CANSAT 2022

Preliminary Design Review

(PDR)

Team Id:2022ASI-002 (Team AstroPeep)

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Acronyms

Acronyms	Meaning
3D	3-Dimensional
A	Analysis
cm	Centimeter
D	Demonstration
dB	Decibel
EPS	Electrical power Subsystem
FRR	Flight Readiness Review
FSW	Flight Software
GCS	Ground Control System
gm	Gram
GNSS	Global Navigation Satellite System

Acronyms	Meaning
GS	Ground Station
GUI	Graphical User Interface
Hz	Hertz
I	Inspection
I2C	Inter-Integrated Circuit
IC	Integrated Circuits
LED	Light Emitting Diode
PC	Personal Computer
QHA	Quasi Harmonic Function
RTC	Real Time Clock
T	Test

Acronyms	Meaning
VM	Verification Method
GHz	Giga Hertz
s	second
csv	Comma separated values
hrs	hours
PCB	Printed Circuit Board
mAh	Milli ampere hour
m	meter
V	Volts
FSS	Flight Software State
SPI	Serial Peripheral Interface
UART	Universal Asynchronous Receiver-Transmitter

System Overview

MISSION SUMMARY

- Innovative Mechanical Gyro-control system that shall demonstrate the descent control of the CANSAT.
- CANSAT descent control system that shall open at an altitude of 500 m.

CANSATs will be launched to an altitude of 800.0 m to 900.0 m from the ground level and above the launch site & deployed near the peak altitude. During the ejection from the rocket orientation of the CANSAT is not controlled. The CANSAT must remain intact during the course of the entire mission and send the data to the ground station through a telemetry link.

MISSION SUMMARY (Optional Objectives)

Provision of video capture from separation till the final touch down.

- We are planning to add this optional objective and we will be dealing regard this objective during our CDR stage planning and preparation.

- The Camera will be mounted with the base of CANSAT or the body panel of CANSAT depending upon the simulation report which will be presented in the Critical Design Review Report.

System Requirements

Sr.no.	Requirement	Priority	Fulfillment	VM			
				A	I	T	D
1	Total mass of the CANSAT shall be under 0.700 kg (+/- 0.050 kg)	High	Mass of Cansat is within limits.	x			X
2	CANSAT shall fit in a cylindrical body of 0.125 m diameter x 0.310 m height. Tolerances are to be included to facilitate container deployment from the rocket fairing.	High	Cansat is designed with appropriate dimensions.	X			X
3	Any sharp edges on the container body shall be avoided as it can cause interfere during the CANSAT ejection from the rocket.	High	No sharp Edges are present.				X
4	Color of the CANSAT body shall be fluorescent i.e., pink, red or orange, and shall embody the Indian flag.	High	Color will be fluorescent and will embody Indian Flag.				X
5	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.	High	Cansat has necessary sensors required for measuring mandatory data.	X			x

System Requirements

Sr no.	Requirements	Priority	Fulfillment	VM			
				A	I	T	D
6	Each data field shall be displayed in real-time on the ground station user interface/software.	High	GUI will be developed for displaying Data.		x	x	
7	CANSAT shall also record the data and save it into an onboard SD card in case of telemetry connection loss.	High	The data shall be recorded in SD Card.			x	
8	All electronics shall be enclosed and shielded from the environment. No electronics can be exposed except for sensors. There must be a structural enclosure.	High	No Electronics is exposed.	x			x
9	CANSAT structure shall be built to survive 15 Gs of launch acceleration & 30 Gs of shock.	High	CANSAT will survive required shock.			x	x
10	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 de-assembling of CANSATs on the launch pad.	High	CANSAT has an external power switch.	x			x
11	The CANSAT shall contain a total of 2 descent control mechanisms, to be used at different stages while descent.	High	has 2-descent control mechanism.				x
12	CANSAT shall immediately deploy the first parachute after ejection from the rocket.	High	1st parachute will be immediately deployed after ejection.				x

System Requirements

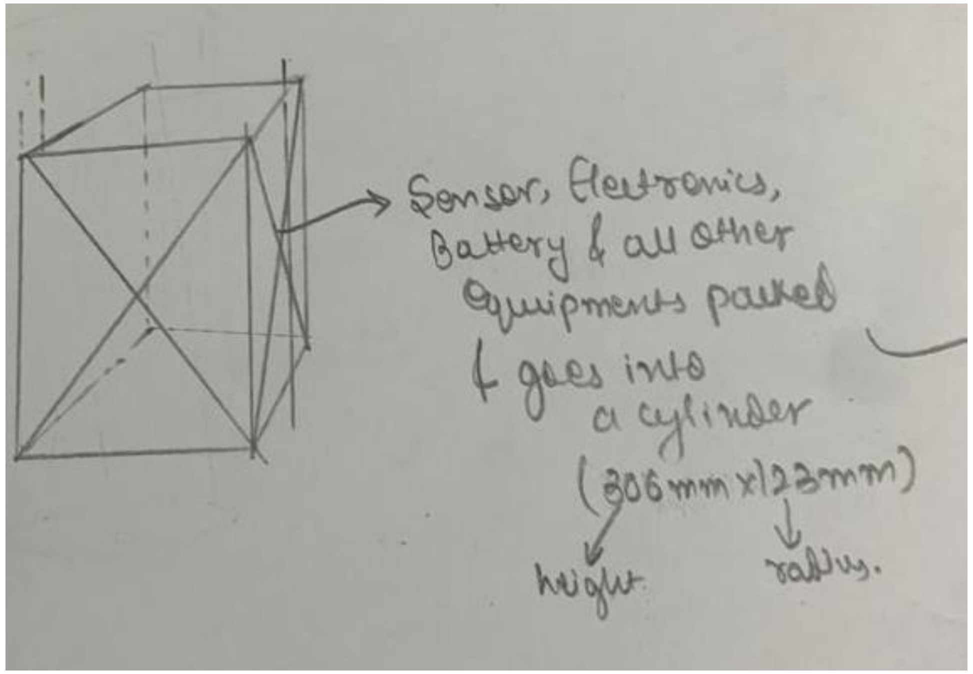
Sr no.	Requirements	Priority	Fulfillment	VM			
				A	I	T	D
13	The first parachute shall be connected to the outer body of the CANSAT and no ejection mechanism shall be attached to it.	High	There would be no ejection mechanism for the 1st parachute.				X
14	The descent rate of the 1st parachute shall be 20 m/s $\pm$5m/s.	High	Descent rate will be 20 m/s $\pm$ 5m/s.				X
15	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.	High	2nd descent rate will have 3m/s.				X
16	CANSAT shall stabilize itself during the decent using the mechanical gyro mechanism.	High	CANSAT shall stabilize using mechanical gyro.	X		X	
17	The CANSAT communications radio shall be the XBEE radio series 1/2/pro.	High	Communication radio is XBEE radio series1/2/pro			X	
18	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.	High	Telemetry will be displayed in real time.			X	X
19	The ground station shall command the CANSAT to start transmitting telemetry prior to launch.	High	All commands shall be given from GS.	x		x	
20	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.	High	CANSAT will transmit telemetry after receiving command from the GS.			x	

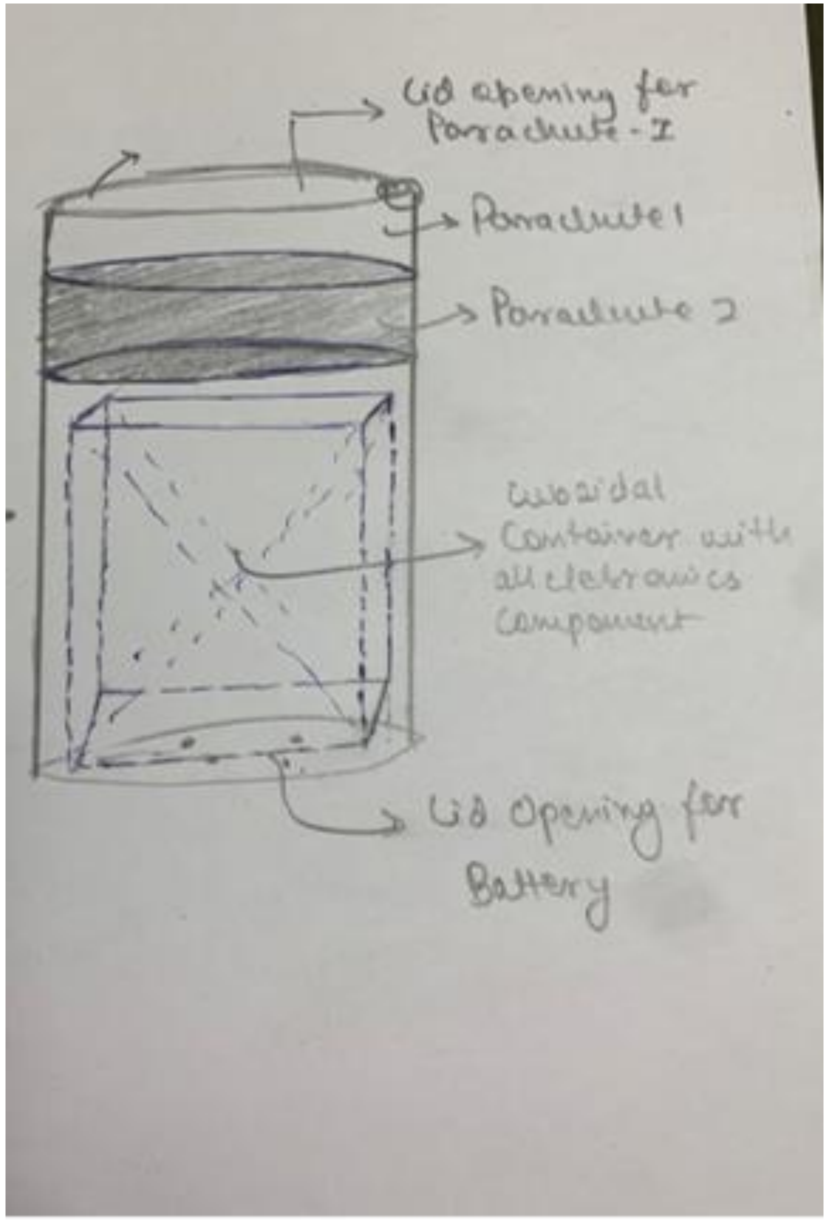
System Requirements

Sr no.	Requirements	Priority	Fulfillment	VM			
				A	I	T	D
21	The ground station shall generate .csv files of all sensor data as specified in the Telemetry Requirements section.	High	GS shall display .csv files.		x	x	
22	Telemetry shall include mission time with one second or better resolution.	High	Telemetry shall have appropriate resolution.	x		x	
23	Mission time/timestamp and system status states shall not be affected in the event of a processor reset during the launch and mission.	High	Will not be affected during launch		x	x	
24	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	High	Has required items				X
25	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).	High	FSW shall maintain FSS.				X
26	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.	High	Telemetry data will be transmitted as specified.	x		x	

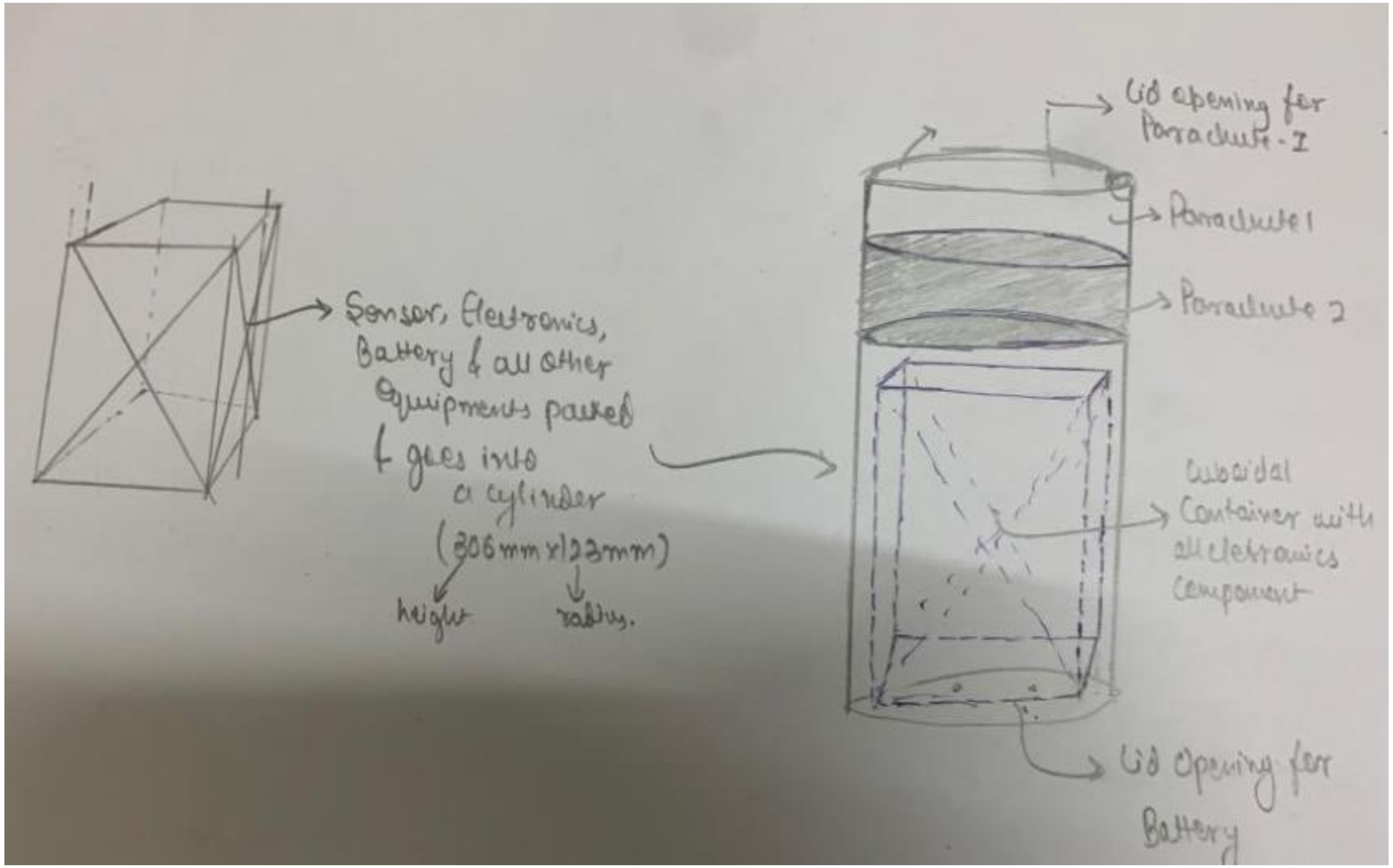
System Configuration Concept 1 Trade & design

- All Sensors shall be inside a cuboidal frame which shall later be deployed at the with the second parachute as per the mission requirement.
- The Housing would be made with cuboidal with the structural reinforcement along the diagonal to provide more integrity.
- The ejection mechanism may have spring to open the lid which would pop with when the Altimeter sensor put the data of the second deployment.
- Aluminium was the proposed material for the frame and the outer body.





System Configuration Concept 1 Trade & Design



Picture is showing all the preliminary ideas within the Concept 1 Proposed.

