CanSat 2019
Critical Design Review (CDR) Outline
Version 1.0

Team 1516

Ballistic Auto-Gyro Satellite (B.A.G.S)

Presentation Outline (1/5)

Presentation Outline (2/5)

Descent Control Design – Riyanshu Motalaya

Mechanical Subsystem Design – Bhavya Arya

Presentation Outline (3/5)

Communication and Data Handling(CDH) Subsystem Design - Sourav Bhattacharjee

Electrical Power Subsystem (EPS) Design - Shikhar Makhjia

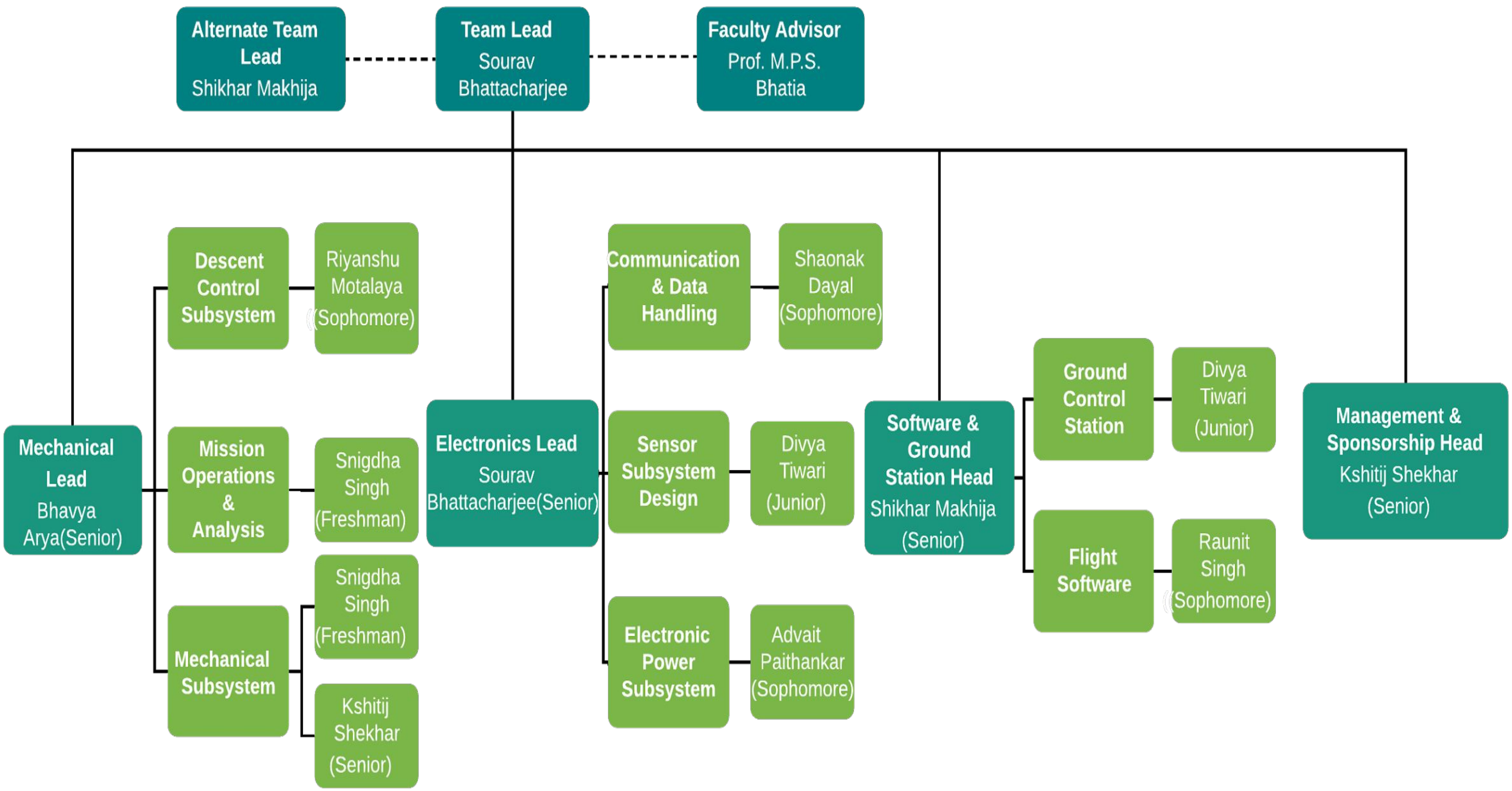
Flight Software (FSW) Design – Raunit Singh

Presentation Outline (4/5)

Presentation Outline (5/5)

Management – Kshitij Shekhar

Team Organization



Acronyms

ADC : Analog and Digital Communication
Alt: Altitude
CDH: Communication and Data Handling
CDR: Critical Design Review
Cp : Pressure coefficient of blades
Ct : Torque coefficient of blades
Cm : Moment coefficient of blades
Cd : Drag coefficient of blades
CDR: Continuous Discharging Rate
Cl : lift coefficient of blades
CSV: Comma Separated Values
EEPROM: Electrically Erasable Programmable Read Only Memory
EPS: Energy Power Subsystem
FSW: Flight Software
GCS: Ground Control System
GPS: Global Positioning System
GUI: Graphical User Interface
IDE: Integrated Development Environment
I2C: Inter-Integrated System(Two Wire Interface)
LDO: Low Dropout Voltage Regulator
Li: Lithium
PID: Proportional Integral Derivative
RF: Radio Frequency
MCU: Microcontroller Unit
MSR: Mechanical Subsystem Requirements
PANID: Personal Area Network Identification Number
RAD: Rapid
SDLC: Software Development Lifecycle
SPI: Serial Peripheral Interface
UART: Universal Asynchronous Transmitter/Receiver
VSWR: Voltage Standing Wave Ratio

Systems Overview

Snigdha Singh

Mission Summary (1/2)

General Objectives

- ❖ To design and fabricate an Auto-Gyro Probe (CanSat).
- ❖ The CanSat shall travel through the planetary atmosphere sampling the atmospheric composition during flight and telemetry data in real time to ground station.
- ❖ CanSat consists of two important parts: Container and Payload.
- ❖ The Payload shall descend using a passive helicopter/ auto-gyro mechanism.

Mechanical Objectives

- ❖ Once released from the rocket at the apogee, the parachute shall deploy packed in a height of 25 mm and container shall descend with a velocity of 20 ± 5 m/s till 450 m height above the ground.
- ❖ At 450 meters, the container shall release the payload.
- ❖ Once released, the payload shall descend with the auto-gyro descent control system with a velocity of 10-15 m/s.
- ❖ The CanSat shall weigh 500 ± 10 g and shall fit in a cylinder of length 310 mm having a diameter of 125mm with appropriate clearances.
- ❖ The auto-gyro descent control shall not be motorized. It must passively rotate during descent.

Mission Summary (2/2)

Electronics Objectives

- Payload shall transmit telemetry consist of sensor data which shall include air pressure, surrounding temperature, altitude, GPS coordinates, pitch, roll, voltage, blade spin and camera direction at the rate of 1 Hz with real-time plots at ground station.
- The container and payload shall have an audio beacon with minimum sound pressure level of 92 dB, unobstructed to aid in recovery.
- The container and payload shall include an easily accessible power switch and a power indicator (LED).

Bonus Objectives

- Camera of resolution 640 x 480 pixels with 30 fps is used to record the descent after the release of payload from the container.
- The video is saved in the SD card on the payload.
- Camera stabilization: It shall point in one direction relative to the earth's magnetic field with a stability of $\pm$ 10 degrees in all directions during descent.

External Objectives

- Raise funding for travel and CanSat fabrication
- Display tilt animation of CanSat and payload after release from container.

Summary of Changes Since PDR

There are some changes since the PDR that are worth mentioning here. Most other changes were done to improve weight, space and ergonomics of the CanSat.

MECHANICAL CHANGES

Parts	PDR	CDR	Rationale
Nichrome heating setup	Placed inside the container above the bottom lid	Places outside the container, attached below the bottom lid	❖ Space constraint ❖ Safer
Shape of the payload	Circular in shape	Octagonal in shape	❖ Capacious ❖ To make ample space for battery and PCB
Rotor mount thickness	4mm	8mm	❖ To increase the efficiency of mounting. ❖ Improved robustness of the overall design
Number of PCBs	Two	One	❖ Light weight ❖ To avoid inter-PCB connections ❖ Reduced circuit complexity
Orientation of PCBs	Horizontally placed	Vertically placed	❖ Could be placed easily ❖ Sufficient space for battery

Summary of Changes Since PDR

CDH CHANGES

PDR	CDR	REASONS
Internal EEPROM of ATtiny85 for container	External EEPROM 24AA64	• Internal EEPROM has less storage space to store BMP280 data during the flight.

EPS CHANGES

PDR	CDR	REASONS
TIP120 NPN BJT for nichrome wire burning setup	12V relay	• There was a very large voltage drop across the BJT which allows less power to be transferred to the nichrome wire. • There was a large power loss in the BJT.

Summary of Changes Since PDR

GCS CHANGES

PDR	CDR	RATIONALE
Telemetry data was stored in an array	Telemetry data is stored in a deque.	❖ Easier to maintain number of operations to render graph on GUI.
Matplotlib.pyplot and Matplotlib.animation for plotting	plotly module is used for plotting	❖ Better graphs are obtained. ❖ Has greater functionality
Use of Tkinter python module to develop the GUI	Dash is used to develop the GUI	❖ Increases functionality with much more customization. ❖ Code becomes shorter and more readable. ❖ Uses a local server to render graphs on browser.

System Requirement Summary (1/3)

Mission RequirementNo.	Requirements Description	Verification methods			
		A	I	T	D
1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	+			+
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.	+	+		+
3	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.		+		
4	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	+		+	+
5	The container shall release the payload at 450 meters +/- 10 meters.	+			+
6	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	+		+	+
7	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	+		+	+
8	The Parachute shall be fluorescent Pink or Orange				+
9	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.	+	+	+	+
10	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	+		+	+

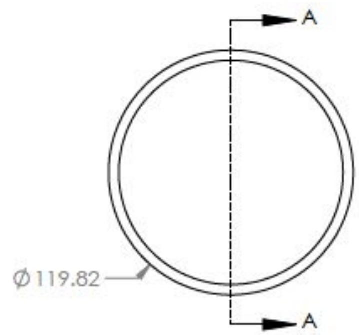
System Requirement Summary (2/3)

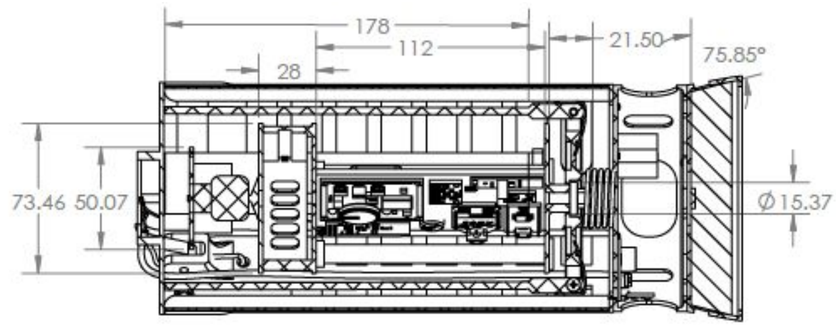
Mission Requirement No.	Requirements Description	Verification methods			
		A	I	T	D
11	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	+		+	+
12	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.		+	+	
13	XBEE radios shall have their NETID/PANID set to their team number.			+	+
14	XBEE radios shall not use broadcast mode.		+	+	+
15	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	+			+
16	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	+	+		
17	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	+	+		
18	Both the container and probe shall be labelled with team contact information including email address.	+			+
19	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	+	+	+	+

System Requirement Summary (3/3)

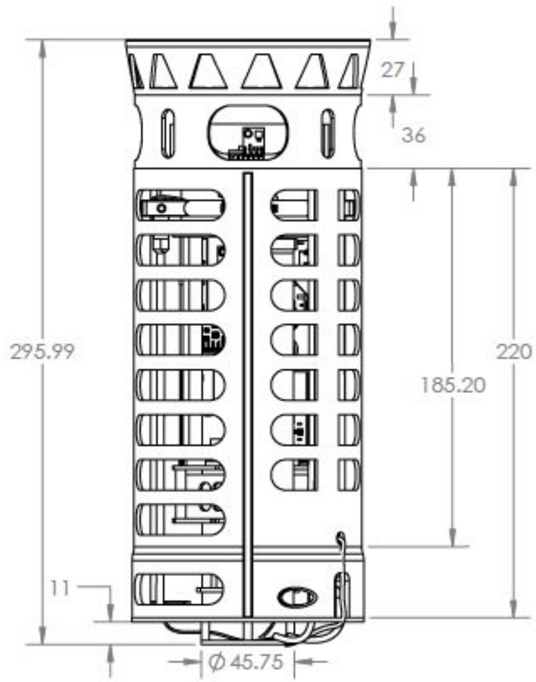
Mission Requirement No.	Requirements Description	Verification methods			
		A	I	T	D
20	No lasers allowed.	+			
21	The probe must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration.		+	+	
22	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the CanSat and in the stowed state.		+	+	
23	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	+		+	+
24	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.			+	+
25	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells	+		+	+
26	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.	+		+	
27	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.		+		
28	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	+		+	+
29	The GPS receiver must use the NMEA 0183 GGA message format.			+	+

Payload Physical Layout (1/5)





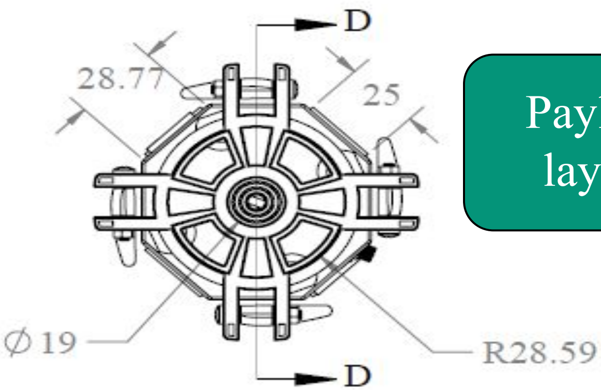
SECTION A-A
SCALE 1 : 2.5

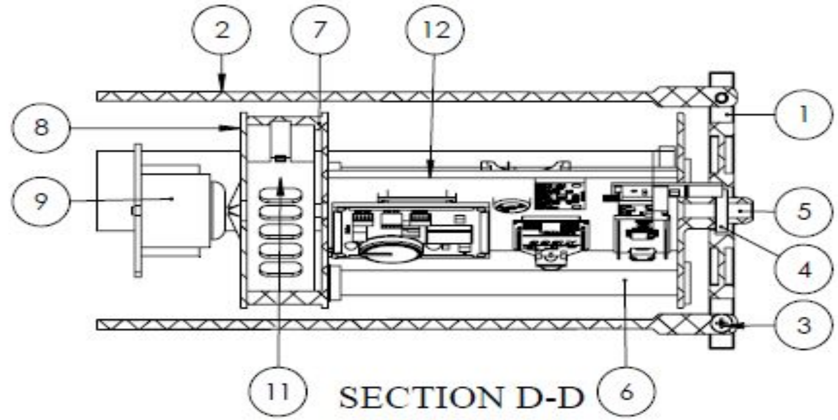


Complete CANSAT layout

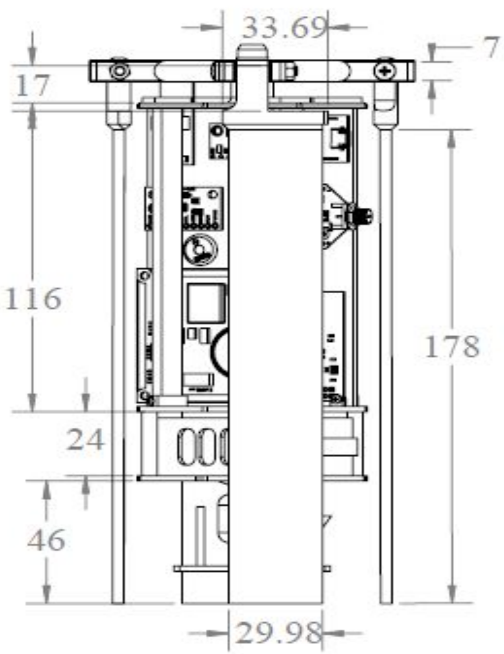
Payload Physical Layout (2/5)

Payload layout





SECTION D-D
SCALE 1 : 2



ITEM NO.	PART NUMBER	QTY.
1	Blade mount	1
2	clark z 2	4
3	B18.6.7M - M3.5 x 0.6 x 25 Type I Cross Recessed PHMS --25S	4
4	AFBMA 12.2 - 0.3750 - 0.6250 - 0.1562 - 16,SI,NC,16	1
5	PAyload top	1
6	Payload support	4
7	PayloadPCB base	1
9	camera stablisation	1
10	B18.2.4.1M - Hex nut, Style 1, M3.5 x 0.6 --D-N	4
11	Battery holder 18650 & battery	1
12	electronics^payload assembly	1
13	IS 7483 - M1.6 x 4 - Z -- 4N	27

Payload Physical Layout (3/5)

Parachute Deployment at launch

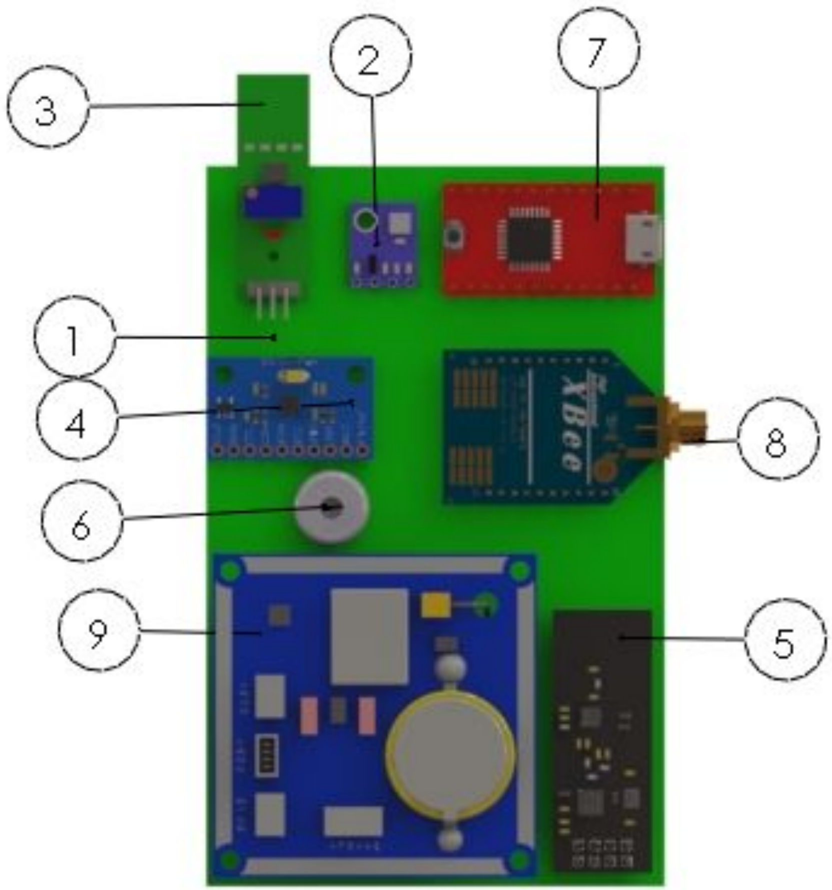
Payload Release and autogyro deployment

Stowed configuration

Transition from Stowed to Deployed

Payload Physical Layout (4/5)

SECTION – A(Payload)

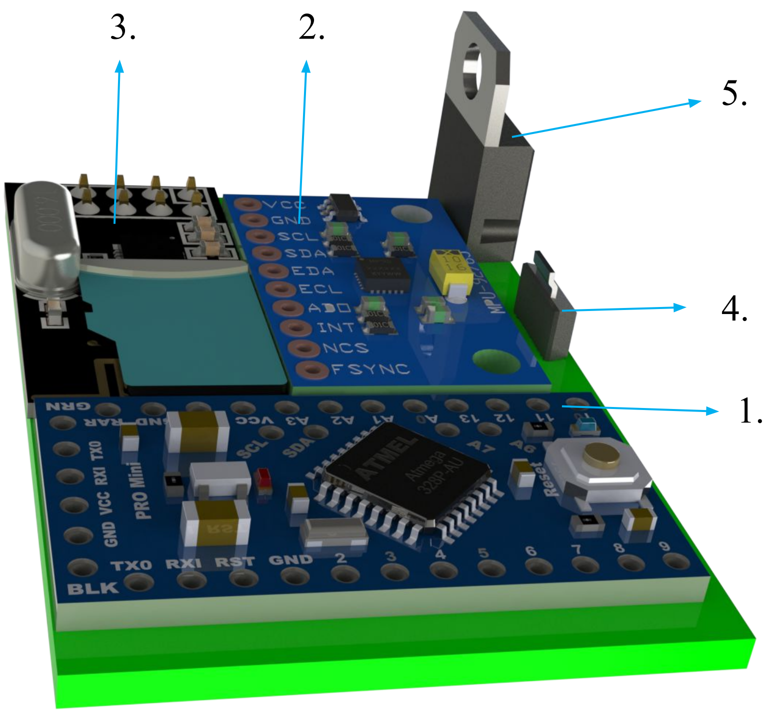


ITEM NO.	PART	QTY.
1	PCB	1
2	Bmp280	1
3	Hall Effect Sensor	1
4	MPU 9250	1
5	Piezo Buzzer	1
6	SAM D21 Breakout	1
7	SD_CARD Shield	1
8	Ublox GPS Module V2.0 NEO-6M v01	1
9	XBEE Pro	1
10	NRF24L01L+Antenna	1

Payload Physical Layout (5/5)

SECTION – B (Camera Stabilization)

Camera Section PCB 1



S.No.	Part	Quantity
1	Arduino Pro Mini	1
2	MPU9250	1
3	NRF24L01	1
4	LM1117 LDO	1
5	LM7805 LDO	1

Payload is divided into 2 sections, Section A: Telemetry Section and Section B: Camera Stabilization Section

System Concept of Operations (1/4)

Pre-Launch

- All mechanical parts are checked
- All circuits are checked
- Functioning of sensors and telemetry is checked
- CanSat body is checked for protrusions or damages

Launch

- CanSat electronics is switched ON
- CanSat is placed safely in the rocket payload section.
- A final system check is done

Rocket Separation+ Parachute Deployment

- The CanSat starts sending telemetry data
- The FSW is active and logging data
- At apogee, the rocket separates violently and parachute is deployed.

Payload Release

- At 450 m, payload is released using nichrome heating setup
- The payload orients itself downwards leading to stable equilibrium

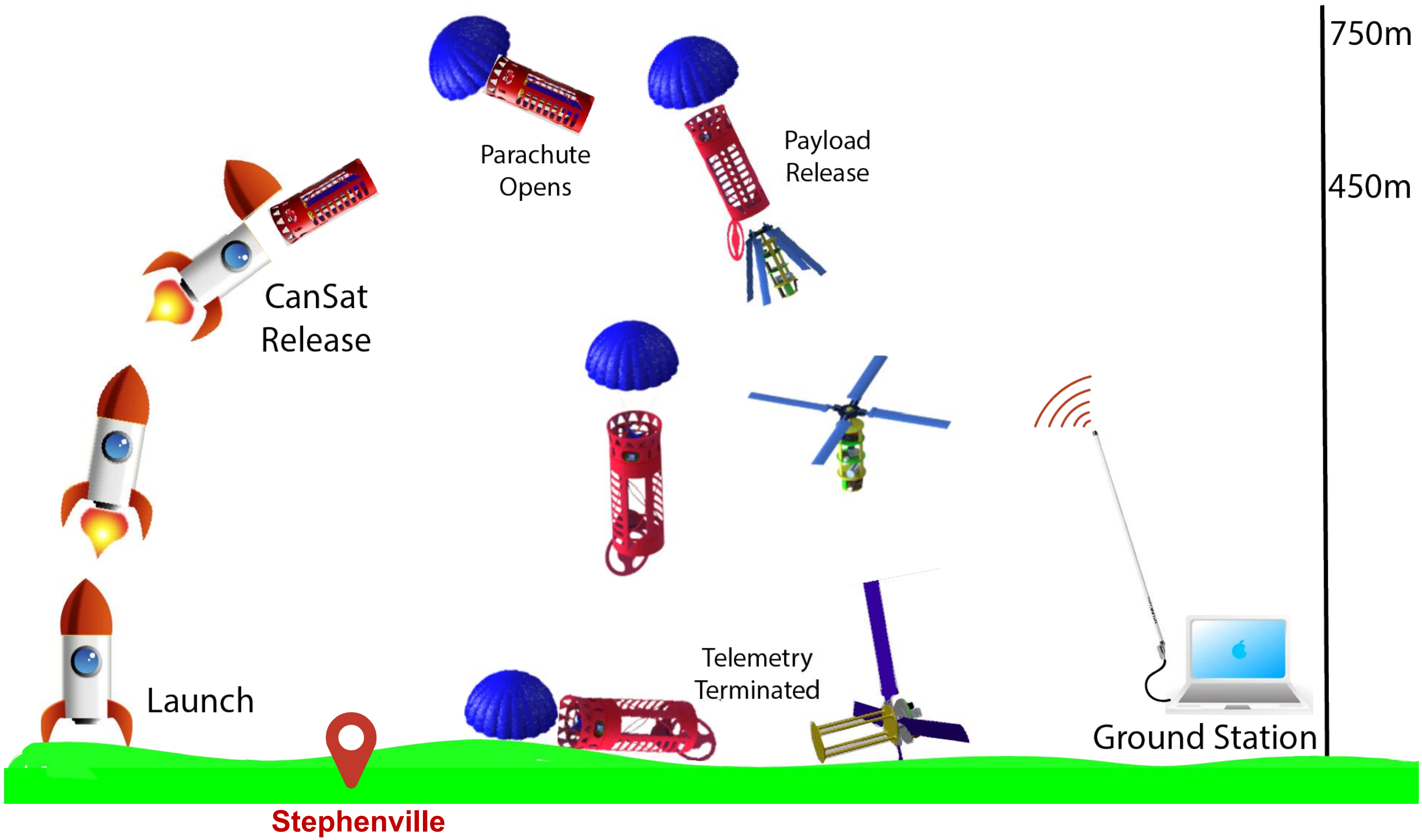
System Concept of Operations (2/4)

Payload Descent with Auto-Gyro	Container Descent with Parachute	Landing	Recovery + PFR
• Auto-Gyro and camera are operational. • The payload sends telemetry data for descent • Velocity tending to terminal is obtained between 10 – 15 m/s.	• Container descends with parachute • The velocity tending to terminal is obtained between 5 – 10 m/s.	• The payload telemetry is stopped and the audio beacons on both container and payload are activated to aid in recovery at < 5m.	• The container and payload are located and the data card is retrieved from the camera • The data is saved in the desired format at the GCS • The PFR is prepared and presented

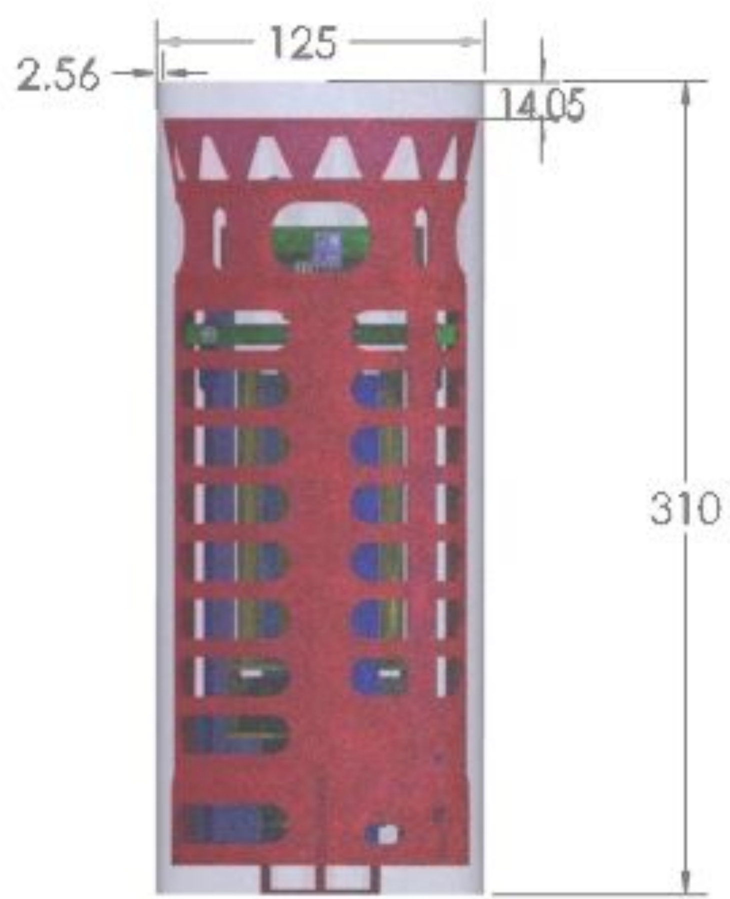
System Concept of Operations (3/4)

Role	Responsibility	Role Assignment
Mission Control Officer	❖ Bears the responsibility of managing team members. ❖ Executing launch procedures and initiating launch sequence.	Sourav Bhattacharjee
Ground Station Crew	❖ Maintaining telemetry connection and performing descent operations. ❖ Analyzing the data after final flight.	Advait Paithankar Raunit Singh Divya Tiwari
Recovery Crew	❖ Responsible for locating container and payload and recovering it.	Riyanshu Motalaya Snigdha Singh Kshitij Shekhar
CanSat Crew	❖ Responsible for CanSat assembly ❖ and integration ❖ Putting CanSat into rocket duringlaunch sequence initiation	Bhavya Arya Shikhar Makhija Shaonak Dayal

System Concept of Operations (4/4)



Launch Vehicle Compatibility



* All dimensions are in mm.

	Height (mm)	Width (mm)
Cylindrical Envelope	310	125
CanSat (Payload + Container)	295.64	118.46
Tolerance	14.05	5.12

- ❖ CanSat and payload will be tested by performing rocket testing.
- ❖ Height clearance to accommodate parachute at the top which requires a packing of 25 mm. (Total height of parachute module = 27 mm)
- ❖ No sharp protrusions.
- ❖ Fit Test has been done.
- ❖ Chamfers have been provided to smoothen out all edges and ensure that no harm will be done to the vegetation under any circumstances

Sensor Subsystem Design

Divya Tiwari

Sensor Subsystem Overview

S.No.	Sensor Name	Purpose	Sensor Utilized	Quantity	Description
1	Pitch and Roll Sensor	To measure pitch and roll of the CanSat.	**MPU-9250**	x2	Returned values include: accelerometer and gyroscope readings in x, y and z axis. Second one is used for camera stabilisation setup.
2	Air Pressure Sensor	To measure air pressure, and Altitude of Cansat	**BMP - 280**	x2 (Science Payload + Container)	Calculation of altitude using the relationship between pressure and altitude. While pressure and temperature served as raw data by sensor.
3	Temperature Sensor	To measure temperature	**BMP - 280**	x1 (Science Payload)	Calculation of external temperature.
4	GPS Sensor	To obtain GPS data.	**U-blox NEO-6M**	x1 (Science Payload)	Returned values include: Time, latitude, longitude, altitude and number of satellites
5	Auto-Gyro Blade Spin Rate Sensor	To obtain blade spin rate	**Hall Sensor AH44E**	x1 (Science Payload)	Calculation of spin rate by summation of gauss entries above threshold.
6	Voltage Sensor (ADC + Voltage Divider)	To measure battery voltage	**Resistor Network + 12 bit ADC**	N.D. (Science Payload)	To obtain the current system battery voltage.
7	Camera Sensor	Video recording	**Piquancy Ultra HD Camera**	x1 (Science Payload)	Bonus requirement: To video record the flight recording.

Sensor Changes Since PDR

No changes were made to the Sensor Subsystem

Sensor Subsystem Requirements (1/2)

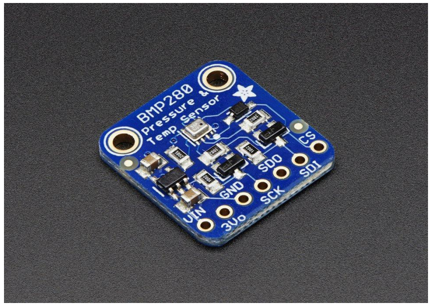
ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
SS – 1	Mass of the cansat shall be 500+/- 10g	Base Requirement	BR – 1		High	+	+	+	
SS – 2	The science payload shall measure altitude using an air pressure sensor.	Base Requirement	BR – 20		High	+		+	+
SS – 3	The science payload shall provide position using GPS.	Base Requirement	BR – 21		High	+		+	+
SS – 4	The science payload shall measure outside temperature.	Base Requirement	BR – 23		High	+		+	+
SS – 5	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Base Requirement	BR – 24	PCDH-02	High	+		+	+

Sensor Subsystem Requirements (2/2)

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
SS – 5	The science payload shall measure pitch and roll	Base Requirement	BR – 25		High	+		+	+
SS – 6	A video camera shall be integrated into the payload with resolution 640 x 480 pixels and 30 fps to record the descent of the payload	Bonus	BONUS		Medium	+	+	+	+
SS – 7	The payload shall measure battery voltage using voltage divider.	Technical Constraint	Subpart BR – 22		High	+	+	+	
SS – 8	All the sensor data shall be transmitted through telemetry to ground station.	Base Requirement	BR – 26	PCDH-02	High		+	+	

Payload Air Pressure Sensor Summary (1/2)

Model Number	Interface	Pressure range (hPa)	Size (mm^3)	Weight (gm)	Resolution (hPa)	Accuracy (hPa)	Supply Voltage (V)	Price ($)
BMP 280	**I2C**	**300-1100**	**19 x 18 x 3**	**1.3**	**0.16**	**土 1**	**1.71 - 3.6**	**3.5**



BMP - 280

BMP 280 fundamental properties:

1. Works at 3.3V, optimal for the design framework.
2. Built in IIR filter minimizes short term disturbances in the output data.
3.High Resolution and low weight, at low cost.

$$p = p_0 * \left(1 - \frac{altitude}{44330}\right)^{5.255}$$

Where:
P = Measured Pressure(hPa)
Po = Pressure at sea level (hPa)

Data processing:
1. BMP280 transmits digital data via I2C protocol.
2. The sensor returns data as an unsigned 32 bit integer in raw form.
3. The pressure measurement resolution is : 0.0016hPa and Altitude measurement resolution is: 0.0133m

Payload Air Pressure Sensor Summary(2/2)

COM4 (SparkFun SAMD21 Dev Breakout)

```
Temperature = 32.34 *C
Pressure = 98761.23 Pa
Approx altitude = 215.67 m

Temperature = 32.33 *C
Pressure = 98768.22 Pa
Approx altitude = 215.08 m

Temperature = 32.32 *C
Pressure = 98764.83 Pa
Approx altitude = 215.37 m

Temperature = 32.30 *C
Pressure = 98768.44 Pa
Approx altitude = 215.06 m

Temperature = 32.32 *C
Pressure = 98764.83 Pa
Approx altitude = 215.37 m

Temperature = 32.33 *C
Pressure = 98767.02 Pa
Approx altitude = 215.18 m

Temperature = 32.33 *C
Pressure = 98772.33 Pa
Approx altitude = 214.73 m

Temperature = 32.35 *C
Pressure = 98771.05 Pa
Approx altitude = 214.84 m

Temperature = 32.35 *C
```

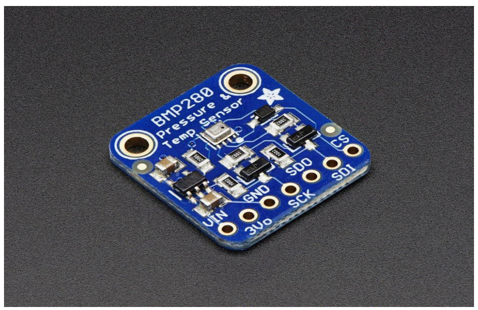
Autoscroll

```
float Adafruit_BMP280::readAltitude(float seaLevelhPa) {
  float altitude;

  float pressure = readPressure(); // in Si units for Pascal
  pressure /= 100;

  altitude = 44330 * (1.0 - pow(pressure / seaLevelhPa, 0.1903));

  return altitude;
}
```

Data Format:
1. Pressure transmitted in the Telemetry packet will be in Pascals.
2. Altitude readings are in meters and will be floating point numbers.

Payload Air Temperature Sensor Summary(1/2)

Model Number	Interface	Range (°C)	Size (mm²)	Weight (g)	Resolution (°C)	Accuracy (°C)	Supply Voltage (V)	Price ($)
BMP 280	**I2C**	**(- 40) – (+ 85)**	**19 x 18**	**1.3**	**0.01**	**土 1**	**1.71 - 3.6**	**3.5**



BMP - 280

BMP 280 fundamental properties::
1.Optimal operation voltage to framework.
2. The very low offset temperature coefficient results in a low temperature drift making it highly precise.

Data Processing:

1. Interfacing of sensor is done with I2C protocol with SAMD21
2. Resolution of 0.01 °C
3. 32 bit sensor data is acquired.

Temperature Calibration:

Calibration of the sensor is done by comparing the data measured by the sensor and the known ground temperature.

Formula used:

$$T = \frac{p}{R * \rho}$$

T : Temperature(°K)
p : air Pressure(Pa)
ρ : Density of dry air(kg/m³)
R : Specific gas constant dry air, 287.05(J/Kg.K)

$$T_K - 273.15 = T_{\circ C}$$

where:

$T_K = Temprature\ in\ Kelvin$
$T_{\circ C} = Temprature\ in\ degree\ Celcius$

Team B.A.G.S.
Ballistic Auto-Gyro Satellite

Payload Air Temperature Sensor Summary (2/2)

COM4 (SparkFun SAMD21 Dev Breakout)

```
Temperature = 32.34 *C
Pressure = 98761.23 Pa
Approx altitude = 215.67 m

Temperature = 32.33 *C
Pressure = 98768.22 Pa
Approx altitude = 215.08 m

Temperature = 32.32 *C
Pressure = 98764.83 Pa
Approx altitude = 215.37 m

Temperature = 32.30 *C
Pressure = 98768.44 Pa
Approx altitude = 215.06 m

Temperature = 32.32 *C
Pressure = 98764.83 Pa
Approx altitude = 215.37 m

Temperature = 32.33 *C
Pressure = 98767.02 Pa
Approx altitude = 215.18 m

Temperature = 32.33 *C
Pressure = 98772.33 Pa
Approx altitude = 214.73 m

Temperature = 32.35 *C
Pressure = 98771.05 Pa
Approx altitude = 214.84 m

Temperature = 32.35 *C
```

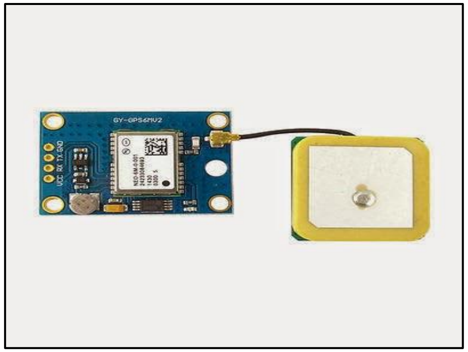
Autoscroll

```
float Adafruit_BMP280::readTemperature(void)
{
  int32_t var1, var2;

  int32_t adc_T = read24(BMP280_REGISTER_TEMPDATA);
  adc_T >>= 4;

  var1  = ((((adc_T>>3) - ((int32_t)_bmp280_calib.dig_T1 <<1))) *
     ((int32_t)_bmp280_calib.dig_T2)) >> 11;

  var2  = (((((adc_T>>4) - ((int32_t)_bmp280_calib.dig_T1)) *
       ((adc_T>>4) - ((int32_t)_bmp280_calib.dig_T1))) >> 12) *
     ((int32_t)_bmp280_calib.dig_T3)) >> 14;

  t_fine = var1 + var2;

  float T  = (t_fine * 5 + 128) >> 8;
  return T/100;
}
```

Data Format:
1. Temperature transmitted in the packet will be in °C .
2. The data will be of floating point type.

