, orientation data, power data & system status.	Comply	Telemetry
7.	Each data field shall be displayed in real-time on the ground station user interface/software.	Comply	GCS
8.	CANSAT shall also record the data and save it into an onboard SD card in case of telecommunication loss.	Comply	Processor and Memory

Pre Flight Requirement- Analysis and Test (2/6)

Req No.	Requirement	Compliance	Team comments
9.	All electronics shall be enclosed and shielded from the environment. No electronics can be exposed except for sensors. There must be a structural enclosure.	Comply	Electronics Structural Integrity
10.	CANSAT structure shall be built to survive 15 Gs of launch acceleration & 30 Gs of shock.	Comply	Drop Test
11.	Electronic circuit boards must be hard mounted using proper mounts such as standoffs and screws. High-performance adhesives can also be used.	Comply	Electronic Structural Integrity
12.	Team number, email address and phone number must be placed on the structure in English, Hindi and the Regional language of the launch state to aid in recovery.	Comply	CanSat Location and Recovery
13.	An audio beacon shall be installed on CANSAT as a recovery assist. It may be powered after landing or operate continuously. The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Comply	CanSat Location and Recovery
14.	The CANSAT shall have an external power switch with an indicator light or sound for being turned on or off, in order to avoid the disassembly of CANSATs on the launch pad.	Comply	EPS

Pre Flight Requirement- Analysis and Test (3/6)

Req No.	Requirement	Compliance	Team comments
15.	The CANSAT shall have a battery capacity to support up to 2 hours of wait in on the launch pad with additional time for flight operations.	Comply	Power Budget
16.	The battery source may be alkaline, Ni-Cad, Ni-MH or Lithium ion. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.	Comply	Power Bus Source
17.	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require total disassembly of the CANSAT.	Comply	Physical Layout
18.	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	Physical Layout
19.	The CANSAT shall contain a total of 2 descent control mechanisms, for use at different stages during descent.	Comply	Descent Control
20.	CANSAT shall immediately deploy the first parachute after ejection from the rocket.	Comply	Descent Control
21.	The first parachute shall be connected to the outer body of the CANSAT and no ejection mechanism shall be attached to it.	Comply	Descent Control

Pre Flight Requirement- Analysis and Test (4/6)

Req No.	Requirement	Compliance	Team comments
22.	The descent rate of the 1st parachute shall be 20 m/s +/- 5m/s	Comply	Descent Control
23.	The second descent control mechanism shall open at an altitude of 500m (+/-10 m) to further decrease the descent rate of the CANSAT to 1 to 3m/s .	Comply	Descent Control
24.	The descent control system shall not use any hazardous chemical-based explosive or pyrotechnic devices. However, green propulsion is allowed if being used under the same weight constraint.	Comply	Descent Control
25.	CANSAT shall stabilize itself during the decent using the mechanical gyro mechanism	Comply	Mechanical Gyro Control
26.	The CANSAT communications radio shall be the XBEE radio series 1/2/pro	Comply	Payload Radio Configuration
27.	The XBEE radios shall have their NETID/PANID set to the team number.	Comply	Payload Radio Configuration
28.	The XBEE radio shall not use the broadcast mode.	Comply	Payload Radio Configuration

Pre Flight Requirement- Analysis and Test (5/6)

Req No.	Requirement	Compliance	Team comments
29.	The XBEE radio can operate in any mode as long as it does not interfere with other XBEE radios.	Comply	Payload Radio Configuration
30.	Each team shall develop and use their own ground station. All telemetry shall be displayed in real-time during launch and descent. All telemetry shall be displayed in engineering units (meters, meters per second, Celsius, etc.). Teams shall plot data in real-time during flight.	Comply	GCS Software
31.	The ground station shall command the CANSAT to start transmitting telemetry prior to launch.	Comply	Telemetry
32.	Ground control station antenna shall be elevated from ground level to ensure adequate coverage and range.	Comply	GCS Antenna
33.	Stability of the ground station must be ensured.	Comply	GCS Design
34.	The CANSAT shall not transmit telemetry until commanded by the team ground station. Command can be executed while the CANSAT is in the rocket on the launch pad.	Comply	FSW State Diagram
35.	The ground station shall be able to command the CANSAT to calibrate gyros, barometric altitude, accelerometer to command the parameters to zero as the CANSAT sits on the launch pad.	Comply	FSW State Diagram
36.	The ground station shall generate .csv files of all sensor data as specified in the Telemetry Requirements section.	Comply	Software development