System Configuration Concept –2 Trade & Design

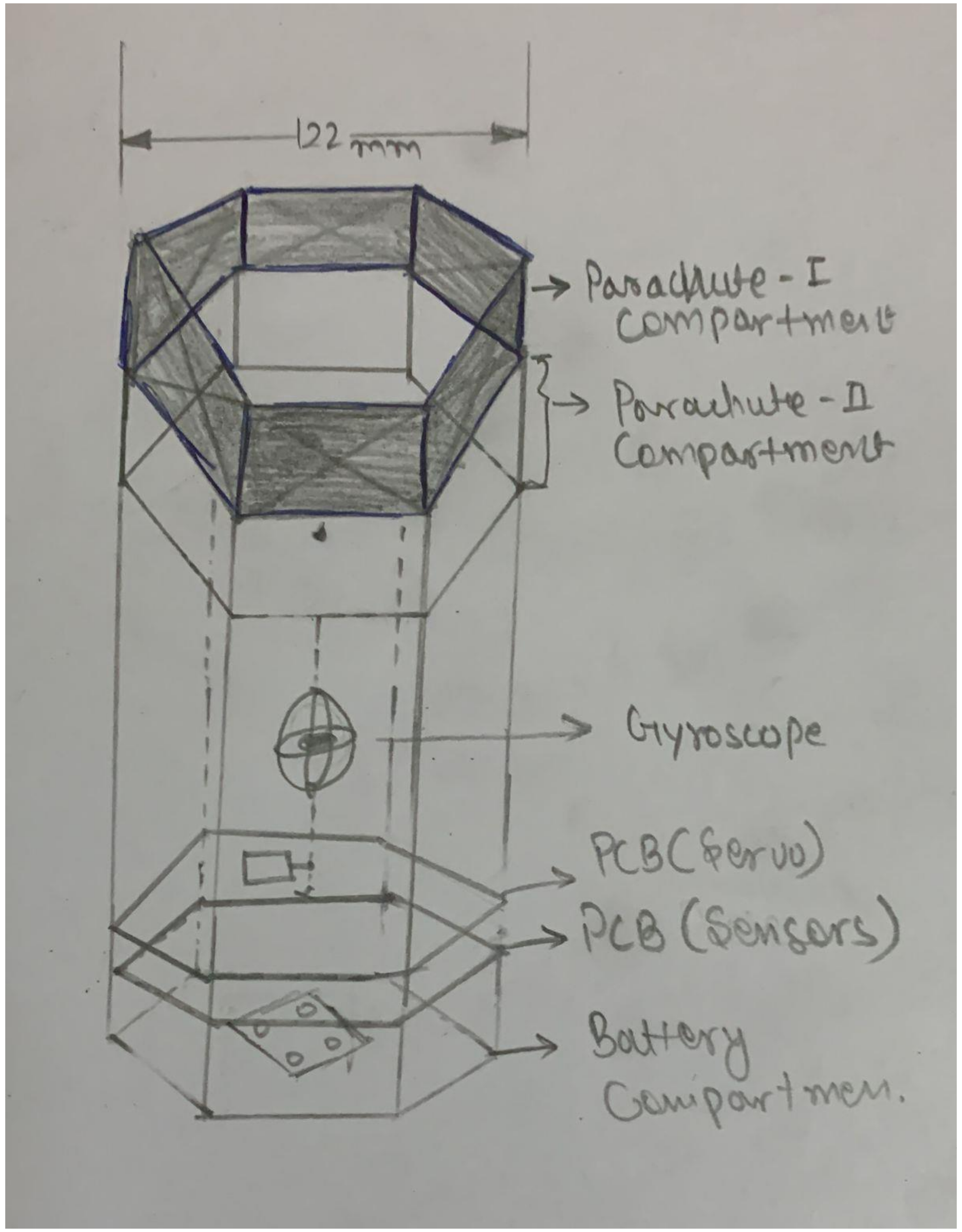
A **Hexagonal shaped** cylinder is proposed with three main compartments.

The compartments were divided as per the utilization of the space. First, the descent control or parachutes compartments which has the top lid being a temporary paper like sheet for the easy deployment of parachute.

Second is the Gyroscope and electronics compartment, which has to stay rigid and intact for the proper & error less telemetry.

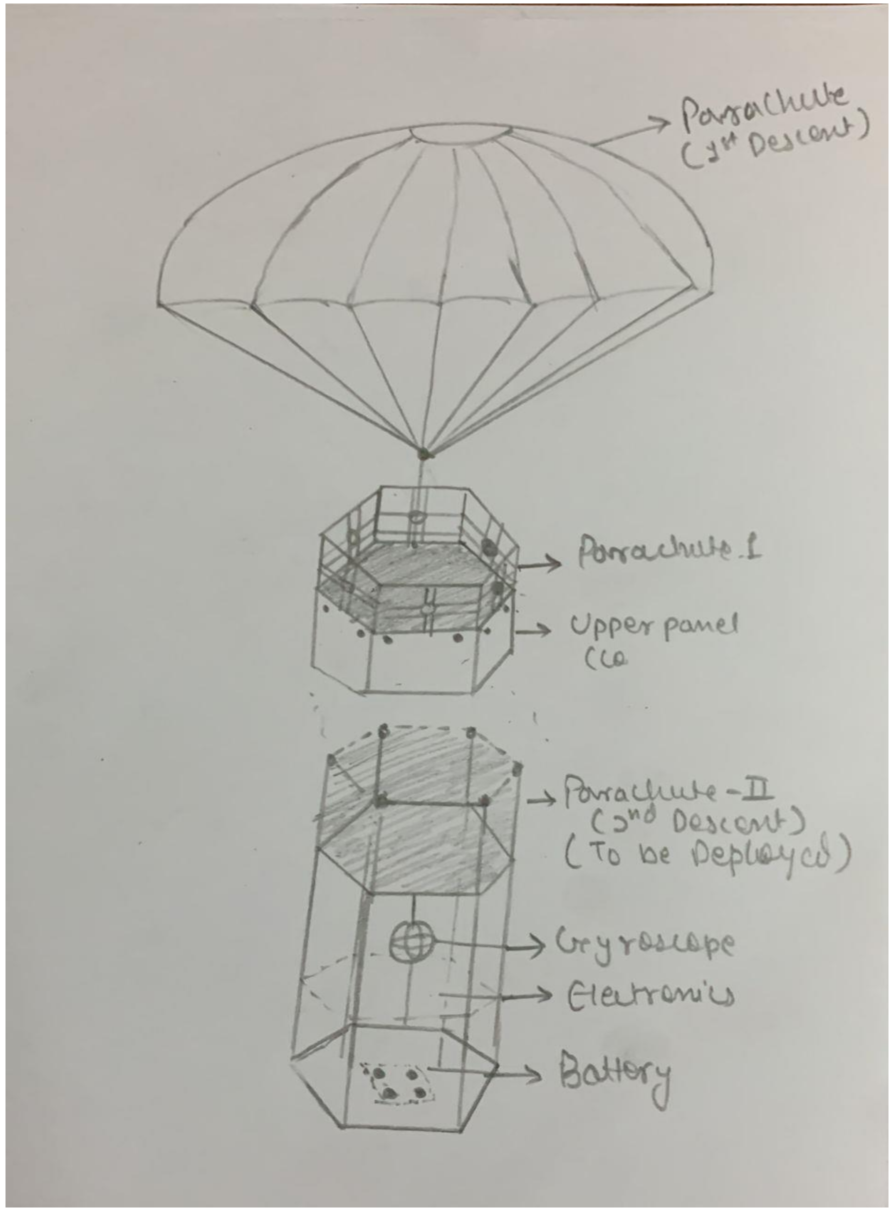
Third the power backup unit where the battery backup will be installed. A screw panel for the easy recharging and easy replacement of the battery.

Six metal rod giving out the strength which are attached to the four hexagonal plates.



System Configuration Concept –2 Trade & Design

- For the Telemetric data acquisition , the Compartment 1 would be ejected from the structure which would be connected to the Parachute and may be recovered later.
- And the Compartment 2 would open and give the Parachute out. This would be done with the POGO pin and Servo Motor driven mechanism.



System Level Configuration Selection

Configuration Selection Table

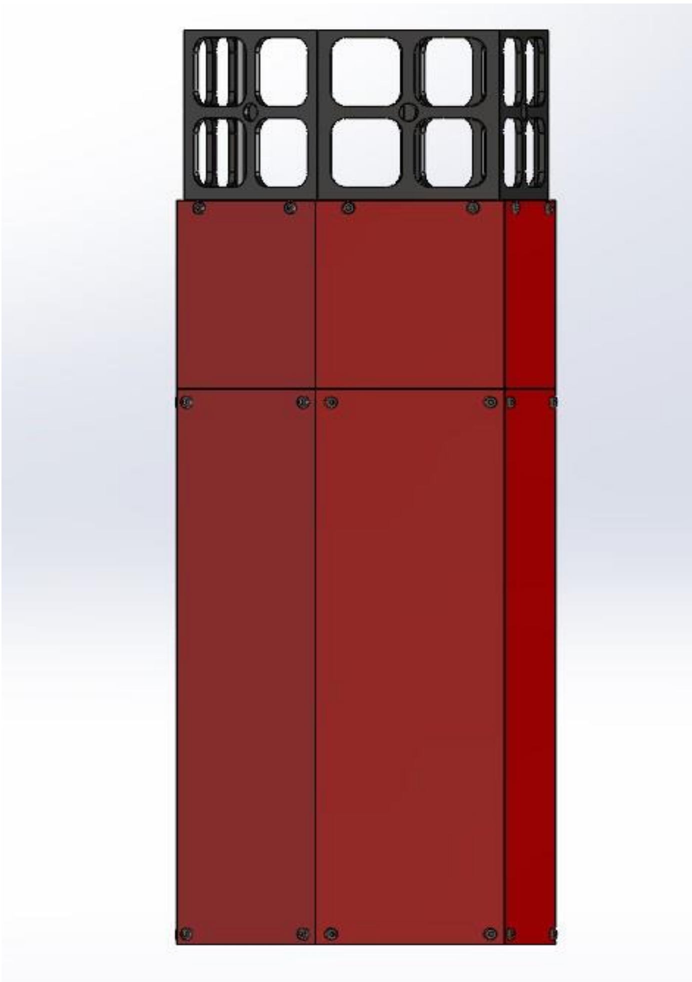
Configuration	Parachute	Decoupling System	CanSat Geometry	Electronic Devices	Mass of structure	Folding s ystem ac tuator	Was able to withstand 30Gs of shock?
Concept 1	At container top. Semi spherical shape. A simple mechanism for its release.	Decoupling by springs	Circular	Placed in a structure different from CANSAT	525.03 grams(S oftware Calculated)	Spring	No
Concept 2	At container top. Semi spherical shape. A simple mechanism for its release.	Decoupling by a gear motor and pogo pin mechanism	Hexagonal	Placed on boar d Payload.	409.16 grams (software calculated)	Gear motor	Yes

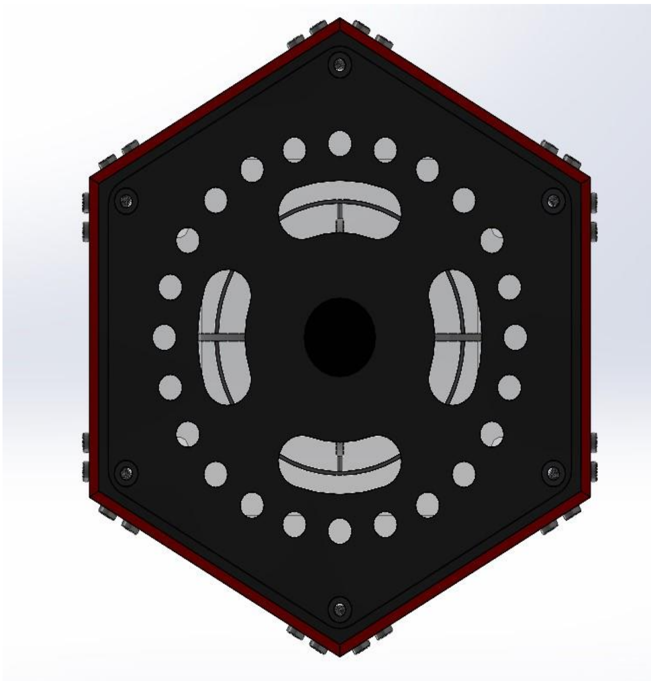
System Level Configuration Selection

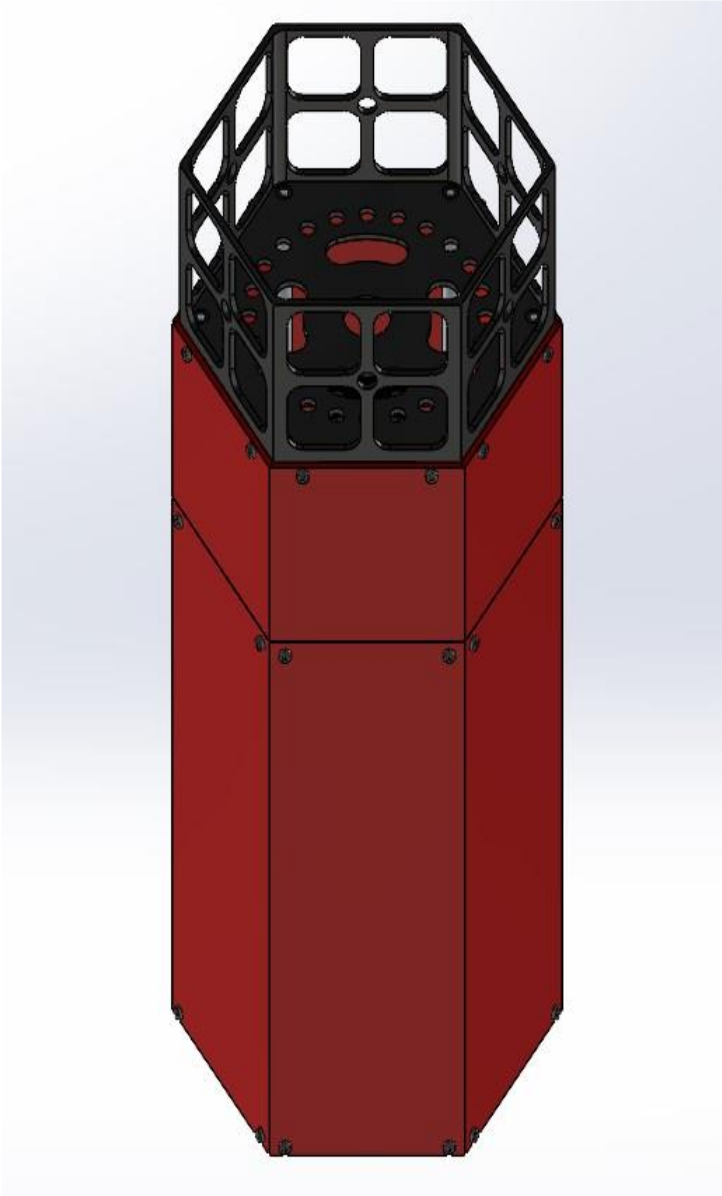
- **Concept two was selected** since it has more working space, being lighter and easier to assemble that design one. On the other hand, having a easier way for the deployment of the parachutes.
- Hexagonal shape for the container reduces considerably manufacture complexity, been composed for rectangular parts and provides plane sides to easier adapt or set other elements.
- Finally, the gear motor attached to the pogo pin mechanism provides better control of the position for the ejection mechanism links, preventing entanglement of Parachute string due to air turbulence.