GPS Sensor Summary (1/2)

Model	Interface	Size(mm^3)	Weight(g)	Accuracy (m)	Power Ratings	Other	Cost($)
U-Blox Neo-6M*	**UART**	**22 x 30 x 4**	**12**	**2.5**	**47mA – 3.3v**	**Cold Start: 27s** **Hot Start: 1s**	**11.09**



U-Blox Neo-6M

Selected GPS Sensor: U-blox NEO-6M

1. Separate antenna relaxes PCB design and is ideal for physically small systems.

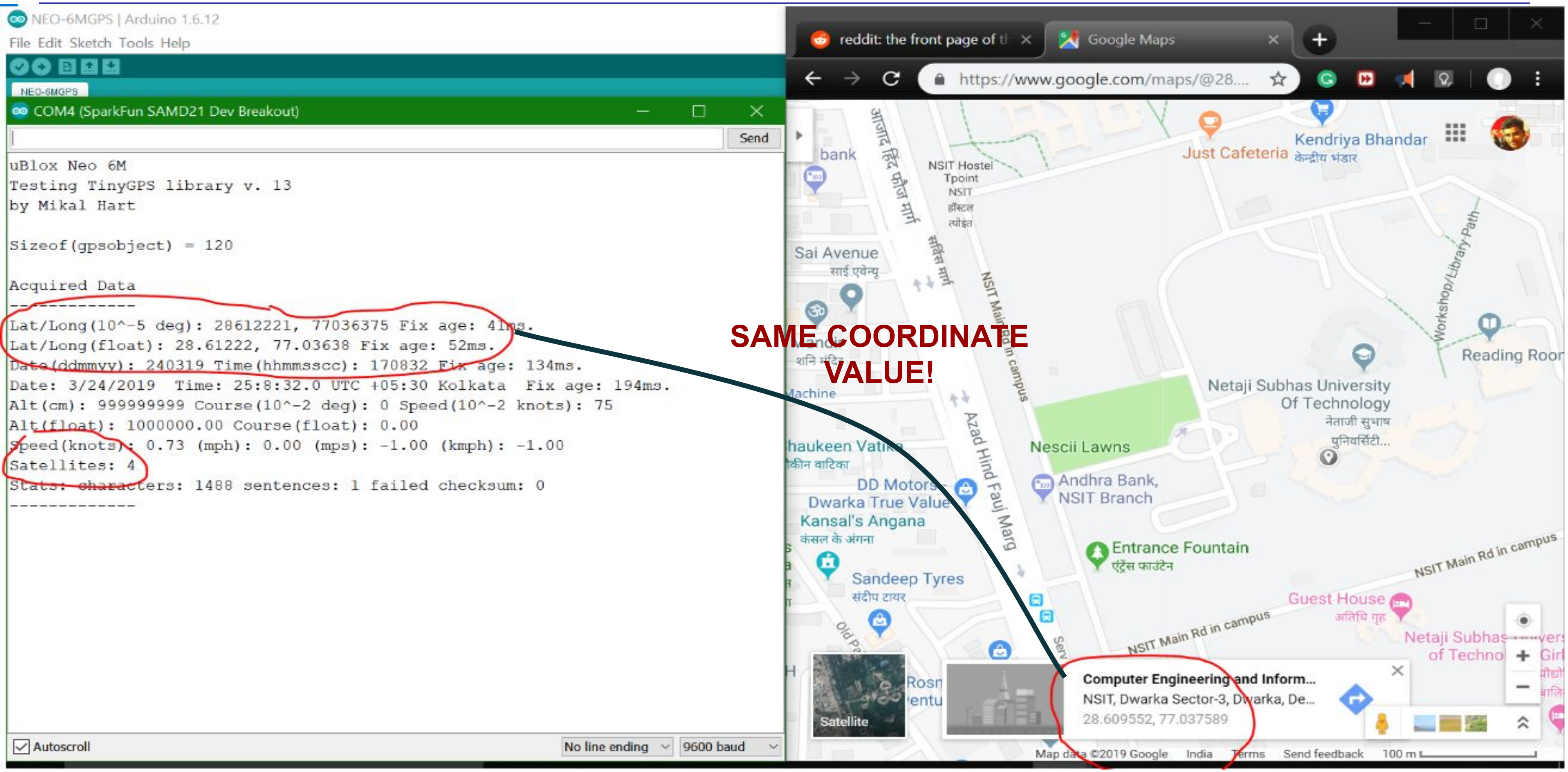
Data Processing:

1. Hot start time of 1s
2. Cold start time of 27s
3. Data is received using UART protocol
4. 50 channels for wireless data transmission
5. 5Hz data update rate, which suits the 1Hz required for packet transmission.
6. Uses the NMEA 0183 GGA message format.

Data Format

1. GPS latitude and longitude is in degrees. GPS altitude is in meters.
2. GPS data will be a float type value.
3. GPS sensor will receive data in NMEA 0183 GGA format.

GPS Sensor Summary (2/2)



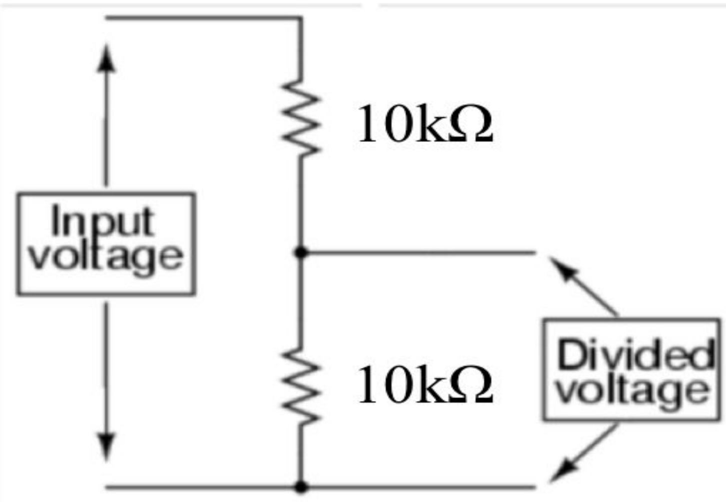
The above screenshot shows the serial data from the Ublox Neo 6m and on the right side we verify our location with the help of google maps by feeding out measured coordinates in the search bar. The values can be cross checked from the bottom right. Also, the number of satellites detected by the sensor is 4.

Payload Voltage Sensor Summary

Sensor	Interface	Resolution (mV)	Weight (g)	Size (mm^2)	Cost ($)
Voltage divider circuit	**ADC port**	**1.61**	**Negligible**	**2 x Resistor Size**	**1**

Data Processing:

1. Analog resistor network interfaced with microcontroller.
2. Utilises internal ADC of SAMD, which offers resolution of 12 bits.
3. Easier implementation.



$$V_{divided\ voltage} = \frac{R_2}{R_1 + R_2} V_{Input\ Voltage}$$

R_1 & R_2 are chosen such that $V_{obs} \leq 3.3V$

Numerical values of resistances is:

$R_2 = 10k\Omega$

$R_1 = 10k\Omega$

The accuracy offered by SAMD21's adc is : 0.001611V

Data Format:

1. Battery voltage is transmitted in volts(V).
2. The data is a float value

Pitch/Roll Sensor Summary (1/2)

Model Number	Interface	Acceleration Range (g)	Size (mm2)	Weight(g)	Resolution (uT)	Accuracy	Operating Voltage (V)	Price ($)
MPU-9250	**I2C**	**±16**	**17x10**	**1.5**	**0.292968/ 14bit**	**+/- 5 °/sec**	**2.4–3.6**	**2.83**

MPU-9250

Data Format:

1. Pitch and roll values shall be transmitted in degrees.
2. The data is a floating type number.

Reasons for selection of **MPU 9250**:
1. DMP (Digital Motion Processor): Clubs accelerometer and gyroscope data to minimize error inherit in each.

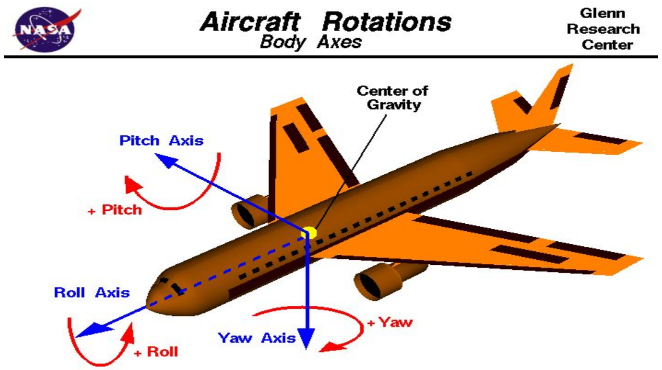
Data Processing:

1. MPU 9250 uses I2C protocol to transmit digital data.
2. On board accelerometer gives full scale range of: ±2g,±4g,±8g,±16g
3. The integrated ADC has a resolution of 16 bits.
4. On board gyroscope gives digital outputs of angular rate of change of roll, pitch and yaw. The scale range is: ±250, ±500, ±1000 and ±2000 °/sec.

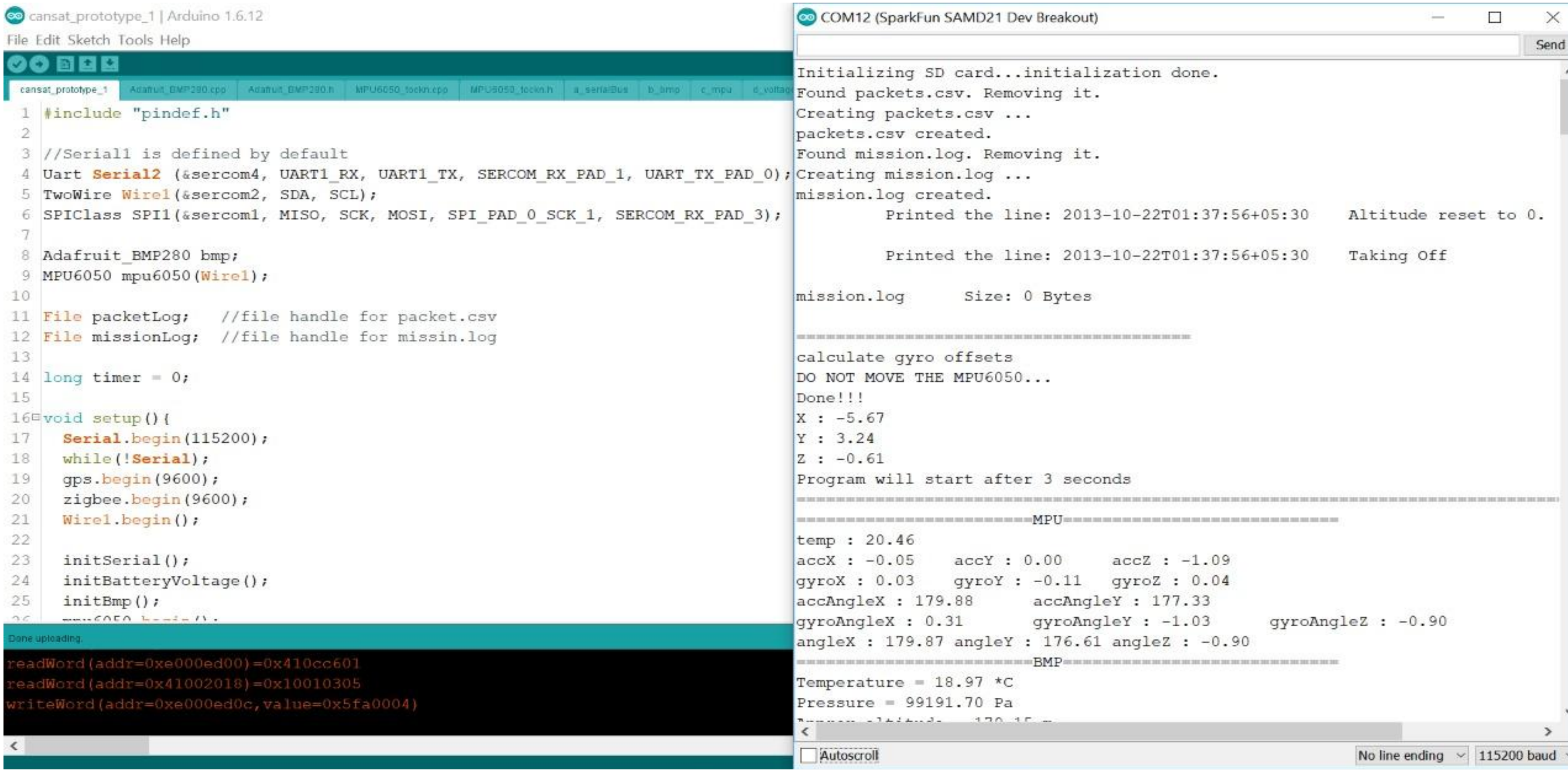
$$rollangle = arctan - \frac{G_x}{G_z}$$

$$pitchangle = arctan - \frac{G_y}{\sqrt{G_x^2 + G_z^2}}$$

$$\begin{aligned} where\ G_x &= acclaration\ in\ x\ direction \\ G_y &= acclaration\ in\ y\ direction \\ G_z &= acclaration\ in\ z\ direction \end{aligned}$$



Pitch/Roll Sensor Summary (2/2)



The pitch (about X axis), roll (about Y axis) and yaw (about Z axis) is calculated using MPU9250's library and Madgwick AHRS algorithm(filter) which uses sensor fusion technique to give accurate sensor readings.

Auto-gyro Blade Spin Rate Sensor Summary (1/2)

Model	Methodology	Size (mm2)	Interface	Resolution (rpm)	Weight(g)	Cost($)
AH44E	**Hall Sensor IC**	**3.10 x 4.17**	**Digital**	**1 rpm**	**<1**	**1.54**

AH44E

Data Format:

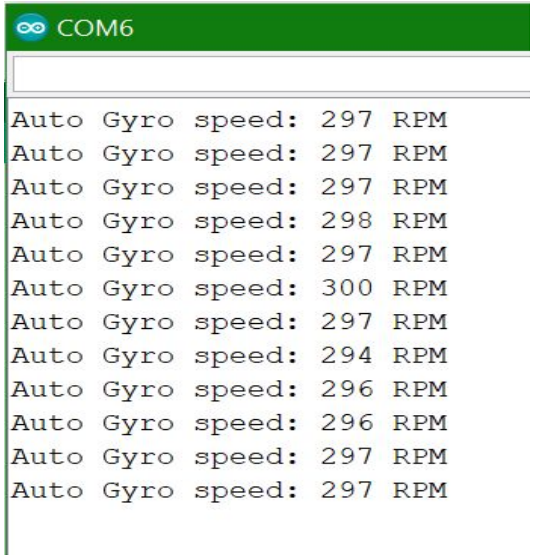
1. Blade spin rate is transmitted in rps.
2. Data is an integer value

AH44E's Notable Properties:

1. Low Noise Output, thus virtually eliminates the need for filtering.
2. Extremely fast response time (200ns).

Data Processing:

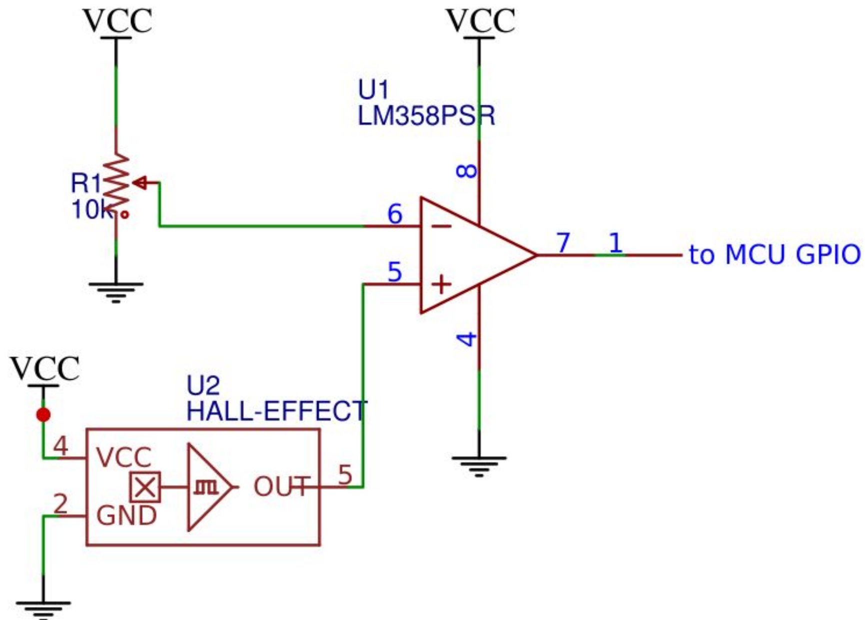
1. Hall effect sensor has been used to detect rapid changes in magnetic field.
2. Every time a field spike is present an interrupt is generated that increments the cycles counter.



Auto-gyro Blade Spin Rate Sensor Summary(2/2)

- ❖ A magnet is attached to each wing of the autogyro.
- ❖ The hall sensor is mounted just below the magnets.

Hall sensor being used to measure blade spin rate



Schematic of hall sensor as Auto Gyro Blade Spin Rate Sensor

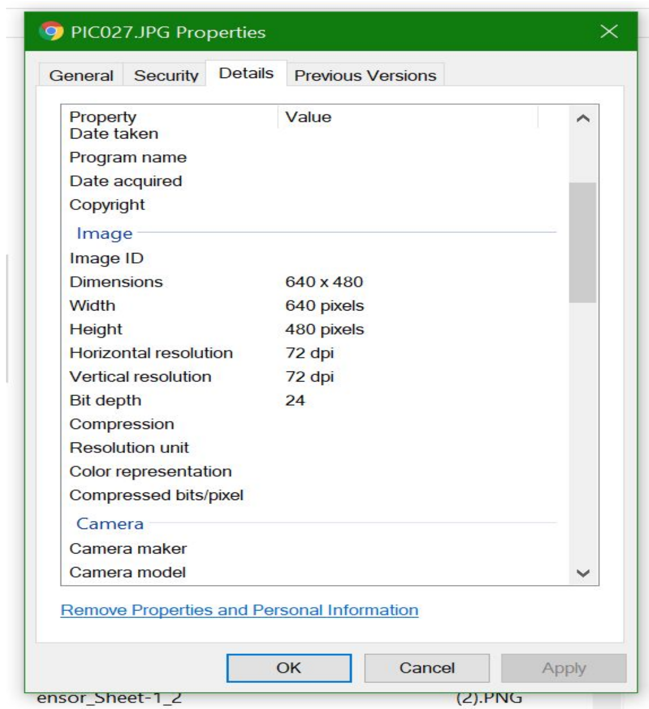
- ❖ The circuit generates an interrupt each time the magnet passes over the sensor.
- ❖ The MCU increments the counter each time an interrupt is detected and calculates RPM of the Auto Gyro.

Bonus Objective Camera Summary (1/2)

Name	Weight(g)	Power	Resolution	FPS	Interface	Supply Voltage (V)	Price($)
Piquancy Ultra HD Camera	**20**	**20 mA x 3.3 V**	**640 x 480**	**30**	**ND (Write)**	**3.3**	**11.21**

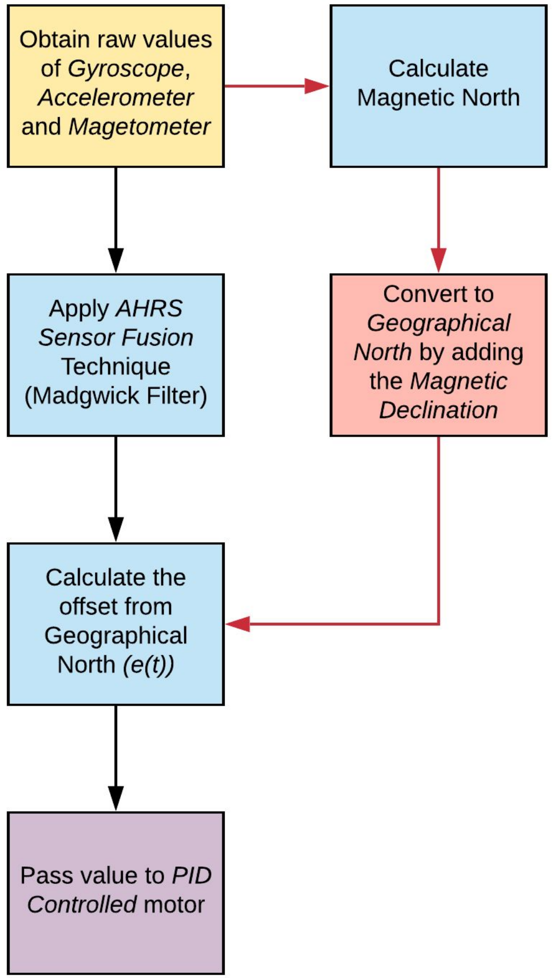
Piquancy Ultra HD Camera:
1. Light camera with high resolution
2. Resolution and megapixel values are suitable for the competition requirements
3. Picture data is stored in an onboard SD card.
4. Image is compressed into a JPG image by the camera hardware itself.

Piquancy Ultra HD Camera



The resolution of the image is 640 x 480 as required

Bonus Objective Camera Summary (2/2)



Single Time Evaluation

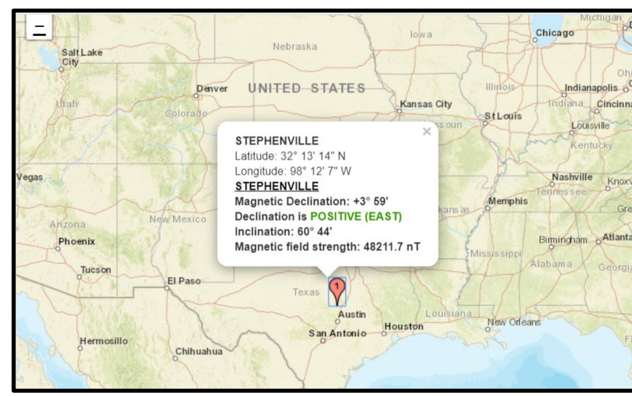
Camera Stabilisation Algorithm Flow

$$\emptyset_M = \tan^{-1}\frac{m_y}{m_x}$$

$$\emptyset_G = \emptyset_M + \delta_{Declination}$$

where:

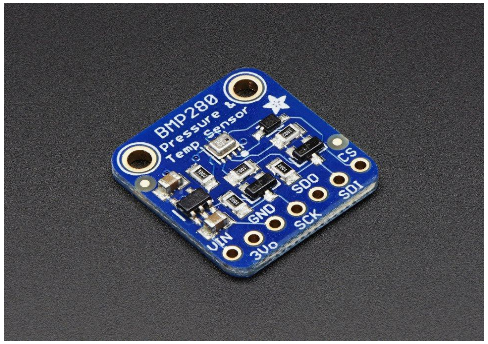
$\emptyset_m$: *location of magnetic north*
$\emptyset_g$: *location of geographical north*
m_y: *magnetometer raw value in y direction*
m_x: *magnetometer raw value in x direction*



Magnetic Declination value at Stephenville, Texas, USA will be used for calculating Geographical North.

Container Air Pressure Sensor Summary (1/2)

Model Number	Interface	Pressure range (hPa)	Size (mm^3)	Resolution (hpa)	Weight (g)	Accuracy (hPa)	Supply Voltage (V)	Price ($)
BMP 280	I2C	300-1100	19 x 18 x 3	0.0016	1.3	+/-0.12	1.71-3.6	3.5



BMP - 280

Selected Air Pressure Sensor, BMP280, as it offers:

1. The very low offset temperature coefficient results in a low temperature drift making it highly precise.
2. Built in IIR filter minimizes short term disturbances in the output data.
3. Multiple modes of operation make this sensor highly flexible for saving energy and providing precise measurements.

Data Format:
Pressure transmitted in the Telemetry packet will be in Pascals.

$$p = p_0 * \left(1 - \frac{altitude}{44330}\right)^{5.255}$$

Where:
P = Measured Pressure(hPa)
Po = Pressure at sea level (hPa)

Data processing:
1. BMP280 transmits digital data via I2C protocol.
2. The sensor returns data as an unsigned 32 bit integer in raw form.
3. The pressure measurement resolution is : 0.0016hPa and Altitude measurement resolution is: 0.0133m

Container Air Pressure Sensor Summary (2/2)

COM4 (SparkFun SAMD21 Dev Breakout)

```
Temperature = 32.34 *C
Pressure = 98761.23 Pa
Approx altitude = 215.67 m

Temperature = 32.33 *C
Pressure = 98768.22 Pa
Approx altitude = 215.08 m

Temperature = 32.32 *C
Pressure = 98764.83 Pa
Approx altitude = 215.37 m

Temperature = 32.30 *C
Pressure = 98768.44 Pa
Approx altitude = 215.06 m

Temperature = 32.32 *C
Pressure = 98764.83 Pa
Approx altitude = 215.37 m

Temperature = 32.33 *C
Pressure = 98767.02 Pa
Approx altitude = 215.18 m

Temperature = 32.33 *C
Pressure = 98772.33 Pa
Approx altitude = 214.73 m

Temperature = 32.35 *C
Pressure = 98771.05 Pa
Approx altitude = 214.84 m

Temperature = 32.35 *C
```

Autoscroll

```
float Adafruit_BMP280::readTemperature(void)
{
  int32_t var1, var2;

  int32_t adc_T = read24(BMP280_REGISTER_TEMPDATA);
  adc_T >>= 4;

  var1  = ((((adc_T>>3) - ((int32_t)_bmp280_calib.dig_T1 <<1))) *
     ((int32_t)_bmp280_calib.dig_T2)) >> 11;

  var2  = (((((adc_T>>4) - ((int32_t)_bmp280_calib.dig_T1)) *
       ((adc_T>>4) - ((int32_t)_bmp280_calib.dig_T1))) >> 12) *
     ((int32_t)_bmp280_calib.dig_T3)) >> 14;

  t_fine = var1 + var2;

  float T  = (t_fine * 5 + 128) >> 8;
  return T/100;
}
```

Data Format:

1. Pressure transmitted in the Telemetry packet will be in Pascals.
2. Altitude readings are in meters and will be floating point numbers.

Descent Control Design

Riyanshu Motalaya

Descent Control Overview (1/2)

Descent Control System

Descent control system consists of three phases:

Combined descent of Container and Payload 1

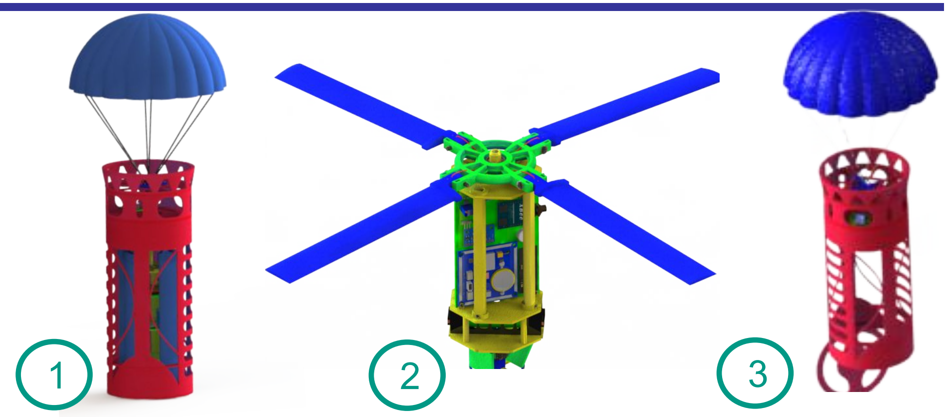
Post separation from the rocket payload and container descent together and it is controlled by the parachute. It should reach a terminal speed of 20 ± 5 m/s

Descent of Payload post separation 2

Post separation auto-gyro comes into action and the descent is controlled mainly by autorotation of the blades and it should achieve a terminal speed of 10-15 m/s

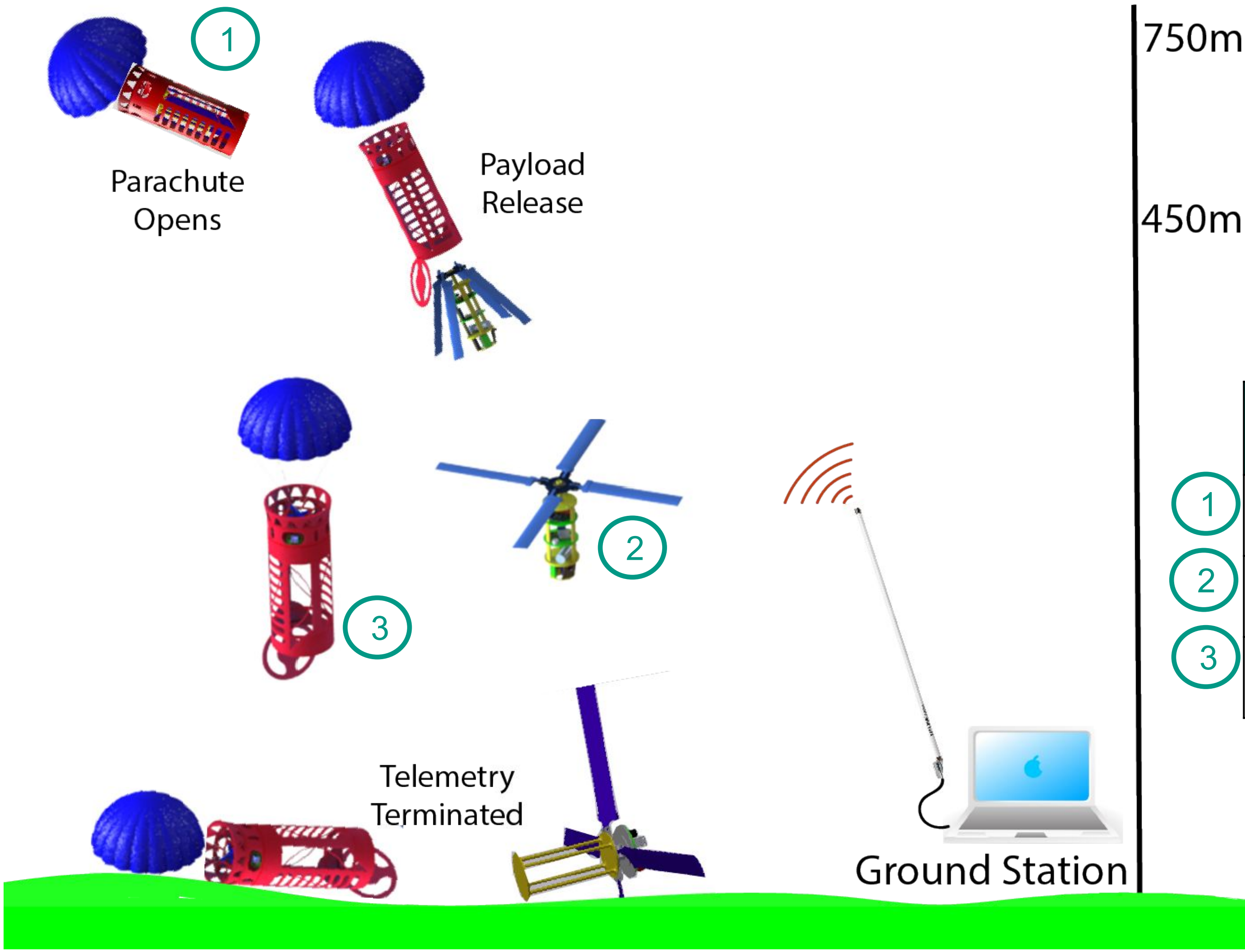
Descent of Container post separation 3

Parachute controls the descent of container post payload separation



Descent Components	Position
Parachute	Top of CanSat (when in nadir direction)
Parachute Tab	To connect O-ring with the parachute mount
O-ring	To connect all parachute shroud lines
Rotor Mount	On the top of payload, for the autogyro blade mounts.
Guides	Inside container to provide a smooth way for payload ejection without its rotation inside the container.
Angular bearing	Payload Top

Descent Control Overview (2/2)



Velocity (m/s)	Time of Flight (s)
16.75	22.08
13.29	32.12
9.76	46.77

Descent Control Changes Since PDR(1/2)

No Changes were made to the Descent Control Design

Descent Control Changes Since PDR(2/2)

PROTOTYPE TESTING

Test name	Procedure	Result
Wind tunnel test	The payload is placed in the wind tunnel and wind is blown at different rates and the values of lift and drag for each speed is obtained.	Blades were running smoothly and provided an axial force of 2.5N at 13m/s
Drone drop test* **A) Payload descent rate**	A. Container is attached to the drone and lid is opened via a signal from ground station and payload descends using autogyro mechanism.	A. Payload's terminal velocity was 14.1m/s. This difference in calculations was due to frictional losses.
B) Container descent rate	B. The cansat is attached to the drone via hook-servo mechanism and released and it descends with the help of parachute (payload is kept inside it)	B. Container's terminal velocity was 16m/s which lies within the range of error of calculations

***Due to Indian government drone restrictions, maximum height for drone could only be 500m, hence tests were carried out in two stages. Our sponsors "DN Aerospace" provided us with drone testing.**

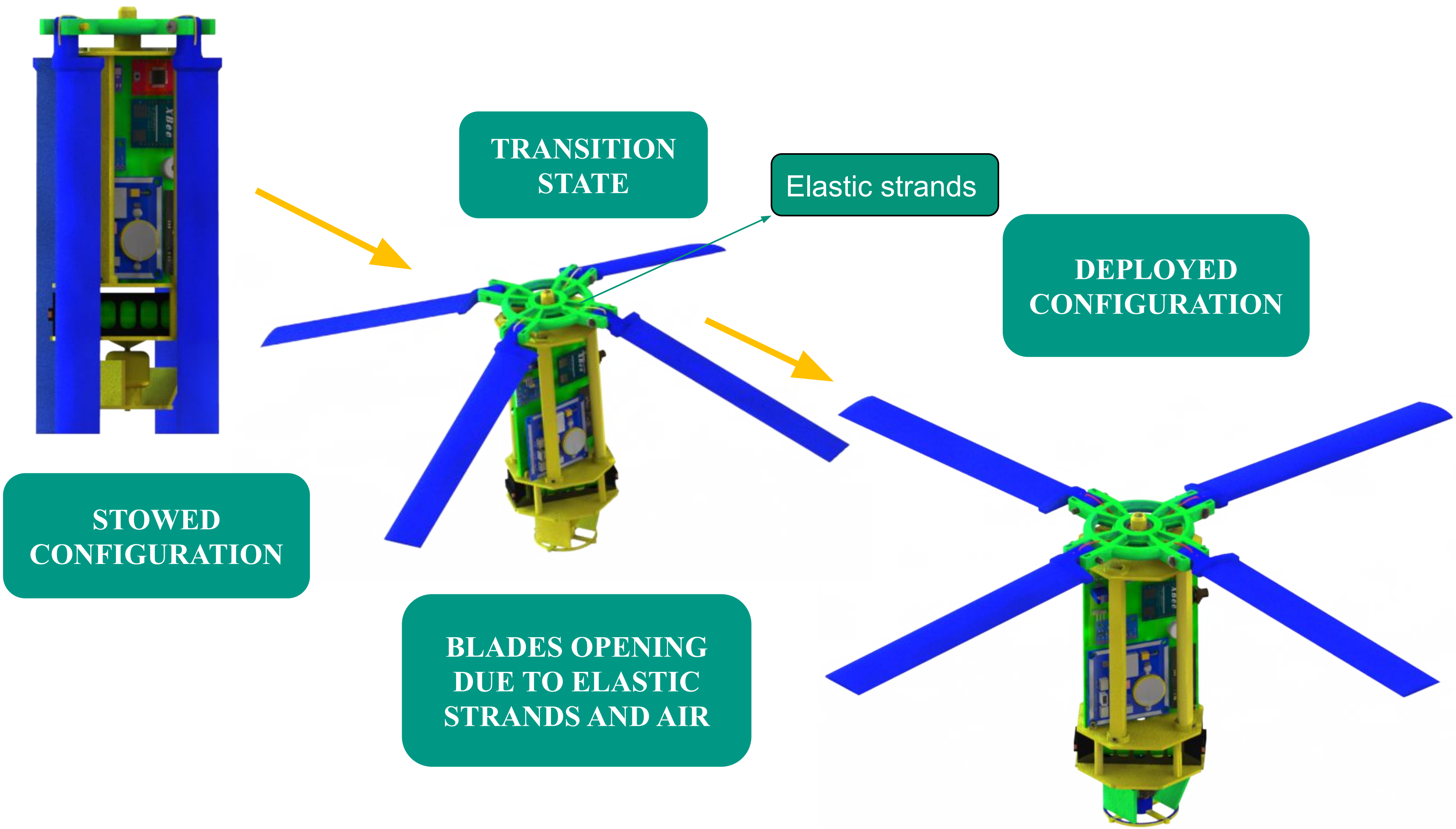
Descent Control Requirements (1/2)

ID	Requirement	Rationale	Parent	Child	Priority	VM			
						A	D	I	T
DCR- 1	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Base Requirement	BR-7		High	+	+		
DCR- 2	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Base Requirement	BR-8		High	+			+
DCR- 3	The container shall release the payload at 450 meters +/- 10 meters.	Base Requirement	BR-9	MSR-6	High	+			
DCR- 4	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Base Requirement	BR-10	MSR- 7	High	+	+		+
DCR- 5	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Base Requirement	BR-11		High	+			+
DCR-6	All descent control device attachment components shall survive 30 Gs of shock.	Base Requirement	BR-12		High			+	+

Descent Control Requirements (2/2)

ID	Requirement	Rationale	Parent	Child	Priority	VM			
						A	D	I	T
DCR- 7	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Base Requirement		MSR-13	High	+	+		+
DCR-8	The Parachute shall be fluorescent Pink or Orange	Base Requirement	BR-27		High	+			
DCR-9	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	Base Requirement	BR-19		High	+		+	+
DCR-10	Mechanisms shall not use pyrotechnics or chemicals.	Base Requirement	BR-18		High	+	+	+	+
DCR-11	All mechanisms shall be capable of maintaining their configuration or states	Base Requirement	BR-17		High	+		+	

Payload Descent Control Hardware Summary (1/4)

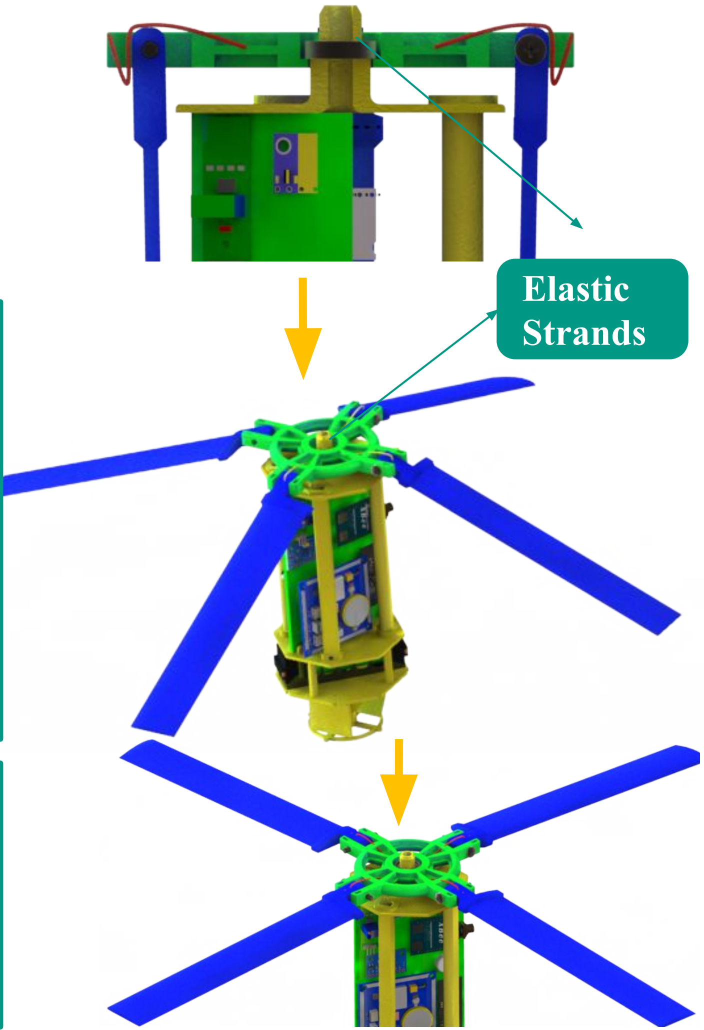


Payload Descent Control Hardware Summary (2/4)