Pre Flight Requirement- Analysis and Test (6/6)

Req No.	Requirement	Compliance	Team comments
37.	Telemetry shall include mission time with one second or better resolution.	Comply	RTC
38.	Mission time/timestamp and system status states shall not be affected in the event of a processor reset during the launch and mission.	Comply	RTC
39.	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Comply	GCS Overview
40.	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line and if required the team can also move to a different location in case of distant landing location in order to locate the CANSAT.	Comply	GSC Software
41.	The flight software shall maintain and telemeter an indicator of the CANSAT flight software state. An example set of states is 0 (BOOT), 1 (TEST_MODE), 2 (LAUNCH_PAD), 3 (ASCENT), 4 (ROCKET_DEPLOY), 5 (DESCENT), 6 (AEROBREAK_RELEASE), and 7 (IMPACT).	Comply	GCS Software
42.	Upon powering up, the CANSAT shall collect the required telemetry at a 1 Hz sample rate or more. The telemetry data shall be transmitted with ASCII comma-separated fields followed by a carriage return	Comply	Telemetry

Logistics and Transportation

Logistics and Transportation

It will be ensured that all essential components, electronics, antenna and the CanSat itself are securely packed and batteries are uninstalled

These will be carried in foam padded boxes/bags to safeguard from damage during baggage handling.

In order to stay within permitted check in weight - the components will be distributed accordingly among all team members.

Essential hardware and GCS laptop should be carried in hand luggage to prevent loss.

Non essential hardware, subsystems, and components will be distributed among team members to minimise loss and/or damage, and will be carried in check-in luggage.

Replacements and spare components will also be carried.

Permissions Required

- All prohibited items will be declared.
- Bills and receipts will be carried.
- Proof of participation in the competition will be carried for verification.

CANSAT Budget

CanSat Budget – Hardware (1/2)

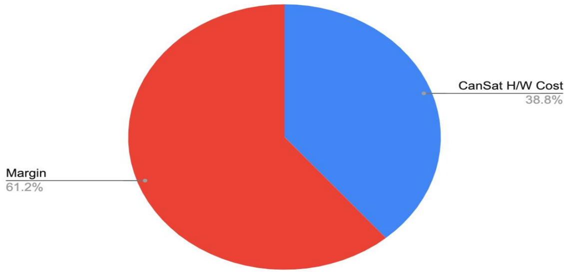
Category	Components	Quantity	Cost per Piece (₹)	Total Cost (₹)
Sensors	BMP 280	1	80	80
	BMX160	1	1400	1400
	Quectel L89	1	1410	1410
Radio	Digi XBee 3 PRO	1	3499	3499
Microcontroller	Teensy 4.1	1	3241	3241
Payload Antenna	FXP 840.07.0055B	1	620	620
Camera	Adafruit Mini Spy	1	1000	1000
Power	Panasonic NCR18650 GA	2	799	1598
	Coin cell CR2032	1	65	65
SD Card	SanDisk Ultra	2	395	790
PCB	-	1	700	700
Voltage Booster	MT3608	1	55	55
Servo motor	SG90	1	120	120
	MG90	2	270	540
BLDC motor	A2212 - 2200KV BLDC	1	395	395

CanSat Budget – Hardware (2/2)