Physical Layout

Container General Design

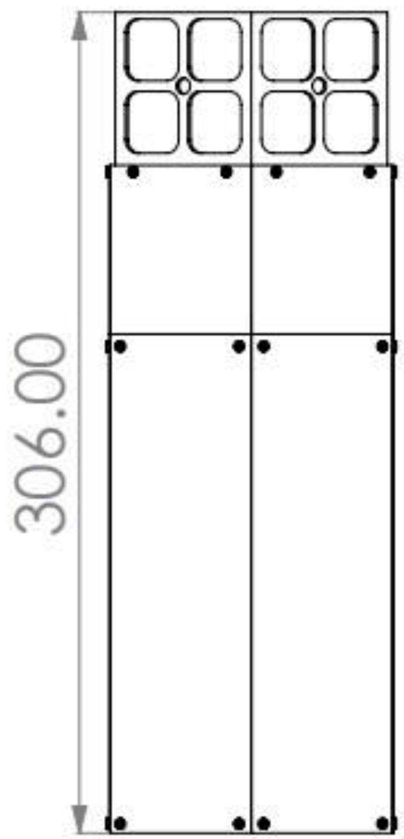


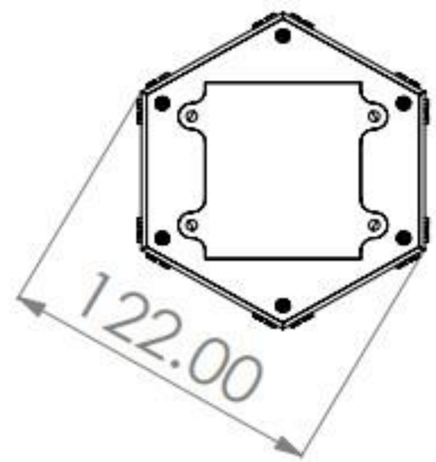




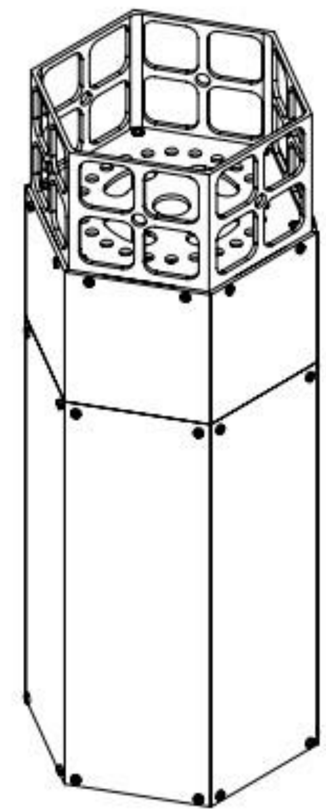
Physical Layout

Container Dimensions:



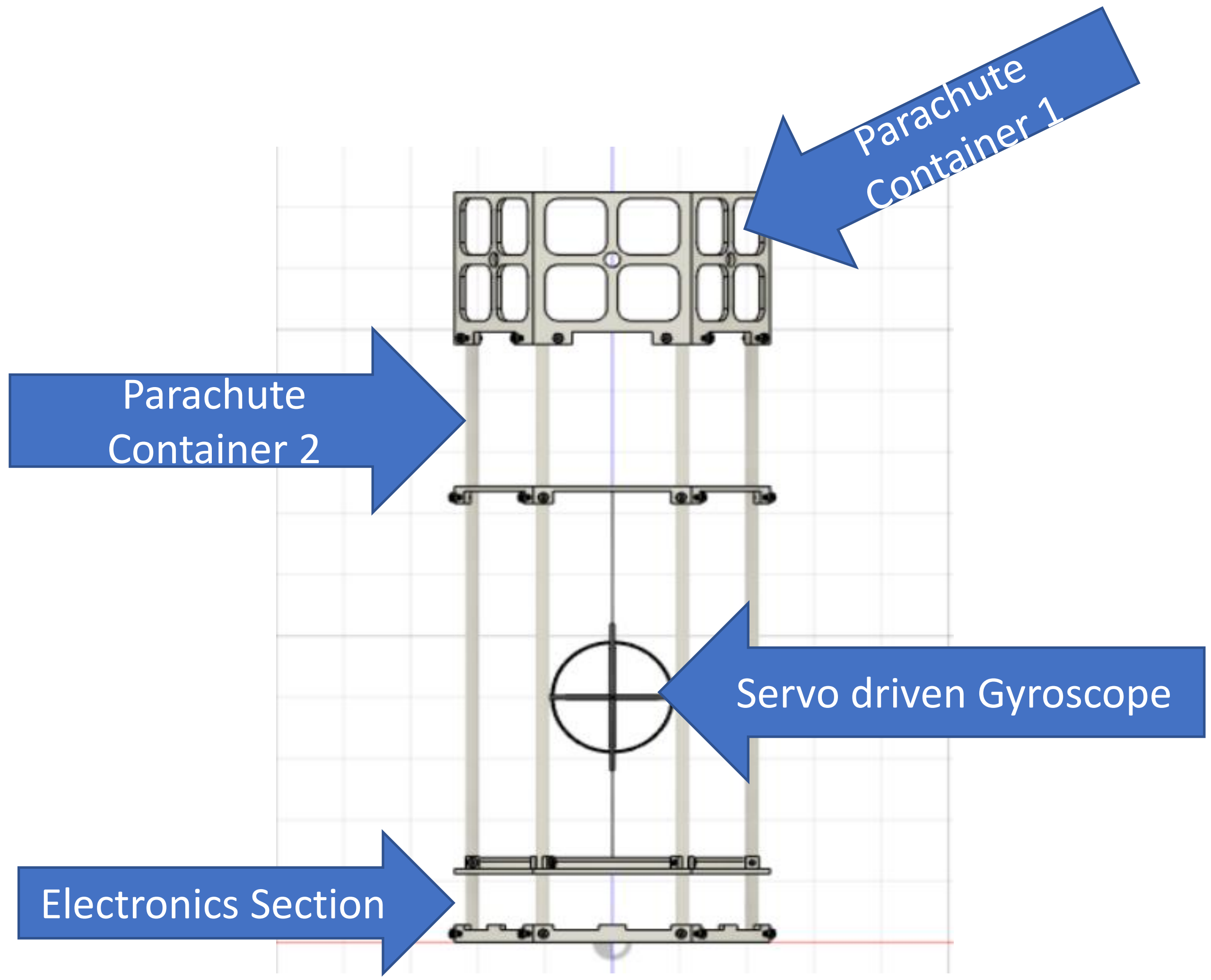


BOTTOM VIEW



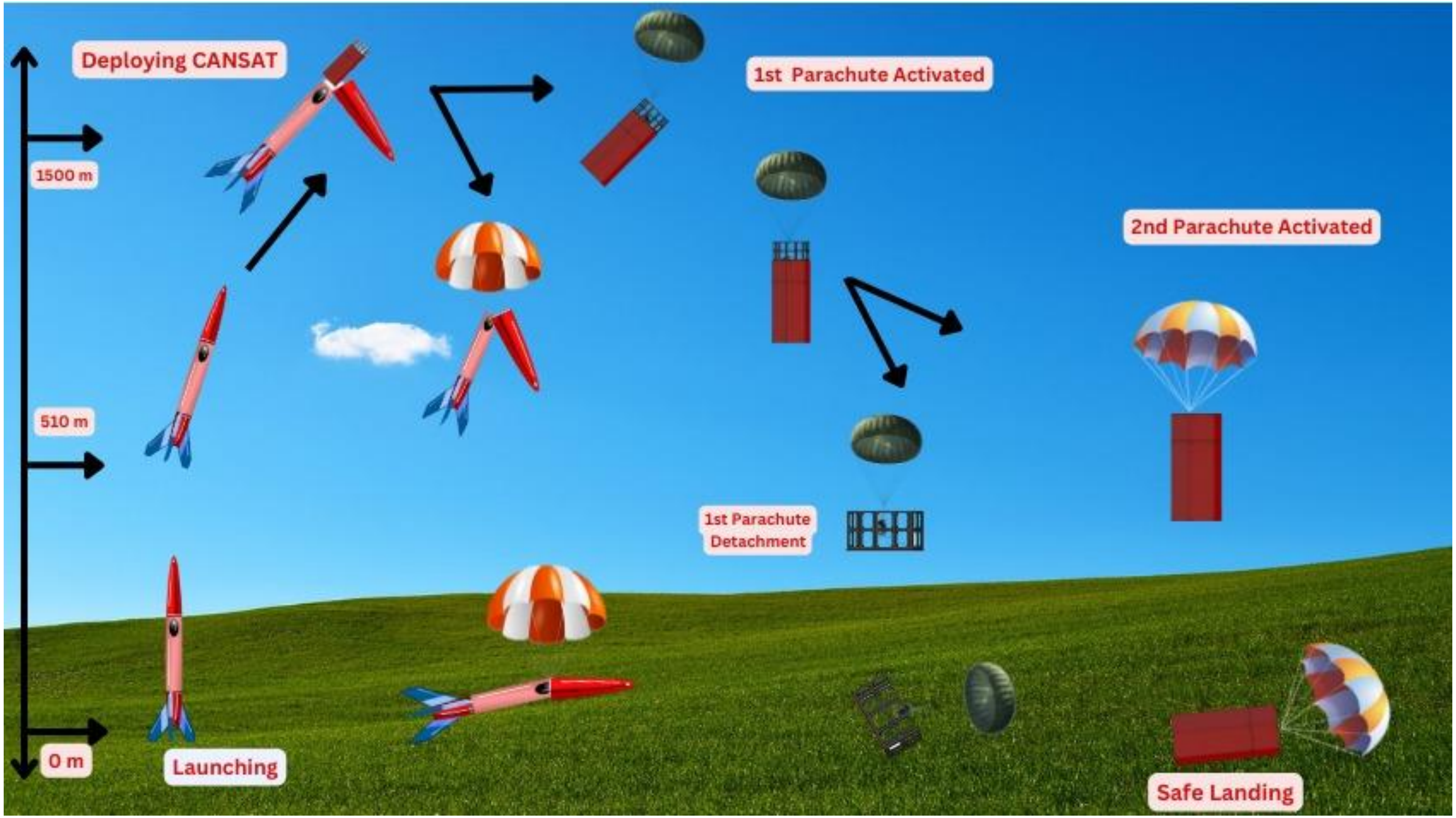
ISOMETRIC VIEW

Physical Layout



System Concept of Operation

System Concept of Operation



System Concept Of Operation

Connection between the CANSAT and the Ground Station is stablished

→ Altimeter sensor defines an altitude reference.

→ GNSS stablishes a valid connection with satellites (3 at least).

→ CANSAT stablishes a framework with gyroscope and accelerometer in order to calculate tilt.

→ CANSAT recognizes a valid SD card and stores the data backup.

→ CANSAT checks constantly, the absolute altitude change.

→ Once the CANSAT is released from launching vehicle the First parachute itself deploys

→ Once the CANSAT reaches an altitude of 500[m], the first parachute is detached from the container and the second parachute gets deployed.

→ Once the CANSAT reaches the ground, the transmission will be stopped.

→ Audio beacon will be powered on.

→ CANSAT will be recovered and the telemetry will be verified further.

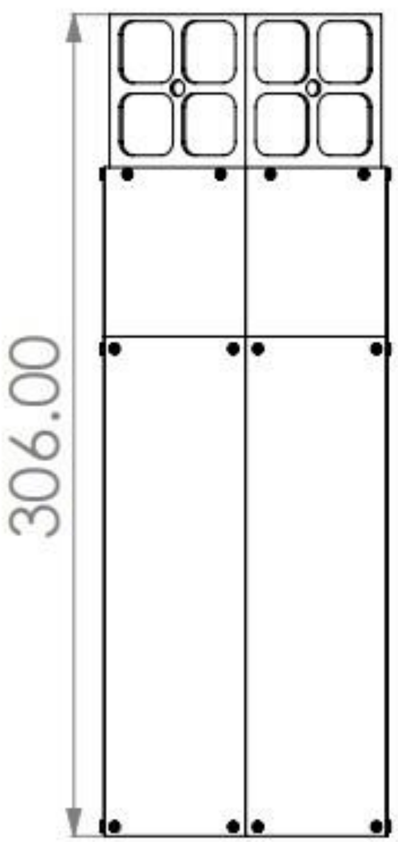
LANDING

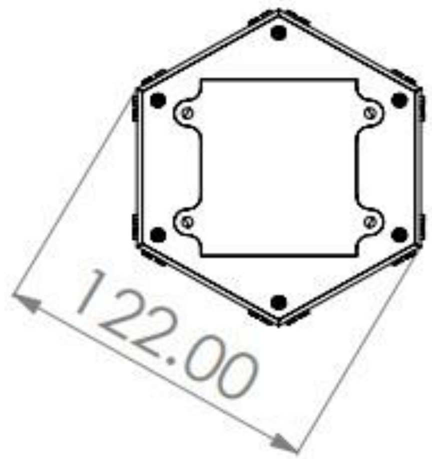
FLIGHT

GROUND OPERATION

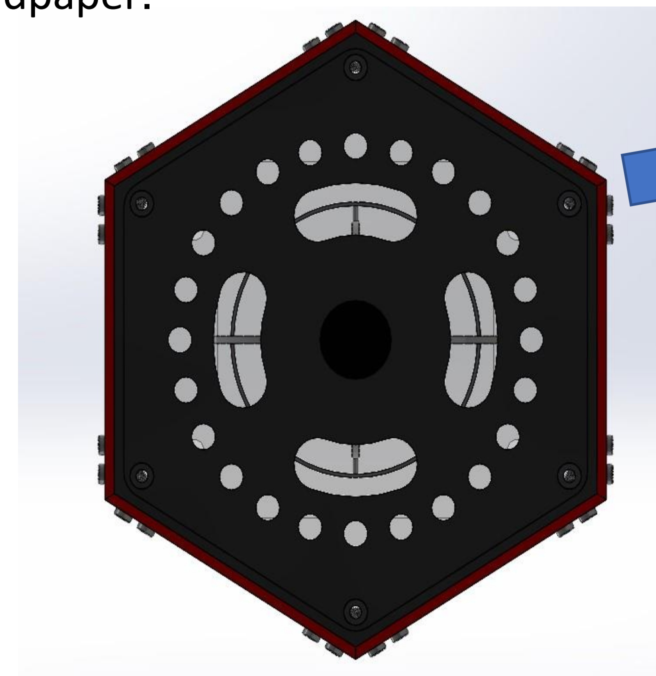
Launch Vehicle Compatibility

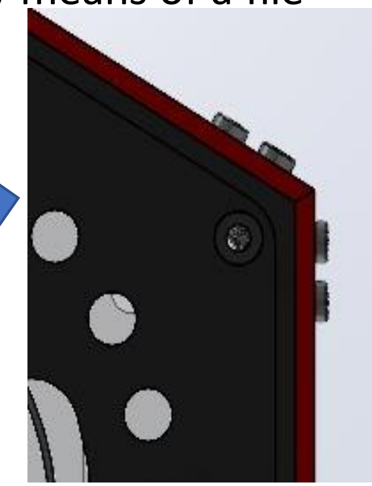
There are no elements that protrude from the established dimensions or have sharp edges. Pieces made with metal elements will be rounded at the edges by means of a file or sandpaper.





BOTTOM VIEW





Payload dimension	Available value [mm]	Actual value [mm]	Clearance[mm]
Width	125	122	3
Height	310	306	4

Sensor Subsystem Design

AstroPeep

Sensor Subsystem Overview :

Sensor	Model	Function
Altimeter Sensor	BMP280	Altitude Measurement
Air Pressure and Air Temperature Sensor	BMP280	Pressure and Temperature Measurement
Acceleration and Orientation Sensor	MPU6050	Orientation and Acceleration Measurement
GNSS Receiver Sensor	S1216F8-GI3	Latitude, Longitude, Altitude, Time, Satellites number Measurement
Voltage Sensor	Voltage Divider , CPU's ADC Converter	Power Status

Air Pressure Sensor Selection Summary :

Reason for selecting BMP280 :

- Small Size , Light Weight and Low Cost.
- BMP280 consists of IIR filter which will help in to minimize the disturbance in the signal which will provide better accuracy.
- BMP280 provides highest flexibility to the designer and can be adapted to the requirements regarding measurement time, accuracy and power consumption.

Model	Range (hPa)	Resolution (hPa)	Accuracy (hPa)	Data Interface	Operating Voltage (V)	Cost (Rs.)	Dimension(mm)	Weight (gm)
BMP280	300 - 1100	0.01	0.12	I2C,SPI	1.71 – 3.6	150	2 X 2.5 X 0.95	0.048

Temperature Sensor Selection Summary :

Reason for selecting BMP280 :

- BMP280 have also better accuracy and resolution for Temperature measurement.
- Using same sensor for a couple of work will reduce the cost and weight of Cansat.