PAYLOAD DEPLOYMENT USING ELASTIC STRANDS

Requirements for Passive Deployment:
- Quick deployment
- Reliable
- Cost effective
- Light weight

Elastic strands mechanism working:
Blades are initially kept in stowed position with the help of ribs from the container. As soon as the payload comes out of the container, elastic strands pull the blades open. This action is further supported by force from air. Maximum opening angle is limited to 90 degrees by the rotor surface



Benefits of using this mechanism:
- 1. Self-sustainable action
- 2. Reliability of mechanism
- 3. Light-weight and cost-effective

Payload Descent Control Hardware Summary (3/4)

PAYLOAD PASSIVE COMPONENTS

Component Name	Description	Key design considerations	Dimensions	Colour
Blades	Clark Z airfoil with constant angle of attack and chord length	Blades should provide the calculated amount of axial forces to achieve terminal velocity of the system	Chord length: 30mm Inclination angle: 2deg Blade length: 180mm	**Orange**
Nut - Bolts	Forms the pin between rotor and blade hinge Pan head, Philips nut bolts are used	They should have high resistance to shear and ease of operate along with cost- effectiveness.	M 3.5 Shank length: 25mm	**Steel grey**
Bearing	Angular contact bearing is snugly fitted between rotor and payload top	It should reduce the friction between the parts and also take up radial as well as axial loads	Outer Diameter: 19mm Inner Diameter.: 9mm Thickness: 6mm	**Steel grey**
Rotor	This forms the centerpiece for the blades to be mount and also for elastic strands	It should form a support structure for mounting and providing sufficient torsion and shear strength	Diameter: 33mm Thickness: 8mm Protrusions: 20mm	**Orange**
Elastic strands	These are used to deploy the blades	Heat resistant strands with a good fatigue strength	Length: 50mm Cross section: $2x2mm^2$	**Red**

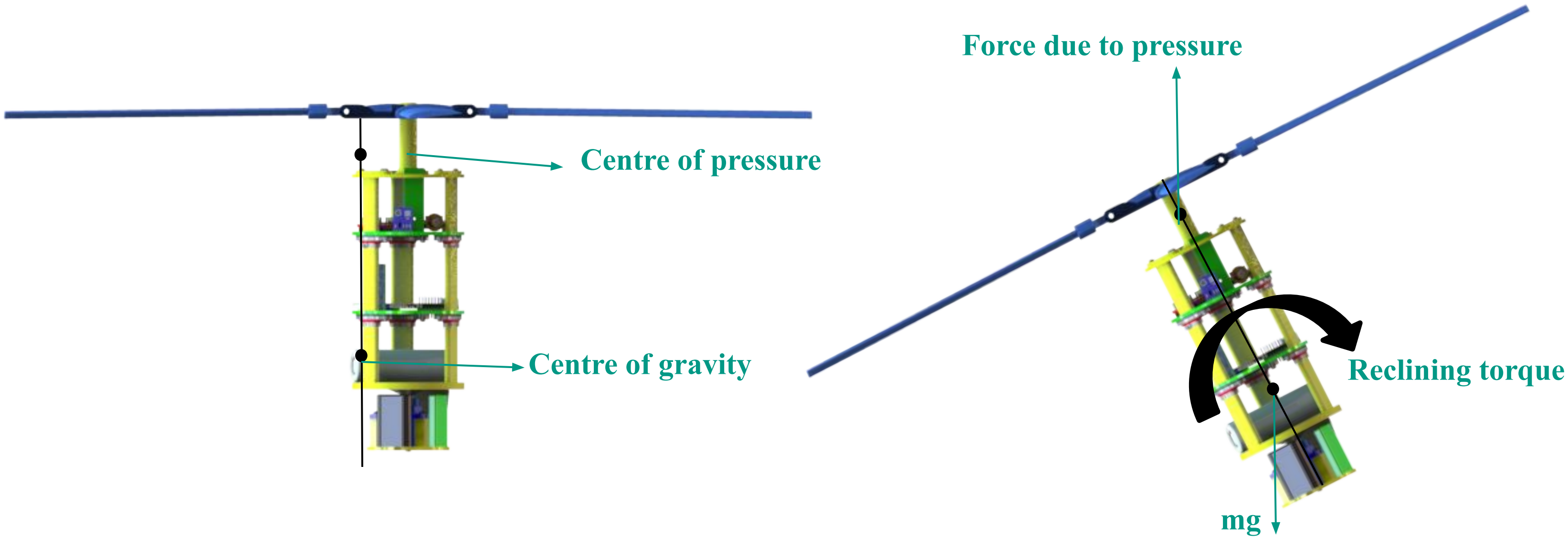
Payload Descent Control Hardware Summary (4/4)

PAYLOAD ACTIVE COMPONENTS

Components	Accuracy	Data format	Data processing
Hall effect sensor	1/(minimum time between two succesive interrupts)	❖ Blade spin rate is transmitted in rps. ❖ Data is an integer value	❖ It detects rapid changes in magnetic field. Every time a field spike is present an interrupt is generated that increments the cycles counter.
BMP280	土 **1** hPa	❖ Temperature transmitted in the packet will be in **ºC** ❖ The data will be of floating point type.	❖ The sensor returns data as an unsigned 32 bit integer in raw form via I2C protocol ❖ The pressure measurement resolution is : 0.0016hPa and Altitude measurement resolution is: 0.0133m
Pitch and Roll Sensor	**+/- 5 °/sec**	❖ Pitch and roll values shall be transmitted in degrees. ❖ The data is a floating type number	❖ The integrated ADC has a resolution of 16 bits. ❖ On board accelerometer gives full scale range of: ±2g,±4g, ±8g,±16g and the on board gyroscope gives digital outputs of angular rate of change of roll, pitch and yaw. The scale range is: ±250, ±500, ±1000 and ±2000 °/sec.
GPS Sensor	**2.5m**	❖ GPS sensor will receive data in NMEA 0183 GGA format.	❖ Hot start time is 1s while cold start time is 27s ❖ Data is received using UART protocol ❖ 50 channels for wireless data transmission ❖ 5Hz data update rate, which suits the 1Hz required for packet transmission

Descent Stability Control Design (1/3)

Design Strategy : Passive Payload Stability Control using COP above COG concept

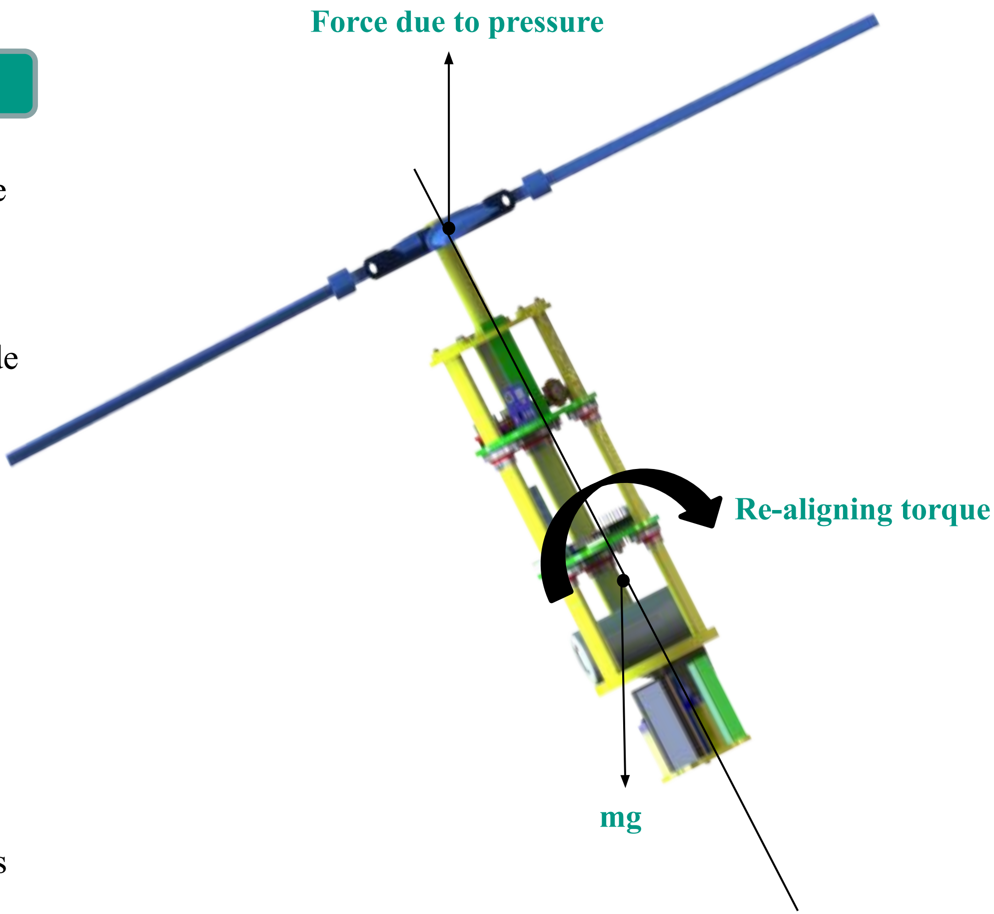


- Components in the payload are arranged such that the Centre of gravity (COG) is very low
- Centre of Pressure (COP) is present almost in the plane of the blades
- Due to this condition, a reclining torque is applied on the container when there is a tilt from the nadir direction leading to stable equilibrium.
- This torque realigns the payload.
- Thus, nadir direction is always maintained.

Descent Stability Control Design (2/3)

Maintaining the NADIR direction

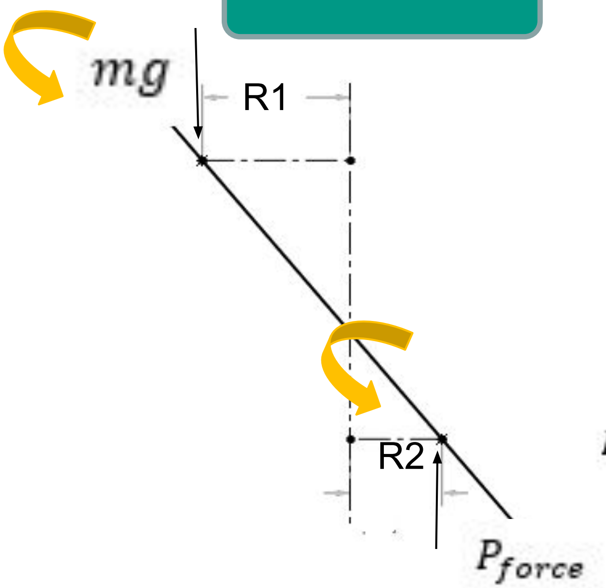
- COP is the point where the net aerodynamic force can be applied so as to inculcate the effect of a distributed force. It is the main point where all upward force is assumed to be applied(air resistance due to descend and rotation will provide a net upward force)
- CG is the point where the gravitational force can be applied to. This is the point where 'mg' force(downward force due to weight) is assumed to be applied
- CG was found to be below center of pressure which provides the re-aligning torque to the payload
- Also the simulation results for various tilt angles showed only a slight variation in the COP so irrespective of the tilt angle t will realign itself
- **Thus NADIR direction is always maintained**



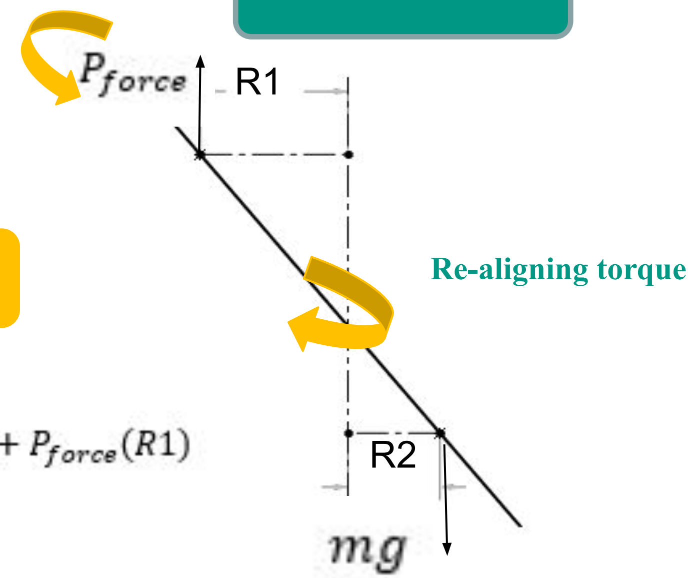
Descent Stability Control Design (3/3)

COG and COP in maintaining the NADIR direction and avoiding tumbling

COG above COP



COP above COG



DESIGN OF METHOD

$$Realligning\ torque = mg(R2) + P_{force}(R1)$$

Forces resulting in angular moment and making the payload tumble hence, UNSTABLE EQUILIBRIUM

REJECTED

Forces keeping payload stable and prevents it from tumbling hence, STABLE EQUILIBRIUM

SELECTED

Container Descent Control Hardware Summary (1/2)

Stowed configuration

It is kept stowed using the bottom lid held taut with the nylon thread to the other end in the container's wall

Parachute Deployment

The parachute deploys after separation from rocket due to vents in the parachute module

Descent without payload

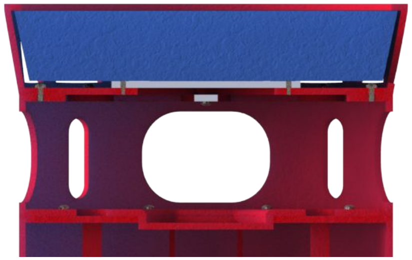
Nylon wire breaks at 450m and the elastic strands open the lid thus releasing the payload

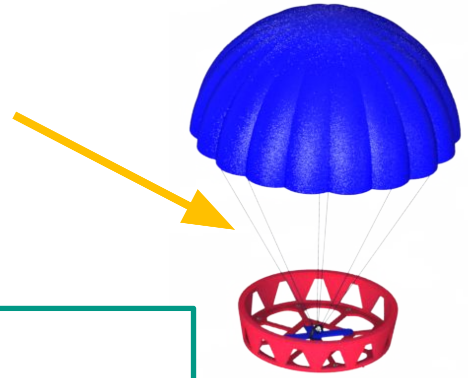
Container Descent Control Hardware Summary (2/2)

CONTAINER PASSIVE COMPONENTS

Component name	Description	Key design consideration	Dimensions	Colour
Parachute	Hexagonal parachute with sufficient drag	Parachute should be strong and also provide calculated value of drag	Shroud length: 203mm Canopy area: 26000mm^2	Orange
Parachute Module	It is the topmost section of the CanSat above the container Electronics module	Openings are provided for ease and quickness of deployment of parachute	Height: 27mm Diameter: 120mm Inclination angle: 75^0	Orange

Deployment method:
As the cansat is released from the rocket, the air stagnates in the openings thus forcing the parachute out, this releases parachute.





Active components:
No active components are being used in container descent control.

Descent Rate Estimates (1/11)

Common Formulae

$$F_d = \frac{1}{2}\rho v^2 A C_d$$

Where, F_d = Drag force , C_d = Coefficient of drag , ρ = Air density (1.0959 kg/m^3)

A = Reference area (taken as Projected Area) , v = Descent velocity

Solving the differential equations obtained from $mg - F_d = ma$ yields the results:

$$v(t) = \sqrt{\frac{mg}{k}}[\tan h\left(t\sqrt{\frac{gk}{m}}\right)]$$

$$x(t) = \frac{m}{k}\ln[\cosh\left(t\sqrt{\frac{gk}{m}}\right)]$$

$$T = \sqrt{\frac{m}{gk}}(\ln 2 + \frac{\Delta hk}{m})$$

Where, v(t) = Descent velocity as a function of time

x(t) = Altitude as a function of time

Descent Rate Estimates (2/11)

Where, m = Mass of the body

g = Acceleration due to gravity ($9.81 m/s^2$)

T = Time of flight

Δh = Altitude travelled

$$k = \frac{\rho A C_d}{2}, \quad A = \frac{6 \times \sqrt{3} \times l^2}{4}$$

l = side length of the hemispherical parachute

Assumptions

- Vertical velocity component tends to zero post rocket-separation approximately at the altitude 700 m
- Air density at 30°C and 350m in Stephenville is taken as the constant value throughout

Descent Rate Estimates (Container + Payload) (3/11)

Descent Rate Estimation for the Container and Payload

- The time of flight from 700m to 450 m for the entire CanSat is obtained from the equation

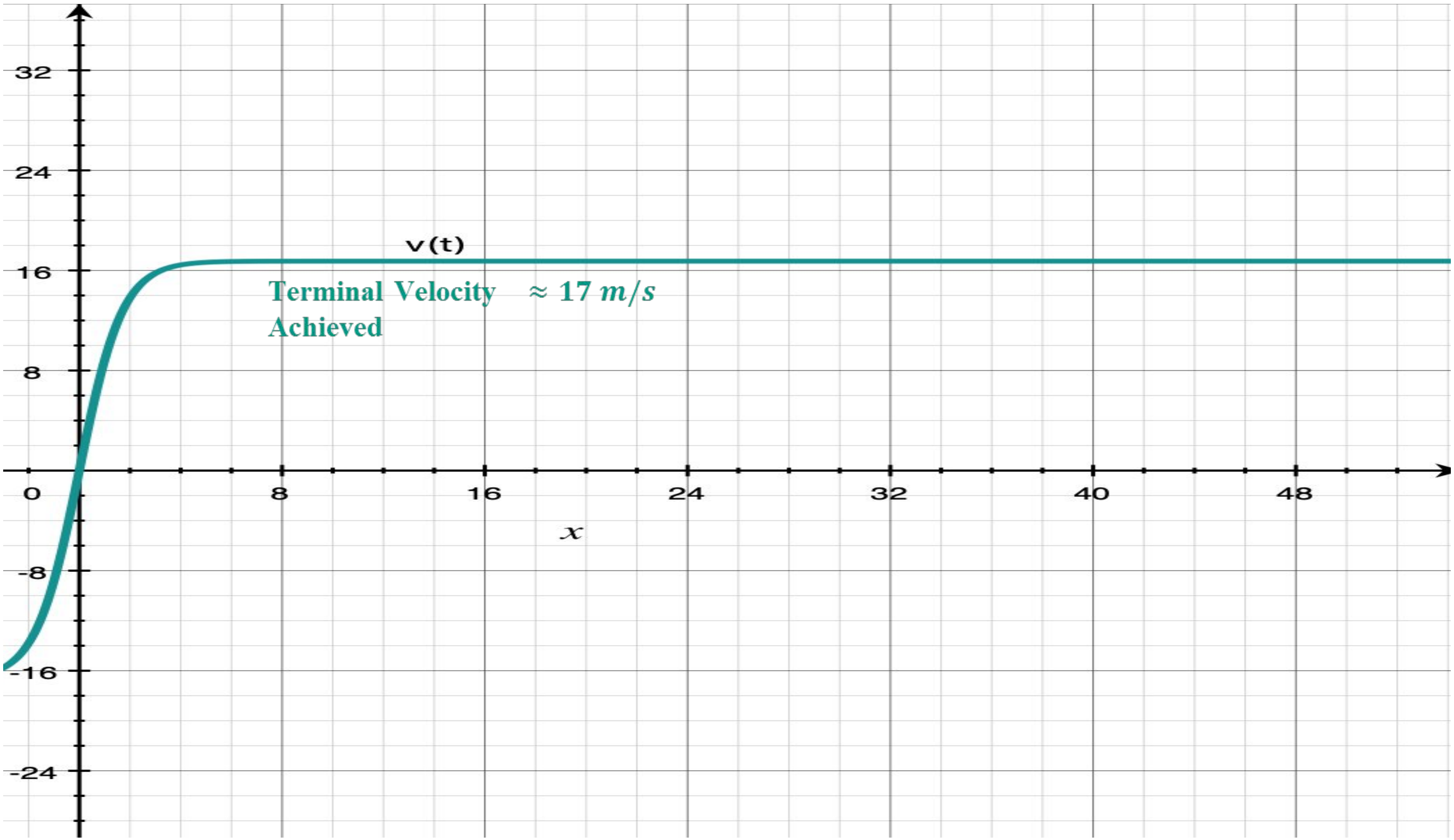
$$\mathbf{T} = \sqrt{\frac{\mathbf{m}}{\mathbf{gk}}}\left(\mathbf{ln2} + \frac{\Delta \mathbf{hk}}{\mathbf{m}}\right) = \mathbf{22.08s}$$

- The velocity of the CanSat at 450 m after 22.08 s is obtained using v(t). Since rho is assumed constant, this value roughly coincides with the final velocity obtained from the drag force equation, i.e .

$$\mathbf{v_f} = \sqrt{\frac{\mathbf{2mg}}{\boldsymbol{\rho} \mathbf{AC_d}}} = \mathbf{16.75\ m/s}$$

Here, m = 0.5 kg , A = 0.0399m^2 , $\mathbf{C_d}$ = 0.8 ,$\Delta\mathbf{h}$ = 350 m

Descent Rate Estimates (Container + Payload) (4/11)



Descent Rate Estimates (Container) (5/11)

Descent Rate Estimation for the Container

- The time of flight from 450 m to ground for the Container is obtained from the equation

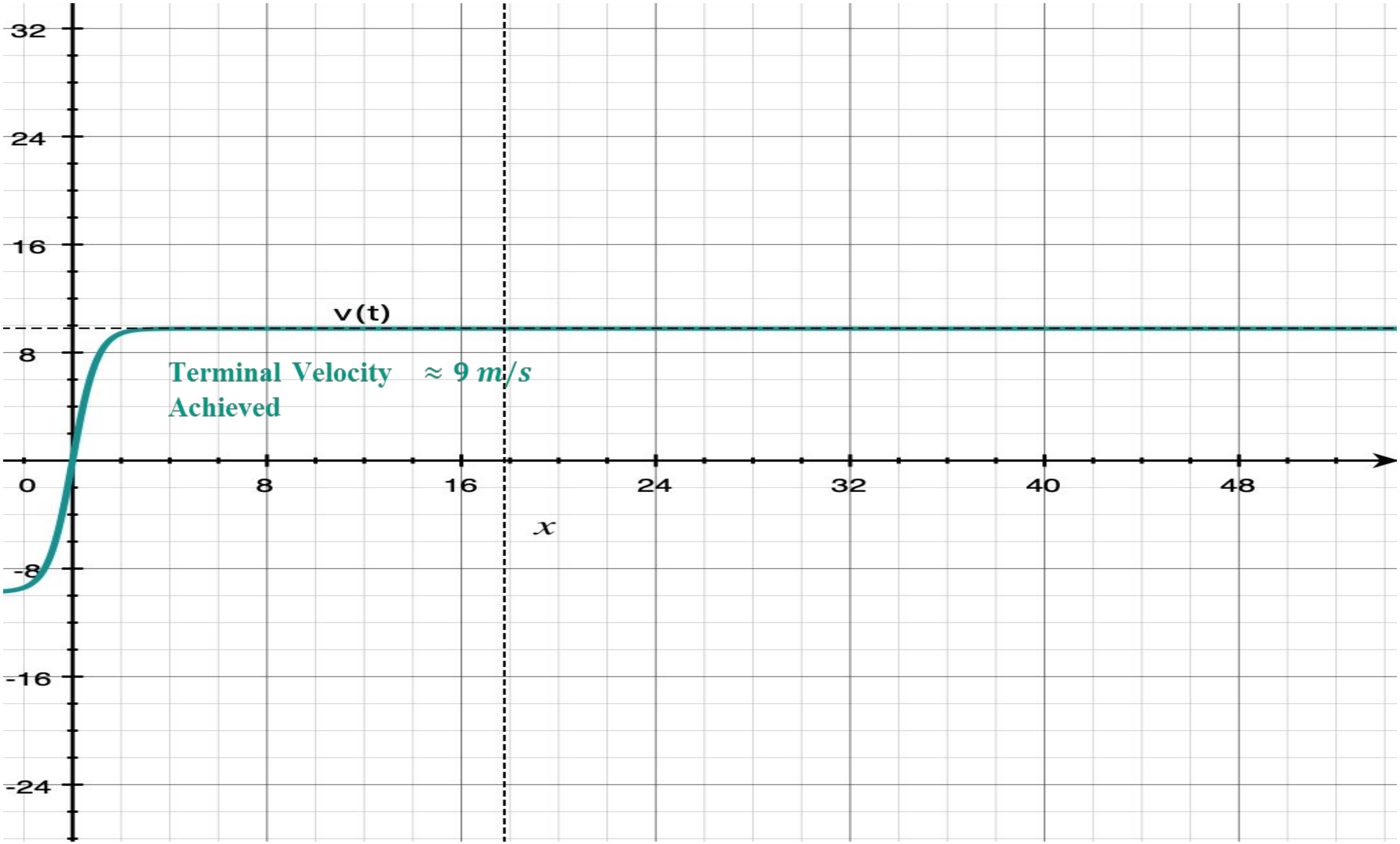
$$\mathbf{T} = \sqrt{\frac{\mathbf{m}}{\mathbf{gk}}}\left(\ln 2 + \frac{\Delta \mathbf{hk}}{\mathbf{m}}\right) = \mathbf{46.77s}$$

- The velocity of the body at 300m after 31.13 s is obtained using v(t). Since rho is assumed constant, this value roughly coincides with the final velocity obtained from the drag force equation. i.e.

$$\mathbf{v_f} = \sqrt{\frac{\mathbf{2mg}}{\boldsymbol{\rho} \mathbf{AC_d}}} = \mathbf{9.76\ m/s}$$

Here, $m = 0.17$ kg , $A = 0.0399\ m^2$, $\mathbf{C_d} = 0.8$, $\Delta\mathbf{h} = 450$ m

Descent Rate Estimates (Container) (6/11)

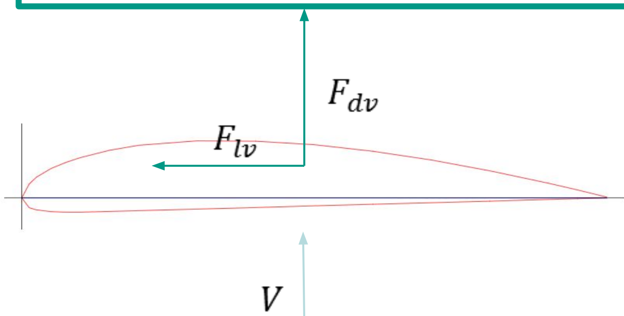


Descent Rate Estimates (Payload) (7/11)

Net Drag and Lift forces are divided into three components

- ❖ Lift and drag due to descent on the auto gyro
- ❖ Lift and drag due to auto rotation on the auto gyro
- ❖ Drag force on body due to descent

Net effect due to both is then superimposed to obtain the results.

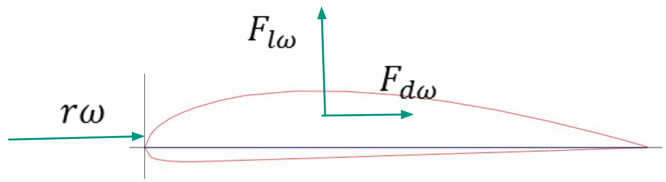


- ❖ Drag force due to descent

$$F_{dv} = \frac{1}{2}\rho A' V^2 C_{dv}$$

- ❖ Lift force due to descent

$$F_{lv} = \frac{1}{2}\rho A V^2 C_{lv}$$

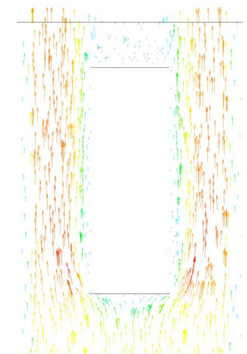


- ❖ Drag force due to rotation (considering on a small cross section with area A')

$$F_{d\omega} = \frac{1}{2}\rho A' (r\omega)^2 C_{d\omega}$$

- ❖ Lift force due to rotation

$$F_{l\omega} = \frac{1}{2}\rho A' (r\omega)^2 C_{l\omega}$$



- ❖ Drag force due to descent (on container body)

$$F_d = \frac{1}{2}\rho A^* V^2 C_{dv}$$

Descent Rate Estimates (Payload) (8/11)

- **Adding forces in vertical direction**

$$m\frac{dV}{dt} = \frac{1}{2}\rho A V^2 C_{dv} + \frac{1}{2}\rho A (r\omega)^2 C_{lv} + \frac{1}{2}\rho A^* V^2 C_{dv}$$

- **Adding moments in tangential direction**

$$I\frac{d\omega}{dt} = \int_{r_1}^{r_2}\left[\frac{1}{2}\rho c V^2 C_{dv} r\right] dr - \int_{r_1}^{r_2}\left[\frac{1}{2}\rho c (r\omega)^2 C_{dv} r\right] dr$$

$$I\frac{d\omega}{dt} = \frac{1}{4}\rho c V^2 C_{dv}(r_2^2 - r_1^2) - \frac{1}{4}\rho c \omega^2 C_{dv}\,(r_2^4 - r_1^4)$$

- **The above equations are solved using fourth-order Runge-Kutta Method on XPPAUT Software. The optimal (terminal) velocity achieved for the auto-gyro is 13.29 m/s.**

Descent Rate Estimates (Payload) (9/11)

Assumptions for calculations

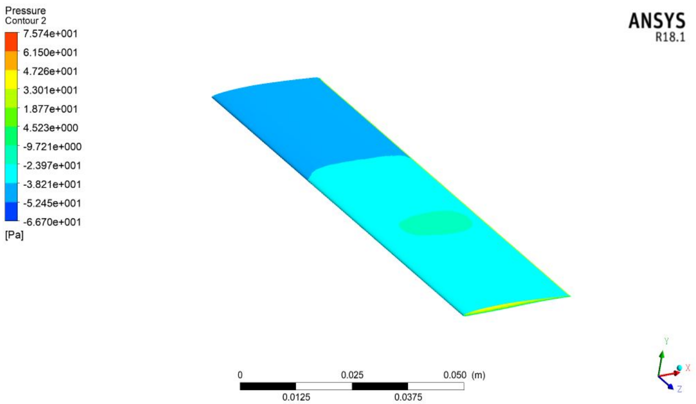
- Effect of natural wind velocity is neglected
- Frontal area for the parachute is approximated to be the area of hexagon
- Tip losses around the blades are neglected
- Frictional losses at the mounting points is neglected
- Bearing losses are neglected
- Coefficients are considered to be constant throughout the journey
- Variables, V and ω are considered to be constant for a time step

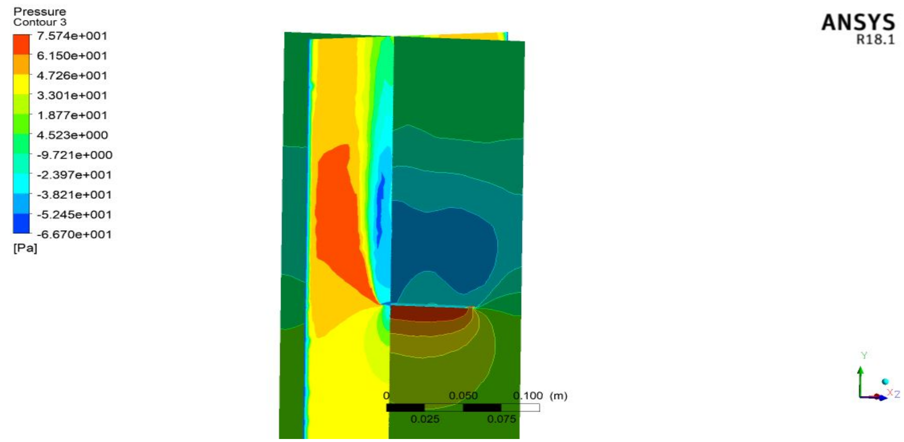
Where,

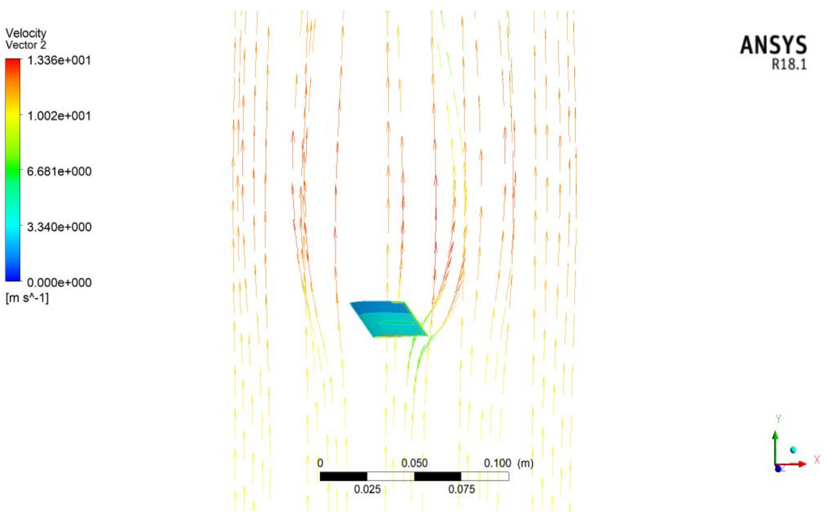
F_{dv} = Drag component of force due to descent on blades
F_{lv} = Lift component of force due to descent on blades
$F_{l\omega}$ = Lift component of force due to rotation on blades
$F_{d\omega}$ = Drag component of force due to rotation on blades
F_d = Drag component of force on container body
C_{dv} =Drag component of force due to descent on blades
F_{lv} = Lift component of force due to descent on blades
$F_{l\omega}$ = Lift component of force due to rotation on blades
$F_{d\omega}$ = Drag component of force due to rotation on blades
F_d = Drag component of force on container body
ρ = Density of air
A, A^* = Area of cross-section for blades and container respectively
r = distance of arbitrary section from the center of container

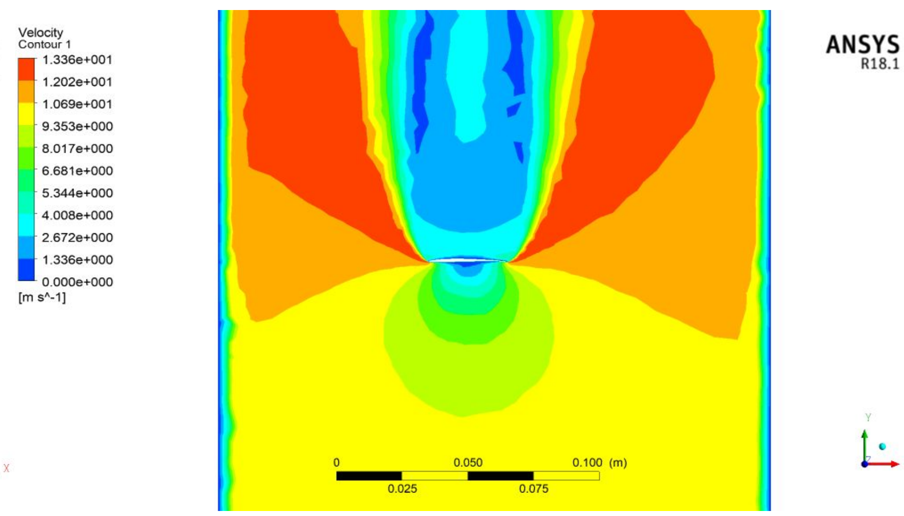
Descent Rate Estimates (10/11)

Blades Analysis









Descent Rate Estimates (11/11)

Descent System	Mass (g)	Terminal Velocity (m/s)	Time of Flight (s)
Container + Payload	500	16.75	22.08
Payload	330	13.29	32.12
Container	170	9.76	46.77

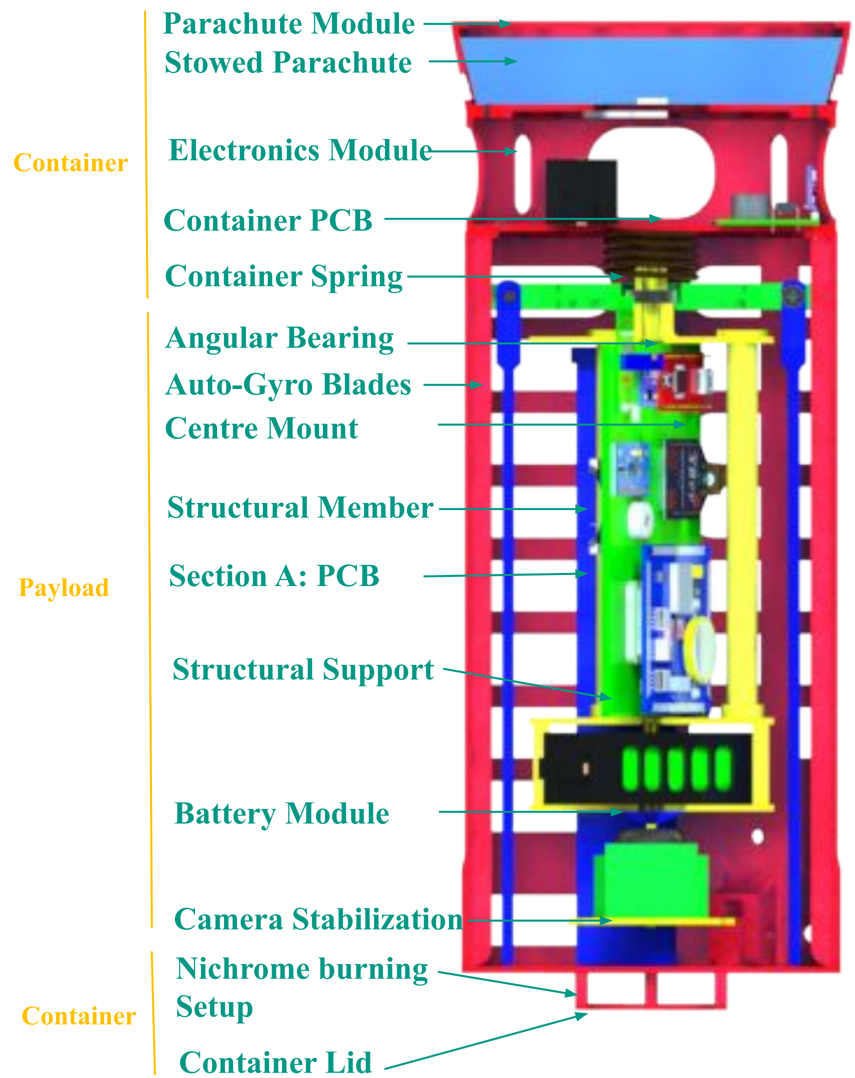
Mechanical Subsystem Design

Bhavya Arya

Mechanical Subsystem Overview

	Material Selection	
	Major Structural Members	**Materials**
Payload	Payload Top	SLS 3-D printed HIPS
	Rotor	Blow-Molded Polycarbonate
	Rotor Hub	Blow-Molded Polycarbonate
	Structural Members	FDM 3-D printed Polypropylene
	Structural Support	FDM 3-D printed Polypropylene
	Camera Stabilization Setup Mount	SLS 3-D printed PLA
Container	Parachute Module	SLS 3-D printed HIPS
	Parachute Mount	SLS 3-D printed HIPS
	Electronics Module	SLS 3-D printed HIPS
	Main Body	FDM 3-D printed HIPS

	Interface Definitions
Payload	Modular design based on vertical modules alignment
	Stowed Configuration: Bottom Lid is closed with a nylon thread which will heat due to a nichrome resistor at 450 m
Container	BMP 280 and an accessible power switch is mounted on container body
	Parachute is mounted using an O-ring to the parachute mount..