Category	Model Selected	Quantity	Cost per Piece (₹)	Total Cost (₹)
LDO	LM1117DT	2	25	50
Buzzer	CEP 1112	1	150	150
Mosfet	IRF 3205	1	75	75
BLDC Motor	A212	1	400	400
Electronic Module	ABS Printed	1	2000	2000
Parachute Module	ABS Printed	1	1300	1300
Parachute	FIrst Parachute	1	2100	2100
	Second Parachute	1	4800	4800
Body	Container parts	1	6000	6000
	Payload Subsystem Parts	1	7000	7000
Total Hardware Cost				**₹38,988**

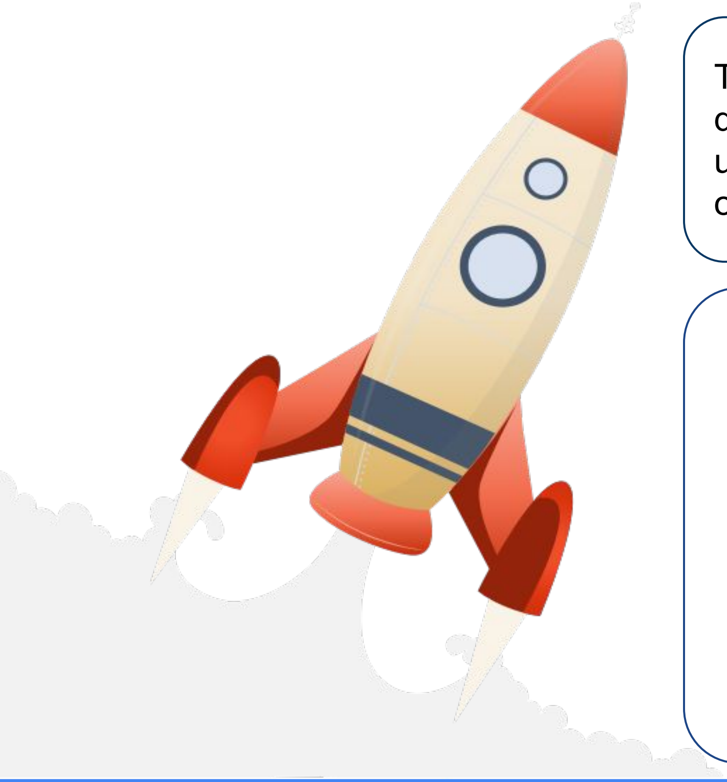
Strictly, new components have been used, to avoid inconsistencies and faulty performance.

Available Budget: **₹1,00,000**



CanSat Ready to Launch and Final Comments

CanSat Ready To Launch and Final Comments



The critical design phase for the mechanical, electronics, and software departments is completed. The major mechanisms and subsystems have undergone thorough testing and further improvements are underway to optimize the performance of the CanSat during flight.

- Based on feedback received during the PDR presentation, the team has made modifications to the electrical power subsystem(EPS), including the implementation of a single system to run the CanSat and the use of only two batteries in series.
- The sensors have been tested and the PCB has been designed to meet the requirements.
- Final prototype of the CanSat is printed and various environmental tests have also been conducted to verify the reliability of the cansat.
- The team has established travel and shipment plans for the competition day.

Conclusion

Conclusion

Accomplishments

Electronics

- Each sensor has undergone testing.
- Completed XBEE Communication exam.
- The Ground Control System has been finished and is currently being tested.
- The PCB design is finished.

Mechanical

- Printing the cansat's final prototype and conducting different tests.
- A printed prototype has been created.
- A brand-new gyro model has been proposed.

Software

- Antenna was constructed and tested.
- Enhanced the general functionality of the GUI and removed unusable components to enhance the UI.
- The Cansat Algorithm is now completed.

Unfinished Work

Electronics

- Stabilizing the CanSat with Active Gyroscope programming.
- Integration and testing of the gyroscope system with the CanSat system.
- PCB printing.

Mechanical

- Testing the Gyroscope
- Verification of descent rates using the competition's actual parachutes
- Simulated testing of strength

Software

- CanSat algorithm development and testing.
- Integrating, testing, and fine-tuning the CanSat algorithm with the sensors.