Model	Range(℃)	Resolution (℃)	Accuracy (℃)	Data Interface	Operating Voltage (V)	Cost (Rs.)	Dimension(mm)	Weight (gm)
BMP280	-40 to 85	0.01	±1.0	I2C,SPI	1.71 – 3.6	150	2 X 2.5 X 0.95	0.048

Acceleration Sensor Selection Summary :

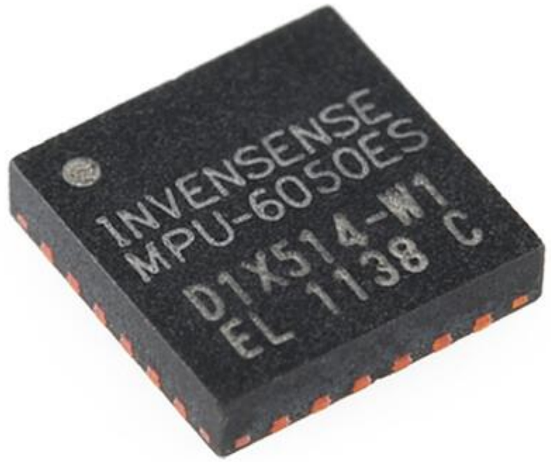
Reason for selecting MPU6050 :

- Light weight and small size.
- Good resolution.
- Low Power Consumption.
- Team have experience on working with MPU6050.

Sensor	Range (g)	Resolution (Bit)	Accuracy (g)	Data Interface	Operating Voltage (V)	Cost (Rs.)	Dimension (mm)	Weight (gm)
MPU6050	± 2	16	0.00006	I2C/IIC	3-5	120	4 X 4 X 0.9	3

Reason for selecting MPU6050 :

- Light weight and small size.
- Low Cost.
- Using same sensor for acceleration and orientation measurement will reduce the cost and weight of Cansat.



Sensor	Range (°/s)	Resolution (bit)	Accuracy (°/s)	Data Interface	Operating Voltage (V)	Cost (Rs.)	Dimension (mm)	Weight (gm)
MPU6050	±250	16	1.9	I2C/IIC	3-5	120	4 X 4 X 0.9	3

GNSS Receiver Selection Summary :

Reason for selecting S1216F8-GI3 :

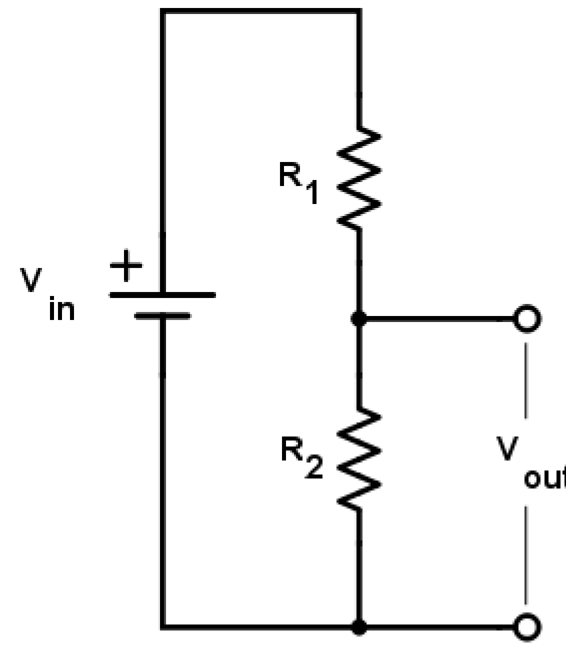
- Support NavIC , Gagan , GPS , GLONASS.
- NavIC + GPS + GLONASS triple-satellite capability enables u sing greater number of satellite signal than GPS-only receivers.
- High sensitivity, low power consumption, and fast TTFF.

Sensor	Operational Limit (m/s)	Accuracy	Data Interface	Operating Voltage (V)	Current Consumption (mA)	Cost (Rs.)	Dimension (mm)	Weight (gm)
S1216F8-GI3	515	Position - 2.5m CEP Velocity - 0.1m/s	UART	3.3	110	1700	12 X 6	2

Voltage Sensor Selection Summary :

Reason for selecting Voltage Divider :

- Low Cost.
- Easy to use.
- Compact in size.



Sensor	Resolution (mV)	Accuracy (mV)	Data Interface	Current Consumption (mA)	Cost (Rs.)	Dimension (mm)	Weight (gm)
Voltage Divider , CPU's ADC Converter	0.1	8.0	Analog	2	20	3 X 3 X 0.6	0.004

Descent Control Design

Descent Control Design

Parachute Physics

The main purpose of the parachute is to make sure that the Cansat has a stable and controlled decent and is not damaged upon impact. To get the correct area we used this formula.

$$A= 2Mg/C\rho v^2$$

A=Area of Parachute

M=Mass of CANSAT (0.7 kg)

G=Acceleration due to gravity(9.81 ms-2)

Terminal velocity(V): *is the point at which the force of drag and the force of gravity (mg) on the can are equal and cancel each other out, this means that while the can still falls thought the air, it no longer accelerates and has reached its maximum speed.*

Coefficient of drag (C):*The C of a semi ellipsoid parachute is known to be 1.2.*

Air density(ρ): *is the mass of the air per cubic metre this is given to be 1.225 at sea level but varies with altitude.*

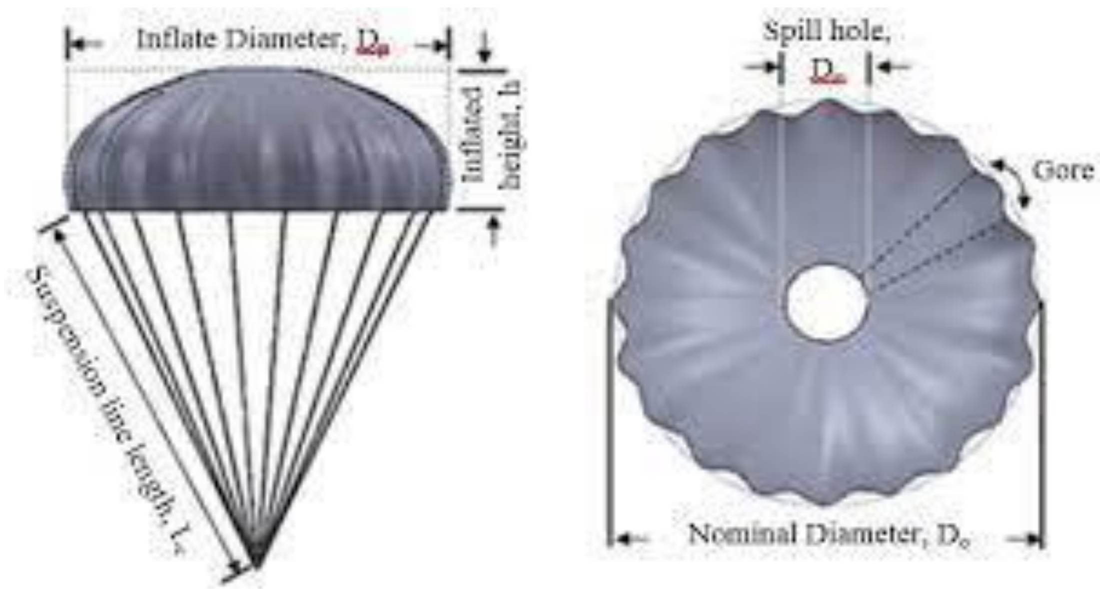
Parachute manufacturing

- We manufactured the parachute out of ripstop nylon cut into and octagonal shape and kite strings(*Ripstop nylon is extremely light and durable it can also be waterproofed with an impermeable coating if required, these are the properties of our parachute*).
- The shroud lines are made of polyester kite strings which have a high tensile strength to withstand the forces of deployment.
- To make sure that the Can decent is as stable as possible we added a swivel hook to the parachute, this made sure that if the parachute spins the can itself stays stationary reducing the stress on the can.

Swivel Hook

We have also tested the parachute with a spill hole in it this makes sure that parachute oscillation is down to a minimum and any oscillation that does occur is quickly corrected.

One consequence of having a spill hole is that it can reduce the effective parachute area if added after manufacturing leading to a faster decent however we compensated for this by making the parachute larger to keep the same effective area once the hole is added.



Semi-ellipsoid Parachute

- We plan to use a parachute in the shape of a semi-ellipsoid, this type of parachute offers more stability than a standard flat parachute due to its aerodynamics.
- The parachute is made up of several different pieces called gores, these are truncated, triangular shapes with curved sides and when they are sewn together they form the shape of the parachute.
- The manufacturing process for the semi-ellipsoid parachute was similar to that of the flat parachute, mainly involving cutting parts out and sewing them together.
- It was made of ripstop nylon like the previous parachute but involved much more sewing due to being made up of multiple parts.
- We used kite string again for the shroud lines although we would like to use Para cord later on but due to time constrains this was not possible.

Descent Rate Estimation

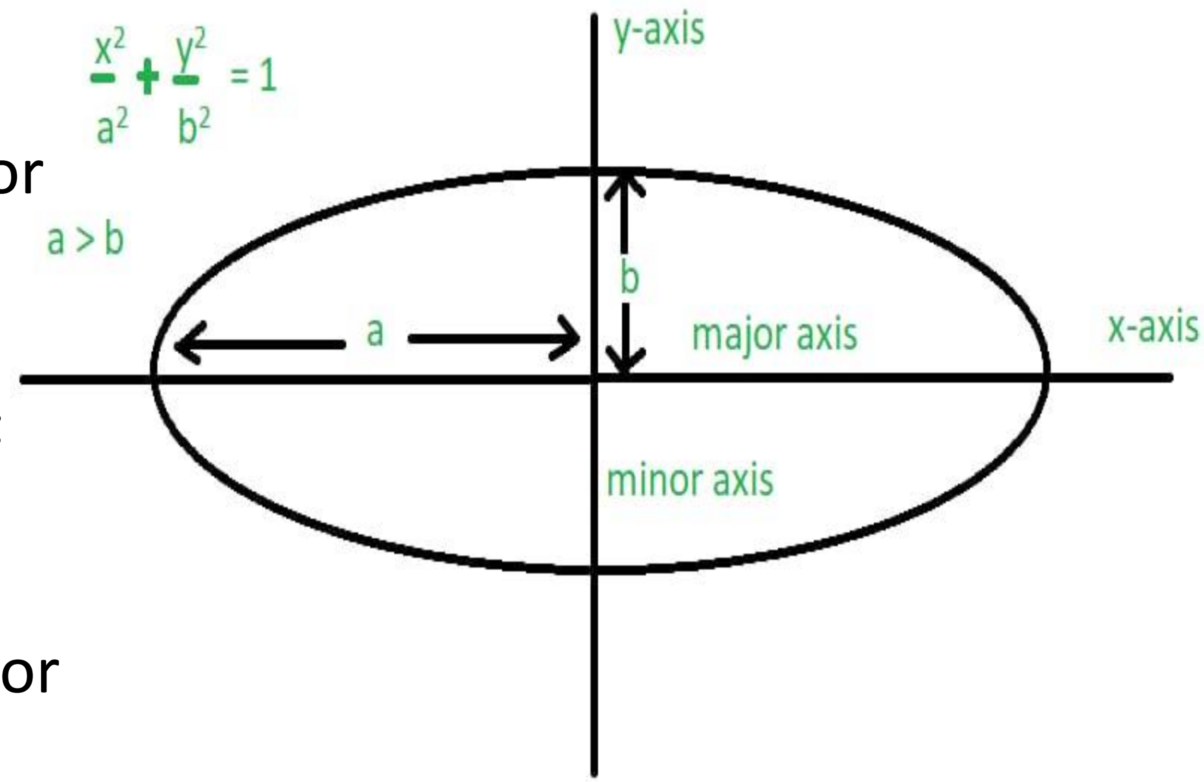
The descent rate of each descent phase will be estimated using different
parameters

First Parachute

- Parameters: Major axis of Parachute (a), Minor axis of parachute(b), Radius of Spill Hole and Side Hole (Rsh)
- Requirement: Descent rate of 5m/s-20 m/s ($\pm 5m/s$)

Second Parachute

- Parameters: Major axis of Parachute (a), Minor axis of parachute(b) , Radius of Spill Hole and Side Hole (Rsh)
- Requirement: Descent rate of 1-3 m/s



Top View Of Parachute

First Parachute

We use the range of descent velocity between minimum [V min = 5 m/s] and maximum [Vmax = 15m/s] to determine major and minor axis of parachute.

$$\sqrt{\frac{2mg}{(0.707)C(v_{max})^2\rho\pi}} \leq a \leq \sqrt{\frac{2mg}{(0.707)C(v_{min})^2\rho\pi}}$$

We take: a/b=0.707

Area (m^2)	Major axis (m)	Minor axis(m)
$0.0418 \leq A \leq 0.0622$	$0.137 \leq a \leq 0.168$	$0.097 \leq b \leq 0.118$

Radius of the spill hole and side hole is 8%-10% of parachute's Major axis
because we set tolerance of ±2%.
Spill hole Radius= Rsh = a * 8% = $\mathbf{0.0120 m}$.

Information:
a= Major axis of parachute
b= Minor axis of parachute m
A=Area of first parachute
v = $Descent\ speed\ (m/s)$
π = 3.14
g = 9.8 m/s^2
Rsh = $Spill\ hole\ and\ side\ hole$ radius (m)
*Assumption
$* C$ = 1.2 $(Coefficient\ drag\ of\ parachute)$
*m = 0.7 $kg\ (container)$
$* \rho$ = 1.225 $kg/m3$

Second Parachute

We use the descent velocity as V = 2.5 m/s and determine diameter of parachute.

$$a = \sqrt{\frac{2mg}{(0.707)C(v_{min})^2\rho\pi}}$$

We take: a/b=0.707

Area(m^2)	Major Axis(m)	Minor Axis(m)
A= 1.45	$a = 0.81$	$b = 0.573$

Radius of the spill hole and side hole is 8%-10% of parachute major axis
because we set tolerance of ±2%.
Spill hole radius = Rsh = a * 8% =**0.0648 m**.

Information:
a= Major axis of $parachute\ m$
b= Minor axis of parachute m
A= Area of second parachute
v = $Descent\ speed$ (m/s)
π = 3.14
g = 9.8 m/s^2
Rsh = $Spill\ hole\ and\ side\ hole$ Radius(m)
*Assumption
$*\ C$ = 1.2 ($Coefficient\ drag\ of\ parachute$)
*m = 0.7 kg ($container$)
$*\ \rho$ = 1.225 $kg/m3$

Communication and Data Handling Subsystem Design

CDH Overview

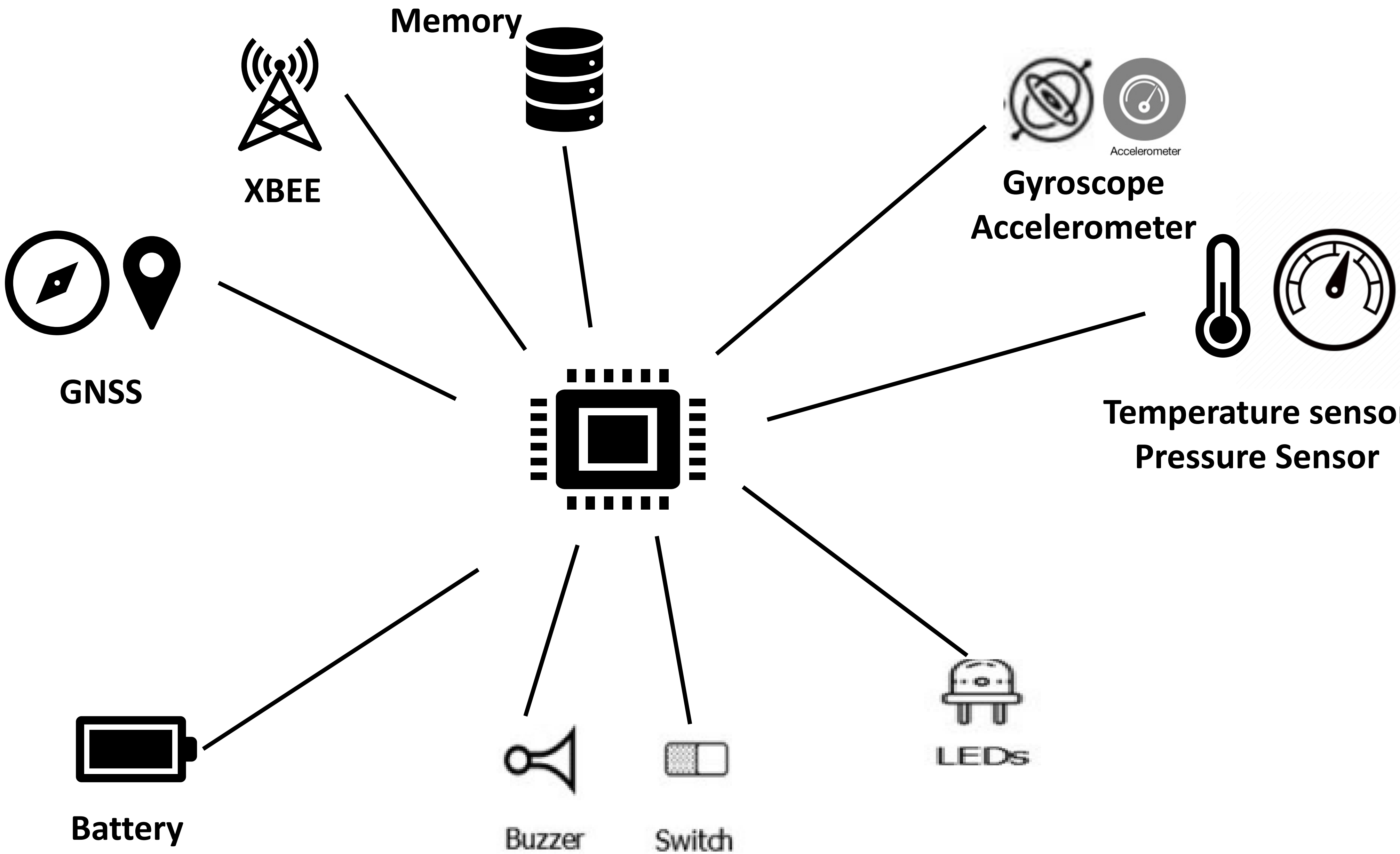
CPU – STM32F103RCT
➢ Receiving data and executing commands coming via UART interface from Xbee radio module ➢ Sending data packets via UART interface to XBee radio module ➢ Receiving and reacting for data coming via I2C interface from sensors ➢ Writing data packets via SPI interface to external flash memory ➢ Communication buses: SPI for sensors and on-board memory, UART for Xbee and GNSS.