Mechanical Subsystem Changes Since PDR

Parts	PDR	CDR	Rationale
Nichrome heating setup	Placed inside the container above the bottom lid	Places outside the container, attached to the bottom lid	❖ More space is available ❖ safety for payload electronics
Shape of the payload	Circular in shape	Octagonal in shape	❖ Capacious ❖ To make ample space for battery and PCB ❖ To accommodate the battery
Rotor mount design	Thickness: 4mm	Thickness: 8mm length of tabs is increased	❖ To increase the efficiency of mounting. ❖ Improved robustness of the overall design. ❖ Increased tabs constraints movement of payload in deployed condition ❖ Facilitates sliding out of payload
Lid	Simple plate with a mounting point	Layered design with structures to support nylon thread and nichrome set-up	❖ This has to be done to accommodate the nichrome heating set-up

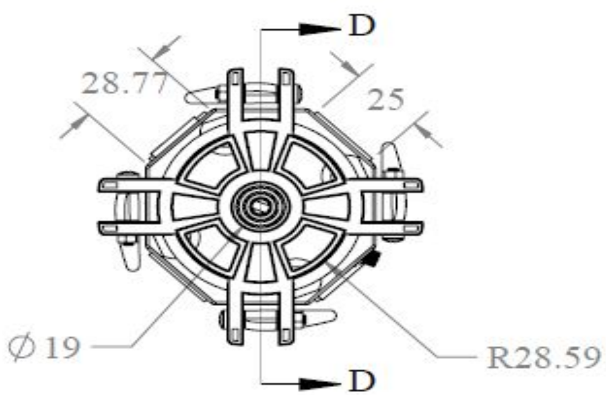
Mechanical Sub-System Requirements (1/2)

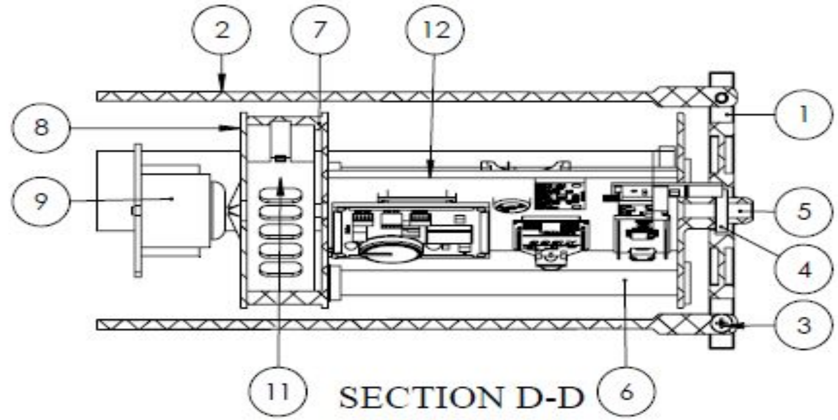
ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
MSR-1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Mission Requirement	Very High	BR-1	SS-1	+		+	
MSR-2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length.	Mission Requirement	Very High	BR-2		+	+	+	+
MSR-3	Tolerances are to be included to facilitate container deployment from the rocket fairing. (Fit check done)	Mission Requirement	Very High			+	+	+	+
MSR-4	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section.	Mission Requirement	Very High	BR-3		+		+	
MSR-5	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Mission Requirement	Very High	BR-7				+	
MSR-6	The container shall release the payload at 450 meters +/- 10 meters.	Mission Requirement	Very High	BR-9 DCR-3		+			
MSR-7	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Mission Requirement	Very High	BR-10 DCR-4		+		+	
MSR-8	All structures shall be built to survive 15 Gs of launch acceleration.	Mission Requirement	Very High	BR-14		+			
MSR-9	All structures shall be built to survive 30 Gs of shock.	Mission Requirement	Very High	BR-15	DCR-6	+			

Mechanical Sub-System Requirements (2/2)

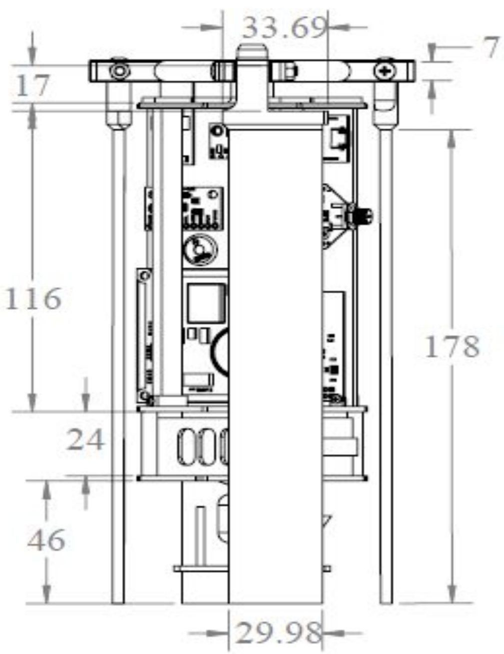
ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
MSR-10	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Mission Requirement	High	BR-16				+	
MSR-11	Mechanisms shall not use pyrotechnics or chemicals.	Mission Requirement	High	BR-18			+	+	+
MSR-12	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Mission Requirement	High	BR-17		+			
MSR-13	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Mission Requirement	Very High	BR-52 DCR-7		+		+	+
MSR-14	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Mission Requirement	High	BR-51			+	+	
MSR-15	Nichrome wire burning setup shall not be exposed to outside environment to reduce risk of setting vegetation on fire.	Mission Requirement	Very High	BR-19		+	+	+	+
MSR-16	Cansat design must be ergonomically correct to facilitate a successful launch.	Design Fundamental	High			+			
MSR-17	Modular alignment of Cansat for easy fabrication and modelling	Design Fundamental	High			+		+	

Payload Mechanical Layout of Components (1/4)



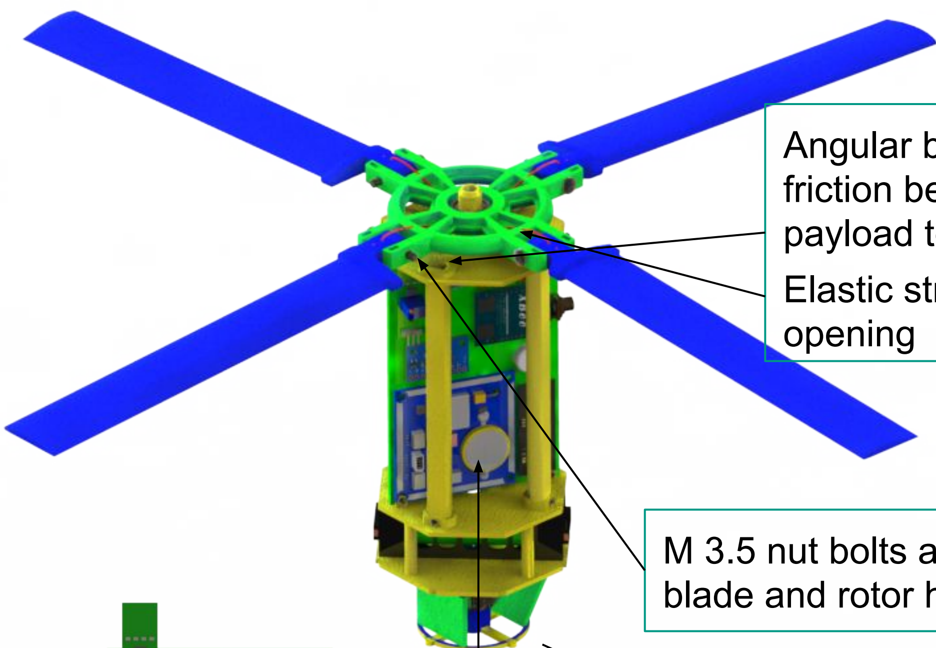


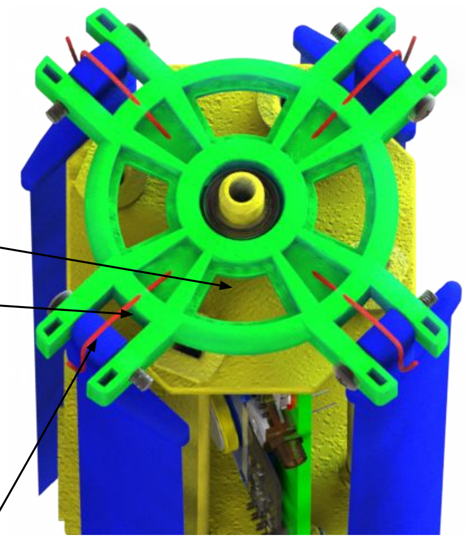
SECTION D-D
SCALE 1 : 2



ITEM NO.	PART NUMBER	QTY.
1	Blade mount	1
2	clark z 2	4
3	B18.6.7M - M3.5 x 0.6 x 25 Type I Cross Recessed PHMS --25S	4
4	AFBMA 12.2 - 0.3750 - 0.6250 - 0.1562 - 16,SI,NC,16	1
5	PAyload top	1
6	Payload support	4
7	PayloadPCB base	1
9	camera stablisation	1
10	B18.2.4.1M - Hex nut, Style 1, M3.5 x 0.6 --D-N	4
11	Battery holder 18650 & battery	1
12	electronics^payload assembly	1
13	IS 7483 - M1.6 x 4 - Z -- 4N	27

Payload Mechanical Layout of Components (2/4)

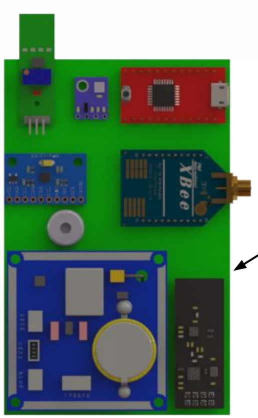




Angular bearing to reduce friction between rotor and payload top

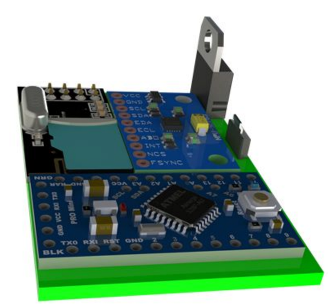
Elastic strands to help blade opening

M 3.5 nut bolts act as pin joint for blade and rotor hinge



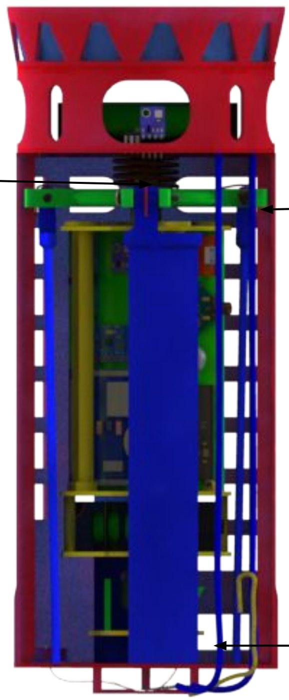
PCB for payload

PCB for camera stabilization set up



Payload Attachment points with Container

Spring connected to container body and helps in payload release



Ribs designed in container and negative rib designed in the rotor helps in maintaining stowed configuration and also helps in smooth removal of payload

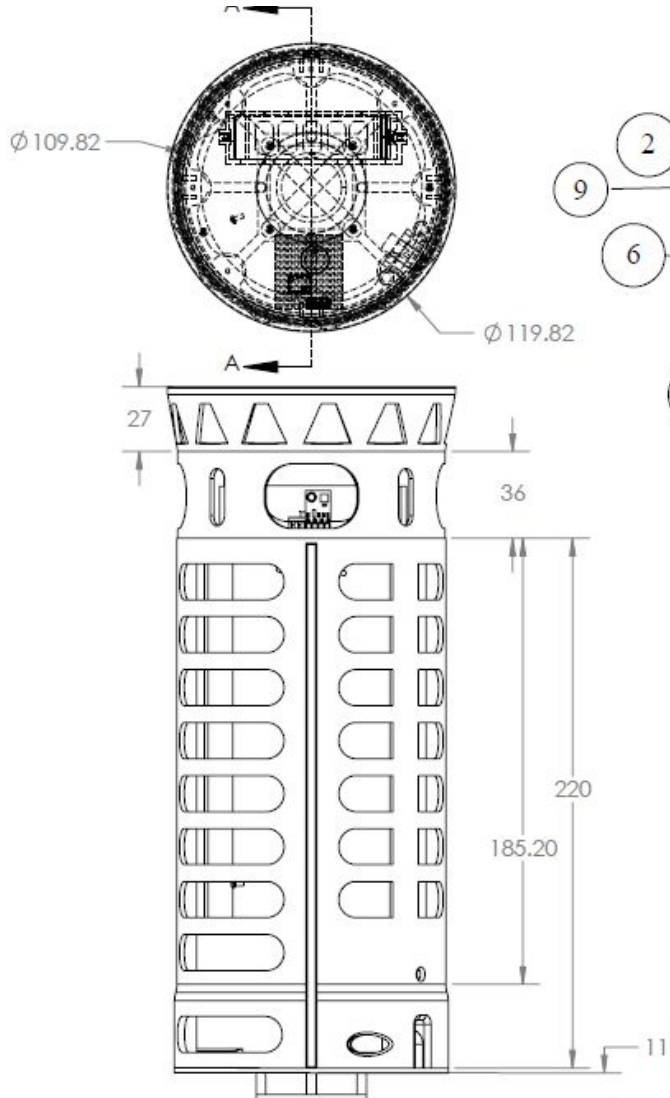
Payload lies on the container lid resting on blade's bottom

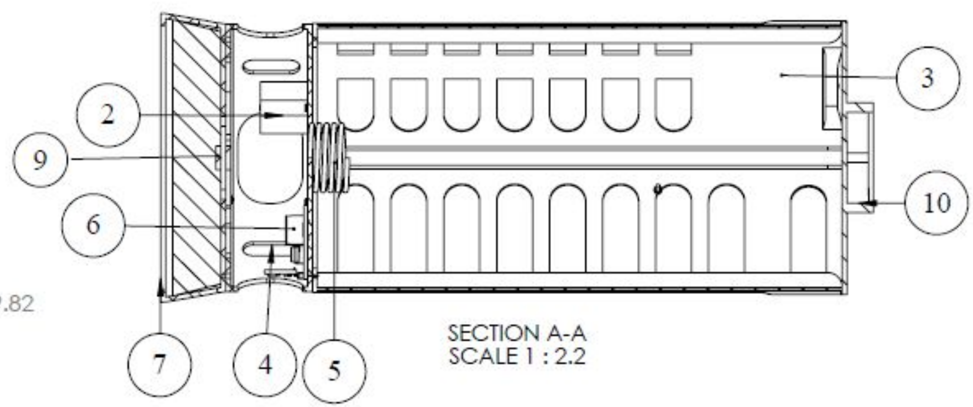
Top sectional view of complete cansat

Payload Mechanical Layout of Components (4/4)

Parts	Material	Density (g/cm^3)	Tensile Strength (MPa)	Cost $/kg	Pros	Cons	Notched Impact Strength (KJ/m^2)
Payload top	HIPS	1.03	100-300	30	❖ Better tensile strength ❖ Good surface finish	❖ Heavier ❖ Blocks Radio Waves	10.0 - 20.0
Rotor hub and Rotor	Polycarbonate	1.2	70-80	30	❖ High stiffness-weight ratio ❖ High tensile strength	❖ More weight ❖ Expensive manufacturing technology	60.0 - 80.0
Structural member and Supports	Polypropylene	0.946	40	30	❖ Stiff and strong ❖ Good surface finish	❖ Impacted by UV ❖ Heavy Warping	3.0-30.0
Camera Stabilization Mount	ABS	1.06-1.08	27-46	20	❖ Lightweight ❖ Ease of fabrication	❖ Brittle in nature ❖ Poor surface finish	8.0-10.0

Container Mechanical Layout of Components(1/3)

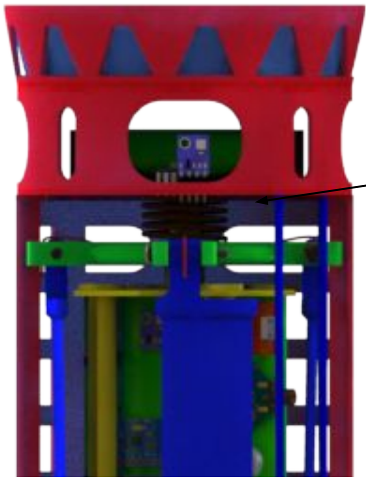


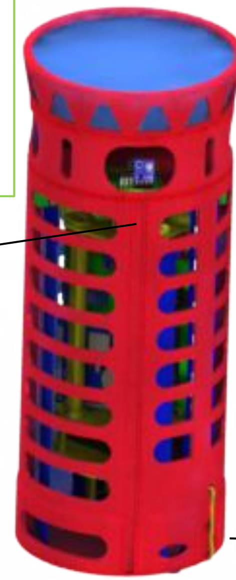


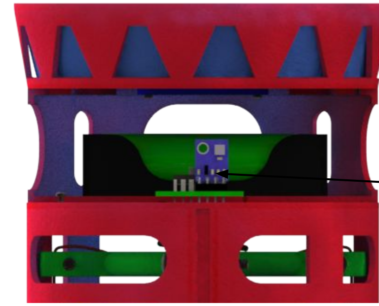
ITEM NO.	PART NAME	QTY.
1	Battery	1
2	Battery holder 18650	1
3	container final	1
4	container electronics	1
5	Spring^payload assembly	1
6	assembly	1
7	parachute module	1
8	parachute mount	2
9	Parachute	1
10	Lid	1

Container Mechanical Layout of Components(2/3)

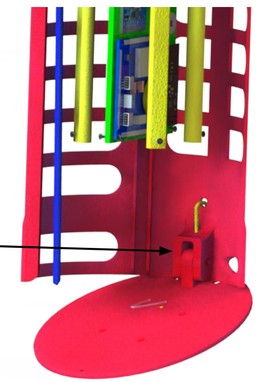
Top surface will be used as resting surface of container inside the rocket





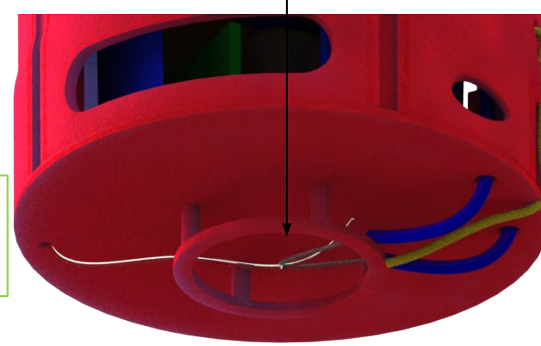


Container electronics



Spring attached to container main body which helps in releasing the payload

Hinge holds the lid to container, a M3.5 nut bolt set will be used as pin for this joint



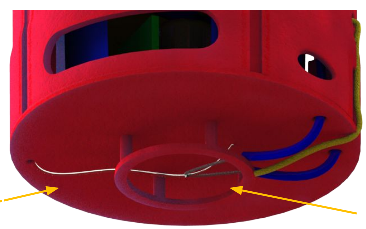
Nichrome heating nylon setup

Elastic strand to support lid opening

Container Mechanical Layout of Components (3/3)

Parts	Material	Density (g/cm^3)	Tensile Strength (MPa)	Cost ($/kg)	Pros	Cons	NotchedImpact Strength(KJ/m^2)
Parachute Module	**HIPS**	1.03	100-300	30	●Better tensile strength ●Good surface finish	●Less stress crack resistance ●Blocks Radio Waves	10.0 - 20.0
Parachute Mount	**HIPS**	1.03	100-300	30	●Better tensile strength ●Good surface finish	●Less stress crack resistance ●Blocks Radio Waves	10.0 - 20.0
Electronics Module and Container Main Body	**HIPS**	1.03	100-300 MPa	30	●Better tensile strength ●Good surface finish	●Less stress crack resistance ●Blocks Radio Waves	10.0 - 20.0

Payload Release Mechanism



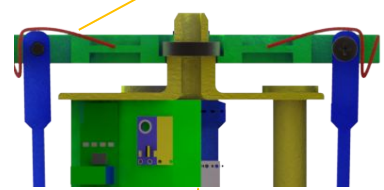
Phase 1: Pre-Deployment

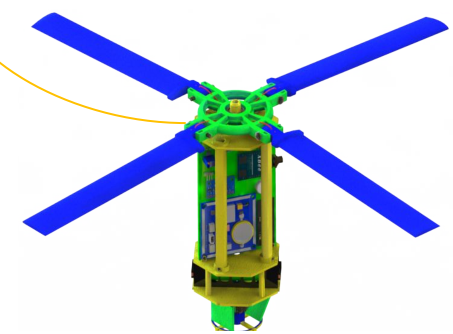
Payload is kept in the container
In the stowed configuration.

The nichrome wire set up will be enclosed in a heat resistant shield and a layer of tafetta nylon

Phase 2: Transition

At 450m, the MCU will command the Nichrome heating setup to pass large current (around 700 mA) through the nichrome wire to burn the nylon thread around which it is wound. The nylon thread is attached to a mount on the cylinder and passing through a hole in the hinged lid on the other end. After heating of the nylon thread, the hinged lid will open, thus payload will start coming out.

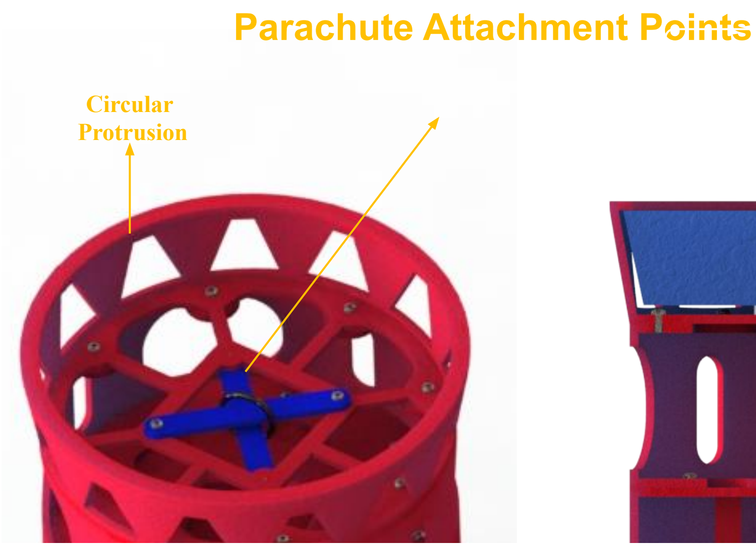


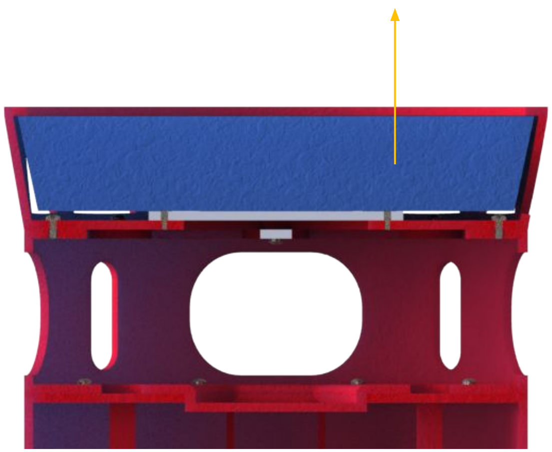


Phase 3: Separation

Elastic strands and air pressure will force the rotors to open. The rotors will start rotating due to lift forces generated by the downward velocity of the container.

Container Parachute Release Mechanism





Key attachment points of parachute to container

2 perpendicular bars will pass through the hook to which shroud lines of the parachute are connected. These bars are mounted on the base of the parachute module via screws.

Stowed Configuration

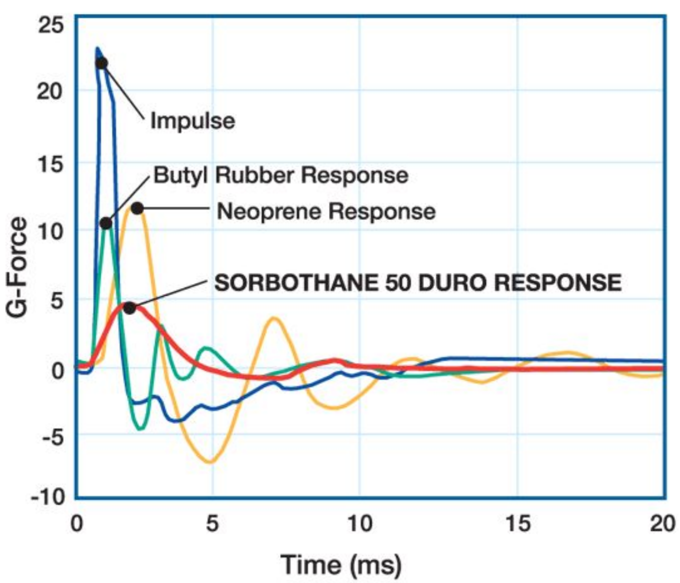
Parachute is packed in a height of 25 mm and the top layer of parachute module has a circular protrusion to restrict parachute's release within the rocket.

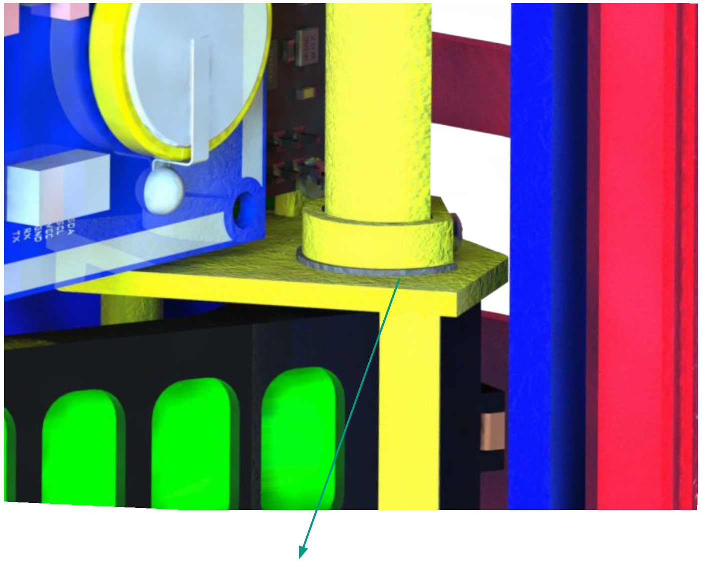
Parachute Release

Parachute will be released automatically at apogee after separation from rocket due to air pressure from air ducts present on the periphery of the parachute module

Structure Survivability (1/2)

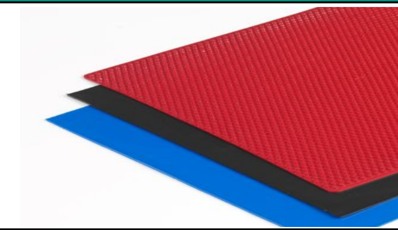
- All PCBs are rigidly mounted to the structural members of the payload via supporting members, all connections are joint through screws.
- A layer of S**orbothane** is provided between the PCB and the support members for shock absorption so that no shock is transferred to the PCBs
- Sorbothane has excellent shock dampening properties, so it will absorb the major part of the 30G's of shock which will be generated on the system





Sorbothane layer

Structure Survivability (2/2)

	Description	Photos
Electronic component mounting methods	Components are properly soldered on the PCB and it is prevented from shock due to damping action of Sorbothane layer	
Electronic component enclosures	Payload is covered with a *taffeta nylon fabric which is wrapped around the structural members of the payload	
Securing electrical connections	Connections are secured via epoxy, resin, glue and electrical PVC tape	 
Descent control attachments	All descent control attachments are securely screwed to respective mounting points also a layer of glue is put on the edges to secure the joints(M2-0.4, Philips screws are used)	

*** Taffeta nylon covering is not shown in any CAD model for better understanding of the model**

Mass Budget (1/10)

Payload Electronics Components

CanSat System	Component	Model Name	Quantity	Mass (g)	Uncertainty	Determination
Payload (Section-A : Telemetry Section)	Temperature sensor	BMP-280	1	1.3540	±0.0001	Measured
	Air pressure sensor					
	GPS sensor	UBLOX Neo-6M	1	12.0142	±0.0001	Measured
	Voltage sensor	SAMD21 ADC	1	-	-	-
	Pitch and roll sensor	MPU 9250	1	1.5186	±0.0001	Measured
	Autogyro spin rate sensor	AH49E Hall Sensor	1	0.5242	±0.0001	Measured
	SD Card Shield	Street27 MicroSD	1	4.5221	±0.0001	Measured
	SD Card	SanDisk 8 GB Class 4	1	0.5231	±0.0001	Measured
	Communication Module	NRF24L01	1	2.0659	±0.0001	Measured
	Processor	SAMD21 MCU Dev Breakout	1	5.0852	±0.0001	Measured
	Payload RTC	SAMD Internal RTC	1	-	-	-
	Payload Antenna	FXP380 Freedom Patch Antenna	1	1.0741	±0.0001	Measured
	Payload radio	XBEE Pro S2C	1	3.8123	±0.0001	Measured
	Audio Buzzer	Multicomp MCKPI-G2437-3671 Piezo Buzzer	1	3.0156	±0.0001	Measured
	Battery	Samsung 18650 25R	1	45.0241	±0.0001	Measured

Mass Budget (2/10)

CanSat System	Component	Model Name	Quantity	Mass (g)	Uncertainty	Determination
	Voltage Regulator	LM1117 LDO	1	0.1121	±0.0001	Measured
	PCB (10% error)	-	2	8.0	±0.8	Estimated (Vendor)
	Boost Converter	LTC3121	1	0.1865	±0.0001	Measured
	Ambient Light Sensor	-	1	0.1795	±0.0001	Measured
Payload (Section-B: Camera Stabilisation Section)	Battery	Envie Battery	1	31.8451	±0.0001	Measured
	Processor	Arduino Pro Mini	1	6.0125	±0.0001	Measured
	Servo	SG90	1	9.0321	±0.0001	Measured
	Pitch and roll sensor	MPU 9250	1	1.5126	±0.0001	Measured
	Bonus camera	Piquancy Ultra HD	1	20.0451	±0.0001	Measured
	SD Card	Sandisk SD Card Class 4	1	0.5642	±0.0001	Measured
	Communication Module	NRF24L01	1	2.0789	±0.0001	Measured
	Voltage Regulators	LM1117 LDO, LM7805 LDO	2	1.6957	±0.0001	Measured
	PCB (10% error)	-	1	3.0	±0.3	Estimated (Vendor)
	Miscellaneous (LEDs and other passive components)	-	-	15	-	Estimated
			Total	**179.7977**		

Mass Budget (3/10)

Container Electronics Components

CanSat System	Component	Model Name	Quantity	Mass	Uncertainty	Determination
Container	Processor	AT Tiny 85	1	1.0159	±0.0001	Measured
	Battery	Samsung 18650 25R	1	45.0147	±0.0001	Measured
	Air Pressure Sensor	BMP280	1	1.3735	±0.0001	Measured
	Transistor	TIP120 BJT	1	0.1465	±0.0001	Measured
	Audio Buzzer	Multicomp MCKPI-G2437-3671 Piezo Buzzer	1	3.0987	±0.0001	Measured
	Nichrome Wire (10% error)	-	1	3.0	±0.3	Estimated
	PCB (10% error)	-	1	2.0	±0.2	Estimated (Vendor)
	Voltage Regulator	LM1117 LDO	1	0.1124	±0.0001	Measured
	Miscellaneous (LEDs and other passive components)	-	-	12		Estimated
			Total	**67.7617**	**±0.5006**	

Mass Budget (4/10)

Mechanical Structural Elements

CanSat System	Component	Material	Quantity	Mass(g)	Uncertainty	Determination
Payload	Payload top	SLS 3D-printed HIPS	1	12.5421	± 0.0001	Measured
	Structural member	FDM 3-D printed Polypropylene	3	10.51	± 0.55	SolidWorks estimates
	Structural support	FDM 3-D printed Polypropylene	6	14.23	± 0.12	SolidWorks estimates
	Rotor hub	Blow-Molded Polycarbonate	1	19.3214	± 0.0001	Measured
	Rotors	Blow-Molded Polycarbonate	4	22.10	± 1.51	SolidWorks estimates
	Setup for camera stabilization	SLS 3-D printed PLA	1	18.37	± 1.24	SolidWorks estimates
			Total	**97.0735**	± 3.4202	
Container	Parachute module	SLS 3-D printed HIPS	1	14.37	± 2.23	SolidWorks estimates
	Electronics module	SLS 3-D printed HIPS	1	11.51	± 1.75	SolidWorks estimates
	Main body	FDM 3-D printed HIPS	1	42.46	± 6.24	SolidWorks estimates
	Parachute Mount	SLS 3-D printed HIPS	2	1.8230	± 0.0001	Measured
			Total	**70.1630**	± 10.2201	

Mass Budget (5/10)

Mechanical Non-Structural Components

CanSat System	Component	Dimensions	Quantity	Mass(g)	Uncertainty	Determination
Payload	Angular Bearing	FAG 7200B	1	15	±1.0	Data sheet
	Nut	M4 Pan head	3	5.1369	± 0.0001	Measured
	Bolt	M4 Pan head	3	12.3999	±0.0001	Measured
	Screws	ST4-20 cros head screws	21	10.7625	±0.0001	Measured
	Sorbothane sheet(10% error)	1 Sheet	1	5.0	± 0.5	Estimated
	Elastic strands	0.25 metres	-	4.2200	±0.0001	Measured
			Total	**52.5193**	±1.5005	
Container	Parachute	Hexagonal with side 230mm	1	16	±1.0	Data sheet
	Nut	M4 Pan head	1	1.7123	±0.0001	Measured
	Bolts	M4 Pan head	1	4.1333	±0.0001	Measured
	Screws	ST4-20 cros head screws	16	8.2100	±0.0001	Measured
	Elastic strands	1 metre	-	1.8100	±0.0001	Measured
			Total	**31.8656**	±1.0005	

Mass Budget (6/10)

		Payload	Uncertainty	Container	Uncertainty
Mechanical	Components (Non-Structural Elements)	52.5193	±1.5005	31.8656	±1.0005
	Structural Elements	97.0735	±3.4202	70.1630	±10.2201
Electronics	Components	179.7977	±1.3023	67.7617	±0.5006

	Payload	Uncertainty	Container	Uncertainty
Components (Non-Structural Elements)	232.3170	± 2.8028	99.6273	±1.5011
Structural Elements	97.0735	±3.4202	70.1630	±10.2201

	Total Mass	Uncertainty
Components (Non-Structural Elements)	331.9443	±4.3039
Structural Elements	167.2365	±13.6403

	Total Mass	Uncertainty
Container	167.7903	±11.7212
Payload	329.3905	±6.2230

Mass Budget (7/10)

Total Mass: 499.1808 $\pm$ 17.9442

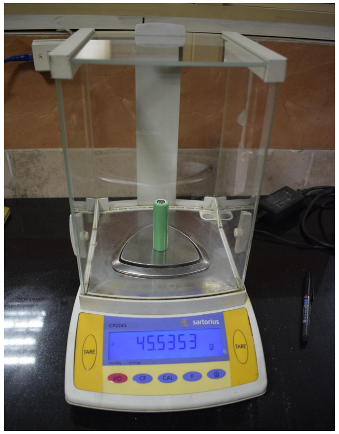
Limit	Total Mass	Margin	Method of Correction
Upper	517.1250	+17.2150	Decrease weight*
Lower	481.2366	-18.7634	Increase weight*

***Through topological optimization on SolidWorks**

Mass Budget (8/10)

Sources of Uncertainties

- ❖ Least count of the weighing scale used is 0.1 g, an error of $\pm$ 0.1 g is introduced in all the components whose weight is measured
- ❖ 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 is considered

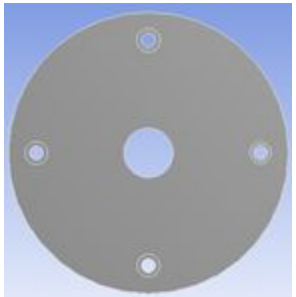


Methods of Correction for weight

- ❖ Mass of electronic components and mechanical non structural elements is fixed and the uncertainties arising can only be confirmed after complete assembly of the model
- ❖ But a variation in mass can be obtained through optimization of the design, so as to achieve the complete mass in a range of 500g +/-10g
- ❖ Topology optimizations are used to reduce the weight of the structure keeping the factors of strength intact which results in weight reduction
- ❖ At present 30% weight is reduced and this value can be increased up to 50% if complete assembly weighs over 510g or it can be reduced to 20%if the complete assembly weighs less than 490g

Mass Budget (9/10)

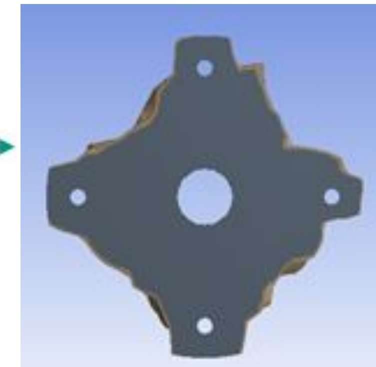
Methods of correcton for weight



Initial design

Design to be used if mass is between 490-500 g

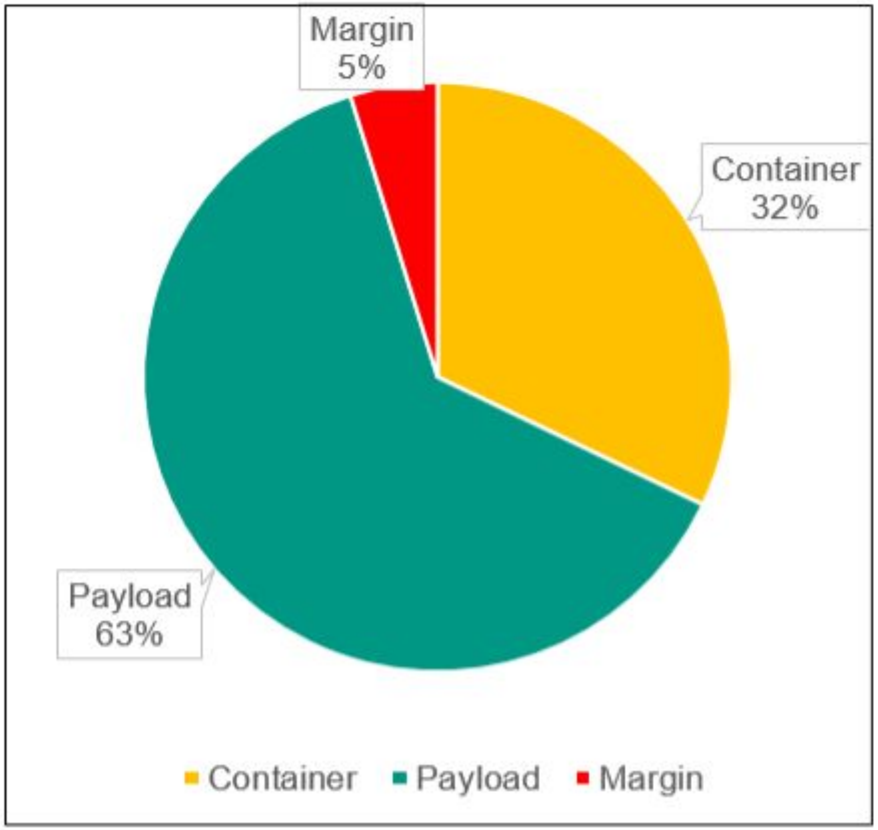
If mass < 490 g more percentage of mass will be retained after optimization

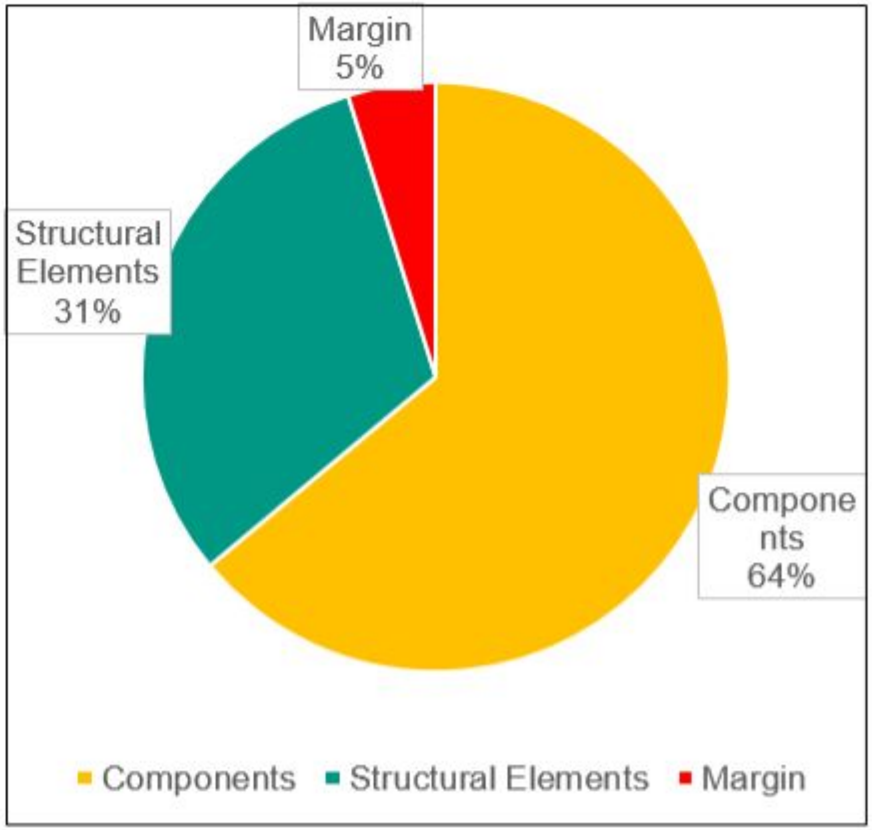


If mass > 510 g less percentage of mass will be retained after optimization

An exemplary optimization of parachute lid is depicted where the mass of the lid can be kept between the two extremes depending upon the weight constraint. Similar analysis can be done on all structural elements to keep the mass in desired range.