Telemetry – Xbee Pro S2C
➢ Receiving data packets from CPU using UART interface ➢ Forwarding data packets from CPU to GS using XBee ➢ Receiving data and commands from GS using XBee ➢ Forwarding data and commands from GS to CPU using UART interface

CDH Overview

Data storing - S25FL512S
➢ Storing telemetry data. ➢ Receiving and saving data coming from CPU using SPI interface.
Sensors
➢ Conducting measurements in order to gather information about external environment , functioning of internal Mechanical Gyro control and Power status. ➢ Forwarding data to CPU using SPI or I2C.
Other
➢ Starting Buzzer of 100dB loud audio beacon for Location Recovery.

CDH Overview



Processor Selection

Model	Clock freq. [MHz]	Flash memory [kB]	Operating voltage [V]	Interfaces			ADC	
				I2C	UART	SPI	Channels	Resolution
STM32F103	**72**	**256**	**2.0 - 3.6**	**2**	**5**	**3**	**16**	**12**

The microcontroller has high clock speed, good memory capabilities, power consumption and a sufficient amount of interfaces available.
The microcontroller meets all of the requirements:

- Many communication interfaces
- High clock frequency
- Multiple interrupts for real-time operations
- Many communication interfaces

Real-Time Clock

Model	Size	Interface	Operating voltage [V]
STM32F103 internal RTC unit	integrated into microcontroller	integrated into microcontroller	2.0-3.6

The RTC unit has appropriate accuracy, size, kind of interface and power needed. The chosen RTC unit meets all of the requirements:

- No extra chip needed since the unit is integrated into.
- No extra interface needed since - RTC is integrated into the CPU
- Sufficient level of accuracy
- Low power consumption in case of processor reset accurate time is red from the GNSS module, since it is able output accurate time even with weak signal.

Memory Selection

Model	Memory (GB)	Interface	Data Transfer Rate		Cost (Rs.)
			Write (MB/s)	Read (MB/s)	
SanDisk Ultra	16	SD Card Interface	98	98	400

Reasons

- More stable data transfer rate
- It is more reliable and easy to use than using EEPROM.

Radio Configuration

Model	Range(Km)	Transmitted Power(mW)	Supply voltage [V]	Supply current [mA]	RF Data Rate [kbps]
XBEE Pro S2C	3.2	6.3	2.1 - 3.6	45	250

Overview of Radio Configuration

- Xbees are operating in one network with the same PANID/NETID number.
- PANID/NETID number is set to TeamID: **2022ASI-002**
- Xbees local number is set to listen the other Xbee.
- Communication will be held in AT command mode which simplify whole communication.
- Unicast mode was chosen, which enables data acknowledgement.

Telemetry

TM Parameter	Function	Resolution /Format
<TEAM ID>	Team Number	2022ASI-002
<TIME STAMPING>	Time since the initial power	Seconds
<PACKET COUNT>	Count of transmitted packets	
<ALTITUDE>	Altitude in units of meters and must be relative to ground	0.1 meters
<PRESSURE>	Measurement of atmospheric pressure	1 pascal
<TEMP>	Temperature in Celsius	0.01℃
<VOLTAGE>	Voltage of the CANSAT power bus	0.01 Volts
<GNSS TIME>	Time generated by the GNSS receiver	Seconds
<GNSS LATITUDE>	Latitude generated by the GNSS receiver	0.0001 degrees
<GNSS LONGITUDE>	Longitude generated by the GNSS receiver	0.0001 degrees
<GNSS ALTITUDE>	Altitude generated by the GNSS receiver	0.1 meters

Telemetry

TM Parameter	Function	Resolution /Format
<GNSS SATS>	GNSS satellites connected	integer number
<ACCELEROMETER DATA>	Data received from the gyroscopic sensor i.e. acceleration and roll & pitch parameters	m/s^2
<GYRO SPIN RATE>	Spin rate of Mechanical Gyro wrt. CANSAT	deg/s
<FLIGHT SOFTWARE STATE>	Operating state of the software	(boot, idle, launch detect, deploy, etc.)

Telemetry

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

The received telemetry for the entire mission shall be saved on the ground station computer as a comma-separated value (.csv) file that will be examined by the competition judges. Teams will provide the file to the judges immediately after the launch operations via USB drive. The .csv file shall include headers specifying each field of data.

The telemetry parameters display format with resolution needs to be provided as given in the table below. The telemetry data file shall be named as follows:

- A. Flight_<TEAM_ID>.csv. It is recommended the ground software produce this
- file, with the correct name, easily from the ground system user interface.

Communication Link and Data Budget

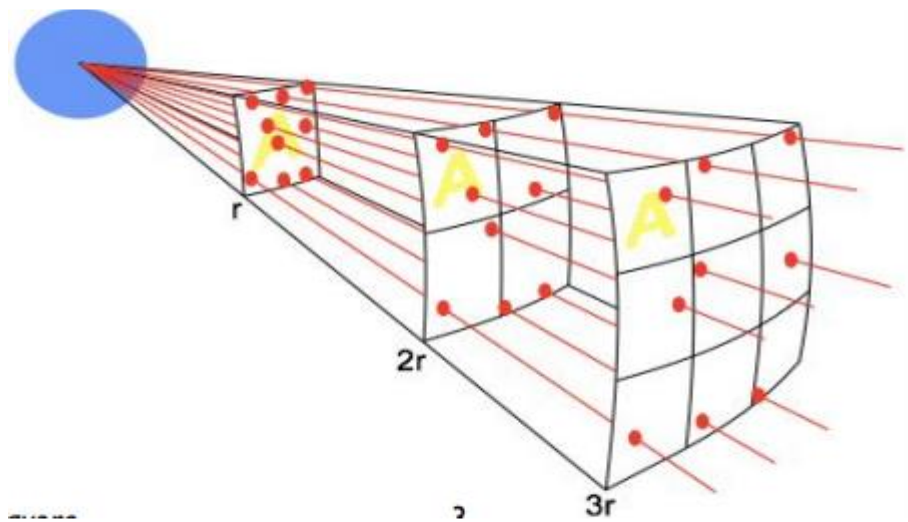
The received power in an wireless link is determined by three factors:

- Transmit power
- Transmitting antenna gain
- Receiving antenna gain

If that power, minus the free space loss of the link path, is greater than the minimum received signal level of the receiving radio, then a link is possible. The difference between the minimum received signal level and the actual received power is called the link margin.
The link margin must be positive, and should be maximized.

Free space loss

- Signal power is diminished by the geometric spreading of the wavefront, commonly known as Free Space Loss.
- The power of the signal is spread over a wave front, the area of which increases as the distance from the transmitter increases.
- Therefore, the power density diminishes.



- The equation for the Free Space Loss is:

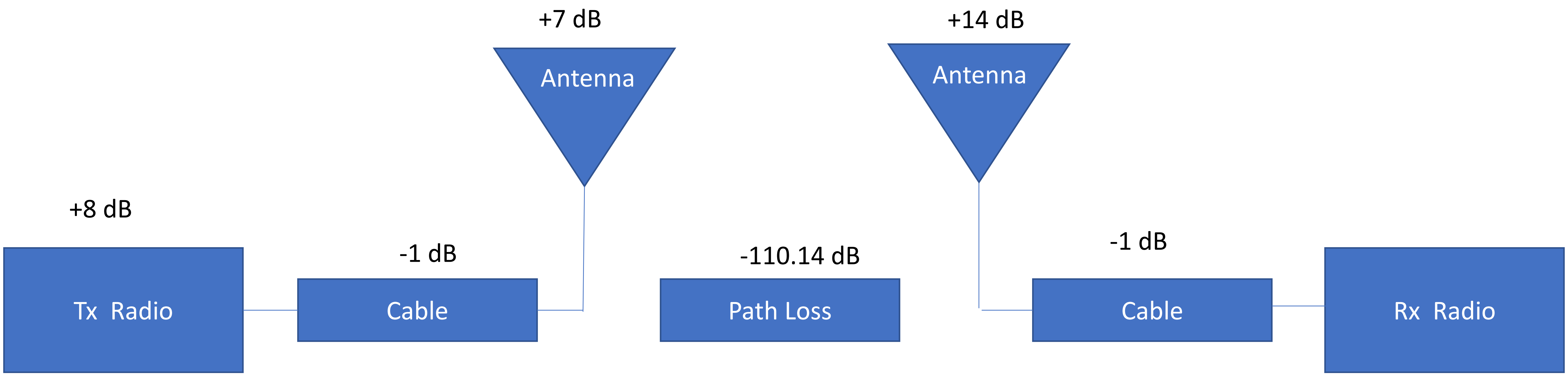
$$L_{fs} = 20^* \, log_{10}(d) + 20^* \, log_{10}(f) - 147.55$$

- where L_{fs} is expressed in dB, d is in meters and f is in Hz.

For Frequency of 2.4 GHz free space loss is :

$$L_{fs} = 40.04 + 20^* log_{10}(d)$$

Communication Link and Data Budget



Communication Link and Data Budget

Calculation :

- Transmitted Power : 8 dB
- Transmitter Antenna Gain : 7 dB
- Transmitter Loss : 1 dB
- Free Space Loss : 110.14 dB
- Miscellaneous Loss : 1 dB
- Receiver Antenna Gain : 14 dB
- Receiver Loss : 1 dB

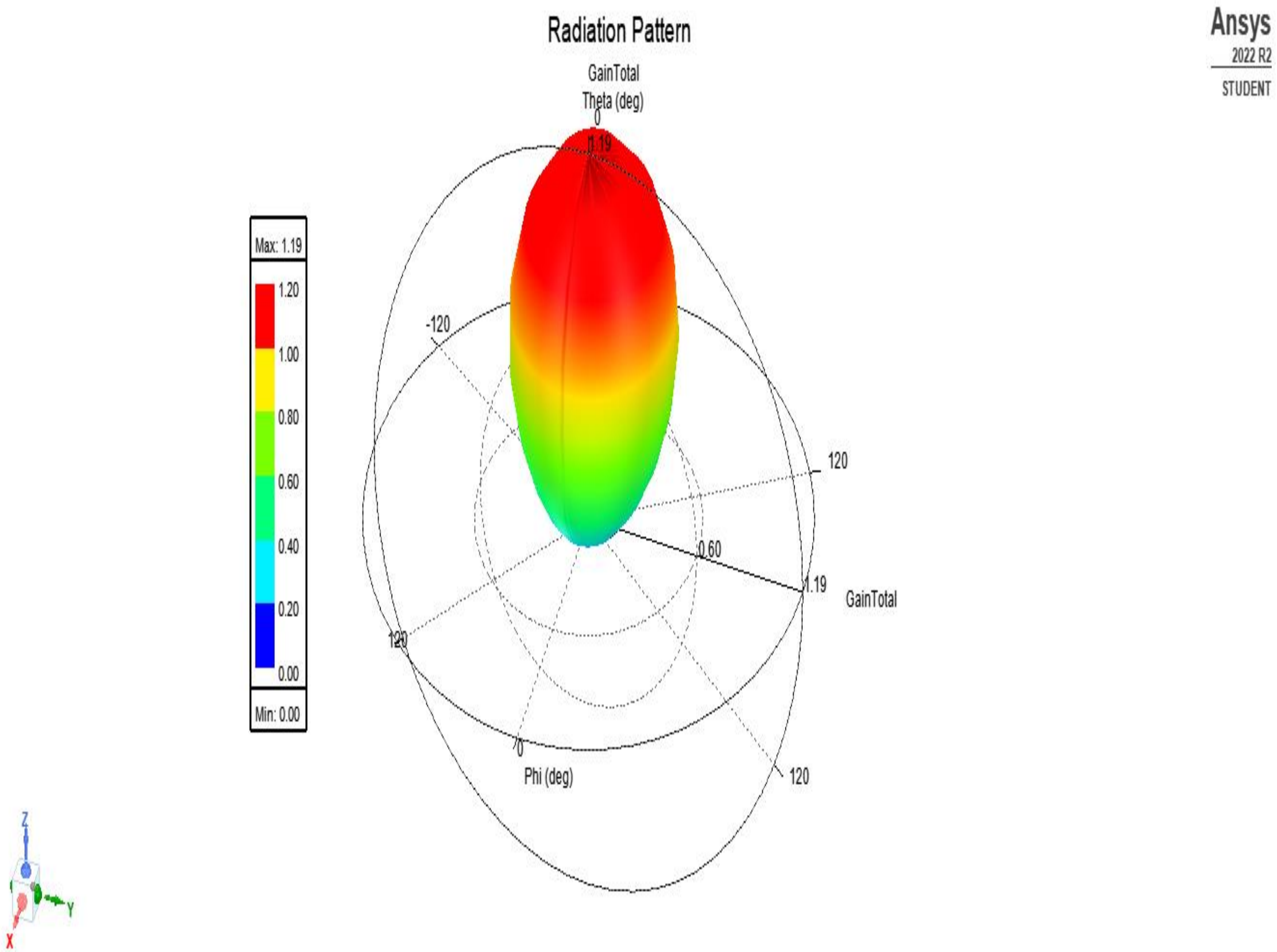
- Received Power : -84.14 dB
- Receiver Sensitivity : -101 dB