Mass Budget (10/10)



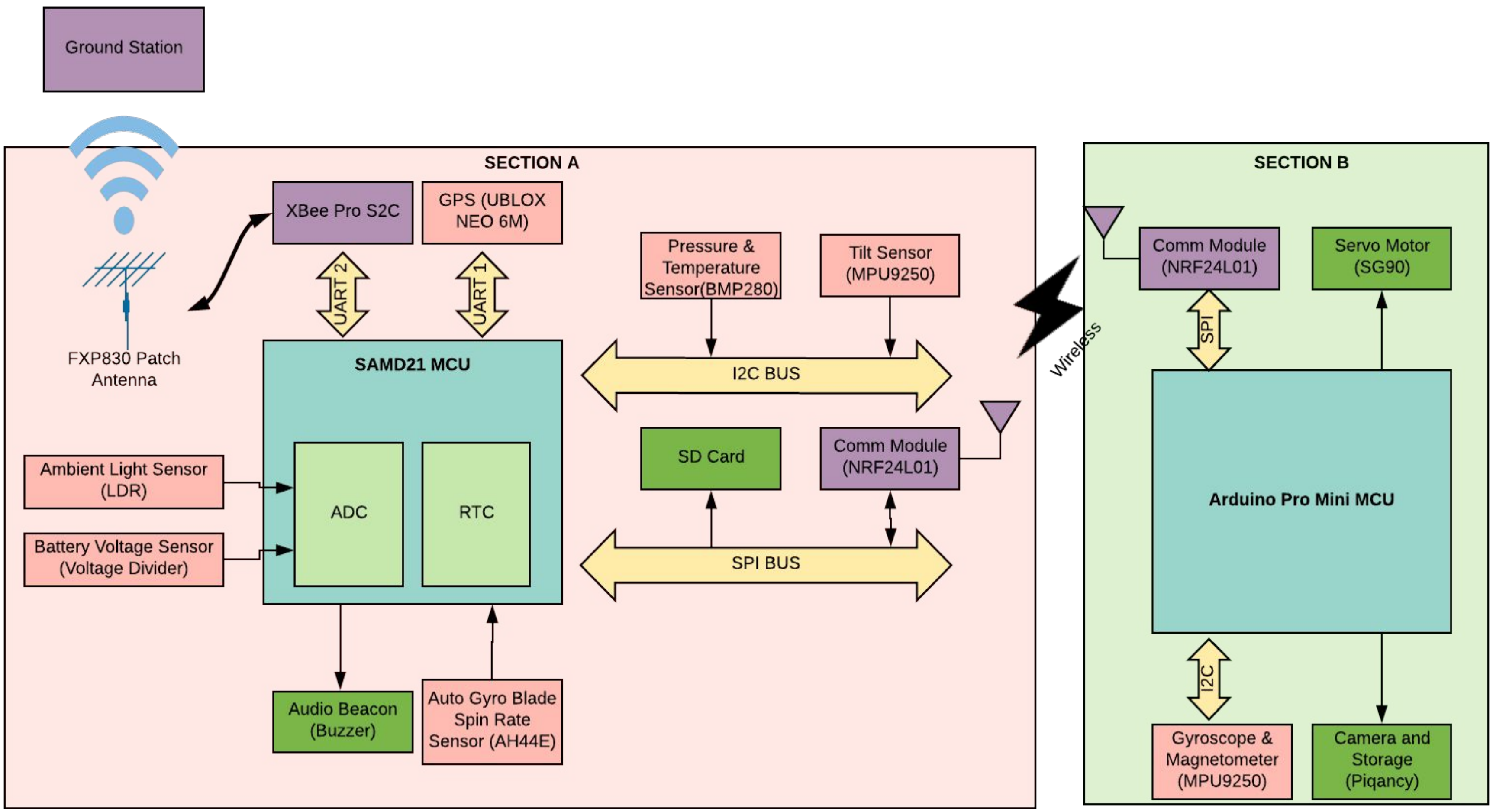


Communication and Data Handling (CDH) Subsystem Design

Sourav Bhattacharjee

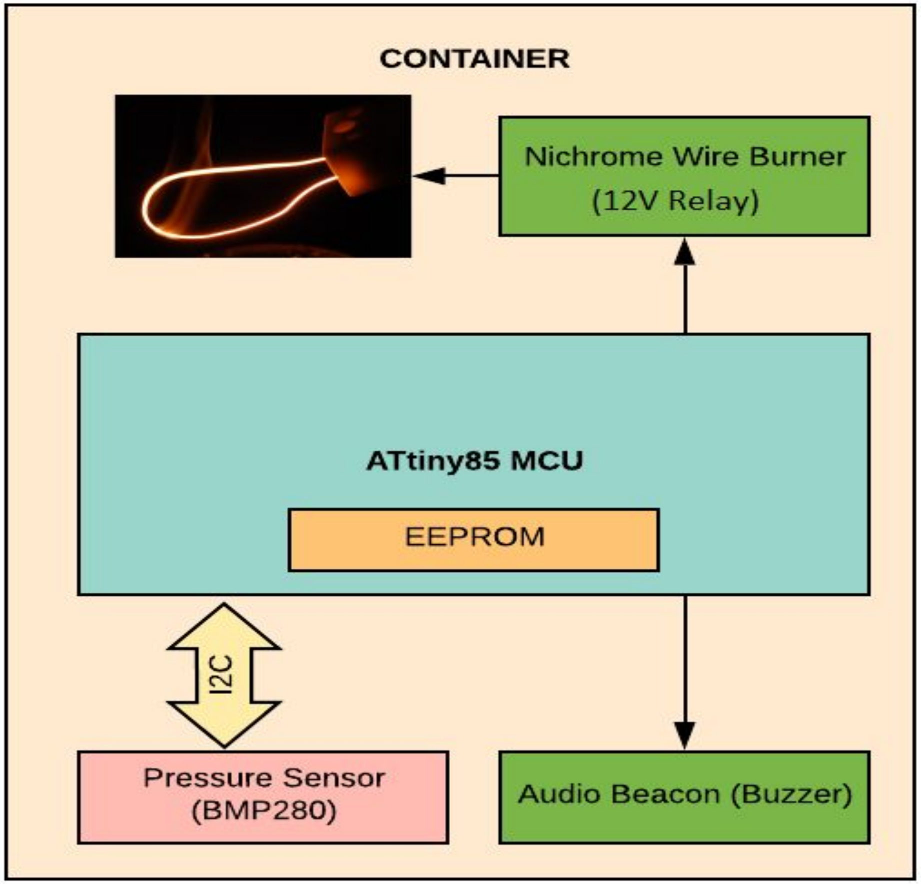
CDH Overview (1/2)

PAYLOAD



CDH Overview (2/2)

CONTAINER



CDH Changes Since PDR

PDR	CDR	REASONS
Internal EEPROM of ATtiny85 for container	External EEPROM 24AA64	• Internal EEPROM has less storage space to store BMP280 data during the flight.

CDH Requirements (1/3)

1. Payload

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
PCDH-01	Mission time shall be transmitted through telemetry with resolution of 1 sec or better. It shall not change even if the processor resets during the launch.	Base Requirement	BR- 30		Very High	+		+	
PCDH-02	The CanSat payload shall transmit telemetry. It shall include the data of all the sensors and it would be collected at 1Hz sample rate.	Telemetry Requirement	FSW-1, Telemetry requirements		Very High	+		+	
PCDH-03	Telemetry shall be accomplished using XBee radios. 2.4GHz radios are used. 900MHz radios are also allowed.	Base Requirement	BR- 31		Very High	+		+	
PCDH-04	XBees shall operate in unicast mode only.	Base Requirement	BR- 33		Very High	+	+	+	
PCDH-05	The telemetry shall stop once the payload lands	Requirement (Given in mission overview)	Mission Overview, FSW-9		Very High		+		+

CDH Requirements (2/3)

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
PCDH-06	All telemetry shall be transmitted in engineering units (meters, meters/sec, Celsius, etc.)	Base Requirement	BR- 37	GCS- 7	Very High	+		+	+
PCDH-07	Telemetry data received shall be plotted in real time and stored in a .csv file	Telemetry Requirement	BR- 29	GCS- 1 GCS-2	Very High	+	+	+	+

CDH Requirements (3/3)

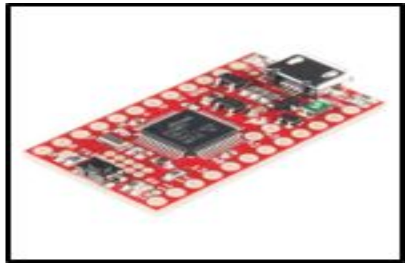
2. Container

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
CCDH-1	The container shall release the science payload at an altitude of 450 +/- 10m during descent.	Base requirement	BR- 9	FSW-8	Very High	+			
CCDH-2	Container shall consist of separate microcontroller, BMP280 for measuring altitude and a nichrome wire, powered by a battery.	To measure the altitude and command the MCU to burn the nichrome wire at 450m.			Very High	+	+		
CCDH-3	The container shall be opened through nichrome burning mechanism by passing a high current through the wire using power BJT.	Quite effective mechanism for container opening	CCDH-1		Very High	+			
CCDH-4	EEPROM of MCU shall be used to save the height at which container opened.	To prove that the container has opened			Very High		+		

Payload Processor & Memory Selection (1/5)

SECTION-A: Telemetry Section

Feature	Quantity
Processor	ARM Cortex-M0+ CPU running at up to 48MHz Single-cycle hardware multiplier Micro Trace Buffer (MTB)
Memory	256KB Flash Memory 32KB SRAM 32KB of EEPROM (emulated in Flash)
Serial Interfaces available	Up to six Serial Communication Interfaces (SERCOM), each configurable to operate as either: •USART with full-duplex and single-wire half-duplex configuration •I2C up to 3.4MHz •SPI •LIN slave
Boot time	~1.7s
Serial Interfaces used	UART: 2 + 1 (for debug only) I2C: 1 SPI: 1
GPIOs available	Total: 21 Analog Input: 11 Analog Output: 1 Digital: 21 PWM: 10 HW Interrupts: 21



Reasons for selection of **Spark Fun SAM D21 Mini Breakout** :

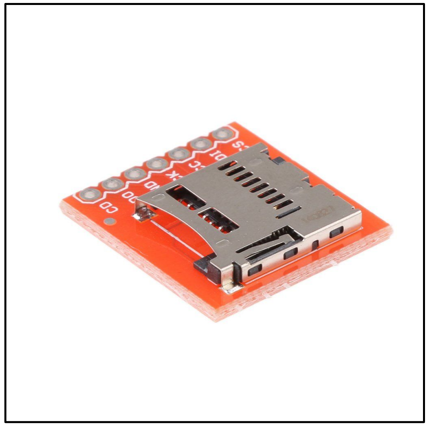
- Multiple UART interfaces: Allows faster communication with multiple UART peripherals·
- Faster CPU and greater memory: Allows faster code execution and more space for code·
- Inbuilt RTC: Allows us to eliminate external RTC·
- 3.3V operation: Allows us to build a more power efficient system

SD Card Sheild Selection

SECTION-A: Telemetry Section

Model Number	Connection Type	Size(cm2)	Weight (gram)	Supply Voltage (V)	Price($)
Street27 MicroSD TF Memory Card Board Adapter Shield	SPI	2.5 x 2.4	4.54	3.0 to 5.0	3.48

Reasons for selection of **Street27 MicroSD TF Memory Card Board Adapter Shield**:
1. Less weight
2. Smaller footprint
3. No redundant LDO and level shifter: More power efficient



Payload Processor & Memory Selection (3/5)

SD Card Slection

SECTION-A: Telemetry Section

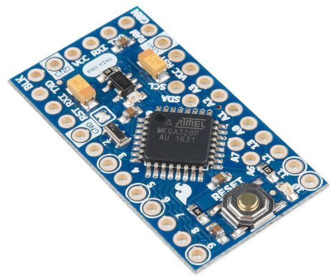
Model Number	Speed	Dimensions (mm^2)	Capacity	Operating Temperature	Price($)
Sandisk 8GB Class 4	**40 Mb/s**	**15 x 11**	**8 GB**	**-25C to 85C**	**5.77**

Reasons for selection of **Sandisk 8GB Class 4** :
1. High Speed
2. More durable.
3. Small size and low weight.
4. Supports all data formats.

Payload Processor & Memory Selection (4/5)

SECTION-B: Stand-Alone Camera Stabilization Section

Feature	Quantity
Processor	AVR enhanced RISC architecture (8 bit) Clock speed of upto 16MHz
Memory	32KB Flash Memory 2KB SRAM 1KB of EEPROM
Boot Time	~2-3s
Serial Interfaces available	1 Programmable Serial USART 1 Master/Slave SPI Serial Interface 1 Byte-oriented 2-wire Serial Interface (Philips I2C compatible)
Serial Interfaces used	UART: 1 (for debug only) I2C: 1 SPI: 1
GPIOs available	Total: 21 Analog Input: 8 Digital: 21 PWM: 6



Reasons for selection of **Arduino Pro Mini (5v/16MHz)** :
- Cheaper
- Lesser number of redundant MCU peripherals
- 5V operation: Allows us to directly communicate to all the PCB I/O devices

Payload Processor & Memory Selection (5/5)

SECTION-B: Stand-Alone Camera Stabilization Section

Model Number	Speed	Dimensions (mm^2)	Capacity	Operating Temperature	Price($)
Sandisk 8GB Class 4	**40 Mb/s**	**15 x 11**	**8 GB**	**-25C to 85C**	**5.77**

Reasons for selection of **Sandisk 8GB Class 4** :

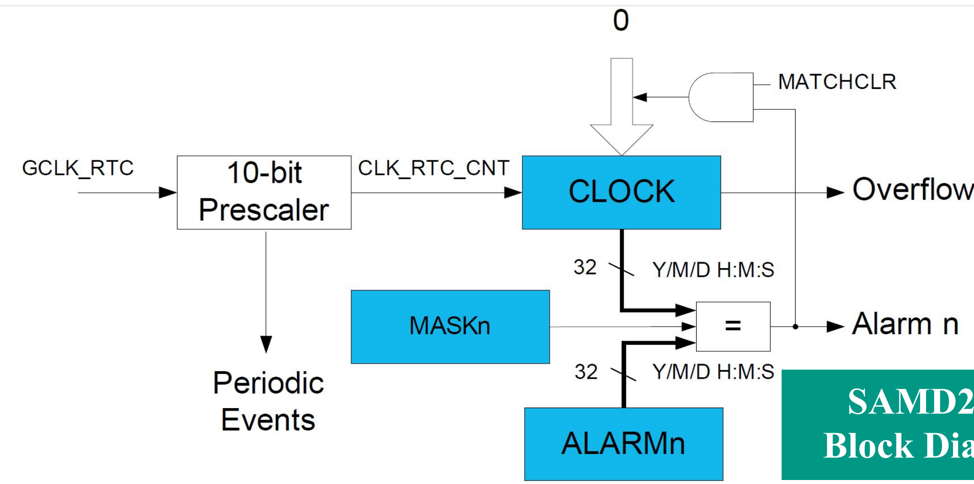
1. High Speed
2. More durable.
3. Small size and low weight.
4. Supports all data formats.

Payload Real-Time Clock

Model	Interface	Hardware/ Software	Weight/size	Cost	Power	Accuracy
SAMD21 INTERNAL RTC	-	**HARDWARE (INTERNAL)**	-	-	**Coin Cell Battery**	**5-20 ppm (determined by crystal selected)**

Reasons for selection of **SAM D21 internal RTC**:

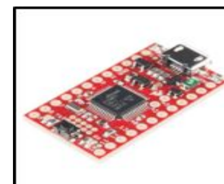
1. Reduces weight by not using external RTC
2. 32-bit counter with a 10-bit programmable pre-scaler
3. Multiple clock sources
4. Digital pre-scaler correction/tuning for increased accuracy
5. Overflow, alarm/compare match and pre-scaler interrupts and events.



SAMD21 Microcontroller Internal RTC Block Diagram (Mode 2 – Clock/Calendar)

Reset Tolerance:

1. The Real-Time Counter (RTC) is a 32-bit counter with a 10-bit programmable pre-scaler that typically runs continuously to keep track of time. It is not affected by the CPU reset.
2. But the MCU needs to be continuously powered.
3. When the battery is disconnected, the MCU is put in Standby mode and is powered by an external coin cell.
4. Only the RTC and a few other peripherals are powered in Standby mode. So the internal RTC can run off the coin cell for years.



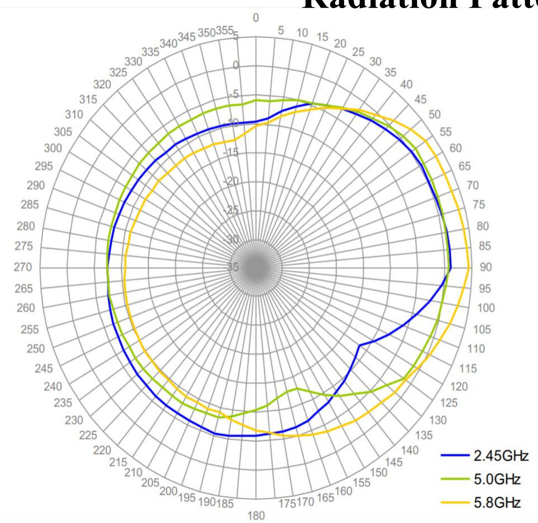
Payload Antenna Selection (1/2)

Model	Frequency	Gain	Impedance	VSWR	Weight	Dimensions	Connector	Polarization	Temperature	Input Power	Range* (m)	Cost
FXP830 Freedom Patch Antenna	2.4 - 2.5 GHz	2.6 dBi	50 Ohms	< 2.0	1g	42 x 7	Ipex MHF	Linear	-40C to 85C	2W Max	1710	$7.88

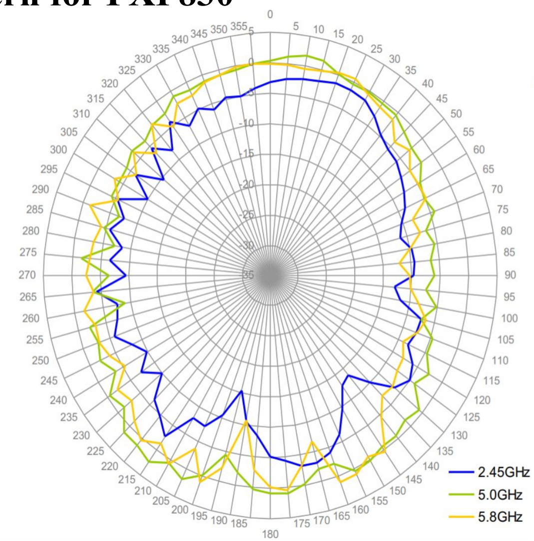
Reasons for selection of **FXP830**:
1. Omnidirectional in nature this antenna allows data transmission in all directions.
2. It's light weight and negligible size helps in the accommodation of other components.
3. Low connector impedance causes low signal loss.
4. Light weight (1g)

Payload Antenna Selection (2/2)

Radiation Pattern for FXP830



Horizontal Plane



Vertical Plane

Antenna VSWR against frequency

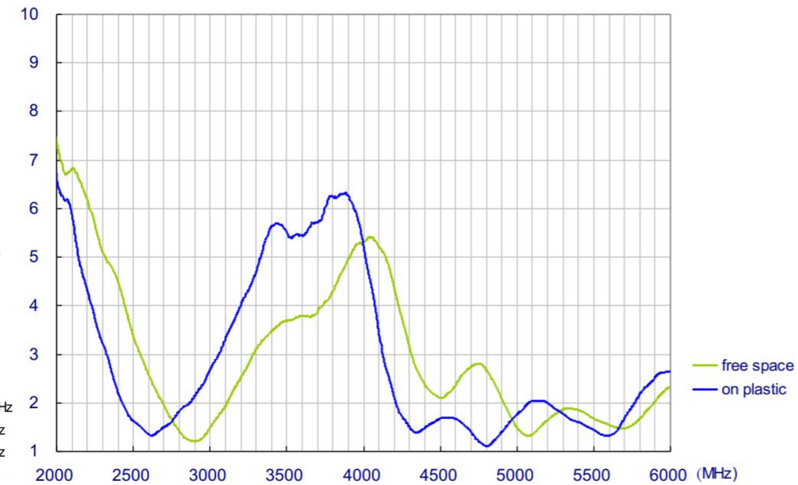


TABLE FOR ANTENNA RANGE CALCULATION

Parameter	Gain(dB)	Transmission Power(dBm)	Frequency(MHz)	Cable Loss(dB)	Receiver Sensitivity(dBm)	Free Space Path Loss(dB)
Value	2.6	33.103	2400	4	-73	111.703

Calculated Range = 1710m

Payload Radio Configuration (1/2)

Device	Operating frequency	Tx supply current	Rx supply current	Sensitivity	Cost
XBee Pro S2C	2.4 GHz	120mA @ 3.3V	31mA @ 3.3V	-101 dBm	27.65

Reasons for selection of **XBEE Pro S2C**:
1. Data/Clock rates of up to 5Mb/s are possible.
2. High operating frequency.
3. Low Tx and Rx currents.

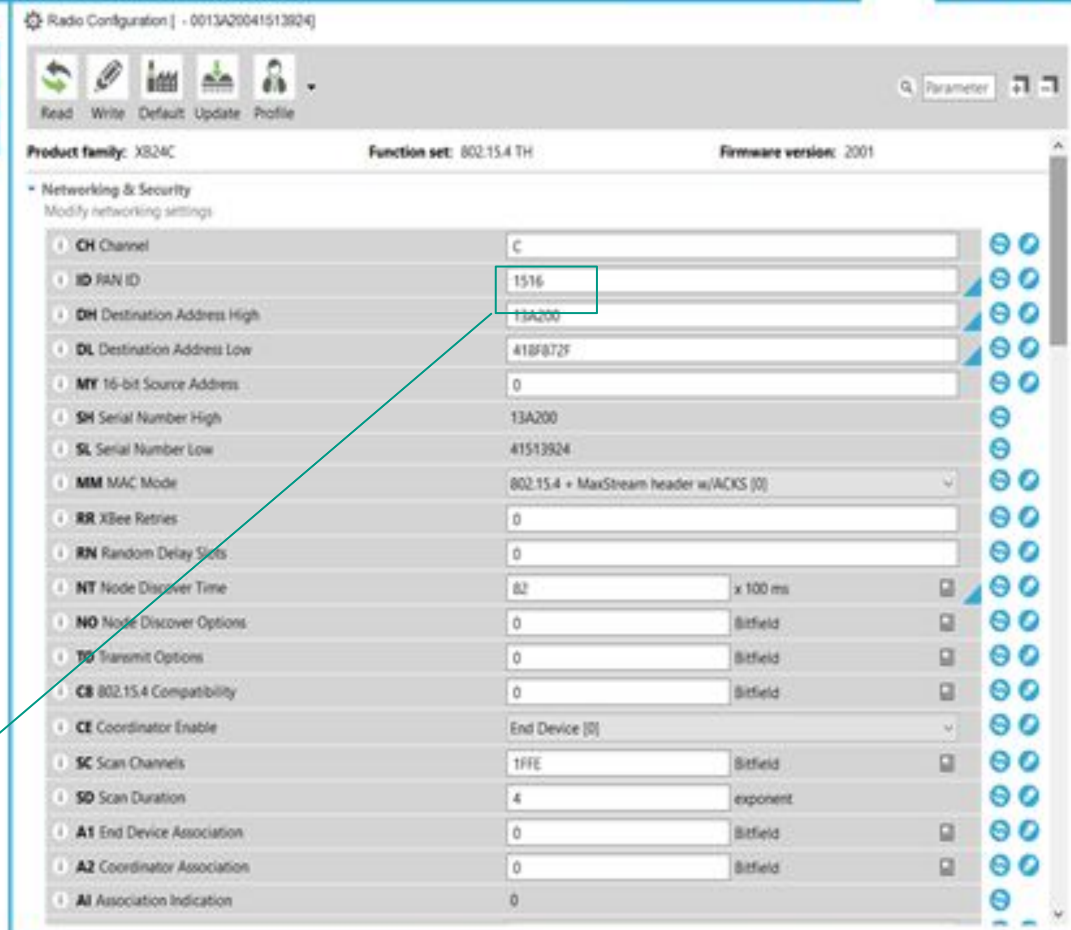
- **Team ID: 1516**
- **Transmission is ceased once landing state is detected by various sensor data (altimeter, blade spin rate sensor)**
- **Upon powering up, the CanSat payload shall collect the required telemetry at a 1 Hz sample rate.**

Payload Radio Configuration (2/2)

Transmission Control

Transmission is ceased once landing state is detected by various sensor data:

- Accelerometer reads a sharp negative pulse.
- Air pressure reaches maxima and becomes constant.
- Blade Spin Rate becomes zero.
- Pitch and roll become constant at some non-zero value.



PANID set to team number

XCTU Screenshot

Payload Telemetry Format (1/2)

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

S.no.	Telemetry Data Field	Description
1.	**Team ID**	ID Allocated at Registration, 1516
2.	**Mission Time (s)**	Time since the initial Power up (Res. = 1/1024 s i.e. 9.765ms)
3.	**Packet Count**	Count of Telemetry Packets, reset fallacy check using SD Card Backup
4.	**Altitude (m)**	Payload altitude from ground level (Res = 0.1m)
5.	**Pressure (Pa)**	Atmospheric Pressure observed (Res = 0.1Pa)
6.	**Temperature (C)**	Atmospheric Temperature observed (Res = 0.01C)
7.	**Voltage (V)**	CanSat Power Bus Voltage (Res of ADC = 1 mV approx.)
8.	**GPS Time (s)**	Time reported by the GPS receiver (Res. = 1 us)
9.	**GPS Latitude (deg)**	Latitude reported by the GPS receiver (Res. = 0.00013 deg.)
10.	**GPS Longitude (deg)**	Longitude reported by the GPS receiver (Res. = 0.00013 deg.)
11.	**GPS Altitude (m)**	Altitude reported by the GPS receiver (Res. = +/- 1mm)
12.	**GPS Satellites**	Number of satellites reported by the GPS receiver
13.	**Pitch and Roll (deg)**	Tilt angle in the Pitch and Roll axis (Res = 0.0003)
14.	**Blade Spin Rate (rpm)**	Rate of rotation of auto-gyro blades rotate wrt. Science payload (Res = 0.25 rpm)
15.	**Software State**	Boot/ Idle / Launch Detect/ Deploy (etc)
16.	**Bonus Direction (deg)**	Direction in which the camera points rel. to magnetic north (Res = 0.6)

Payload Telemetry Format (2/2)

Packet Transition Format

<TEAM ID>,<MISSION TIME>,<PACKET COUNT>,<ALTITUDE>, <PRESSURE>,<TEMP>, <VOLTAGE>,<GPS TIME>,<GPS LATITUDE>,<GPS LONGITUDE>,<GPS ALTITUDE>,<GPS SATS>, <PITCH>, <ROLL>, <BLADE SPIN RATE> ,<SOFTWARE STATE>, <BONUS(camera)>

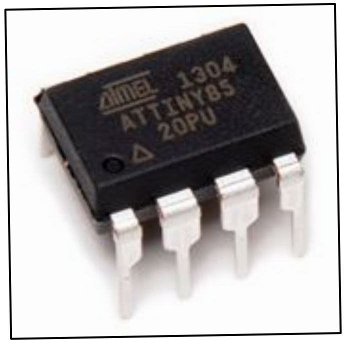
Example:

1516,200,121,410,60,6.01,3.65,02:00,20.59,78.96,405,4,40,20,3,1,7

1. Data is transmitted at a rate of 1Hz.
2. Baud rate utilized for packet transmission is 9600.
3. Transmission Mode-Continuous

Container Processor & Memory Selection (1/2)

Feature	Quantity
Processor	AVR enhanced RISC architecture (8 bit) running at 10 MHz
Boot Time	64ms
Memory	8KB Flash Memory 512 Bytes SRAM 512 Bytes of EEPROM
Serial Interfaces available	1 USI – Universal Serial Interface with start condition detector.
Serial Interfaces used	I2C: 1
GPIOs available	Total: 6 Analog Input: 4 Digital: 6 PWM: 2



Reasons for selection of **ATtiny 85**:
- Small form factor saves weight and space.
- More power efficient.
- Easy to programme and test.

Container Processor & Memory Selection (2/2)

Memory Selection

Model Number	Weight (g)	Dimensions (mm^2)	Capacity	Interface	Price($)
EEPROM 24AA64	**1**	**4.8 x 5.8**	**64 kB**	**I2C**	**0.45**

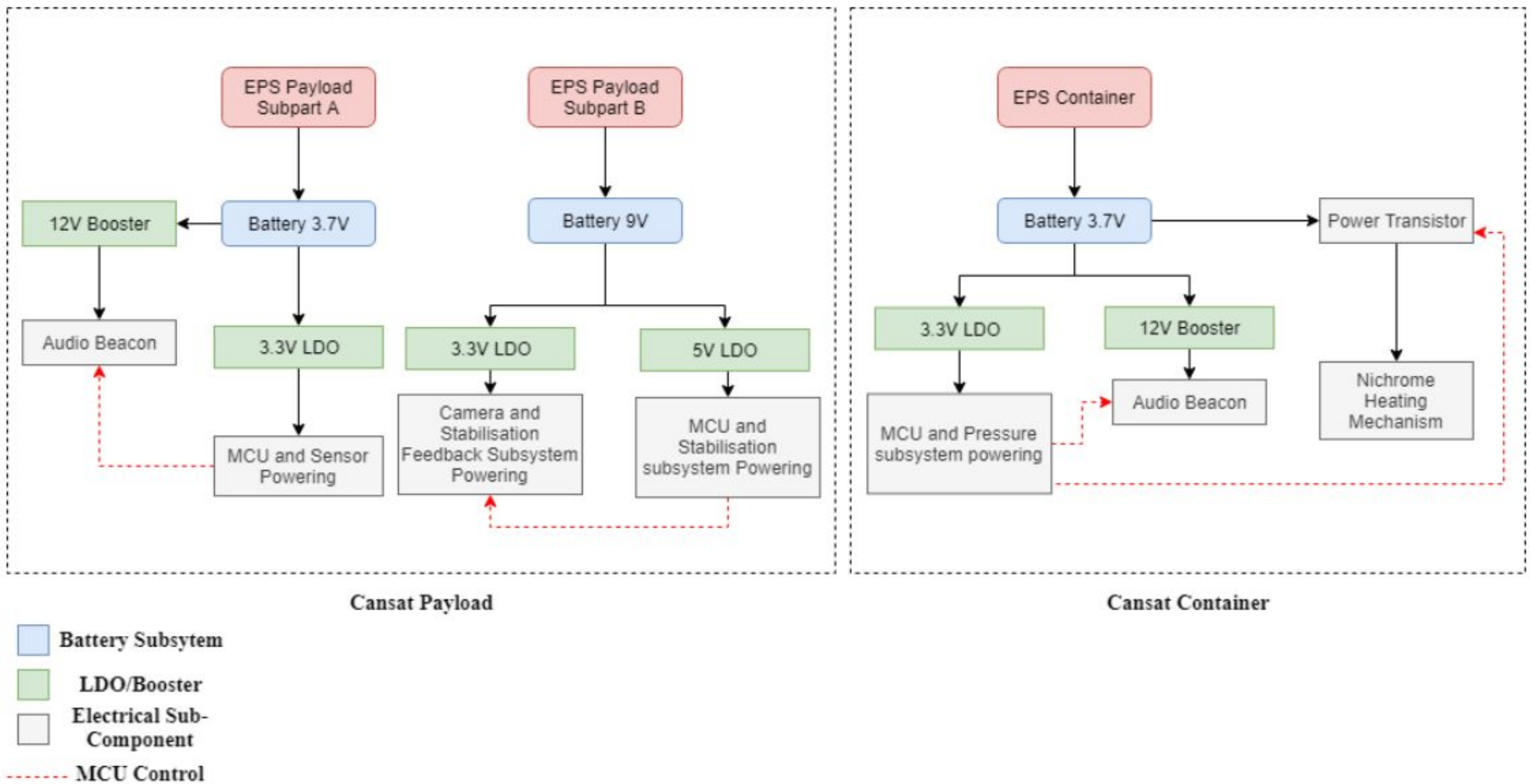
Reasons for selection of **EEPROM 24AA64**:

1. Sufficient storage space to save altitude data for container opening.
2. Operates on less power as it works on low power CMOS technology.
3. Noise is suppressed using Schmitt trigger.

Electrical Power Subsystem (EPS) Design

Shikhar Makhija

EPS Overview



EPS Changes Since PDR

PDR	CDR	REASONS
TIP120 NPN BJT for nichrome wire burning setup	12V relay	• There was a very large voltage drop across the BJT which allows less power to be transferred to the nichrome wire. • There was a large power loss in the BJT.

EPS Requirements (1/2)

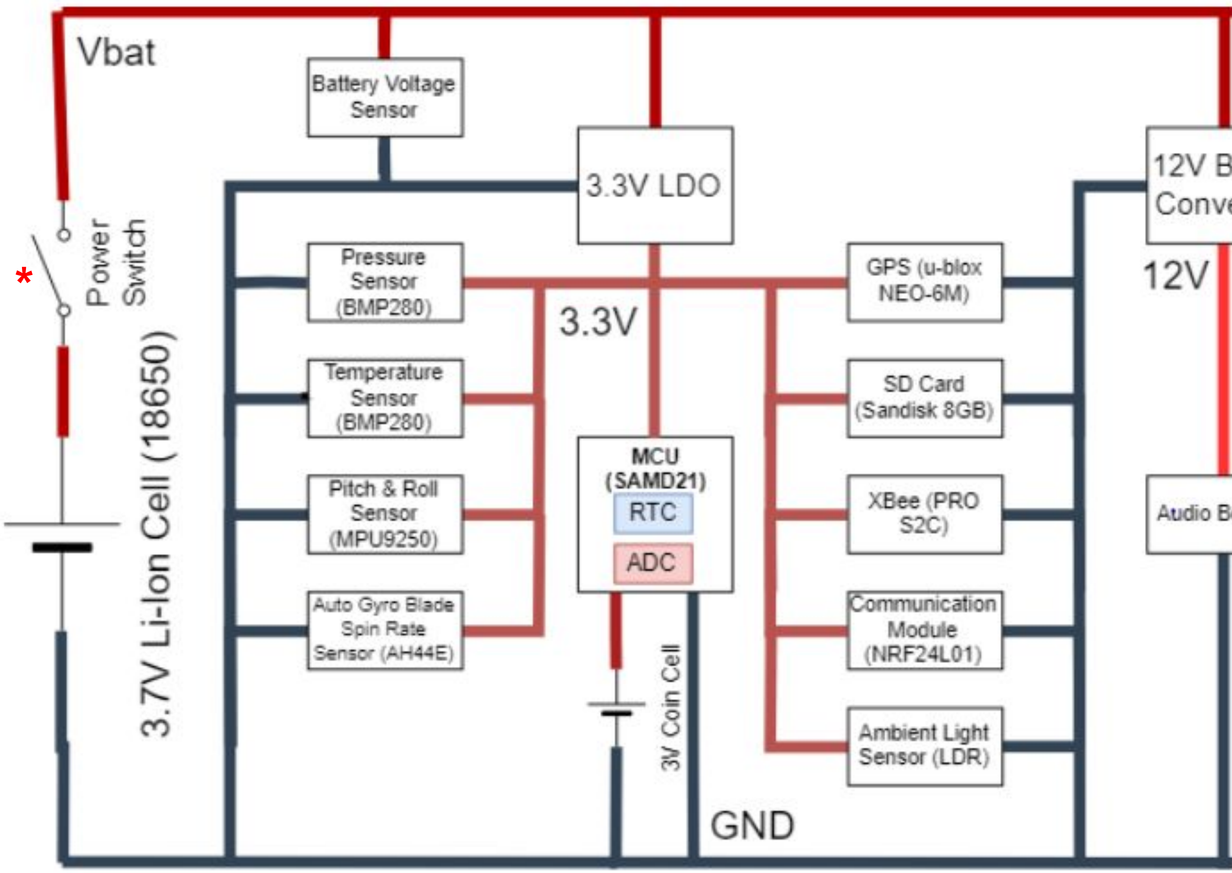
ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
EPS- 1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Base Requirement	BR- 1		Very High	+	+	+	
EPS- 2	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Base Requirement	BR- 13		High	+	+	+	
EPS- 3	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.	Base Requirement	BR- 19		High	+	+	+	
EPS- 4	The probe must include an easily accessible power switch that can be accessed without disassembling the cansat and in the stowed configuration	Base Requirement	BR- 45		Very High		+	+	+
EPS- 5	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.	Base Requirement	BR- 46		Very high	+	+	+	
EPS- 6	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Base Requirement	BR- 47	FSW- 9	Very high		+	+	+

EPS Requirements (2/2)

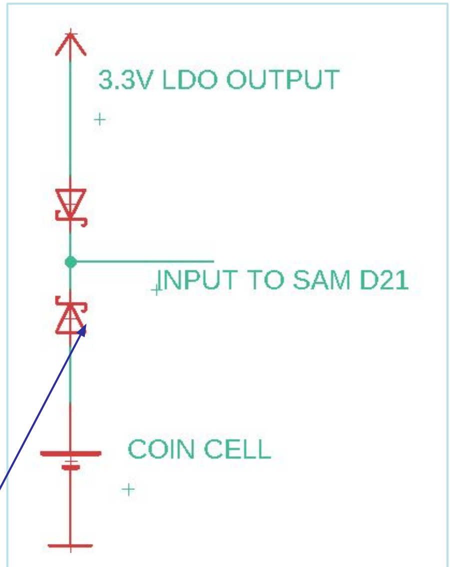
ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
EPS- 7	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Base Requirement	BR- 48		Very high	+	+	+	+
EPS- 8	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.	Base Requirement	BR- 49		Very high	+	+	+	+
EPS- 9	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.	Base Requirement	BR- 50		High	+	+	+	
EPS- 10	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Base Requirement	BR- 51		High	+	+		
EPS- 11	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Base Requirement	BR- 55		Very high	+	+	+	+

Payload Electrical Block Diagram (1/2)

The Payload EPS, is divided into two sub-parts A and B.