- Link Margin : 16.86 dB

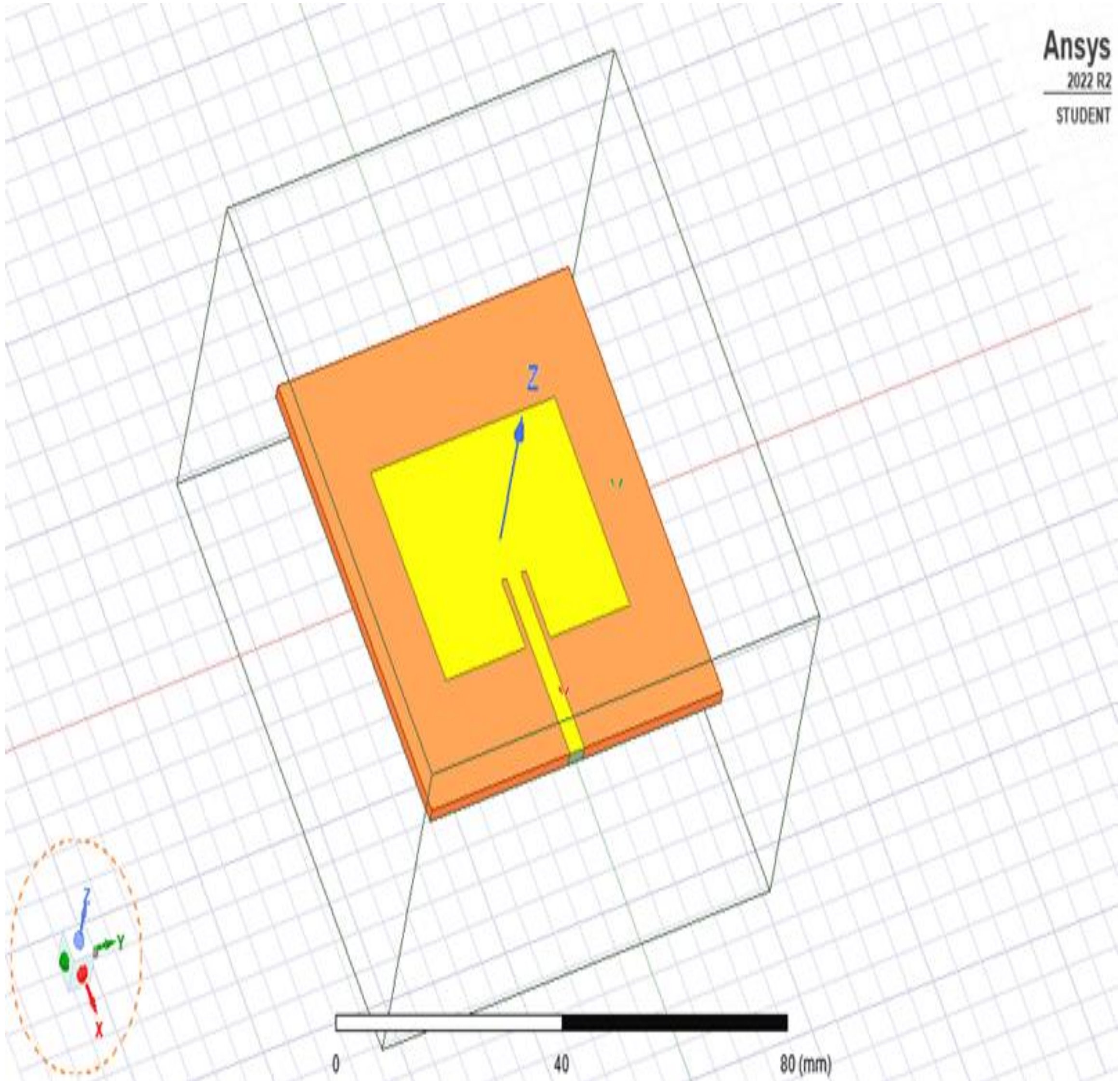
Formula used for Received Power Calculation :

$$P_{out} = P_t + G_t - L_t - L_{fs} - L_m + G_r - L_r$$

Antenna Selection



Radiation pattern of
Microstrip Patch Antenna



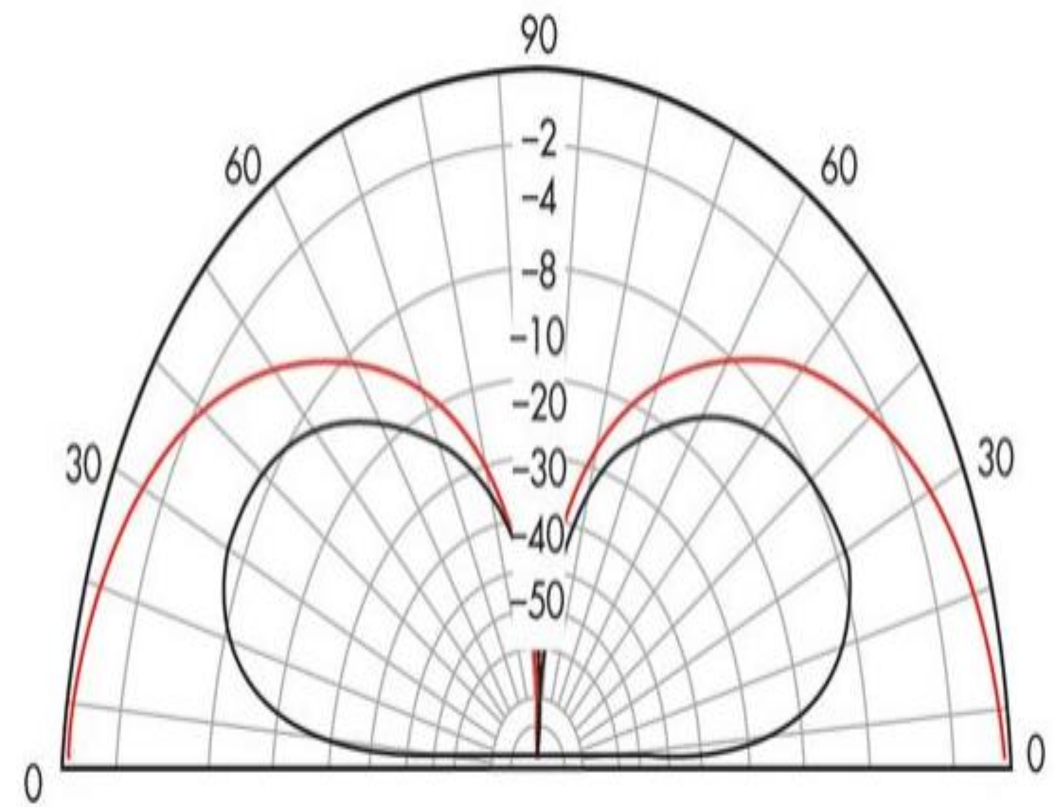
Microstrip patch antenna design

Antenna Selection

Reason for selecting Microstrip Patch Antenna :

- The choice of monopole antenna, the most common XBee antenna, has been rejected due to 0dBi gain in 90deg. altitude. This is very undesirable, because if the CanSat was to find itself directly above GS, we could potentially loose communication with Can.

- And Single wire antenna would also occupy lots of valuable space which is saved by using Microstrip Patch Antenna as it is very small in size.
- Microstrip Patch Antenna are also light in weight as it is fabricated on a PCB.



Monopole antenna radiation pattern

Electrical Power Subsystem Design

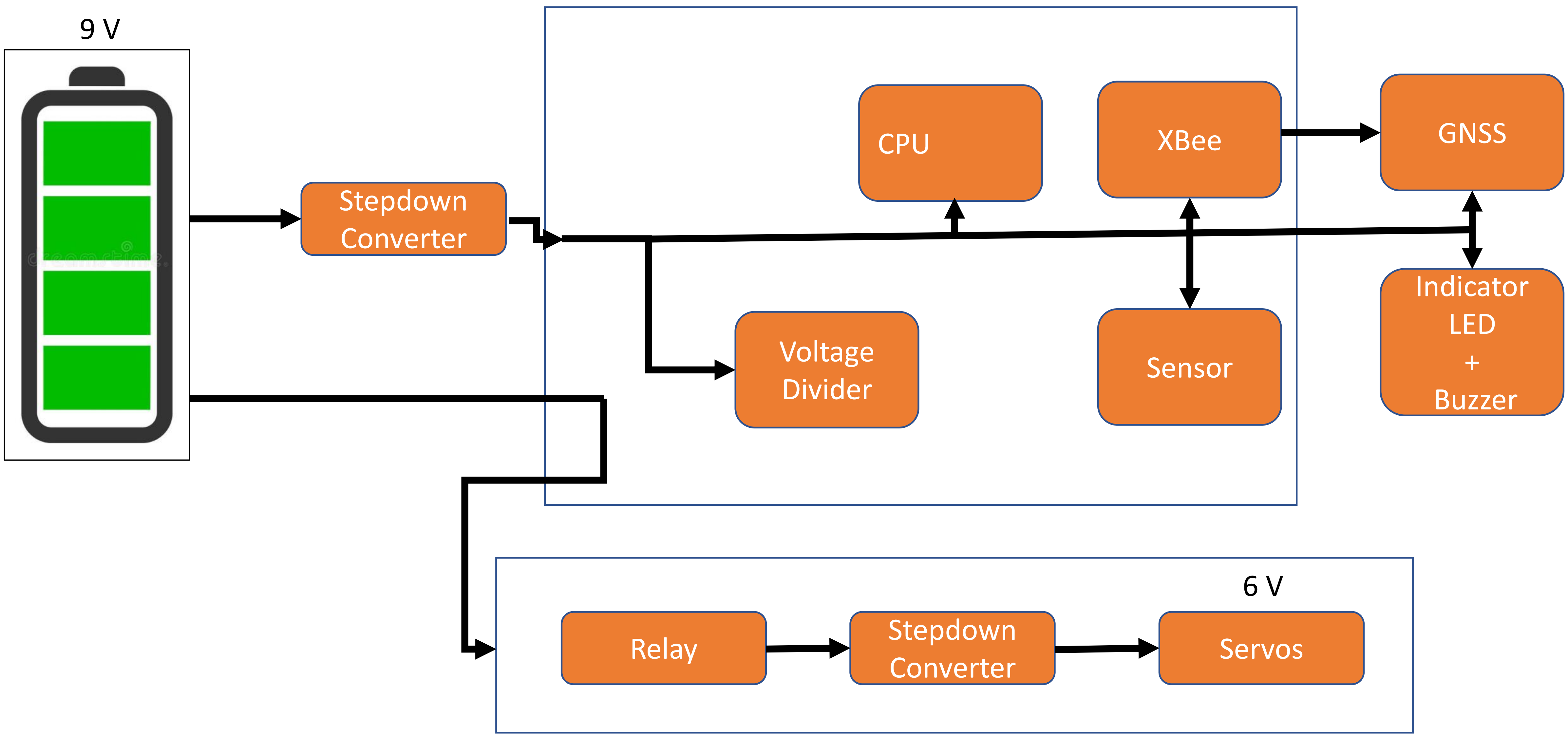
Electrical Power Subsystem Overview :

- As mentioned before, key power saving feature of payload is ability to switch off power consuming components like servos and camera, and enabling them to be turned on only in flight mode. This feature lets us operate and communicate with CanSat for period significantly longer than duration of the competition.
- Power switch shall be located at the cross sectional surface area of CanSat for easy accessibility. Furthermore, switch we've chosen is a DIP type, which is very hard to accidentally toggle. Next to it is located an LED indicator ensuring us whether the electronics is turned on or off.
- We have refrained from lasers as they can cause harm or fire.
- Use of 9V batteries meant using dedicated battery clips which can be easily interlocked and thus without any additional connectors we can hook up auxiliary power supply for testing purposes in order not to drain.

Electrical Power Subsystem Requirements :

Sr no.	Requirements	Priority	Fulfillment	VM			
				A	I	T	D
1	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 disassembling of CANSATs on the launch pad.	High	External switch with an indicator LED is provided.				x
2	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.	High	Battery is able to support wait of up to 2 hours.				X
3	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.	High	Lithium ion batteries are used.				X
4	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.	Medium	External Battery compartment is provided and can be installed without disassembly.				X
5	Spring contacts shall not be used for making electrical connections to batteries. Care must be taken as the shock forces can cause momentary disconnects of power.	High	No spring contacts are used.				x

Electrical Block Diagram :



Flight Software Design

Overview

Overview of the CanSat FSW Design

- The CanSat will collect sensor data then save to SD card and send to ground station via XBee.
- The CanSat will deploy 2nd Parachute deploy mechanism after reaching 500m altitude.
- The buzzer will keep beeping after landing until turned off with power switch.

Programming Language

- C/C++ for CanSat container
- Python/C++ for ground station

Development Environment

- Arduino IDE
- Visual Studio Code

Operations

On the Ground, before Start

- Awaiting on arming signal from CGS,
- Continuous communication with ground starts now.
- Measurement Task is started, measured values are transmitted and also stored on SD card.

After Arming Operation

Probe waiting for release CanSat from the rocket.

When released From Rocket

- All previous tasks are maintained.
- CanSat is awaiting for desired altitude.

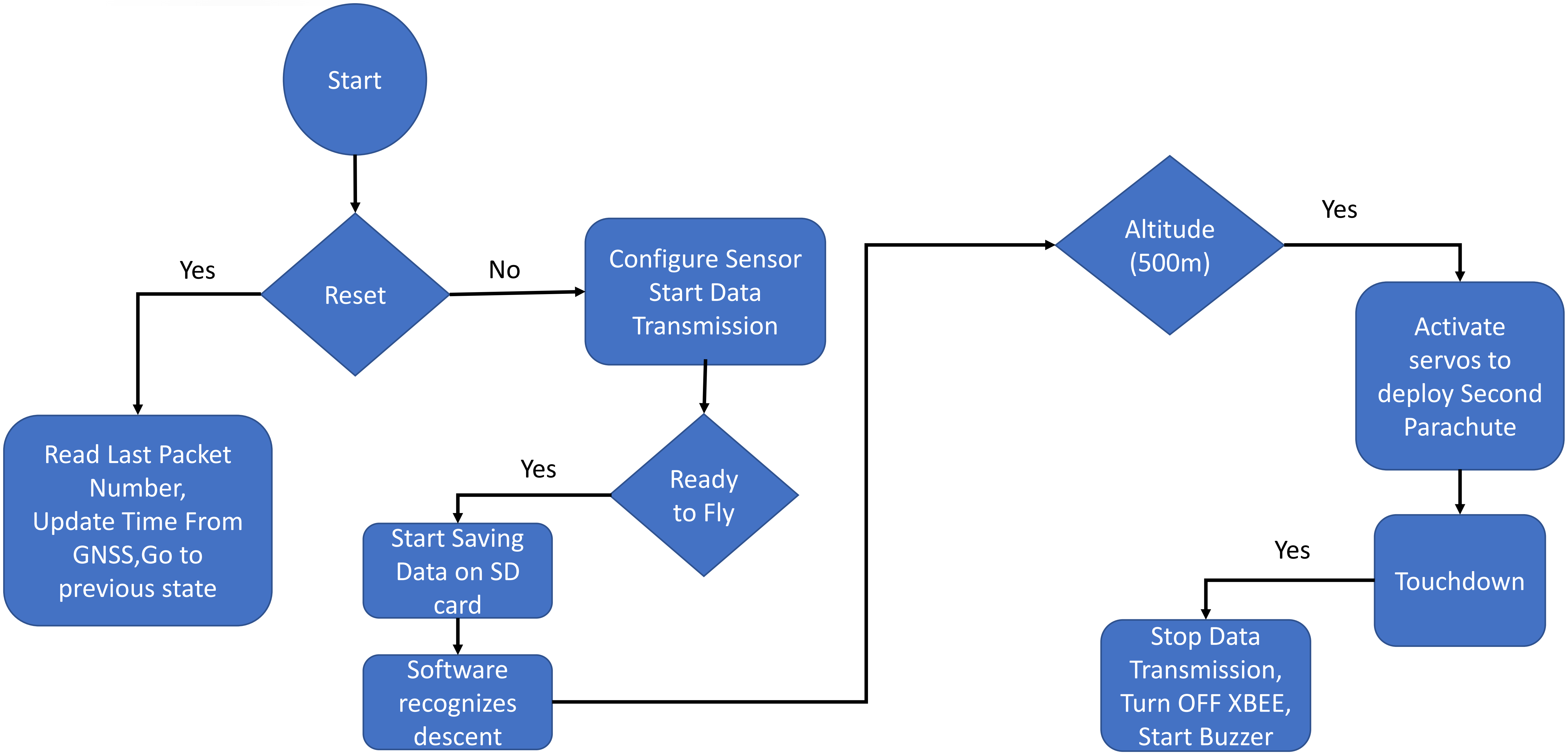
After Critical Altitude crossing

- CanSat will deploy 2^{nd} Parachute.
- Cansat is awaiting for landing.

After Landing

- Measurement operations will be no longer performed
- Buzzer signalization starts, and transmission stops.

FSW State Diagram



FSW State Diagram

As far as power management goes, all devices are ON for all time except two (Servo motor for Deployment of 2nd Parachute and Buzzer for recovery) as Servo motor will deployed only for some time after crossing critical altitude (500m) and Buzzer will be turned ON after landing for location and recovery of CanSat.

After reset of processor in flight mode, previous state of mission together with last packet count can be retrieved from flash.
This information with current GNSS time is sufficient to continue mission.

Mechanical Subsystem Design

CANSAT

Composed of two major components:

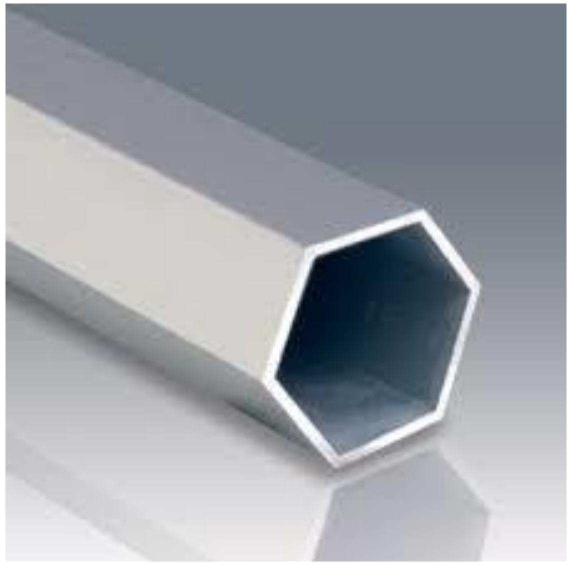
- Container
- Payload

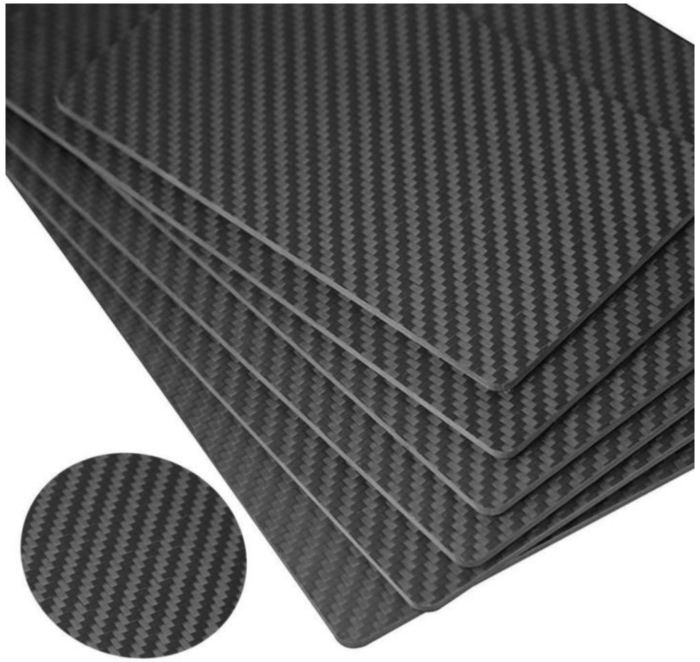
Container

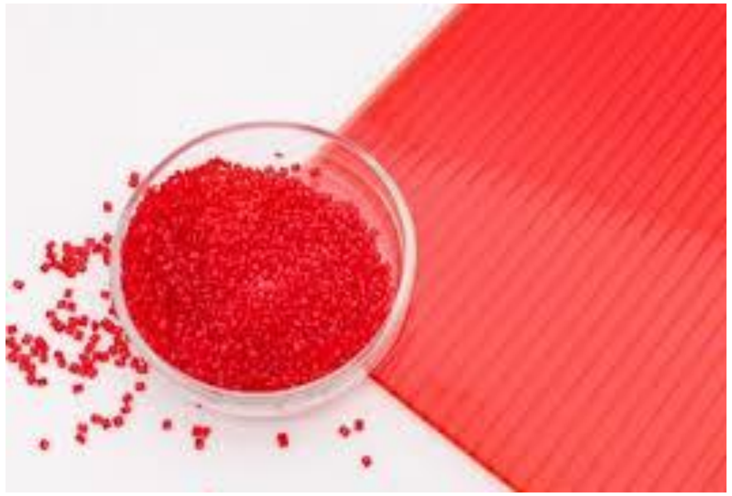
- Protects the stowed payload during launch
- Equipped with a parachute to ensure proper descent rate in fir phase of descent.
- Made from 2024 T3 Al alloy and Polycarbonate ABS plastic material

Payload

- Uses a inverted Pendulum with a Mechanical Gyroscope Concept that ensure stability made from PC ABS plastic and Carbon Fiber Composites parts with laminated carbon fiber around it for descent using auto rotation
- Main structural part covered with Polycarbonate ABS plastic cover for better protection.
- Provides integrated deployment mechanism
- Real life transmits all telemetry
- Integrated active stabilization by four ailerons to ensure stable descent
- Low center of mass for high stability







Mechanical Subsystem Design

ID	Requirement	Rationale	Fulfillment	Priority	VM			
					A	I	T	D
1	Total mass of the CANSAT (Payload and container) shall be 700 grams +/- 50 grams.	Mass of CANSAT can not be higher as its descent could be dangerous and influence rocket's trajectory.	Total mass of CANSAT is not exceeding imposed tolerances	High	x	x	x	x
2	CANSAT shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Rockets have compartments with fixed dimensions and in order to reassure proper ejection adequate tolerances must be met.	The CANSAT is designed and manufactured with appropriate dimensions.	High	x	x	x	x
3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	Blockage in rocket compartment would cause failure of whole mission.	All sharp edges will be chamfered	High	x	x		
4	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition requirement. To lower the risk of CANSAT getting stuck in rocket.	Airframe of the rocket is not used by CANSAT	High		x		
5	The rocket airframe shall not be used as part of the CANSAT operations.	Competition requirement. CanSat should be separate autonomous system.	Airframe of the rocket is not used by CanSat.	High		x		
6	The payload shall descend using an parachute recovery descent control system.	Competition requirement.	Payload is designed to use auto-gyro descent control system.	High	x	x	x	x
7	All descent control device attachment components shall survive 30 Gs of shock.	CanSat should be able to operate in multiple flights	All attachments are designed to fulfill durability requirements	High	x		x	
8	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Electronics needs to be protected from environment	Electronics is enclosed in the Polycarbonate ABS tube.	High	x	x		

ASTROPEEP

Mechanical Subsystem Design

ID	Requirement	Rationale	Fulfillment	Priority	VM			
					A	I	T	D
9	All structures shall be built to survive 15 Gs of launch acceleration.	Damage prevention.	It is designed so. Will be tested.	High	x		x	
10	All structures shall be built to survive 30 Gs of shock.	Damage prevention.	It is designed so. Will be tested.	High	x		x	
11	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Damage prevention.	All electronics will be hard mounted using proper mounts.	High			x	
12	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Safety measure.	Mechanisms are tested in all varying conditions and some simulations will be performed.	High	x	x	x	
13	Mechanisms shall not use pyrotechnics or chemicals.	Safety measure, can cause fire or contamination.	No pyrotechnics or chemicals used.	High		x		x
14	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Safety measure, can cause fire	Nichrome wire is hidden inside the body of payload assuring safety.	High		x		x
15	Both the container and probe shall be labeled with team contact information including email address.	Safety measure, during mission failure can cause recovery after competition.	Labels are adequately placed and safely secured.	Medium		x		x
16	The probe must include an easily accessible power switch that can be accessed without disassembling the CANSAT and in the stowed configuration.	In case of electronics failure such as short circuit a safe way of aborting is needed.	Power switch is placed at top of payload, assuring easy access.	High	x	x	x	x

Mechanical Subsystem Design

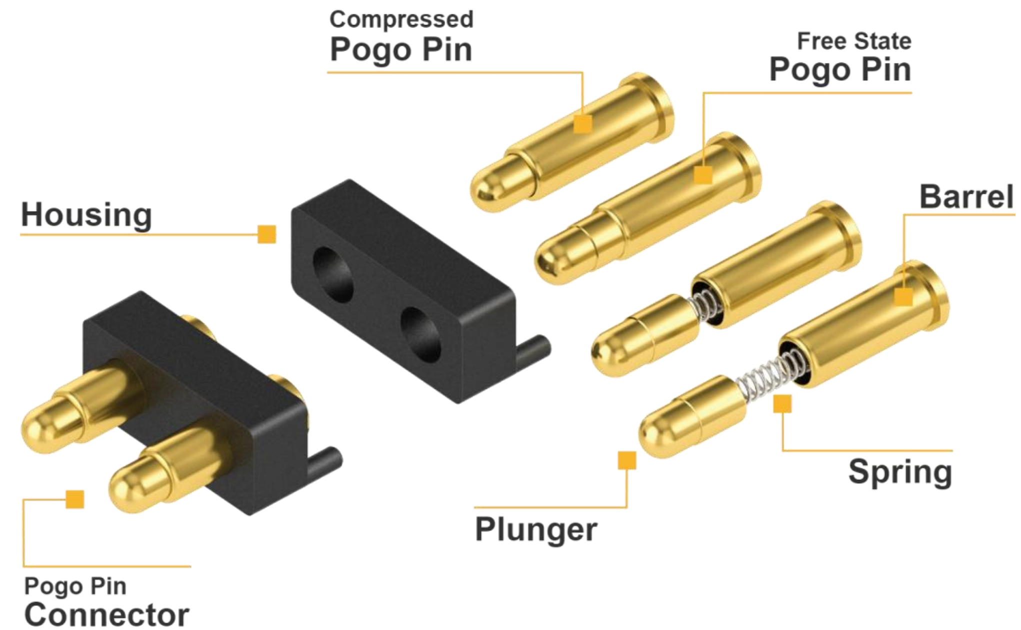
ID	Requirement	Rationale	Fulfillment	Priority	VM			
					A	I	T	D
17	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the cansat and in the stowed state.	Safety measure, helps finding the CanSat after mission , reducing the environmental risk.	LED indicator and buzzer implemented to comply with requirements.	High			x	x
18	An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require a total disassembly of the CanSat.	Safety measure, in case of battery discharge can recover mission success.	Design allows for replacement of batteries after removing only 4 screws and connecting cables.	High			x	x
19	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Can cause mission failure.	Clip on connectors are used.	Medium	x	x		
20	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Competition requirement.	Contra-rotating rotor passive system is designed.	High	x	x	x	x

Deployment Mechanism Design and Selection

Deployment Mechanism Design

Concept 1 :

- The Pogo Pins would be attached to the base of Top Container and are compressed with the flap which is servo governed.
- The time which reach the altitude of 500m the PCB would actuate the servo to rotate the flap which would release the spring and detach the parachute 1 and its container.
- And simultaneously deploy the Parachute 2.



Deployment Mechanism Design

Concept 2:

- The housing would have a particular slot which would be particularly for the servo flap.
- This would create a reactional force between the Parachute 1 and the CANSAT.
- During deployment the flap would turn and come out of the slot and the Parachute 2 would be deployed with the reaction to the compression within the container 2.

- **Concept 1 is selected,** as Concept 2 is more prone to the shock force as mentioned before and might fail with in the flight.
- Also the in concept 2 the chances of tangling of parachute strings are more.

Power Budget

Power Budget

Component	Power Consumption (Wh * 2)	Duty Cycle (%)	Calculation Source
CPU(STM32F103)	0.238	100	Estimated/ Datasheet
Pressure Sensor(BMP280)	0.007392	100	Datasheet
Acceleration and Gyro Sensor(MPU6050)	0.02574	100	Datasheet
GNSS(S1216F8)	0.792	100	Datasheet
XBEE	0.726	100	Datasheet
Servo Motor(Mechanical Gyro Control)	3.32	100	Test
Servo Motor (Parachute Ejection) (x 2)	12.24	2	Test
Buzzer	0.792	2	Estimated

In the above Budget Power Consumption is calculated for a period of 2 hrs on assumption that CanSat may be turned on for 2h, while the actual flight time might be less than that.

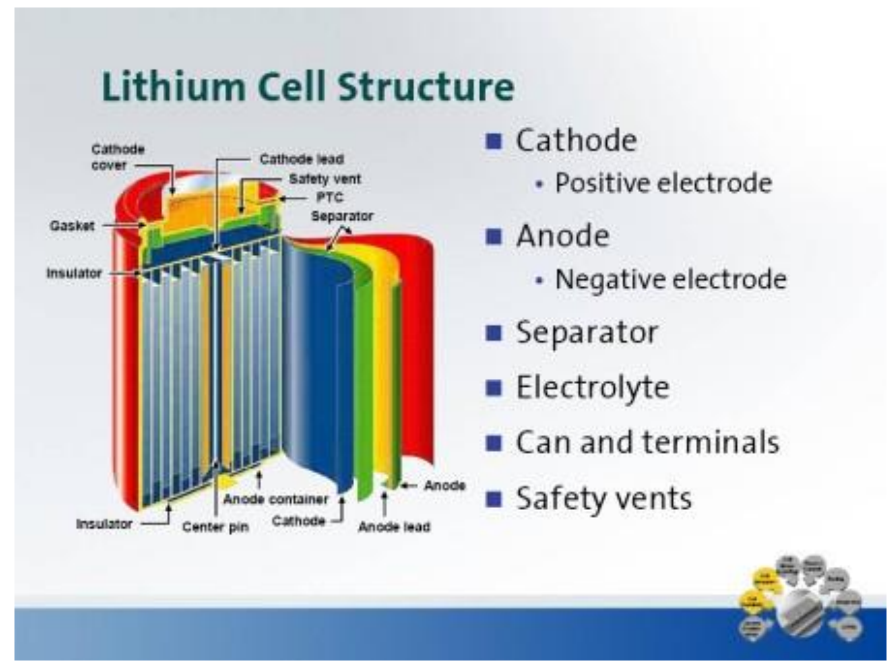
Total Power Drained from the Battery for 2 hrs operation = 5.369772 Wh.

Power Budget

Looking onto the Power consumption requirements of approximately **5.36** Wh for 2hrs duration of operation we chose pack of two 9 V battery and 600 mAh and it will give us a good margin in Power Consumption.

Reason for selecting Li-ion Battery :

- Light in weight
- Compact in size
- Relatively cheaper



Mass Budget

Method of correction:

- In case any error occurs the lower part will be equipped with extra space for increasing weight with screws and nuts. Initially it will include 6 screws that can be detached if the structure is too heavy.
- Margin = 500-497.1= 2.9g

Comparison	
Total mass	Required mass
667.16 ± 4.6	700g ± 50g

Part	Container Mass(in g)	Determination
PC ABS Panels	43.79 ± 0.2	Measured
Aluminium Rods	61.33 ± 0.2	Measured
Base Plate	12.67 ± 0.2	Measured
Parachute 1 CF Container	54.84 ±0.2	Measured
Parachutes	90±.02	Measured
Shackle	10±.02	Measured
Total	272.63 ± 1.2	
Total structural	172.63 ± 0.8	
Total compo nents mass	100 ± 0.4	

Part	Payload Mass(in g)	Determination
Carbon Fiber tube	20.28 ± 0.2	Measured
Dampers & foam	30 ± 0.5	Estimated
Screws, washers, nuts	20.25 ± 0.2	Estimated
Servos	27 ± 0.2	Measured
Other 3D printed parts	10±0.2	Estimated
PCB 1	75 ± 0.5	Estimated
Camera	20±0.2	Estimated
PCB 2	40 ± 0.5	Estimated
Gyroscope	22±0.2	Measured
Wiring	25 ± 0.5	Estimate
Batteries	105±.02	Measured
Total	394.53 ± 3.4	
Total structural	80.53 ± 1.1	
Total components m ass	314.0 ± 2.3	

Hardware Budget

S No.	Component	Requirement	Buy Out	Estimated Cost per unit (Rs.)
1	Aluminium 2024 Alloy Rod	1.836 m	2 m	2680-3600 (per Kg)
2	PC/ABC Printing(3D) Filament	3 rolls	5 rolls	950-1000 (per Kg)
3	PC/ABC Sheet(6''*8'')	7 sheets	8 sheets	1560-2200
4	Servo Motor	3	4	200-250
5	Mechanical gyroscope	1	1	1200-1500
6	SanDisk Ultra(16Gb)	1	1	400

Hardware Budget

S No.	Component	Requirement	Buy Out	Estimated Cost per unit(Rs.)
7	Pressure Sensor(BMP280)	1	1	150-200
8	Acceleration and Gyro Sensor(MPU6050)	1	1	120-180
9	GNSS(S1216F8)	1	1	1700-2500
10	XBEE PRO S2C	2	2	2400-3000
11	CPU(STM32F103)	1	1	1000-1500
12	Voltage Sensor (Voltage divider)	1	1	20-30
13	Ripstop nylon	150 gm	150 gm	1200-1800
14	Battery(Tenergy 9V 600mAh)	2	2	900-1000

Hardware Budget

S No.	Component	Requirement	Buy Out	Estimated Cost per unit(Rs.)
15	Pogo Pin	2	2	250
16	Screws, washers, nuts	-	-	65
17	Dampers & foam	-	-	25
18	Carbon Fiber tube	-	-	1800-2000
19	Wiring	-	-	-
20	Shackle	2	2	300
21	Buzzer	1	1	280-300

GCS Design and Overview

GCS Overview

Overview

- Main Computer is a laptop running GS application. The application is configured in GUI so that an appropriate port and baud rate can be selected.
- QHA antenna receives data from the probe (i.e. CanSat CPU) and transmits commands.
- Xbee PRO S2C module forwards and receive data to form communication link between CanSat and GCS.
- GS application, written in C++/Python, saves and displays data. It also saves received data in a local area network.