Sub-part: A



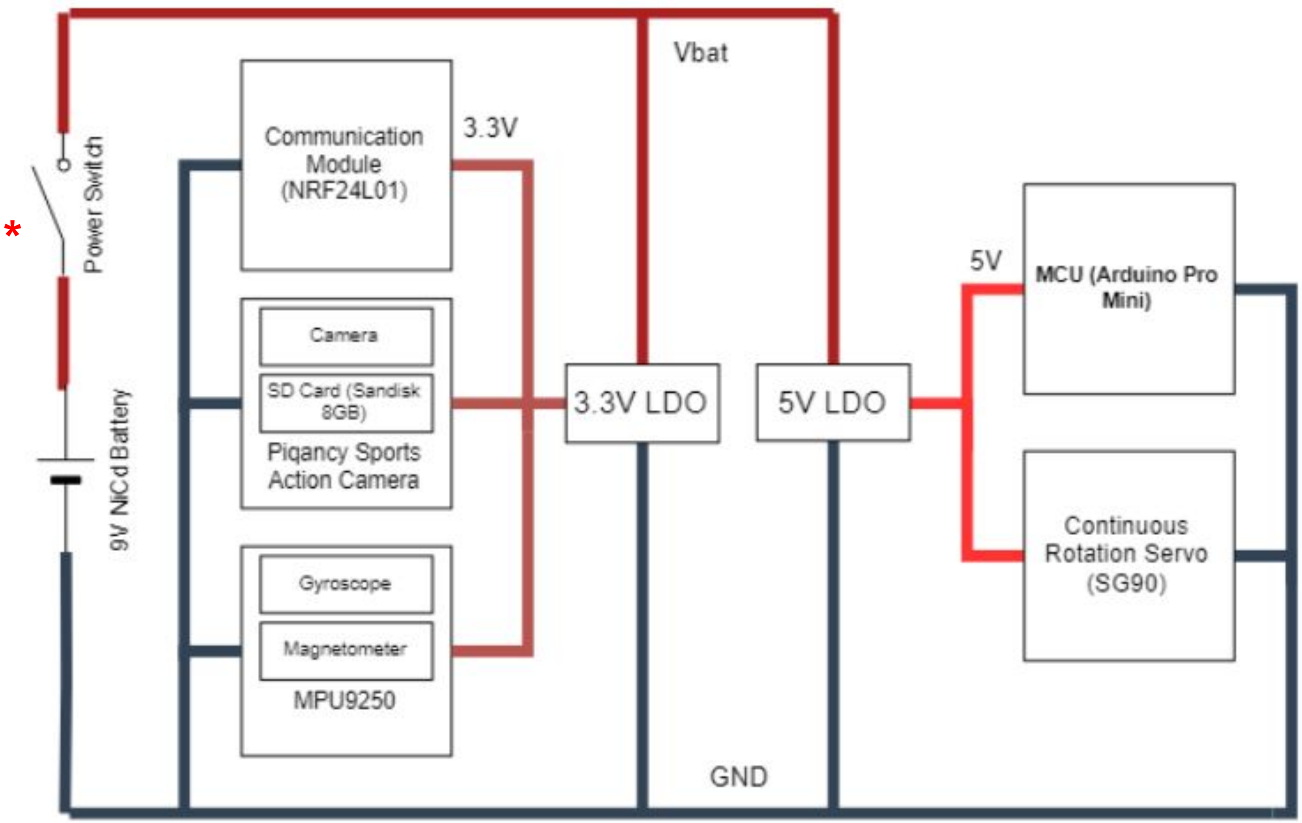
Schottky diode for faster switching and low drop

Battery to Coin-cell Switching Circuit (Internal RTC Management)

Payload Electrical Block Diagram (2/2)

The Payload EPS, is divided into two sub-parts A and B.

*Payload is divided into two parts: Section A- Telemetry Section and Section B: StandAlone Camera Stabilization Section



Sub-part: B

Umbilical power source to CanSat: DC Jack with voltage 9V.

Payload Power Source(1/2)

The Payload Power Trade and Selection – Subpart A

Model	Type	Voltage(V)	Capacity (mAh)	Dimensions (mm^2)	Mass (g)	Price ($)
Samsung 18650 25R	**Li-ion cell**	**3.7**	**2500**	**18.3 x 64.8**	**45**	**14.33**

Battery Configuration: A single 3.7V Samsung 18650 25R was utilized in powering Payload Subpart – A.

Salient features:

1. Nominal Voltage: 3.6V
2. Current Capacity: 2500 mAh
3. Max. continuous discharge current: 20A(at 25℃), 60% at 250 cycle

Reasons for selection of **Samsung 18650 25R**, for subpart-A :

1. High capacity, needed to operate payload for 2 hours, satisfies for system.
2. Voltage requirement of all sensors and MCU is fulfilled.
3. Longer battery life.

Payload Power Source (2/2)

The Payload Power Trade and Selection – Subpart B

Model	Type	Voltage(V)	Capacity (mAh)	Dimensions (mm^2)	Mass (g)	Price ($)
Envie Rechargeable Battery	Ni-Mh	9	300	48.5 X 26.5	31.8	8.80

Battery Configuration: A single 9V Envie rechargeable battery was utilized in powering Payload Subpart – B.

Salient features:

1. Nominal Voltage: 9V
2. Current Capacity: 300 mAh
3. **Max. continuous discharge current: 700mA**

Reasons for selection of **Envie Rechargeable Battery**, for subpart-B:

1. Caters to the need of power subsystem, and eliminates the need for boost, and in turn the use of a more complex circuit.

Payload Power Budget (1/4)

The Payload Power Budget – Subpart A

Pre – Flight Time = 2 hrs.
In – Flight Time = 2 min = 0.033 hrs.
Post – Flight Time = 1 hrs.

Component	Current (mA)			Voltage (V)	Duty Cycle (%)			Average Power Consumed (mW)			Average Energy Consumed (Wh)	Source
	Min	Typical	Max		Pre-Flight	In-Flight	Post-Flight	Pre-Flight	In-Flight	Post-Flight		
Sparkfun SAMD21 Mini	0.025	30	92	3.3	100	100	100	99	99	99	**0.305247**	Datasheet/ Estimate
Xbee-Pro S2C	36	120	120	3.3	2	2	2	124.34	124.34	118.8	**0.377838**	Datasheet
GPS UBLOX-NEO6m	39	47	67	3.3	0	100	100	128.7	155.1	128.7	**0.39902**	Datasheet
NRF24L01	0.4	11.95	13.5	3.3	0	1.6	0	1.32	36	1.32	**0.006959**	Datasheet
Buzzer	0	20	20	12	0	0	100	0	0	240	**0.24**	Datasheet
BMP280	0.003	0.72	1.12	3.3	0	100	0	0.009	2.37	0.009	**0.000225**	Datasheet
MPU9250	0.008	3.7	3.7	3.3	0	100	0	0.027	12.21	0.027	**0.0011**	Datasheet
SD Card	0.25	3.61	75	3.3	0	4.5	0	0.825	11.92	0.825	**0.003468**	Datasheet

Payload Power Budget (2/4)

Team B.A.G.S.
Ballistic Auto-Gyro Satellite

The Payload Power Trade and Selection – Subpart A

Component	Current (mA)			Volta (V)	Duty Cycle (%)			Average Power (mW)			Average Energy Consumed (Wh)	Source
	Min	Typical	Max		Pre-Flight	In-Flight	Post-Flight	Pre-Flight	In-Flight	Post-Flight		
Auto-Gyro Blade Spin Rate Sensor	6	6	9	3.3	100	100	100	19.8	19.8	19.8	**0.061049**	Datasheet
Battery Voltage Sensor	0.185	0.185	0.185	3.7	100	100	100	0.684	0.684	0.684	**0.002109**	Calculation
Ambient Light Sensor	0.165	0.247	0.33	3.3	100	100	100	0.815	0.815	0.815	**0.002513**	Calculation
Miscellaneous (LEDs and other passive components)	50	50	50		100	100	100	165	165	165	**0.508745**	Estimate
LM1117 LDO	132.04	273.41	431.83	3.7	100	100	100	52.8	109.36	52.8	**0.16751**	Estimate
LTC3121 Boost Converter	0.5	20	20	3.7	0	0	100	1.65	1.65	12.6	**0.016037**	Estimate
Total			**665.577**					**594.97096**	**738.249**	**840.381**	**2091.819**	

Total Power Consumed = 2091.819 mWh

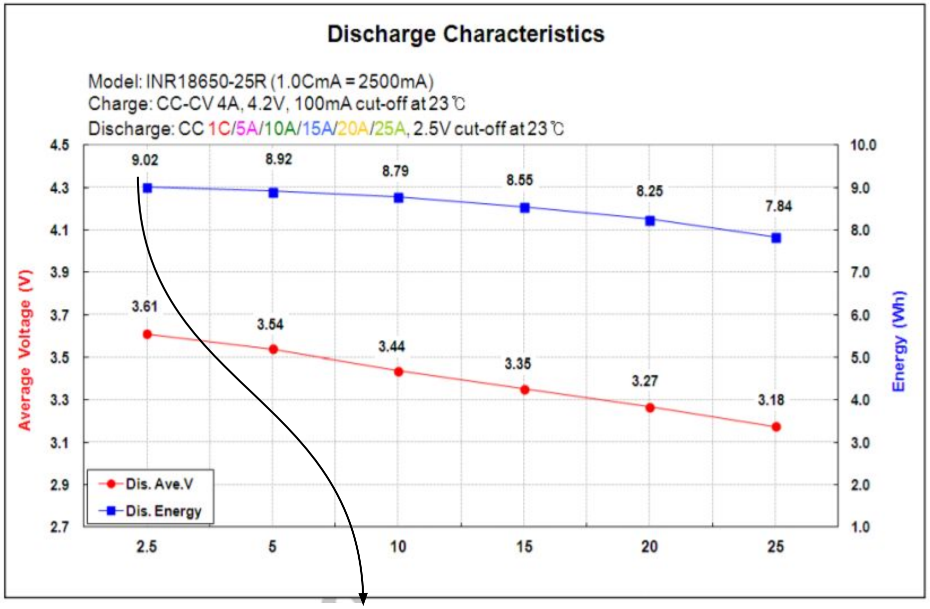
Payload Power Budget (3/4)

The Payload Power Trade and Selection – Subpart B

Component	Current (mA)			Voltage(V)	Duty Cycle(%)			Average Power (mW)			Average Energy Consumed	Source
	Min.	Typical	Max.		Pre-flight	In-flight	Post-flight	Pre-flight	In-flight	Post-flight	Net(Wh)	
Arduino Pro Mini	0.025	50	92	5	100	100	100	250	250	250	**0.770825**	Datasheet/ Estimate
Servo (SG90)	20	50	125	5	0	80	0	100	550	100	**0.345815**	Datasheet/ Estimate
MPU9250	0.0084	3.7	3.7	3.3	0	100	0	0.028	12.21	0.0277	**0.0011**	Datasheet
NRF24L01	0.4	11.95	13.5	3.3	0	1.6	0	1.32	36	1.32	**0.006959**	Datasheet
SD Card	0.25	3.61	75	3.3	0	33	0	0.825	24.92	0.825	**0.00455**	Datasheet
Piqancy Sports Action Camera	0.003	10	20	3.3	0	50	0	0.009	33	0.009	**0.002776**	Estimate
Miscellaneous (LEDs and other passive components)	50	50	50		100	100	100	165	165	165	**0.508745**	Estimate
LM1117 LDO	5	19.26	117.2	9	100	100	100	28.5	109.36	114	**0.18011**	Estimate
LM7805 LDO	4.3	160	221.3	9	100	100	100	480	640	480	**1.493312**	Estimate
Total			**338.5**					**1026**	**1821**	**1111**	**3314.192mWh**	

Total Power Consumed = 3314.192 mWh

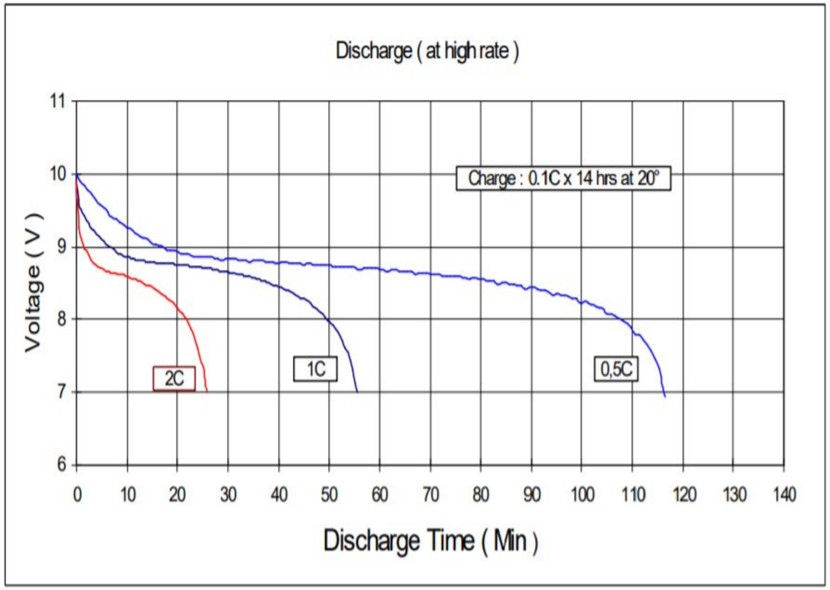
Subpart – A: Samsung 18650 25R



From the graph, the battery capacity is approximately, 9.250Wh at **average** current drawn rate 0. 5A (80% of peak, approx.)

Energy required by Payload Sub-Part A = 2.0918Wh
Margin Offered = 9.250 – 2.0918 = 7.1582Wh

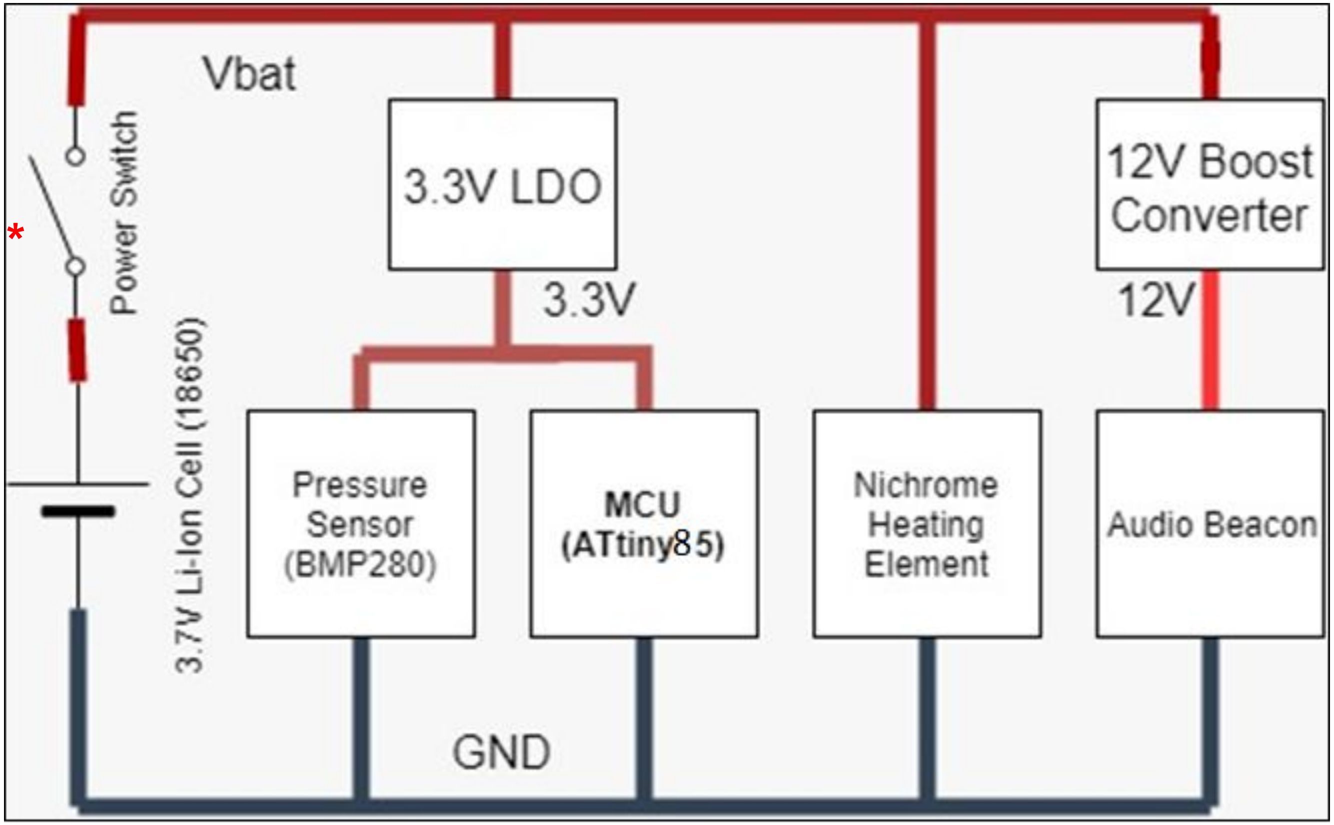
Subpart – B: Envie 9V NiMh



The battery capacity averaged: 8V x 700 mA = 5.6Wh

Energy required by Payload Sub-Part B = 3.314Wh
Margin Offered = 5.6 – 3.314 = 2.286Wh

Container Electrical Block Diagram



Container Block Diagram

Umbilical power source to CanSat: 5V DC Jack

Container Power Source

Model	Type	Voltage(V)	Capacity (mAh)	Dimensions (mm^2)	Mass (g)	Price ($)
Samsung 18650 25R	Li-ion cell	3.7	2500	18.3 X 64.8	45	14.33

Battery Configuration: A single 3.7V Samsung 18650 25R was utilized in powering Container.

Salient features:

1. Nominal Voltage: 3.6V
2. Current Capacity: 2500 mAh
3. **Max. continuous discharge current: 20A(at 25℃), 60% at 250 cycle**

Reasons for selection of **Samsung 18650 25R,** in container subsystem are:

1. High capacity of 20A CDR, to cater to the large current req. For nichrome burning mechanism.
2. Voltage requirement of all sensors and MCU is fulfilled.
3. Great weight-capacity ratio.

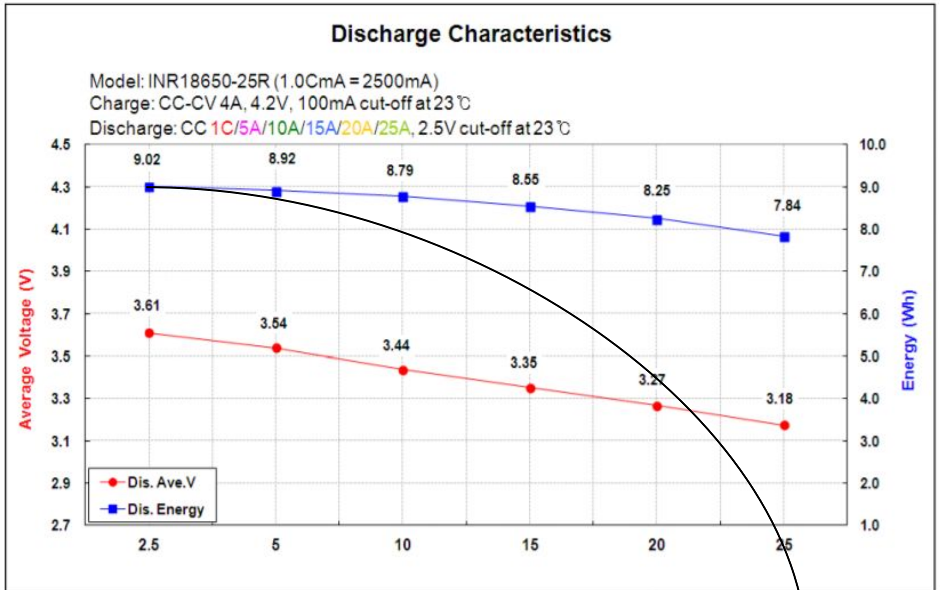
Container Power Budget (1/2)

Component	Current(mA)			Voltage (V)	Duty Cycle(%)			Average Power			Average Energy (Wh)	Source
	Min.	Typical	Max		Pre-Flight	In-Flight	Post-Flight	Pre-Flight	In-Flight	Post-Flight		
ATtiny85	0.35	2.5	10	3.3	100	100	100	8.25	8.25	8.25	**0.0254**	Datasheet/ Estimate
BMP280	0.0028	0.72	1.12	3.3	0	100	0	0.009	2.37	0.00924	**0.00022**	Datasheet
Buzzer	0	20	20	12	0	0	100	0	0	240	**0.24**	Datasheet
Nichrome Wire Burner	0	2000	2000	3.7	0	1.667	0	0	3.334	0	**0.0003**	Calculated
Miscellaneous (LEDs and other passive components)	50	50	50		100	100	100	165	165	165	**0.509**	Estimate
LM1117 LDO	5	3.22	11.12	3.7	100	100	100	2	11.288	2	**0.007**	Estimate
LTC3121 Boost Converter	0.5	20	20	3.7	0	0	100	1.65	1.65	12.6	**0.0160**	Estimate
Total			**2084.8**					**176.91**	**191.89**	**427.859**	**797mWh**	

Total Power Consumed = 797 mWh

Container Power Budget (2/2)

Container: Samsung 18650 25R



From the graph, the battery capacity is approximately, 9.250Wh at **average** current drawn rate 0.5A (80% of peak, approx.)

Energy required by Container = 0.797Wh

Margin Offered = 9.25 – 0.797Wh = 8.453Wh

Flight Software (FSW) Design

Raunit Singh

FSW Overview(1/2)

Programming Language

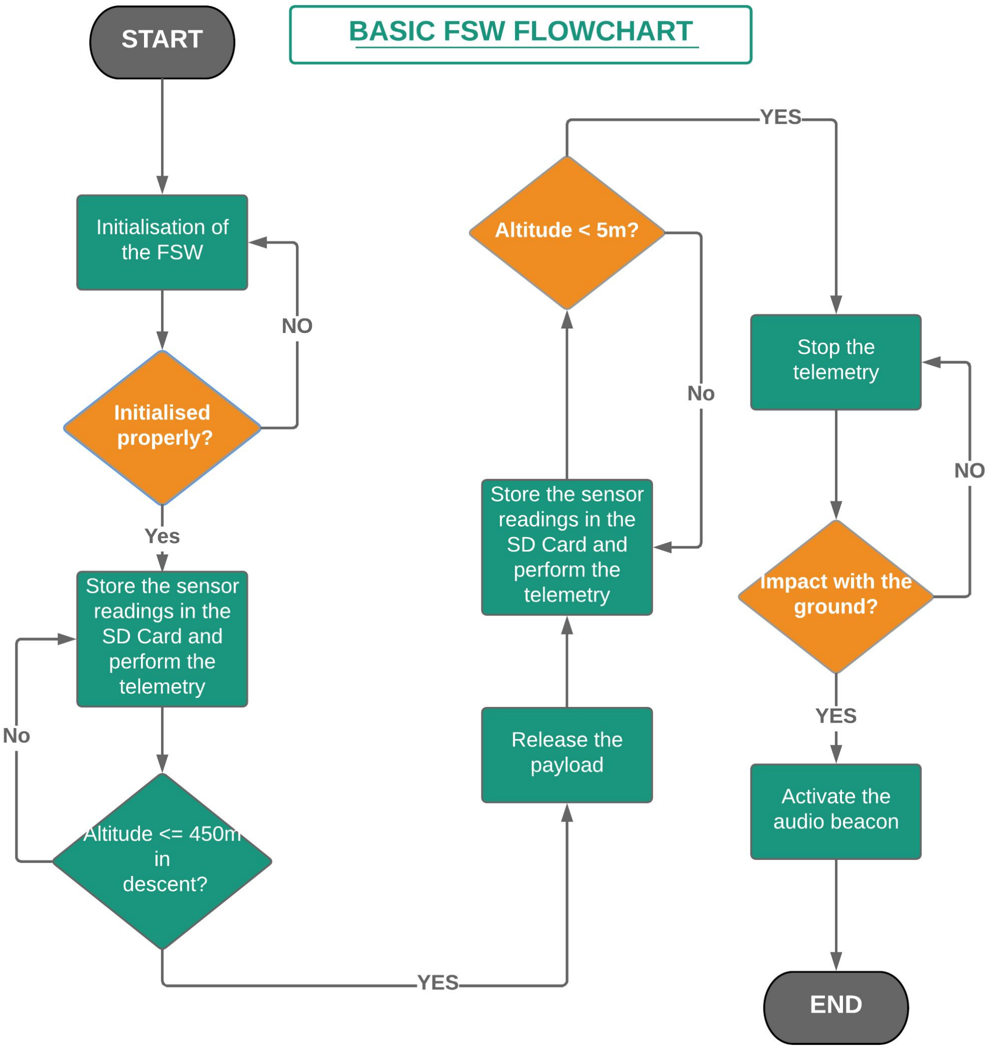
- C
- C++

Development Environment

- Arduino IDE

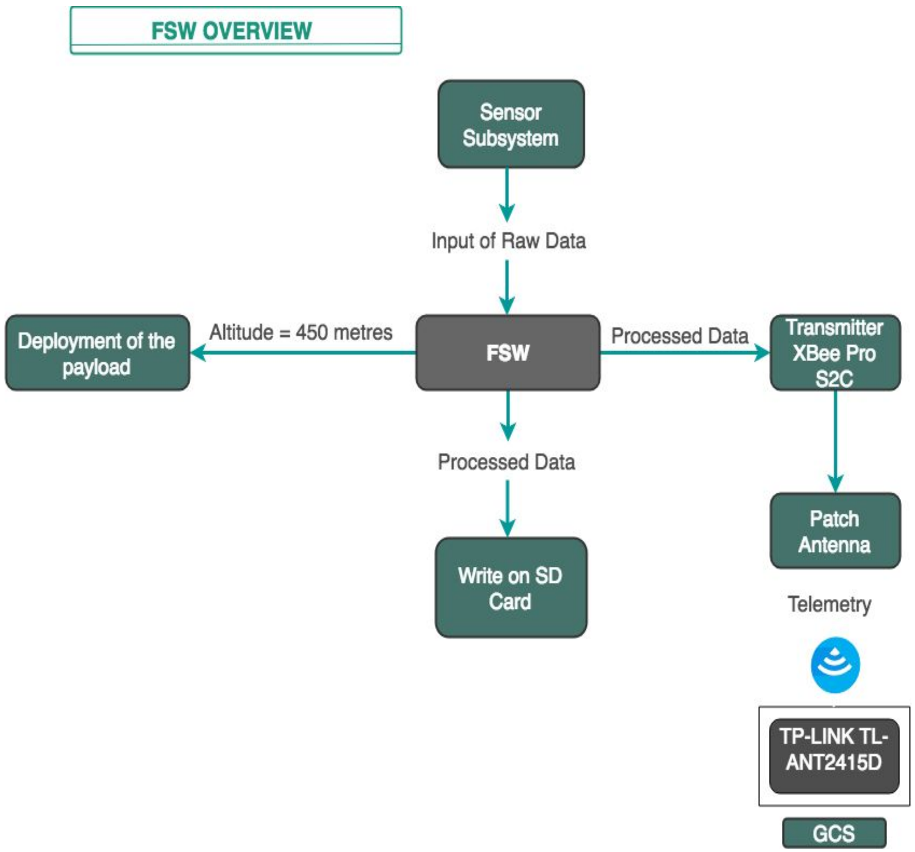
Rationale

- Vast set of predefined libraries.
- Reduces hassle of interfacing with a PC.
- Memory management of C/C++ extends the support for lower end microcontrollers.
- Great community support.
- Versatile and robust.
- Extremely fast execution as compared to other languages like python.



Brief Summary of FSW Tasks

- Calibrating the sensors and resetting the mission time to 0.
- Read the data from sensors (in raw format) and process the data.
- Telemetry of the processed data and storing the data in the SD card.
- Deployment of the payload when altitude = 450 meters.



FSW Changes Since PDR

No major changes were made to the Flight Software

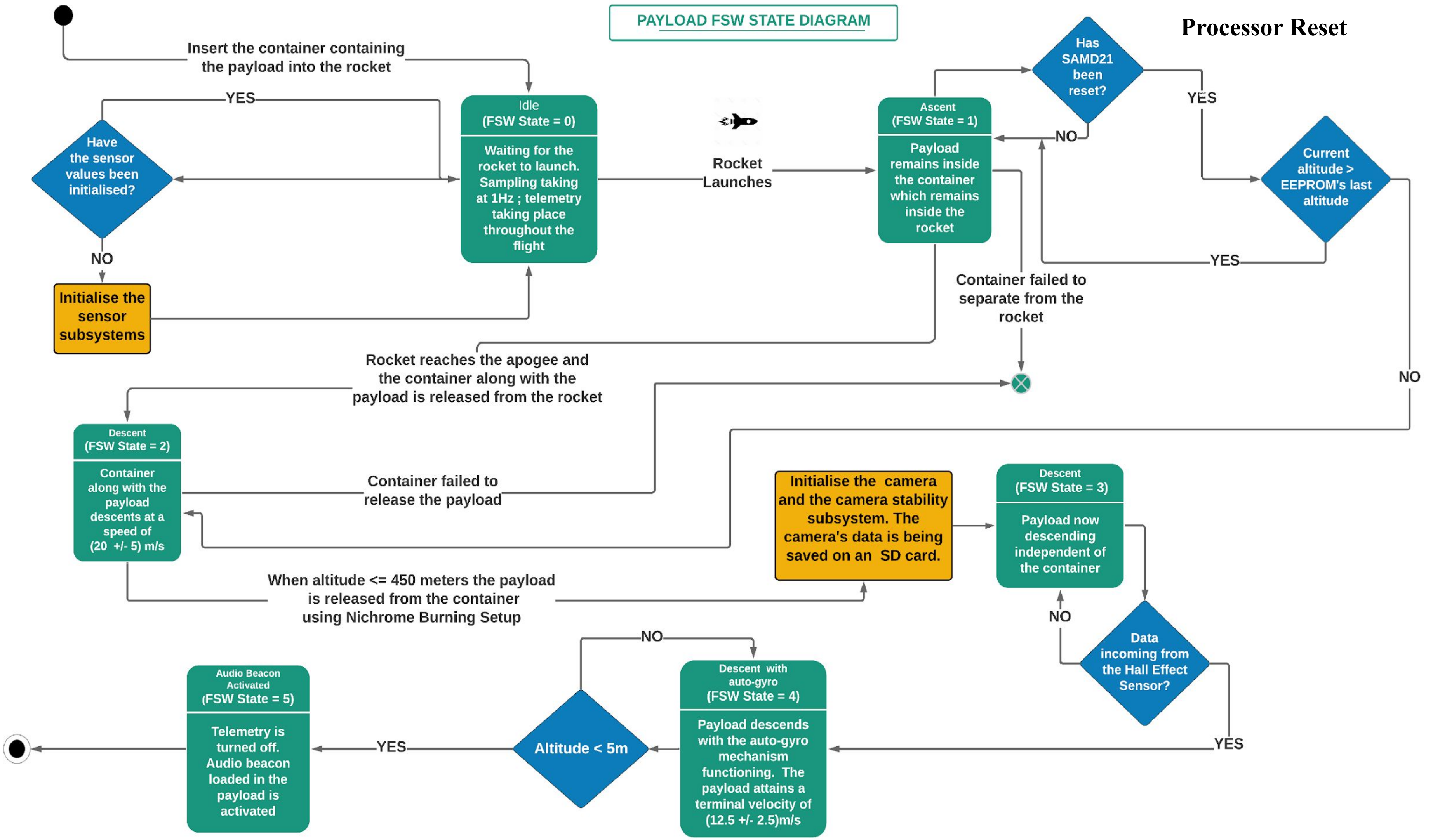
FSW Requirements (1/2)

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
FSW-1	The payload shall sample all the sensor data at a rate of 1Hz.	Base Requirement		PCDH- 02	High	+	+	+	
FSW-2	All the sensor data shall be transmitted through telemetry via XBEE radios.	Base Requirement	BR-31		High			+	+
FSW-3	The flight software maintains a count of the number of packets transmitted, it increments its value after sending each packet. The packet count value is maintained even if the processor resets.	Base Requirement	BR-42		High		+	+	
FSW-4	The microcontroller is programmed using Arduino IDE to acquire all the sensor data and transmit it through telemetry.	Base Requirement			High		+	+	+
FSW-5	The flight software shall have various software states (idle, ascent, descent, boot) which changes during flight, it will be transmitted through telemetry also.	Base Requirement			High		+	+	+

FSW Requirements (2/2)

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
FSW-6	All the sensors shall calibrate or reset when the payload sits on the Launchpad.	Base Requirement	BR-28 GCS- 6		Medium	+	+	+	
FSW-7	SD card is also used to store all the telemetry data during flight and descent.	Base Requirement			Medium		+	+	+
FSW-8	The flight software shall open the container when altitude is 450m, and the software state will change.	Base Requirement	BR-9 CCDH- 1		High	+	+	+	
FSW-9	Once the payload lands, all the telemetry shall stop with the activation of audio beacon.	Base Requirement	EPS- 6	PCDH- 06	High		+	+	+

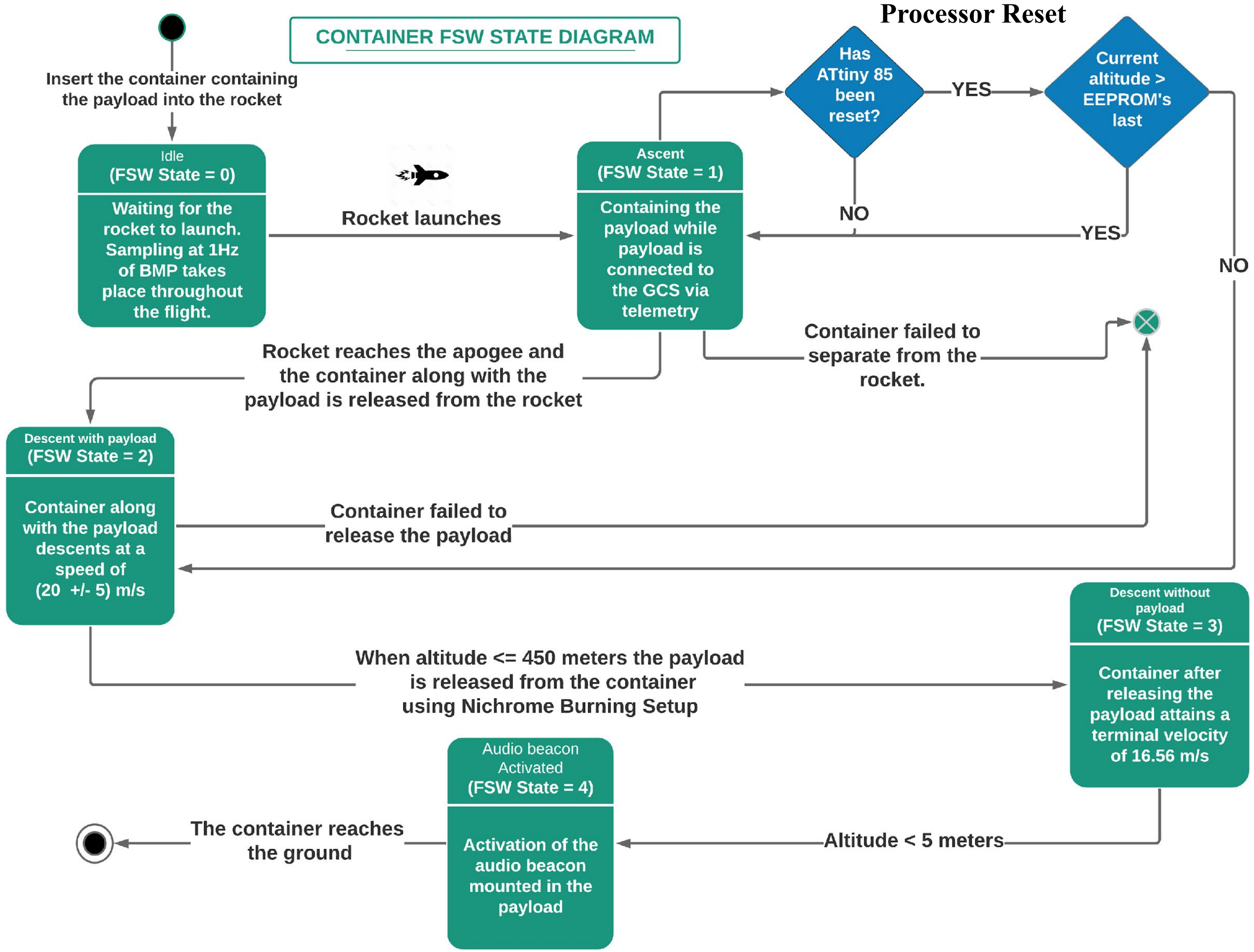
Payload CanSat FSW State Diagram (1/2)



Payload CanSat FSW State Diagram (2/2)

Sr. No.	Process	Description
1	**Sampling of sensors**	The sampling of sensors takes place throughout the flight at 1Hz frequency.
2	**Communication**	The communication between the payload and the GCS takes place via RF waves. The half-duplex communication (calibration command) between the payload and the GCS takes from patch antenna (FXP830) installed in the payload and the GCS Antenna(TLANT-2415D).
3	**Data Storage**	The storage of the camera's data after the initialisation of the camera subsystem takes place on the Camera module's SD card. The sensor's raw data is stored in the pre-installed SD card present in the Spark Fun SAMD21.
4	**Mechanism activations**	At 450m, the payload is released from the container which results in the kicking in of the auto-gyro mechanism(which is not controlled by software system). After turning off the telemetry, the audio beacon is activated.
5	**Major Decision Points in Logic**	Backup of the FSW State throughout the flight(refer to the state chart diagram for the details of the same). Activation of the auto-gyro mechanism(incoming of the data from the Hall Effect Sensor).
6	**Power Management**	The SAMD21 is kept on standby mode and is woken up when the power switch is pushed. It switches unused modules to standby mode when they are not being used to conserve power.

Container CanSat FSW State Diagram (1/2)



Container CanSat FSW State Diagram (2/2)

Sr. No.	Process	Description
1	**Sampling of sensors**	The sampling of sensor(BMP) takes place throughout the flight at 1Hz frequency.
2	**Communication**	No direct communication takes place between the container and the GCS, the communication takes place via the payload. The communication between the payload and the GCS takes place via RF waves. The half duplex communication between the payload and the GCS takes from patch antenna (FXP830) installed in the payload and the GCS Antenna(TLANT-2415D).
3	**Data Storage**	The sensor's raw data is stored in the ATtiny85 EEPROM.
4	**Mechanism activations**	Activation of the audio beacon when the container makes contact with the ground.
5	**Major Decision Points in Logic**	Backup of the FSW State throughout the flight(refer to the state chart diagram for the details of the same).
6	**Power Management**	The ATtiny85 is kept on normal mode throughout the flight. It switches pressure sensor to low power mode when it is not being used.

Software Development Plan (1/2)

To avoid the delay of Software Development

- We have been holding regular meets.
- By following the RAD SDLC, the testing has been done regularly.

Software Subsystem Development Sequence

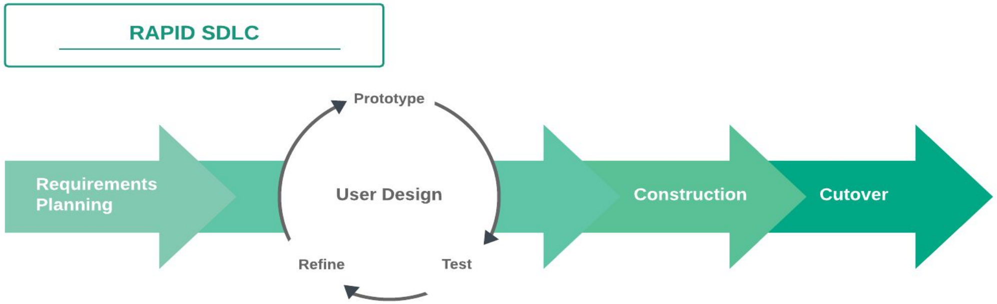
- SDLC model followed for the development of the software is RAPID or RAD.

Test Methodology

- The test methodology followed is **Functional Testing.**
- The sequence of the various types of testing:
  1. *Unit Testing*: Each module is tested independently.
  2. *Integration Testing*: The unit tested modules are integrated and tested.
  3. *System Testing*: The entire system is tested for bugs and errors.
  4. *Functional Testing*: The whole system is tested to check if the all the requirements are met seamlessly.

Prototyping and Prototyping Environments

- The software is being tested on breadboard regularly.
- Once the PCB is ready, the testing would take place on that.



Development Team

- Sourav Bhattacharjee
- Raunit Singh
- Shikhar Makhija

Software Development Plan (2/2)

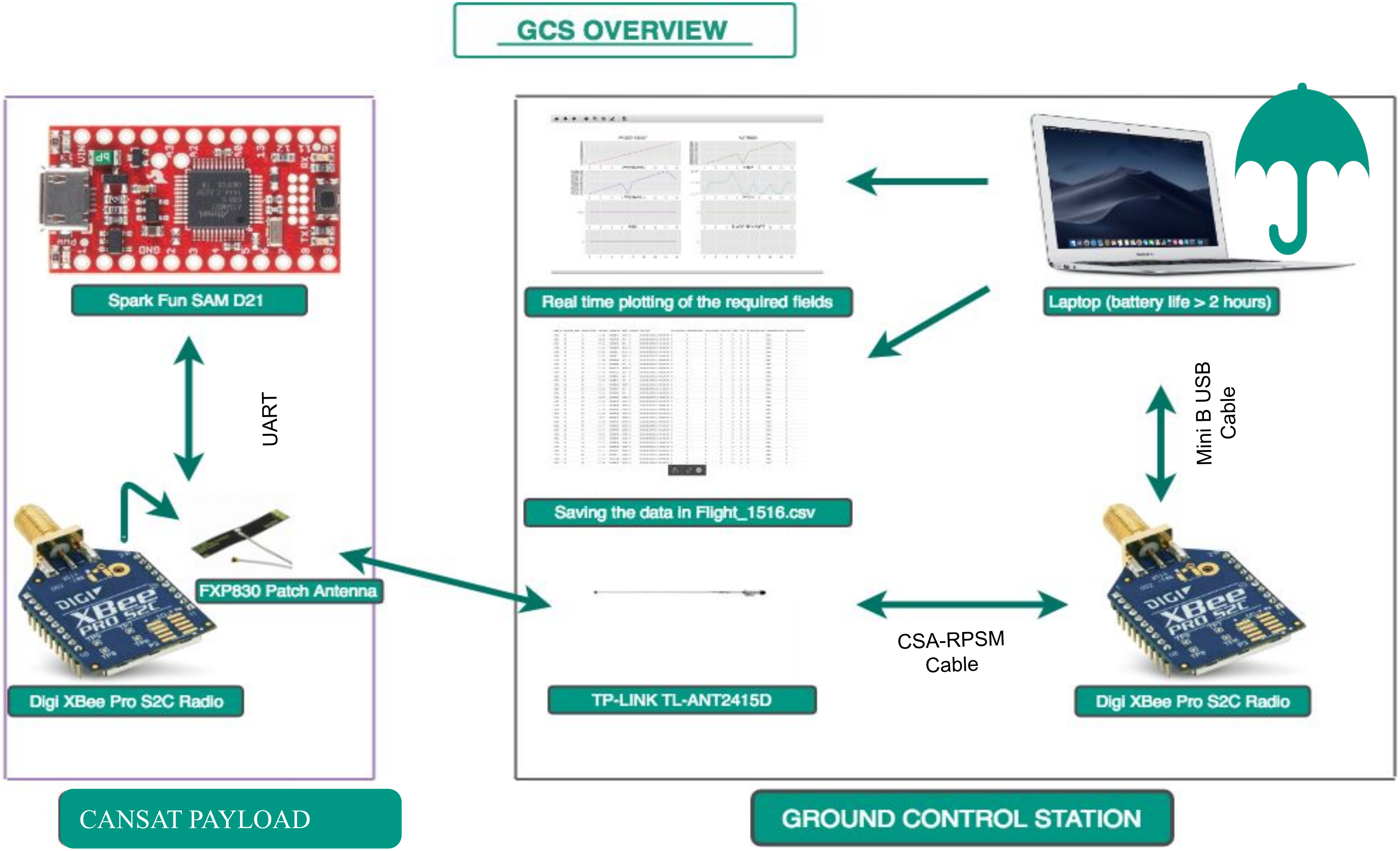
Progress since PDR

- All the sensors have been individually tested and calibrated, and then have been integrated into the main source code.
- The deep sleep functionalities of the microcontroller necessary for using the internal RTC has been tested and successfully integrated.
- Minor improvements and optimizations to the existing codebase.
- In payload section B (Camera stabilization section), NRF module for communication between Section A and B has been interfaced with Arduino Pro Mini and servo motor has also been tested.
- AHRS sensor fusion with MPU9250 (tilt sensor) and Arduino Pro Mini is also completed, PID control logic is currently in development.
- For container, nichrome wire burning and the BMP280 sensor has been tested with the ATtiny85.

Ground Control System (GCS) Design

Shaonak Dayal

GCS Overview



GCS Changes Since PDR

PDR	CDR	RATIONALE
Telemetry data was stored in an array	Telemetry data is stored in a deque.	❖ Easier to maintain number of operations to render graph on GUI.
Matplotlib.pyplot and Matplotlib.animation for plotting	plotly module is used for plotting	❖ Better graphs are obtained. ❖ Has greater functionality
Use of Tkinter python module to develop the GUI	Dash is used to develop the GUI	❖ Increases functionality with much more customization. ❖ Code becomes shorter and more readable. ❖ Uses a local server to render graphs on browser.

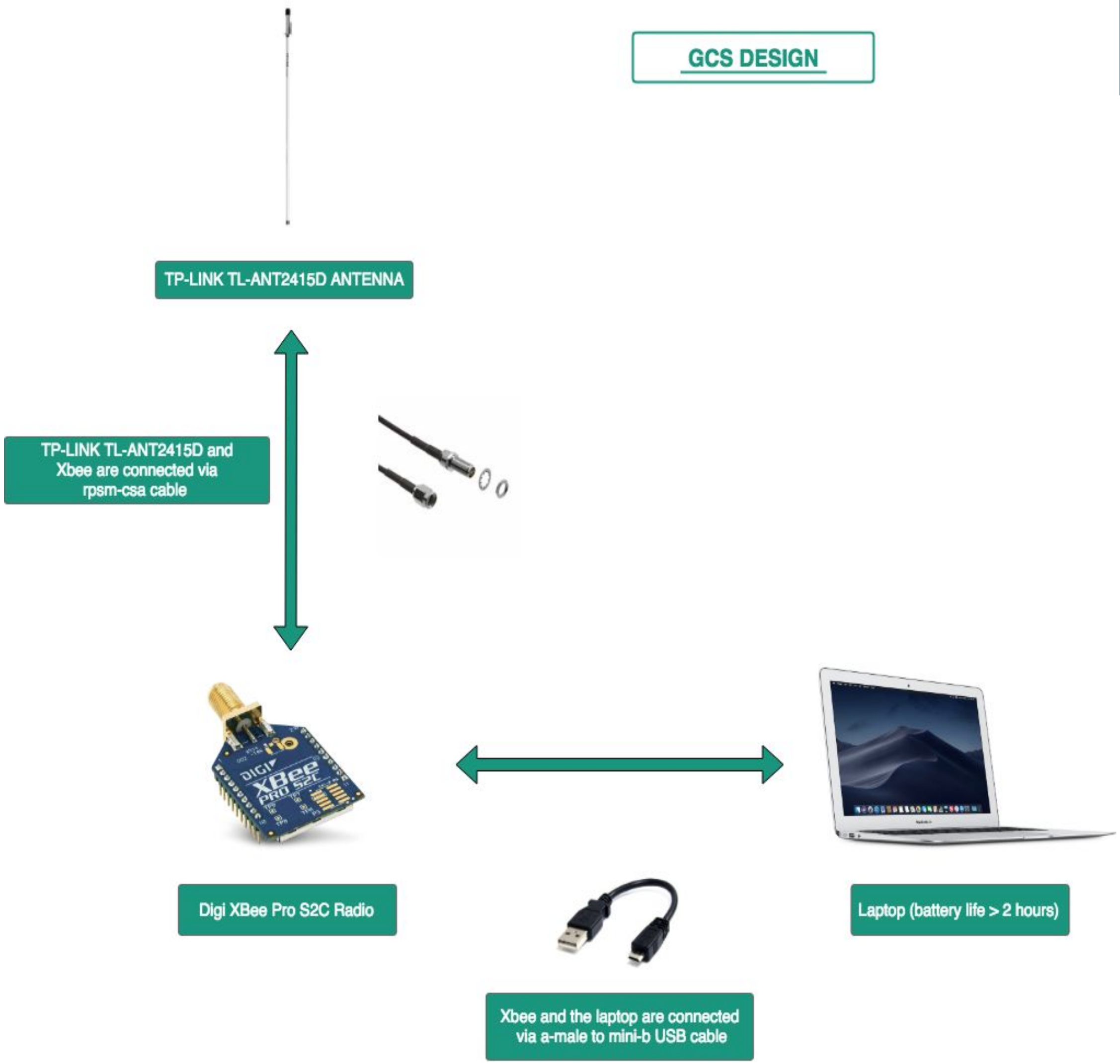
GCS Requirements (1/2)

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
GCS- 01	Telemetry shall be displayed in real time and plotted.	Base Requirement	BR- 38	PCDH- 8	Very High	+	+	+	+
GCS- 02	The ground station shall generate a csv file of all the sensor data.	Base Requirement	BR- 29	PCDH- 8	Very High	+	+	+	+
GCS- 03	The ground station shall consist of one laptop, an XBee radio connected to it and a hand-held antenna	Base Requirement	BR- 39		Very High	+	+		
GCS- 04	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	Base Requirement	BR- 40		Very High		+	+	

GCS Requirements (2/2)

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
GCS- 05	The ground station shall command the payload to set the altitude, pitch to zero at the launchpad.	Base Requirement	BR- 28	FSW- 6	Very High		+	+	
GCS- 06	Each team shall develop their own ground station.	Base Requirement	BR- 35		Very High		+		
GCS- 07	Telemetry shall be displayed in engineering units(m, sec, Pa, etc)	Base Requirement	BR- 37 PCDH-7		Very High		+	+	+

GCS Design



GCS Laptop battery operational time

The laptop's battery life is greater than 2 hours.

Overheating mitigation

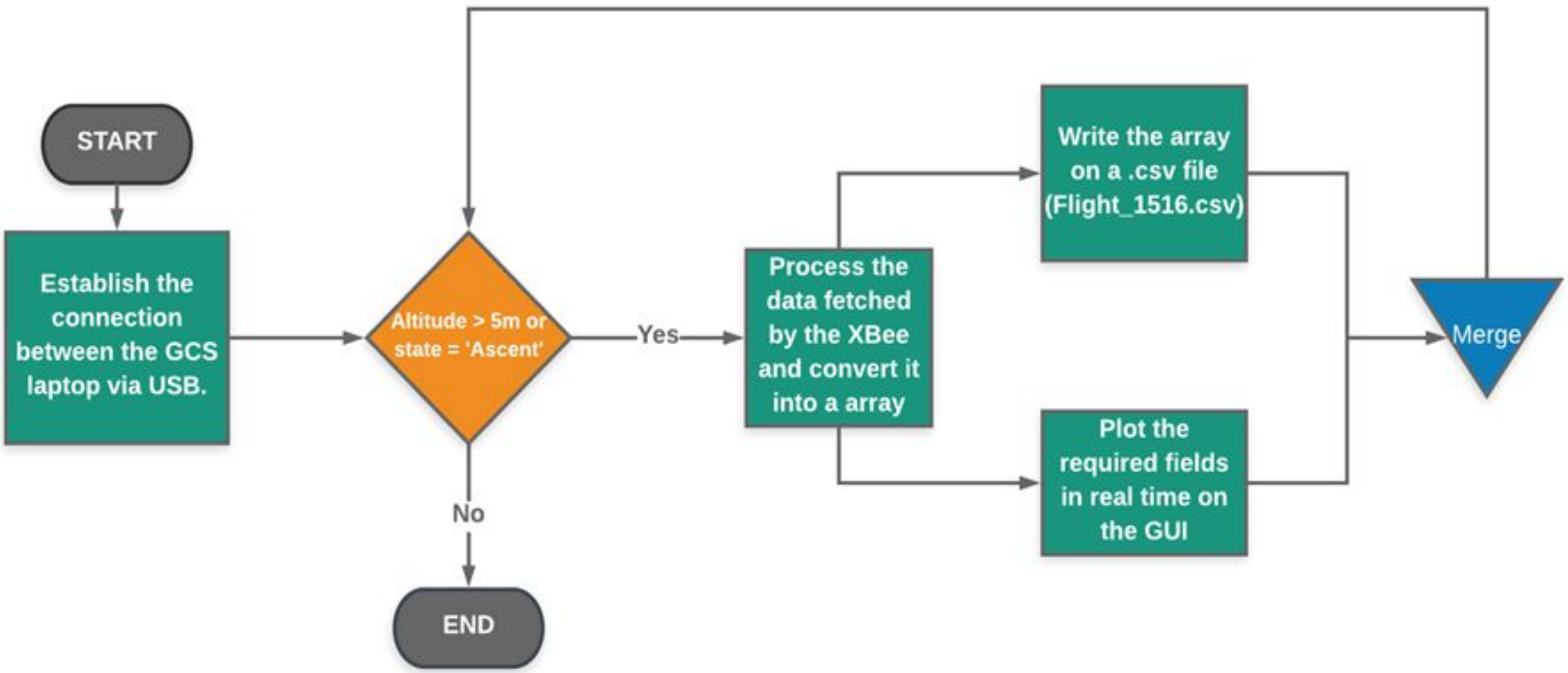
We will use an umbrella to cover the laptop and sensors to avoid direct sunlight.

Auto update mitigation

We will be using MacOS. Auto update is off.

GCS Software (1/9)

GCS FLOWCHART: Real time plotting and saving the data in Flight_1516.csv file



GCS Software (2/9)

GCS DESIGN: Software Breakdown

- GCS Sofrware Breakdown
  - 1.1 Save the telemetry data in Flight_1516.csv file.
  - 1.2 Plot the required fields vs Time on the GUI (Real Time plotting)
  - 1.3 GPS Plot on Google Maps(Earth) using Google Earth Engine
  - 1.4 Virtual tilt animation of the CANSAT

GCS Software (3/9)

Telemetry Data Recording and Media Presentation

- ❖ Telemetry data is written on Flight_1516.csv file in real time using ***python's*** CSV module.
- ❖ The .csv file would be handed to judges in a pen drive for inspection.

.csv Telemetry File Creation

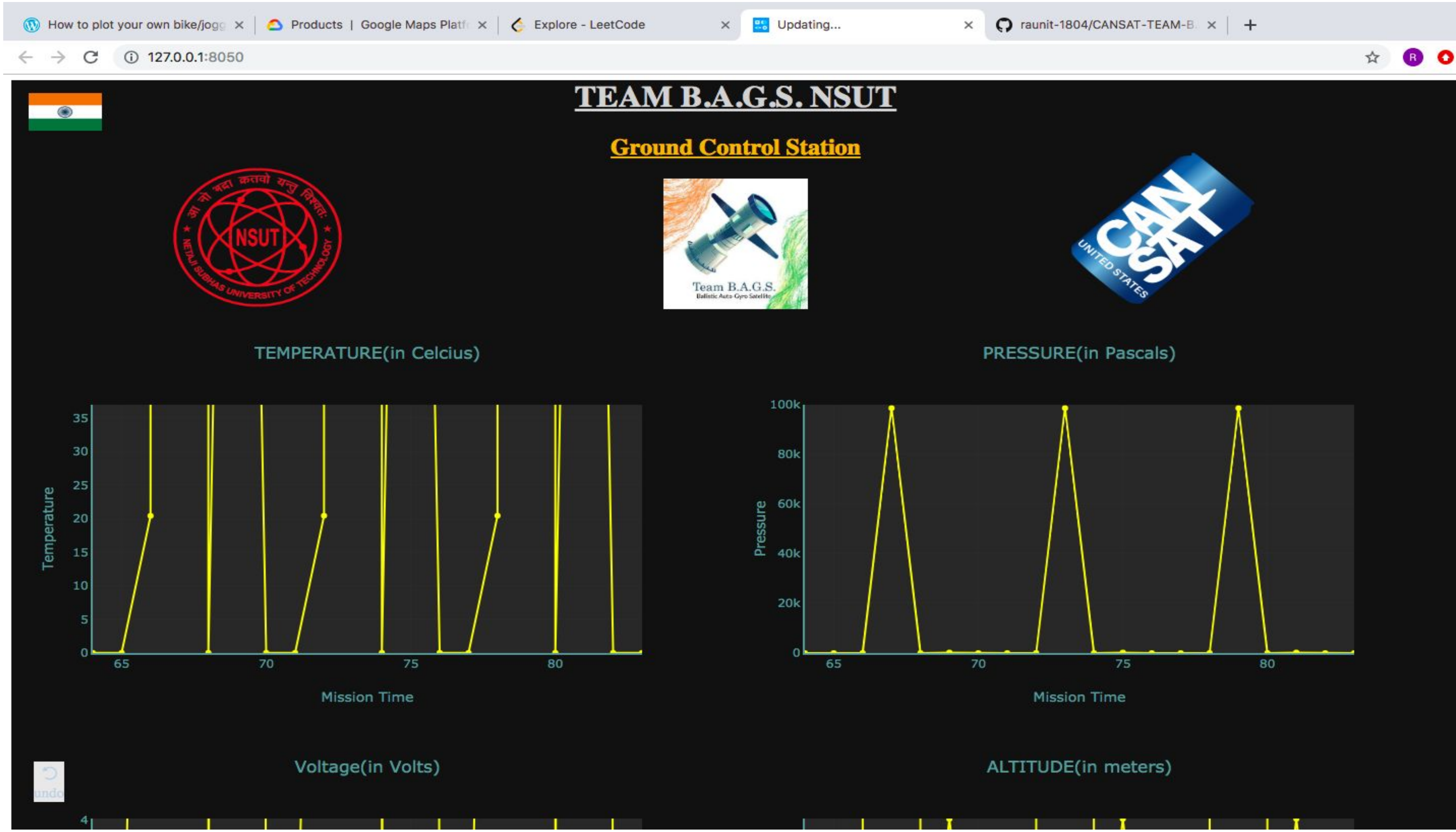
- ❖ The path to an empty .csv file of the name 'Flight_1516.csv' is given to the python program. First, the header row is set using a simple command from the ***csv*** package on python.
- ❖ The file is opened in ***wb*** i.e. writing in binary mode. If some garbage values are already present in the data, then the program would overwrite on the .csv file.
- ❖ The package used is ***python's*** csv module.

Telemetry display screenshot

Real-time plotting software design

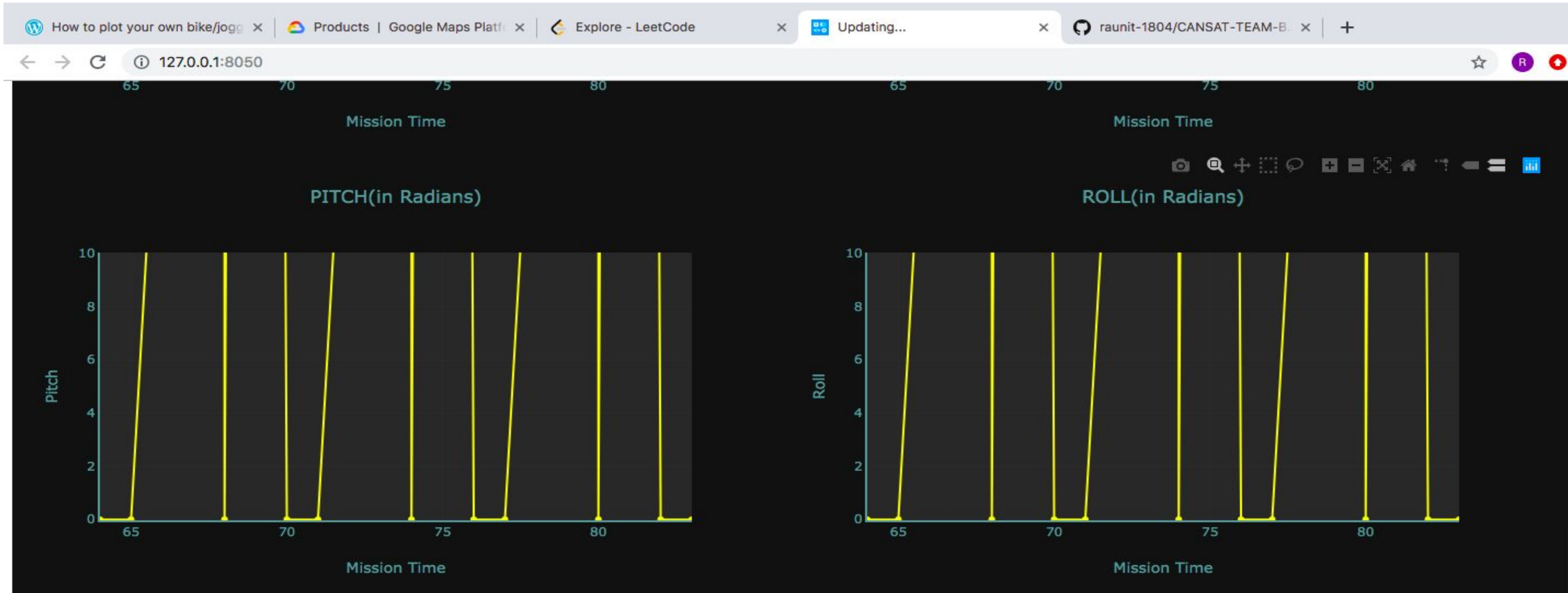
- ❖ Using python package, **pyserial**, the data from **XBee** is received in the python console . This data is converted from a string to an array(A1) by splitting the string on ',' and typecasting the fields to float if required.
- ❖ By maintaining a deque(doubly ended queue data structure) of the fields which are to be plotted in real time, we push the appropriate values in respective deques via index addressing on A1 which are then plotted using **plotly** and **Dash by plotly** packages.
- ❖ The real time plot is rendered on the GUI developed on python using **Dash by plotly** package.

GCS Software (4/9)



Screenshot of the GUI during testing

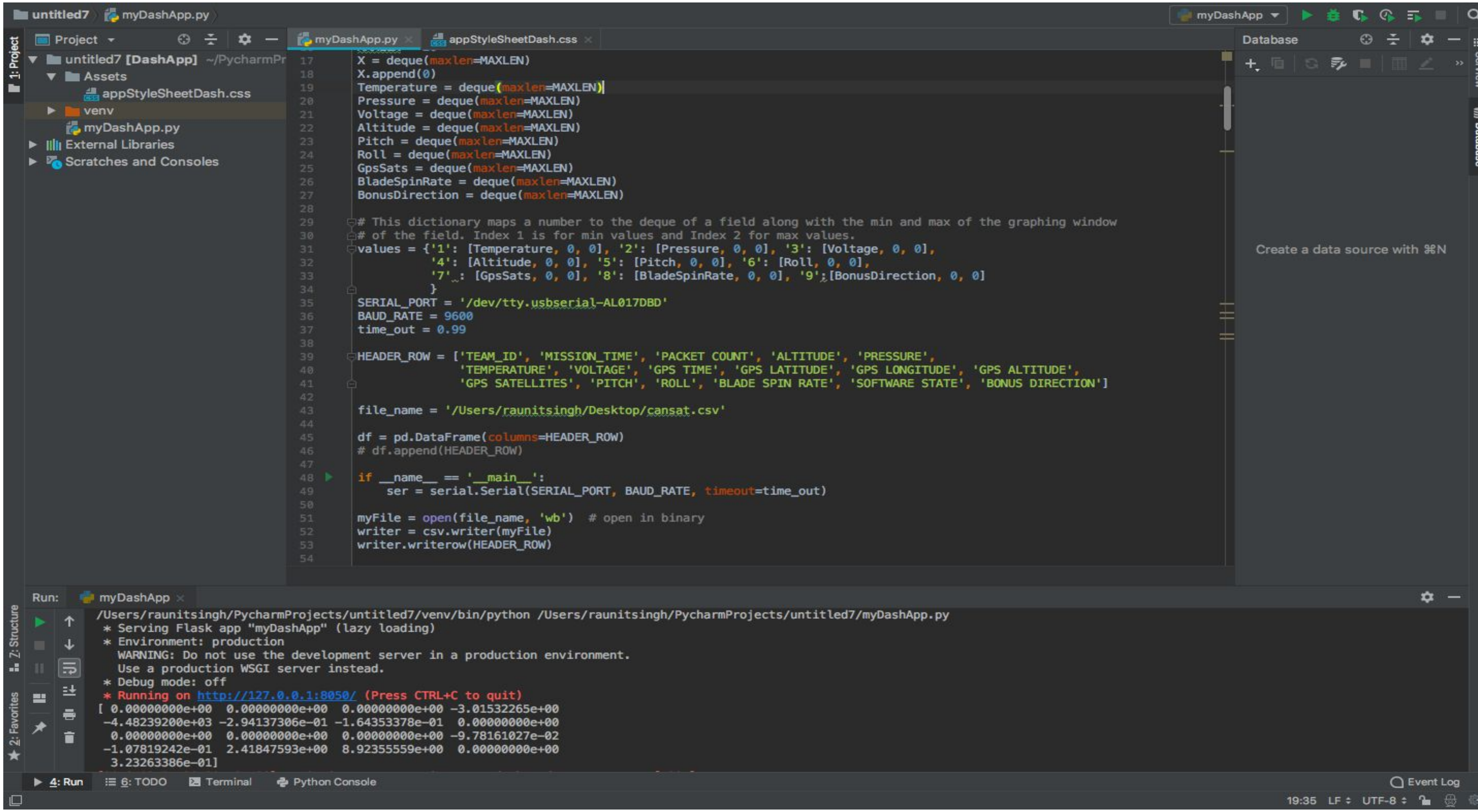
GCS Software (5/9)



TEAM_ID	MISSION_TIME	PACKET COUNT	ALTITUDE	PRESSURE	TEMPER
1516	0	13	225.40	98646.88	20.69
1516	0	14	225.40	98646.78	20.70
1516	0	15	225.37	98647.19	20.70
16		1	225.06	98650.81	20.70
1516	0	20	225.43	98646.50	20.69
1516	0	21	225.38	98647.12	20.68
151[illegible]	0	22	225.85	98641.50	20.69
151[illegible]	0	23	225.26	98648.53	20.70
1516	0	24	225.41	98646.67	20.71

Screenshot of the GUI during testing

GCS Software (6/9)



Implementation of the creation of the .csv file and reading the data from the port

GCS Software (7/9)

Team B.A.G.S.
Ballistic Auto-Gyro Satellite

```python
# The callback for updating all the graphs
@app.callback([Output('temperature-live', 'figure'),
               Output('pressure-live', 'figure'),
               Output('voltage-live', 'figure'),
               Output('altitude-live', 'figure'),
               Output('pitch-live', 'figure'),
               Output('roll-live', 'figure'),
               Output('gps-live', 'figure'),
               Output('blade-live', 'figure'),
               Output('bonus-live', 'figure'),
               Output('datatable-container', 'data')],
              [Input('interval-component', 'n_intervals')])
def update_graph(n):
    global values, df
    X.append(X[-1] + 1)
    # Here the sensor updating code will be there
    message = ser.readline()
    message = message[:-2]  # to remove '\r' and '\n'
    # Converting the message to a list
    data = list(message.split(','))
    indices_values = ['1', '2', '3', '4', '5', '6', '7', '8', '9']
    indices_data = [5, 4, 6, 3, 12, 13, 11, 14, 16]
    # Updating the deque by adding the corresponding values to the corresponding arrays
    if len(data) > 16:
        print(data)
        for index in indices_data:
            for j in indices_values:
                values[j][0].append(float(data[index]))
        writer.writerow(data)

    # Use of so many variables for optimisation over using min(deque) and max(deque)
    if len(values['1']) == 1:
        for i, j in zip(indices_values, indices_data):
            values[i][1] = values[i][2] = data[j]
    # Calculating the min and max values for the graph windows
    for i, j in zip(indices_values, indices_data):
        values[i][1] = min(values[i][1], data[j])
        values[i][2] = max(values[i][2], data[j])
```

```
rmProjects/untitled7/venv/bin/python /Users/raunitsingh/PycharmProjects/untitled7/myDashApp.py
DashApp" (lazy loading)
on
he development server in a production environment.
```

Implementation of the saving of the serial data in the .csv file and maintaining the deque for the different fields

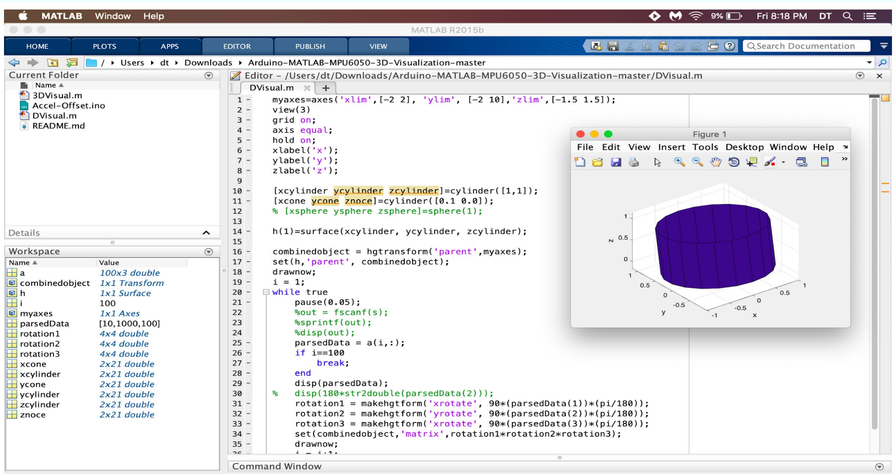
GCS Software (8/9)

Commercial off the shelf (COTS) software packages used

S.No.	Software Package	Rationale
1	MacOS	Development team has been using the MacOS and is comfortable with it.
2	Python 3.4	A wide variety of very useful packages available readily available.
3	PyCharm IDE	A great IDE(Integrated Development Environment) for scientific development with inspection and documentation support along with a great stack based file system.
4	Pyserial module	A very convenient module to read data from a serial port with a lot of functionalities.
5	Dash by Plotly	To develop the interactive web-based GUI.
6	Plotly module	The module to perform the real time plotting with faster rendering than Matplotlib.pyplot module.
7	CSV module	A reliable module to deal with .csv files. This module is used to form the required .csv file
8	XCTU	A high level interactive software to configure and test the Xbee Radio modules.
9	MATLAB	Appropriate software for the visualization of the tilt animation of the CANSAT with a myriad predefined libraries.
10	CSS	It has been used to style the GUI.

GCS Software (9/9)

Screenshot of the test of the 3D GPS plot using the Google Earth Engine API



Tilt animation of cansat on MATLAB using Pitch, Roll and Yaw values

Command Software and Interface

X-CTU software is used to give commands from ground station to CanSat to for calibration of sensors, resetting mission time to zero.

Progress since PDR

- ❖ A new GUI has been built from scratch which is much more interactive and efficient in terms of computation along with addition of a dataframe in the GUI.
- ❖ Testing of the newly built GUI has been done.
- ❖ Tilt animation code of the CANSAT has been done and tested.

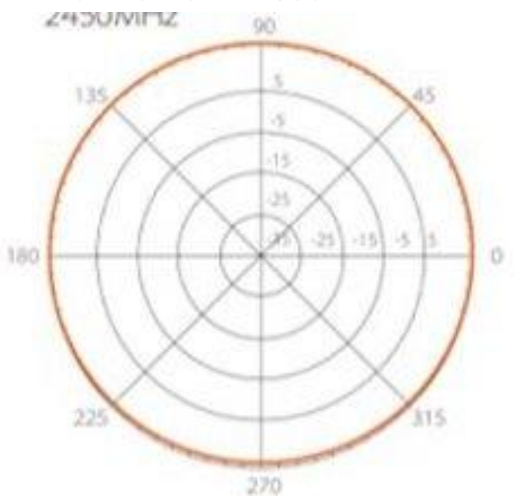
GCS Antenna (1/4)

Model	Gain	Frequency	Directivity	Range (m)	VSWR	Weight (kg)	Connector	Cost
TPLink- TL-ANT2415D	**15dbi**	**2.4GHz**	**Omni-Directional**	**2500**	**2.0:1**	**1.81**	**N-Female**	**$140.39**

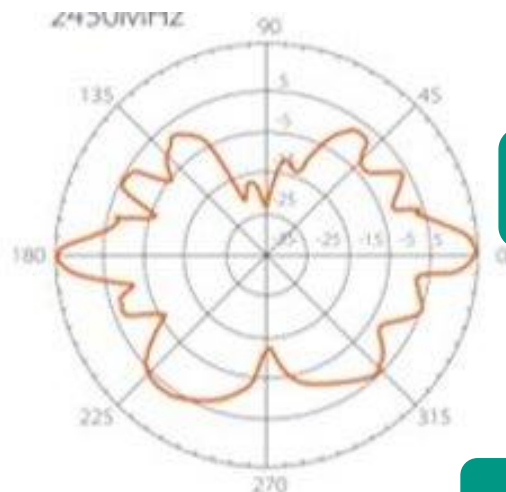
Reasons for selection of TL-ANT2415D:

- 15dBi Omni-directional operation highly enlarges the wireless coverage.
- Lower impedance causes low signal loss.
- N-Female connector, compatible with all our electrical equipment.
- Excellent Transmission Range.
- Easier estimation of antenna efficiency, as the antenna pattern similar to **FXP830.**

TP Link TL-ANT-2415D ANTENNA



Horizontal Plane



Vertical Plane

Radiation Pattern
TP Link TL-ANT-2415D

GCS Antenna (2/4)

Antenna Construction	❖ The GCS antenna is made up of a metallic conducting rod which is inserted inside a glass pipe. To connect with XBee module, we are using an RP-SMA coaxial cable. ❖ GCS antenna will be held by one of the team members during flight. No specific antenna mounting technique has been employed.
Antenna Portability	❖ Antenna is easy to carry and is lightweight. It will be shipped to competition site beforehand.
Antenna Coverage	❖ Antenna has been successfully tested till a range of 1km. It still needs to be tested for a longer range.

GCS Antenna (3/4)

GCS Antenna Mounting

CANSAT

Patch antenna installed in the payload transmits the data

Calibration Command

RF Signal

Antenna Mounting	
TPLink- TL-ANT2415D	Hand-Held

TP Link TL-ANT-2415D ANTENNA

Ground Control Station

Antenna would be hand held by one of the GCS Crew member

GCS Antenna (4/4)

From the Friis Transmission Equation the Free Space Power Loss(FSPL) is given as:

$$FSPL = \left(\frac{(4 \times \pi \times D)}{\lambda}\right)^2$$

Solving, for the transmission distance D, we have:

$$D = FSPL + 20Log_{10}(\lambda) - 21.98$$

To solve the above equation, we need to compute the FSPL.

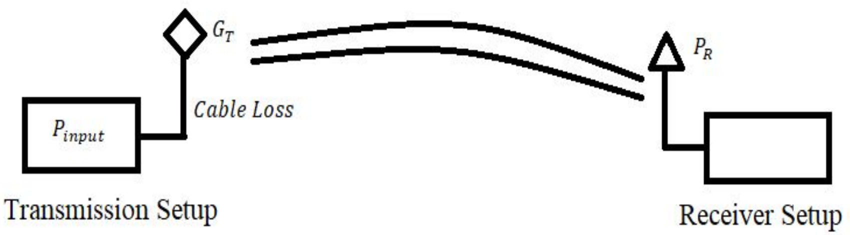
The transmission diagram consider is shown in the figure.

$$T_{Power} = P_{input} - Cable\ Loss + G_T$$

$$FSPL = T_{Power} - P_R$$

The transmission diagram consider is shown in the figure.

Calculated range = 2500m

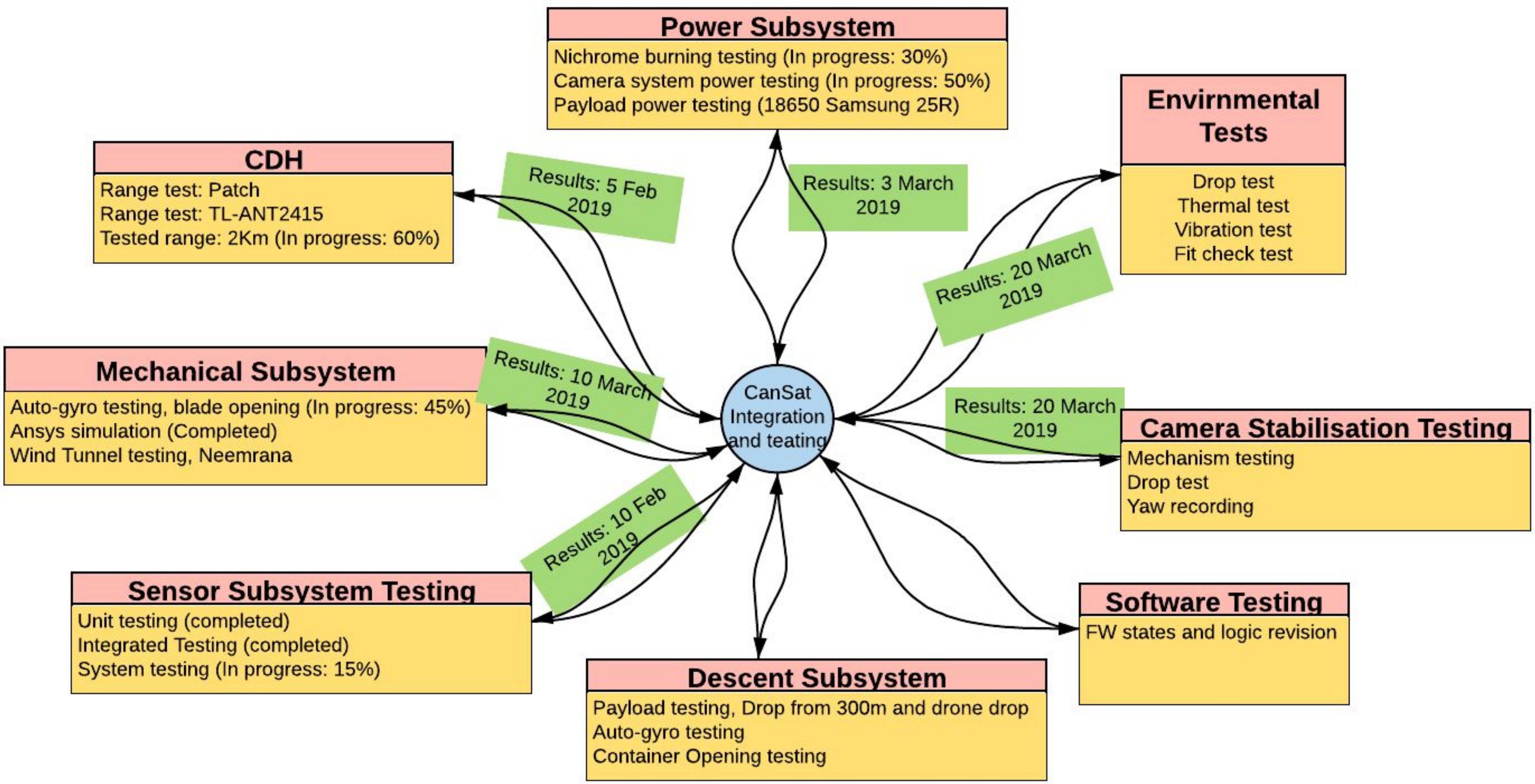


Parameter	Value
Antenna Gain(dB)	15
Transmission Power (dBm)	43.01
Operating frequency (MHz)	2400
Cable loss (dB)	15
Receiver Sensitivity (dBm)	-65
Free space path loss (dB)	108.01

CanSat Integration and Test

Advait Paithankar

CanSat Integration and Test Overview (1/2)



CanSat Integration and Test Overview (2/2)

System Level Testing Plan

- Electronics System: Individual testing of Sensors, telemetry as well as range test for antenna are to be performed.
- Mechanical System: Stress strain simulations along with shock simulation, Drop test for Auto-gyro and parachute.
- Software System: Complete software system testing and debugging.