GCS Requirements

ID	Requirement	Rationale	Fulfillment	Priority	VM			
					A	I	T	D
1	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.	Competion Requirement	The Ground Station shall Command the CanSat.	High				X
2	The ground station shall generate .csv files of all sensor data as specified in the Telemetry Requirements section.	Competion Requirement	csv file will be generated	High				X
3	Telemetry shall include mission time with one second or better resolution.	Competion Requirement	Telemetry shall include mission time with required resolution.	High			x	
4	Mission time/timestamp and system status states shall not be affected in the event of a processor reset during the launch and mission.	Competion Requirement	Mission time will not be affected during launch and mission.	High			x	
5	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Competion Requirement	GS consists of one Laptop.	High				X
6	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.	Competion Requirement	GS is portable	High				X

GCS Design

Data Flow and Components

- The antenna receives data over radio from the probe.
- Using Xbee explorer cable , forwards data to the Xbee module.
- Xbee PRO S2C module forwards data to GS’s Main Computer using micro USB to USB cable.
- Software developed in C++ parses and then displays data in engineering units and save them into a CSV file.
- Main computer is capable of sending predefined commands to the probe.

GCS Design

Major Components		
ID	Component	Description
1	Main Computer	An efficient laptop computer with an i5 Intel processor with 8gb of ram needed for running application. The laptop also has a good battery which lasts up to 4 hours of intensive usage. It also runs the main GS application. The main application is responsible for configuring USB Serial Port connection and for parsing data and sending it to its GUI submodules.
2	QHA Antenna	Antenna used to transfer data from the probe to the GS. More information presents the GCS Antenna slide.
3	Xbee PRO S2C	Xbee radio module is used for communication of GS with the probe.
4	Command terminal incorporated in GS application	Terminal allows user to send commands to the probe and to plot raw telemetry frames as well as application internal notifications to user.
5	Real Time Charts	GS consists of Laptop with battery able to work up to 4 hours, XBee module and directional antenna.
6	CSV files	The main application saves data to a CSV file.

GCS Design

Specification

- Ground Station can operate on battery at ease up to 4 hours and longer with an extra power bank.
- Ground Station team member carries an umbrella to cast a shadow on the main computer in case of a sunny day.
- Before start the main computer is kept in a special thermal case.
- Main Computer runs Windows offline and all possible automatic updates are turned off.

GCS Antenna Trade & Selection

Monopole antenna	QHA Antenna
Omnidirectional, yet has 0 dB gain in 90deg altitude	Fully omnidirectional
Linear polarisation	Circular polarisation
Easy to make	Slightly more complicated
ZL=37.5+j21.25 -> would require matching circuit	50 Ohm -> good S11 parameter

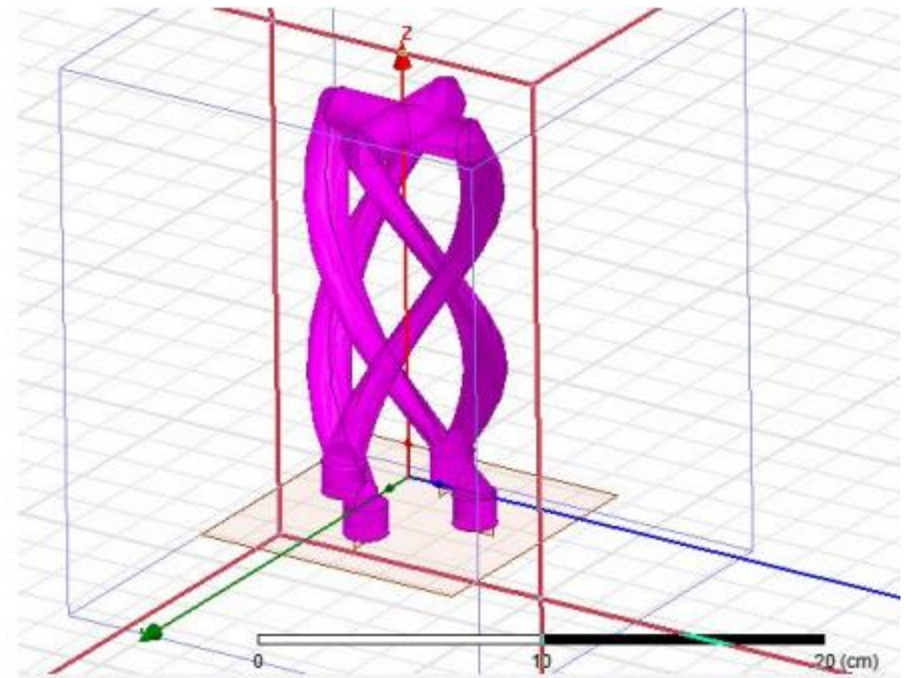
Selection Rationale

Even though QHA antenna is slightly more complicated to manufacture it is far superior in comparison to monopole antenna, mainly because it has circular polarization.

GCS Antenna Trade & Selection

Custom designed QHA antenna

Parameter	Value	Performance
Type	Omnidirectional	The propagation loss of 2.4 GHz band experiences due to its shorter Wavelength is also the very feature that enables it to use antenna diversity to overcome the losses.
Frequency	2.4 [GHz]	Frequency meets the requirement and it is compatible with XBee radio module.
Peak Gain	+14 [dB]	Signal is strengthened evenly around the radiation pattern.



GCS Software

Overview of the GCS Software Design

- The GUI will collect sensor data from Cansat and send command to CanSat via XBee.
- The GUI will do real time plotting of data using matplotlib.
- The GUI will also contain terminal tabs for sending predefined and custom commands to CanSat.

Programming Language

- Python/C++

Development Environment

- Visual Studio Code

Software specifics

- Real-time data is received via micro USB , USB cable. Application is analyzing the beginning and end of each telemetry frame. After being received, a frame is divided into parts and directed into the data flow and then the whole frame or its part is sent to software listeners like in e.g. Database module or a real time chart module.
- GUI is equipped with indicators which inform about mission phase and onboard computer system state.
- Real-time plotting software relies on matplotlib chart components which are configured to listen to data.
- Matplotlib charts are optimized for handling real time data.
- Command software and interface is included in the application as the Terminal Tab.
- It is possible to send predefined and custom commands to the probe with the Terminal Tab.
- The CSV file is created by writing every telemetry frame with an End Of Line sign at the end to a file with a proper name.

Cansat Integration and Testing Plan

CanSat Integration and Test Overview

Before integration of the CanSat each individual required subsystem was tested in order to reassure that CanSat as a unit also will work properly. Tests allow us confirm if everything works as expected, if something needs to be replaced or if there is better solutions for some tasks. For example critical was checking the parameters of auto-gyro, flight stability and communication quality of radio modules to exclude the possibility of failure of the whole subsystem. After performing all planned tests of subsystems integration of CanSat can be done - details are provided in the following slides.

Integration allows to check if all systems work as desired as a unit. Simplified mission in the drone as well as in our own rocket can verify also main objectives of the competition - communication between the CanSat and the ground station, recovery system, auto-gyro and structure durability. Environmental tests such as drop, thermal rocket and vibration tests will show if CanSat can operate without failure during the mission in various conditions (such as 15Gs of launch acceleration and 30Gs of shock), what will lead to successful mission. Fit check, performed with usage of our rocket, which has the same diameter as required, will assure us that CanSat will be deployed as desired, without any troubles.

Subsystem Level Testing Plan

CanSat subsystems level tests (before integration)	
Sensors	Sensors will be checked and properly calibrated separately, before mounting them to a CanSat. It will assure us, that all used components are fully functional and will not cause mission failure. Calibration will be done with usage of oscilloscope sending the data via UART to PC and checking if the values are correct.
CDH	Preliminary tests for data acquisition – checking if sample data send via radio modules can be properly handled by ground station software. Checking the time of sending data along working under various conditions. Checking if data frame format is as desired.
EPS	Supplying a voltage divider with various voltages of a battery working range from laboratory power supply to determine the correct behaviour of the circuitry. Checking for damage such as short circuits. Battery tests will be performed - maximum current consumed by hot wires need to be compromised with battery parameters - checking if they make hotwire hot enough. Checking battery lifetime. Voltage checking on the checkpoints.
Radio Communication	Sending and receiving known amount of packets and checking the loss percentage in various areas, such as between buildings/trees or on an open field. Verification of radio modules parameters and communication quality on ground.
FSW	Checking designed software functionalities such as: proper visualization of sample data, sending remote commands to the onboard computer. Sequences chronology and order will be tested in all possible scenarios and events.

Subsystem Level Testing Plan

CanSat subsystems level tests (before integration)	
Mechanical	All mechanical elements separately must be checked if they are made properly and have good dimensions. Then, components must be preassembled in order to see if a whole structure is stiff enough and have no looseness. Checking if fast moving and rotating structure does not cause any problems. If not, then we test all mechanisms used separately if they work properly – e.g. if wings can be opened and closed easily. Container has to be checked on the ground for its stiffness and durability and visually if a composite does not have any cracks and flaws. Container must be fluorescent color to be easy to find - test of luminescent addings to glass fiber composite
Descent Control	Checking if parachute descent is stable with a sample mass attached. For probe - checking if descent rate of the designed wings is as desired and what is their rotation rate. Test performed in aerodynamic tunnel. Rotation rate checked by suitable sensor.

Integrated Level Functional Test Plan

CanSat subsystems level tests (after integration)	
Descent Testing	Checking if the flight is stable and detumbled with parachute deployed. Testing if the flight is stable with rotors. We check it by deploying CanSat from high building with known height - recording the test with the camera lets us calculate descent rates of parachute and rotors. Testing the parachute from a smaller height if it is stable and if the descent rate is appropriate. Testing if detumbling system works as desired and stabilizes Probe during auto-gyro descent and if recording from camera is stable. Preliminary tests were performed with our rocket and will be repeated with the drone and rocket again.
Communication	Checking on the ground if communication between CanSat and Ground Station works. Checking wireless modules, every sensor, the power modules, CanSat – ground station application. On that stage we can perform final data flow from sensors to its acquisition on the ground station application.
Mechanism	Testing if rotors open well and work in desired way and if elastic bands give enough force for unfolding rotors. Everything is well-fitted and the capsule is able to slide easily in the structure.

Environmental Test Plan

Environmental Tests

CanSat Environment Tests	
Drop Test	Drop tests will show if CanSat as a unit can survive sudden acceleration (all structures and descent control devices attachment components shall survive 30Gs shock). Test will be performed by dropping CanSat on a string from known, proper altitude - about 1.5m. We power on CanSat and check if telemetry is being received, then attach it via parachute to the cord. We release the CanSat and verify the CanSat did not lose power. Then inspection for any damage, or detached parts is made and verify telemetry is still being received.
Thermal Test	Thermal tests will show if high temperature, which can occur during the mission in rocket, does not cause any major harm to the CanSat (e.g. to electronics, communication with Ground Station, structure). Test will be performed by using a thermometer, heater and a closed box. CanSat will be turned on for 2 hours in thermal chamber in about 60 degrees Celsius. Communication and electronics test will be performed for all time when CanSat will be heated. After, when CanSat is still warm, mechanical parts and joints will be checked
Vibration Test	Vibrations tests will verify if all components of CanSat are properly integrated, if any screws does not unscrew during the mission or structure loosens, what would cause CanSat to fail a mission. Test will be performed with usage of device provided by our University, to which we will attach CanSat. After powering on the CanSat accelerometer data collecting is verified. Then we power up device for 5 seconds, then power down. Repeat test 5 times while still verifying accelerometer data collecting. After this, mechanical parts and their functionality are being checked. After it, we power down CanSat.
Fit Check	Fit check will be performed by using a pipe of proper size in order to check if CanSat can be easily deployed from rocket.

Mission Operation and Analysis

Overview of Mission Sequence of Events

Arrival

- Check in Weight and Fit check of the CanSat
- Check for any damages caused by the travel

Setting Up Ground Station

- Localization of the place allocated for the ground station.
- Antenna assembly and setting up ground station.
- Checking communication devices and algorithms.

CanSat Preparation and Assembly

- Communication test
- CanSat structure has no mechanical damages
- CanSat Assembly

Overview of Mission Sequence of Events

Preparation for Flight

- Power Cansat On
- Integrate CanSat into rocket payload
- Confirmation of telemetry data reception by line of judges.

Mission

- Telemetry is constantly transmitted to the ground station and monitored.
- First Parachute opens right after deployment of the cansat.
- The second descent control mechanism shall open at an altitude of 500m.
- Buzzer is turned on upon Landing.

Recovery

- Retrieval of the CanSat.
- Delivery of the telemetry data file to a line of judge for inspection.

Overview of Mission Sequence of Events

Analysis

- Analysis of the obtained data
- Mission assessment and analysis

Mission Operations Manual Development Plan

The Mission Operations Manual developed after the final design of CanSat introduced will comprise of the following procedures.

Setting up GS

- Computer and Antenna

Communication Test

Pre-Flight check and Tests

- Structure
- Electronics
- DCS components

Cansat Integration

- Container assembly

CanSat recovery

Cansat Location and Recovery Plan

Container

- CanSat shall be of Fluorescent Red color.
- Container will contain Team details.
- Buzzer giving high pitch sound signal.

Additional labelling

- Each component will be equipped with Team Details and Contact information.
- Recovery crew shall be equipped with GNSS.

Program Schedule

Serial Number	Name	Start Date	End Date	Day Number	Task Duration
1	Overall Designing	01-08-2022	30-09-2022	0	61
2	Executing Subsystem Test	01-10-2022	30-11-2022	61	30
3	Selecting Final solution	01-12-2022	31-12-2022	91	31
4	Complete CanSat Prototype	01-01-2023	31-01-2023	122	31
5	Drop , Vibration and Thermal Testing	01-02-2023	30-02-2023	153	30
6	Rocket Test	01-03-2023	31-03-2023	183	31
7	Final Correcting and Evaluation	01-04-2023	31-04-2023	214	30
8	Competition Preparation and Flight	01-05-2023	15-05-2023	244	15

Conclusion

Accomplishments

- Team is formed and responsibilities are assigned.
- All subsystems are designed.
- Ground Station application is partially developed.
- Tests and stages of development are planned and scheduled.

Unfinished work

- The fully integrated electronic & mechanical subsystem are not entirely functional yet and needs to be tested.
- Flight Software is only partially developed.

Next stage of development

- Software Development for the flight Software
- Code Review
- Testing of integrated system
- All the components are yet to be ordered and received