Environmental Test Plans

- Fit check will be done using aluminium cylinder
- Drop test performed while Integrated Level testing.
- Vibration testing done using orbit sander.
- Thermal test performed in a steady temperature of 60 degrees Celsius.

Integrated Level Functional Test Plans

- Payload and Container combined drop test from drone.
- Drop test with auto-gyro activated.
- Wind tunnel testing at Neem Rana.
- Packet generation and transmission by collecting data from sensor subsystem.
- Complete sensor subsystem and camera subsystem testing with battery.
- Camera subsystem testing on rotating surface for stabilization testing.

Subsystem Level Testing Plans

- All the subsystems to be tested individually.
- All sensors to be tested on breadboard.
- Telemetry to be tested on by transmitting sensor data.
- Defining flight software states for different phases during CanSat flight.
- Testing range of XBEEs using inbuilt tool from XCTU.
- Testing the power consumed by all electronic components.
- Structural integrity will be tested on subsystem level by creating near actual environment

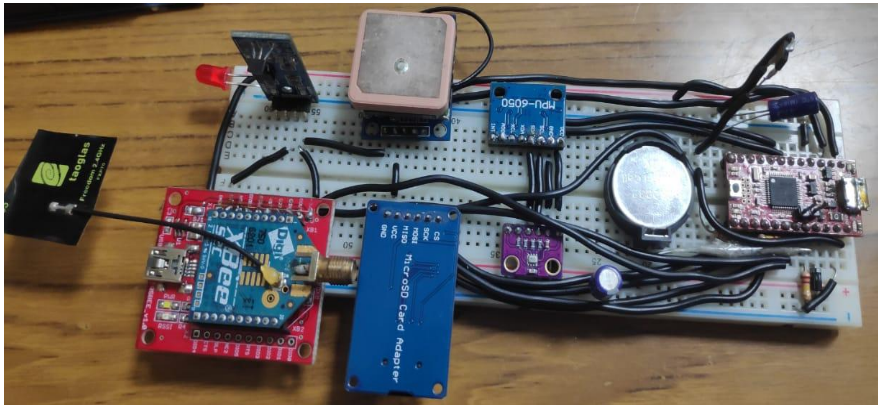
Subsystem Level Testing Plan (1/3)

Sensors

- ❖ Interfacing of sensors with microcontrollers is tested using their respective protocols(SPI, I2C etc.).
- ❖ The sensors were calibrated before testing.
- ❖ All the sensors have been tested together on breadboard and are found to work successfully.

Radio Communications

- ❖ XBees are configured and tested using X-CTU software.
- ❖ Range test performed between the two XBees on X-CTU.
- ❖ XBees used in unicast mode.
- ❖ Sending command from ground station to calibrate pressure and pitch and roll is to be tested.



Sensor Testing Setup

XCTU's Range Test

Subsystem Level Testing Plan (2/3)

Flight Software Testing

- Sensor values were obtained from the backup SD card by powering the setup from external power source. Thus simulating actual flight conditions.

```
------------------------------------------------------
File:   packets.csv            Size: 975 Bytes
------------------------------------------------------
1516,16,1,157.19,99451.19,19.27,4.42,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,177,-171,0,Idle,0
1516,17,2,157.54,99447.08,19.28,4.44,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-100,0,Idle,0
1516,18,3,157.54,99447.08,19.28,4.44,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-79,0,Idle,0
1516,19,4,157.54,99447.08,19.28,4.44,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-81,0,Idle,0
1516,20,5,157.70,99445.19,19.28,4.44,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-110,0,Idle,0
1516,21,6,157.66,99445.61,19.28,4.44,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-53,0,Idle,0
1516,23,7,157.62,99446.03,19.29,4.44,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-75,0,Idle,0
1516,24,8,157.43,99448.30,19.28,4.42,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-38,0,Idle,0
1516,25,9,157.25,99450.47,19.29,4.44,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-115,0,Idle,0
1516,26,10,157.59,99446.45,19.29,4.45,2013-10-22T01:37:56+05:30,0.00,0.00,0.00,0,179,-74,0,Idle,0
------------------------------------------------------
```

Data on Arduino Serial Monitor

Communication and Data Handling

- Telemetry was tested by transmitting the sensor data in a packet and was plotted and stored in a CSV file simultaneously.
- The data was collected from sensors at a rate of 1Hz.
- Data storage was tested by logging the sensor data in SD card.

TEAM_ID	MISSION_TIME	PACKET COUNT	ALTITUDE	PRESSURE	TEMP	VOLTAGE	GPS TIME	GPS LATITUDE	GPS LONGITUDE	GPS ALTITUDE	GPS SATS	PITCH	ROLL	BLADE SPIN RATE	SOFTWARE STATE	BONUS DIRECTION
1516	0	17	177.66	99209.27	19.91	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	18	178.02	99204.95	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	19	177.26	99213.94	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	20	177.65	99209.39	19.91	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	21	177.58	99210.2	19.91	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	22	177.87	99206.7	19.91	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	23	177.98	99205.45	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	24	177.94	99205.88	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	25	177.82	99207.31	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	26	177.83	99207.22	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	27	177.75	99208.14	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	28	177.75	99208.14	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	29	177.9	99206.38	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	30	177.26	99213.94	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	31	177.53	99210.83	19.9	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	32	178.05	99204.62	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	33	177.89	99206.48	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	34	177.63	99209.58	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	35	177.78	99207.82	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	36	177.89	99206.48	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	37	178.01	99205.14	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	38	177.82	99207.41	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	39	177.54	99210.63	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	40	177.77	99207.95	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	41	178.16	99203.38	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	42	177.97	99205.55	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	43	177.73	99208.36	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	44	177.93	99206.06	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	45	177.4	99212.27	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	46	177.62	99209.7	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	47	177.43	99211.98	19.88	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0
1516	0	48	177.89	99206.48	19.89	0	2013-10-22T01:37:56+05:30	0	0	0	0	0	0	0	Boot	0

Data in CSV file on SD card

Packet Data after running a check on the Flight Software as well as Communication Setup

Subsystem Level Testing Plan (3/3)

Electrical Power Subsystem

- Batteries were tested for their voltage and currents
- Power dissipation for each component (sensor, buzzer, etc) was calculated.
- The calculated values were verified practically by measuring currents and voltages using multimeter.

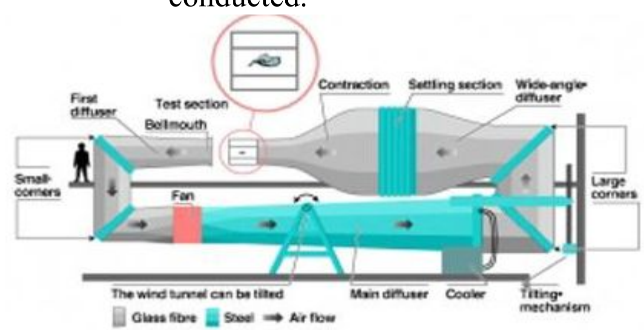
Battery testing for the voltage and current

Mechanical

- Mechanical system is divided into 3 subsytems
- Container opening: Container opening is tested by using the container model elastic strands will be decided on the basis of these tests also the strength of the model will be tested in these tests
- Autorotaion of blades, the approximate thrust and rotational velocity achieved by the payload was tested in this system
- Payload deployment: In this system opening mechanism of blade opening was tested
- Tests for checking strength, durability of CanSat is being performed.

Descent Control

- For auto-gyro descent, the descent control test is planned to be done in a wind tunnel. 1:1, actual model of the rotor and blades will be placed in a wind tunnel. Strain gauges will be placed on different locations of the blades.
- Values of Cp, Ct, Cm, Cd, Cl will be obtained from the wind tunnel testing
- The values obtained will then be tested against the theoretical model and causes of deviation will be studied
- For parachute's descent too, the wind tunnel test would be conducted.



Integrated Level Functional Test Plan (1/3)

Descent Testing

- The container prototype attached to the parachute is dropped from a couple of floor height and the telemetry is received from which the descent rate is analysed and similar test is performed for the auto-gyro subsystem.
- CanSat would be put through the drone test where it would be dropped from a height of 700 meters with the help of a drone and from the received telemetry the descent rate would analysed for the mission compliance.

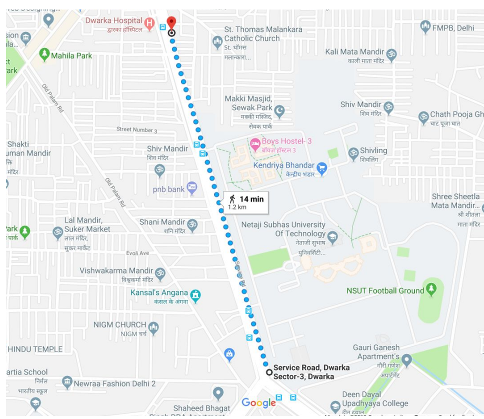
Mechanism

- All mechanism will be tested at ground level
- Simultaneous working will be tested by setting time lag as per the descent values and
- Near actual conditions will be created for the system and harsh testing will be carried out
- The drop test is to be performed on the container and the payload with weights equal to the mass of the integrated container and payload.
- Thermal test is to be performed to test the thermal stability of the material.
- Vibration test is to be performed to test the strength of electrical components' interface.

Integrated Level Functional Test Plan (2/3)

Communications

- A sample packet will be created by the payload and be sent to the ground station via the XBEE modules, and the received packet will be displayed in the ground station laptop in XCTU software.
- Commands from the ground station will be transmitted to the payload and the response be noted.
- These steps will be carried out with increasing distance between payload and ground station to test their range.

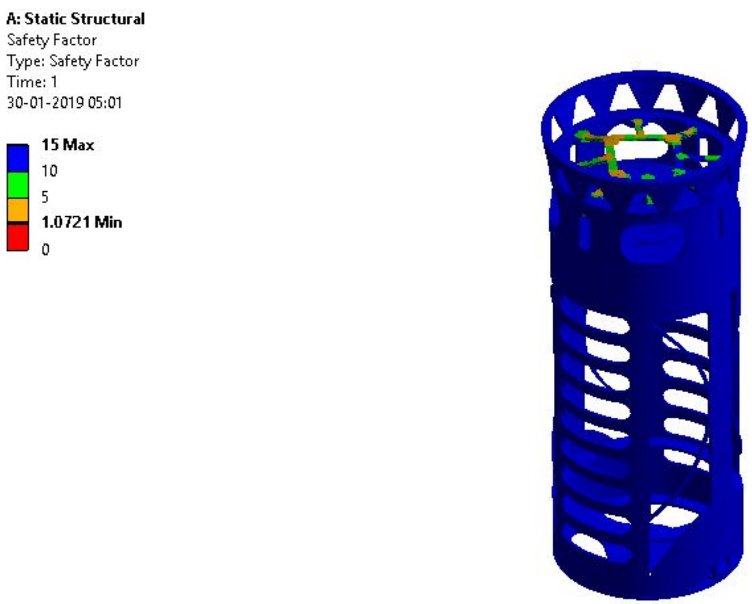


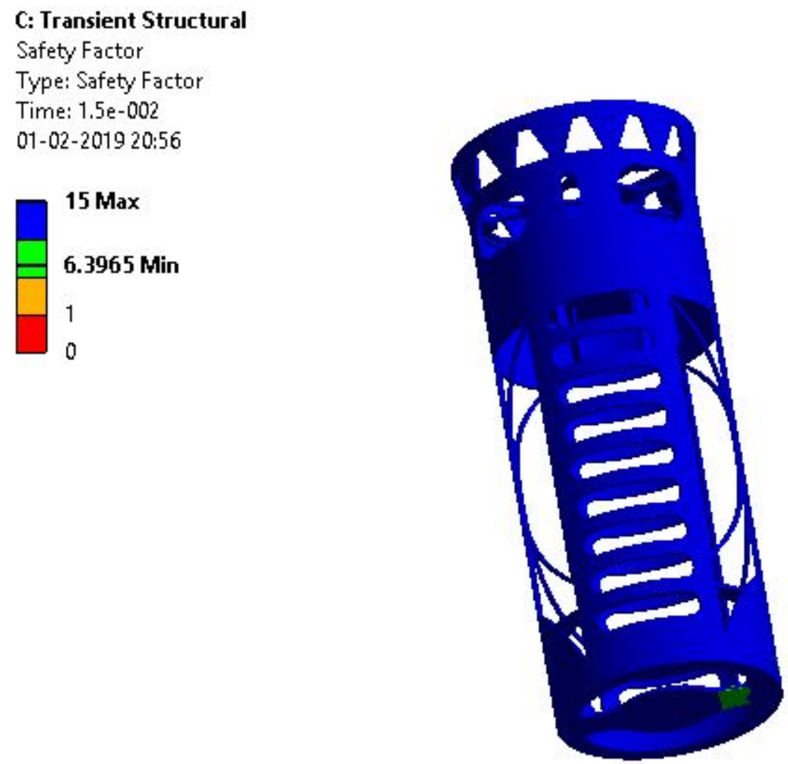
Deployment

- Deployment will be tested initially by dropping it off from top of the building
- Opening of container while in downward motion will be observed
- Blade opening and autorotaion will be the main point of observation
- The elasticity of strands will then be selected based on the time required to open the blade and also the stiffness needed
- Final testing will be done using a drone where container will be dropped from a height of 700m
- All the values of sensors will be recorded and compared with the results obtained from theoretical calculations
- Probable cause of deviatio will thenbe studiedand eqaution will be corrected
- Based on these results elastic strands will be selected and the spin rate of fans will be measured and validted

Integrated Level Functional Test Plan (3/3)

30 Gs Shock Simulation on Ansys

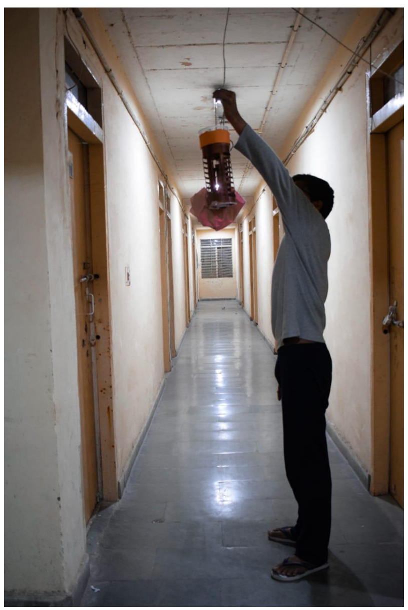




Environmental Test Plan (1/2)

Drop Test

- A 1m long rope is taken with one end connected to a rigid test rig and other end is connected to the parachute mounting points
- Cansat is then dropped in free fall and the effects are studied



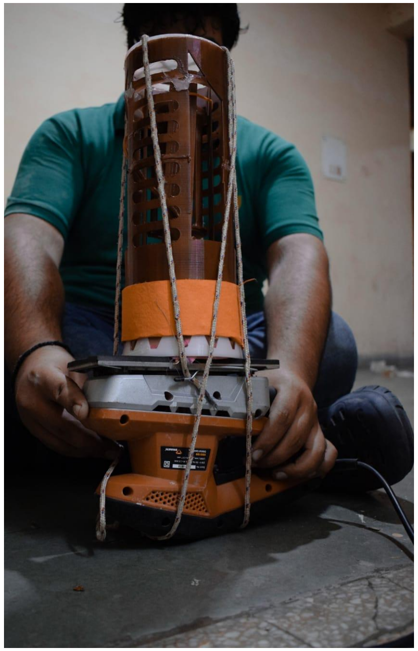
Thermal Test

- Cansat is placed in a thermal chamber and heating it at about 60C for a period of 2 hours and inspecting it for any damage caused to the part.

Environmental Test Plan (2/2)

Vibration Test

- ❖ It is to be conducted using the orbit sander.
- ❖ The CanSat is attached to the vibrating end of the orbit sander and the handle of the sander is attached to the bench vice.



Fit Check

- ❖ 2mm aluminium plate with a 125mm dia hole made by CNC milling is used as the test rig
- ❖ Cansat should pass through it easily

Test Procedures Descriptions(1/4)

Test	Test description	Requirements	Pass/Fail Criteria	Pass/Fail
1.	All the sensors are connected to the MCU, interfaced with respective I2C/UART protocols, the code is integrated and their data is collected	9,11,27,29	All sensors must work simultaneously	Pass
2.	A data packet is transmitted through XBee and checked at the receiver end.	9,10,11,12,13,14,19,29	All data must be transmitted at 1Hz without any loss of packets	Pass
3.	The breadboard setup is powered by a battery and time is checked till which the electronic system is working.	16,19,25,26,23	All electronic systems must be powered for at least 2 hours	Pass
4.	The ground station antenna is tested for its range by sending a packet and gradually moving the transmitter away from the receiver.	9,11,12,13,14,17	Packet loss should be minimal even at larger range.	Pass
5.	All sensor data is transmitted through telemetry to the receiver and the flight software status is checked during various values of altitude.	5,9,11,19	The data from sensors must be sampled and flight software status should change during deployment, payload release, landing, etc.	Pass
6.	All the mechanisms are tested on the ground	1,2,3,4,5,6,7,8,15,18,20 ,21,22,26,27,28	Mechanisms must perform the required task in required time	Pass
7.	Cansat is dropped from a height and its velocity and trajectory is recorded	3,4,5,6,7,8,28	CanSat descent must comply with all the expected trajectory requirements	Pass

Test Procedures Descriptions(2/4)

Test	Test description	Requirements	Pass/Fail Criteria	Pass/Fail
8	Complete assembly is placed on a weighing scale and measured	1,2	Weight must be between 490 - 510g then it is considered as passed	Pass
9.	Cansat is dropped from different heights and terminal velocity is calculated	3,4,5,6,7,8,28	Terminal velocities must be achieved within the required range then it is considered as passed	Pass
10	Parachute deployment is tested by throwing it cansat from a high building and calculating the distance and time it takes for deployment	3,8,15	Pparachute must be deployed within 20m it is considered as passed	Pass
11	Nichrome burning set up is tested by placing the circuit on a breadboard and keeping the nichrome wire in viscinity of nylon thread in tension	5,6,7	Nylon thread must breaks within 1 second then it is considered as passed	Pass
12	Payload release is tested by fixing container at certain height and starting the nichrome melting set-up	5,6,7	Payload must come out of container smoothly it is considered as passed	Pass
13.	Payload is placed in a wind tunnel and strain gauges are attached to it to measure axial loading	1,2,3,4,5,6,7,8,16,18,20,21,22,26,27,28	Axial force is obtaine more than 2.5N it is considered as passed	Pass

Test Procedures Descriptions(3/4)

Test	Test description	Requirements	Pass/Fail Criteria	Pass/Fail
14	The tilt sensor is attached to a breadboard and its respective pitch, yaw and roll values are varied and tested against actual values	6,10	If the roll, pitch and yaw values must be accurately calculated	Pass
15	The data transmission is tested to be in the expected format without any packet loss	10,13,14,19	If the data format must be same as the mission guidelines	Pass
16	Camera is pointing in a single direction during entire descent and capturing 30 frames per second.	6	If the camera must produce colour footage at at least 640x480 at least 30fps and that it points in a constant direction.	Pass
17	The recorded coordinates are matched with online maps to ascertain accuracy	29	If the real time location of the CanSat can be obtained up to an error of 2.5m	Pass
18	The altitude is calculated by measuring air pressure of current place with respect to sea level and is verified with actual altitude of New Delhi	--	Altitude given by the sensor must be same as the actual altitude of the place.	Pass
19	A magnet is attached to auto-gyro blades. A hall sensor is kept below the blades and speed is measured by finding the number of times magnet crosses the hall sensor in 1 sec.	7	If the speed calculated matches with the exact speed of the auto-gyro blades	Pass

Test Procedures Descriptions(4/4)

Test	Test description	Requirements	Pass/Fail Criteria	Pass/Fail
19.	Container is connected to a drone via servo hook mechanism and taken to a height of 500m, where it is released	3,4,6,7,8	Mechanism must function as per the requirement	Pass
20	Cansat is placed in a thermal chamber and heating it at about 60C for a period of 2 hours and inspecting it for any damage caused to the part.	--	Parts must be working properly and there should be no sign of melting then it is considered as passed	Pass
21	The CanSat is attached to the vibrating end of the orbit sander and the handle of the sander is attached to the bench vice.	--	All the components must be working properly after the test then it is considered as passed	Pass
22	2mm thick aluminium plate with a 125mm hole is passed around the cansat	2	Plate passes smoothly through the cansat it is considered as passed	Pass
23.	A 1m rope is tied to parachute attachment point while the other point is connected to a fixed rig the cansat is then dropped and checked for damages	--	No mechanical failure after the test d	Pass

Mission Operations & Analysis

Snigdha Singh

Overview of Mission Sequence of Events (1/4)

Onsite arrival

- Team is divided into sub teams with designated roles.
- Initial setup of ground station antenna testing on XCTU software.

Pre-Launch checklist

- Parachute deployment mechanism is checked.
- Payload deployment is checked.
- Auto-gyro deployment is verified.
- Sensors' working is checked.
- Camera stabilization system is verified.
- CanSat is weighed and inspected for physical damage.

Preparing CanSat

- Rotors are folded and payload is placed in the container in the stowed configuration.
- Parachute is attached to the container and is packed into the designated compartment
- CanSat is turned on and the communications are verified
- CanSat assembly is integrated into the rocket.

Overview of Mission Sequence of Events (2/4)

Launch

- Rocket takes off from the launchpad.
- Telemetry is being received for the ascent.
- Rocket reaches the height of 700 meters (apogee).
- CanSat is released and parachute is deployed immediately.
- Telemetry for descent starts.
- Payload is released at 450 meters and autogyro DCS is deployed and the
- camera stabilisation system activates and the camera is turned on.
- Audio beacon activates at landing and the telemetry stops at altitude < 5 m.

CanSat Recovery

- Recovery crew starts the hunt for the CanSat and accompanies the field judge
- during scoring.
- Received telemetry helps in locating the CanSat using GPS values.
- Audio beacon pin points the location of container and payload.
- Container and payload are recovered and examined for possible damages that
- may incur on impact.

Overview of Mission Sequence of Events (3/4)

Data Analysis and PFR Preparations

- SD card is acquired from the CanSat and video is analysed.
- Received telemetry is analysed.
- Telemetry is backed up and submitted to organisers in the thumb drive.
- Telemetry is then used for PFR presentation.
- Final presentation on the following day.

Overview of Mission Sequence of Events (4/4)

Role	Responsibility	Role Assignment
Mission Control Officer	❖ Bears the responsibility of managing team members. ❖ Executing launch procedures and initiating launch sequence.	Sourav Bhattacharjee
Ground Station Crew	❖ Maintaining telemetry connection and performing descent operations. ❖ Analyzing the data after final flight.	Advait Paithankar Raunit Singh Divya Tiwari
Recovery Crew	❖ Responsible for locating container and payload and recovering it.	Riyanshu Motalaya Snigdha Singh Kshitij Shekhar
CanSat Crew	❖ Responsible for CanSat assembly and integration ❖ Putting CanSat into rocket during launch sequence initiation	Bhavya Arya Shikhar Makhija Shaonak Dayal

Field Safety Rules Compliance

5-Checklist Team BAGS Mission Operations Manual

1. Configuring the ground station
   - 1.1 Antenna check
   - 1.2 Communication test
2. Preparing the CanSat
   - 2.1 Cansat Assemble
   - 2.2 Descend mechanisms Check
   - 2.3 Payload Separation Mechanism test
   - 2.4 Prelaunch cansat last check
3. Integrating the CanSat and putting it safely in the rocket
4. Recovery
   - 4.1 Trigger the recovery mechanism
   - 4.2 Recovery of both Payload and Container
5. Prepare the collected data during the flight of CanSat for presentation (PFR: 16 June, 2019)

Additional Items in Checklist

Mission Operations manual also includes :-

1.Crew Assignment,launch operations and descriptions.

2.Sequence of events and safety instructions.

Development Status:

3/4th of the Mission Operations Manual has been prepared and will be completed duly by April 15, 2019

2 copies of Mission Operations Manual will be assembled in 3 ring binders

CanSat Location and Recovery

Structural Element	Recovery
Container	❖ Bright-coloured parachute (Pink or Orange) ❖ Container will be painted orange to enhance visibility ❖ Audio beacon to help locate from some distance
Science payload	❖ Last GPS coordinates from UBLOX Neo-6M ❖ Payload will be painted orange to enhance visibility ❖ Audio beacon to help locate from some distance

The container and science payload would have team name, team number, contact number and email address.

TEAM NAME: TEAM BAGS
TEAM NUMBER: 1516
EMAIL ADDRESS: souravb.ec@nsit.net.in
CONTACT NUMBER: +91-9873131423

Return Address Labelling

Mission Rehearsal Activities (1/2)

Ground System Radio Link Check

- Communication between XBEE Pro S2C RPSMA and TL-ANT 2415-D (Receiver Antenna) has been tested well over a range of around 2 km.
- Packet has been sent from FXP830 Freedom Patch Antenna (Transmitter Antenna) and received by TL-ANT 2415-D (Receiver Antenna) with real-time plots.

Rehearsed during CDH and GCS subsystem testing

Powering ON/OFF the CanSat

- Container and payload both are easily powered on through an accessible external power-switch

Rehearsed in January, 2019

Launch Configuration Preparation

- Folding the parachute into its compartment
- Adding electronics to the container and payload
- Mounting blades on the payload
- Integrating Cansat
- Closing lid with nichrome wire
- Powering up the cansat, initializing telemetry connection

Some rehearsals are done and will be totally completed in the upcoming days.

Mission Rehearsal Activities (2/2)

Electronics and Telemetry Processing

- ❖ During power on check all systems are working and initialize telemetry connection
- ❖ Check receiving data on GCS
- ❖ Archiving data on GCS by .csv, analyzing the archived data

Rehearsed during CDH and GCS subsystem testing

Loading Cansat in the Launch Vehicle

- ❖ Fit check and weight check on the fully integrated CanSat
- ❖ Loading CanSat into the rocket

Fit check is done and rest will be done on the launch day.

Recovery

- ❖ Tracking the CanSat after rocket separation
- ❖ Tracking the container and the payload after separation
- ❖ Locating the container and payload after landing through GPS and their outer color

Rehearsal will be done during rocket testing

Requirements Compliance

Kshitij Shekhar

Requirements Compliance Overview

- All the requirements mentioned in the guidelines were taken with the highest priority. All the departments worked within the guidelines stated.
- The majority of the requirements are currently complied.
- We have worked even on the bonus point and hope to fulfill it..
- Various tests have been conducted to check the impact severity and our CanSat have withstood them all.
- Overall CanSat show great results but if there will be any possibility for loopholes, then improvements and optimizations will be made and will be updated post-CDR.
- The following slides trace and demonstrate compliance with all requirements. Comments have been added wherever necessary.
- The table filled according to requirement based compliance helps us to see which subsystem is needed to be developed.
- The legend gives color coding to indicate if a requirement is met.

No Comply	Partial	Comply

Requirements Compliance (1/7)

Rqmt. No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Comply	**91-100**	
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	Comply	**18,19,26**	
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.	Comply	**18,19,26**	
4	The container shall be a fluorescent color; pink, red or orange	Comply	**18,26,191**	
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	**20**	
6	The rocket airframe shall not be used as part of the CanSat operations.	Comply	**18-20**	
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Comply	**26,88**	
8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Comply	**64-74**	
9	The container shall release the payload at 450 meters +/- 10 meters.	Comply	**26,87**	

Requirements Compliance (2/7)

Rqmt. No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Comply	50,56,59,56	
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Comply	64-74	
12	All descent control device attachment components shall survive 30 Gs of shock.	Comply	86,87	
13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	89,90	
14	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	89,90	
15	All structures shall be built to survive 30 Gs of shock.	Comply	89,90	
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	89,90	
17	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	81,82	
18	Mechanisms shall not use pyrotechnics or chemicals.	Comply	81,82	

Requirements Compliance (3/7)

Rqmt. No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
19	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.	Comply	**85**	
20	The science payload shall measure altitude using an air pressure sensor.	Comply	**33,34**	
21	The science payload shall provide position using GPS.	Comply	**37,38**	
22	The science payload shall measure its battery voltage.	Comply	**39**	
23	The science payload shall measure outside temperature.	Comply	**35,36**	
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Comply	**42,43**	
25	The science payload shall measure pitch and roll.	Comply	**40,41**	
26	The probe shall transmit all sensor data in the telemetry	Comply	**118,119**	
27	The Parachute shall be fluorescent Pink or Orange	Comply	**88,191**	

Requirements Compliance (4/7)

Rqmt. No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
28	The ground station shall be able to command the science vehicle to calibrate barometric altitude, and roll and pitch angles to zero as the payload sits on the launch pad.	Comply	168	
29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Comply	161,162	
30	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Comply	119,113	
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	116	
32	XBEE radios shall have their NETID/PANID set to their team number.	Comply	117	
33	XBEE radios shall not use broadcast mode	Comply	119	
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	212-217	
35	Each team shall develop their own ground station.	Comply	168-182	
36	All telemetry shall be displayed in real time during descent.	Comply	160,161	

Requirements Compliance (5/7)

Rqmt. No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	**160,161**	
38	Teams shall plot each telemetry data field in real time during flight.	Comply	**160,161**	
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	**156**	
40	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line. AC power will not be available at the ground station operation site.	Comply	**156**	
41	Both the container and probe shall be labeled with team contact information including email address.	Comply	**190**	
42	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission. The value shall be maintained through processor resets.	Comply	**140**	
43	No lasers allowed.	Comply	**17**	
44	The probe must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration.	Comply	**76, 146, 148, 163, 188**	

Requirements Compliance (6/7)

Rqm. No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
45	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.	Comply	**146**	
46	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	Comply	**102**	
47	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Comply	**127**	
48	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package similar to 18650 cells.	Comply	**129,130,136**	
49	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.	Comply	**76**	
50	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	**126**	
51	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Comply	**59,60**	
52	The GPS receiver must use the NMEA 0183 GGA message format.	Comply	**37**	
53	The CANSAT must operate during the environmental tests	Comply	**179,180**	

Requirements Compliance (7/7)

Rqmt. No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
54	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Comply	131-133,137	
BONUS	A video camera shall be integrated into the science payload to record the descent after being released from the container. The camera shall point downward 45 degrees from 10 nadir of the science payload. It shall point in one direction relative to the earth's magnetic field with a stability of +/- 10 degrees in all directions during descent. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The direction the camera is pointed relative to earth's magnetic north shall be included in the telemetry.	Comply	44	Stabilization setup is yet to be tested to demonstrate compliance

Management

Kshitij Shekhar

Status of Procurement(1/5)

Payload Electronics

CanSat System	Component	Model Name	Quantity	Received (YES/NO)	Date of Arrival/ Expected date of Arrival
Payload (Section-A: Telemetry Section)	Temperature sensor	BMP-280	1	YES	26/12/2018
	Air pressure sensor				
	GPS sensor	UBLOX Neo-6M	1	YES	27/2/2019
	Voltage sensor	SAMD21 ADC	1	YES	26/12/2018
	Pitch and roll sensor	MPU 9250	1	YES	26/12/2018
	Autogyro spin rate sensor	AH44E Hall Sensor	1	YES	13/12/2018
	SD Card Shield	Street27 MicroSD	1	YES	15/1/2019
	SD Card	SanDisk 8 GB Class 4	1	YES	15/1/2019
	Communication Module	NRF24L01	1	YES	27/2/2019
	Processor	SAMD21 MCU Dev Breakout	1	YES	26/12/2018
	Payload RTC	SAMD Internal RTC	1	YES	26/12/2018
	Payload Antenna	FXP830 Freedom Patch Antenna	1	YES	7/12/2018
	Payload radio	XBEE Pro S2C	1	YES	17/12/2018
	Audio Buzzer	Multicomp MCKPI-G2437-3671 Piezo Buzzer	1	YES	15/1/2019
	Battery	Samsung 18650 25R	1	YES	5/3/2019
	PCB	-	2	NO	3/4/2019

Status of Procurement(2/5)

Team B.A.G.S. Ballistic Auto-Gyro Satellite

Payload Electronics

CanSat System	Component	Model Name	Quantity	Received (YES/NO)	Date of Arrival/Expected date of Arrival
	Boost Converter	LTC3121	1	YES	27/2/2019
	Ambient Light Sensor	-	1	YES	27/2/2019
Payload (Section-B: Camera Stabilisation Section)	Battery	Envie Battery	1	YES	1/2/2019
	Processor	Arduino Pro Mini	1	YES	1/2/2019
	Servo	SG90	1	YES	26/12/2019
	Pitch and roll sensor	MPU 9250	1	YES	26/12/2019
	Bonus camera	Piquancy Ultra HD	1	YES	15/1/2019
	SD Card	Sandisk SD Card4	1	YES	15/1/2019
	Communication Module	NRF24L01	1	YES	27/2/2019
	Voltage Regulators	LM1117 LDO, LM7805 LDO	2	YES	5/3/2019
	PCB	-	1	NO	3/4/2019
	Miscellaneous (LEDs, repairs and other passive components)	-	-	NO	3/4/2019

Status of Procurement (3/5)

Payload Mechanical

CanSat System	Component	Description	Quantity	Received (YES/NO)	Date of Arrival/Expected date of Arrival
Payload	Prototype Payload top	SLS 3D-printed HIPS	1	YES	25/2/2019
	Prototype Structural member	FDM 3-D printed Polypropylene	3	YES	9/3/2019
	Prototype Structural support	FDM 3-D printed Polypropylene	6	YES	10/3/2019
	Prototype Rotor hub	Blow-Molded Polycarbonate	1	YES	26/2/2019
	Prototype Rotors	Blow-Molded Polycarbonate	4	YES	26/2/2019
	Setup for camera stabilization	SLS 3-D printed PLA	1	NO	13/4/2019
	Angular Bearing	FAG 7200B	1	NO	8/4/2019
	Final 3-D printed Payload	-	2	NO	15/4/2019

Team B.A.G.S.
Ballistic Auto-Gyro Satellite

Status of Procurement (4/5)

Container Electronics

CanSat System	Component	Model Name	Quantity	Received (YES/NO)	Date of Arrival/Expected date of Arrival
Container	Processor	ATtiny85	1	YES	15/1/2019
	Battery	Samsung 18650 25R	1	YES	15/1/2019
	Air Pressure Sensor	BMP280	1	YES	26/12/2019
	Transistor	TIP120 BJT	1	YES	15/1/2019
	Audio Buzzer	Multicomp MCKPI-G2437-3671 Piezo Buzzer	1	YES	15/1/2019

Status of Procurement (5/5)

Container Mechanical

CanSat System	Component	Description	Quantity	Received (YES/NO)	Date of Arrival/Expected Date of Arrival
Container	Parachute & Electronics modules	SLS 3-D printed HIPS	1	YES	18/3/2019
	Prototype Main body	FDM 3-D printed HIPS	1	YES	18/3/2019
	Parachute	Hexagonal with side 320mm	1	YES	3/3/2019
	Final 3-D printed Container	-	-	NO	11/4/2019

GCS

Component	Model No.	Quantity	Received (YES/NO)	Date of Arrival/ Expected Date of Arrival
Ground Station Antenna	TPLINK- TL-ANT2415D	1	YES	20/1/2019
Radio Module	XBEE Pro S2C RPSMA	1	YES	10/1/2019
Connector	N-female to RPSMA Male	1	YES	20/1/2019

CanSat Budget – Hardware (1/7)

Payload Electronics

CanSat System	Component	Model Name	Quantity	Total price($)	Determination
Payload (Section-A: Telemetry Section)	Temperature sensor	BMP-280	1	3.5	Actual
	Air pressure sensor				
	GPS sensor	UBLOX Neo-6M	1	11.09	Actual
	Voltage sensor	SAMD21 ADC	1	-	-
	Pitch and roll sensor	MPU 9250	1	2.83	Actual
	Autogyro spin rate sensor	AH49E Hall Sensor	1	1.99	Actual
	SD Card Shield	Street27 MicroSD	1	3.48	Actual
	SD Card	SanDisk 8 GB Class 4	1	3.93	Actual
	Communication Module	NRF24L01	1	1.89	Actual
	Processor	SAMD21 MCU Dev Breakout	1	31.46	Actual
	Payload RTC	SAMD Internal RTC	1	-	-
	Payload Antenna	FXP830 Freedom Patch Antenna	1	3.25	Actual
	Payload radio	XBEE Pro S2C	1	27.65	Actual
	Audio Buzzer	Multicomp MCKPI-G2437-3671 Piezo Buzzer	1	2.43	Actual
	Battery	Samsung 18650 25R	1	14.33	Actual
	Voltage Regulator	LM1117 LDO	1	0.6	Actual
	PCB	-	2	28.5	Estimated (Vendor)

CanSat Budget – Hardware (2/7)

Payload Electronics

CanSat System	Component	Model Name	Quantity	Total price($)	Determination
	Boost Converter	LTC3121	1	0.91	Actual
	Ambient Light Sensor	-	1	0.2	Actual
Payload (Section-B: Camera Stabilisation Section)	Battery	Envie Battery	1	5.48	Actual
	Processor	Arduino Pro Mini	1	2.95	Actual
	Servo	SG90	1	1.66	Actual
	Pitch and roll sensor	MPU 9250	1	2.83	Actual
	Bonus camera	Piquancy Ultra HD	1	11.21	Actual
	SD Card	Sandisk SD Card4	1	3.93	Actual
	Communication Module	NRF24L01	1	1.89	Actual
	Voltage Regulators	LM1117 LDO, LM7805 LDO	2	1.2	Actual
	PCB	-	1	10.2	Estimated (Vendor)
	Miscellaneous (LEDs, repairs and other passive components)	-	-	23	Estimated
Total				**202.39**	

CanSat Budget – Hardware (3/7)

Container Electronics

CanSat System	Component	Model Name	Quantity	Total price($)	Determination
Container	Processor	ATtiny85	1	1.12	Actual
	Battery	Samsung 18650 25R	1	14.33	Actual
	Air Pressure Sensor	BMP280	1	3.5	Actual
	Transistor	TIP120 BJT	1	0.9	Actual
	Audio Buzzer	Multicomp MCKPI-G2437-3671 Piezo Buzzer	1	2.43	Actual
	Nichrome Wire	-	1	2	Estimated
	PCB	-	1	7	Estimated (Vendor)
	Voltage Regulator	LM1117 LDO	1	0.6	Actual
	Miscellaneous (LEDs and other passive components)	-	-	20	Estimated
			Total	**51.78**	

CanSat Budget – Hardware (4/7)

Payload Mechanical

CanSat System	Component	Description	Quantity	Price ($)	Determination
Payload	Payload top	SLS 3D-printed HIPS	1	35.3	Actual
	Structural member	FDM 3-D printed Polypropylene	3	15	Estimated
	Structural support	FDM 3-D printed Polypropylene	6	30	Estimated
	Rotor hub	Blow-Molded Polycarbonate	1	14	Actual
	Rotors	Blow-Molded Polycarbonate	4	50	Estimated
	Setup for camera stabilization	SLS 3-D printed PLA	1	35	Estimated
	Angular Bearing	FAG 7200B	1	5.23	Actual
	Nut	M4, Pan heaed	3	0.3	Actual
	Bolt	M4, Pan head	3	0.3	Actual
	Screws	ST4-20 cros head screws	21	0.8	Actual
	Sorbothane sheet(10% error)	1 sheet	1	18.17	Actual
	Elastic strands		-	1	Actual
	Miscellaneous			15	
			Total	**220.1**	

CanSat Budget – Hardware (5/7)

Container Mechanical

CanSat System	Component	Description	Quantity	Price ($)	Determination
Container	Parachute module	SLS 3-D printed HIPS	1	12	Estimated
	Electronics module	SLS 3-D printed HIPS	1	11	Estimated
	Main body	FDM 3-D printed HIPS	1	24	Estimated
	Parachute Mount	SLS 3-D printed HIPS	2	6	Actual
	Parachute	Hexagonal with side 320mm	1	15	Actual
	Nut	M4, Pan head	1	0.1	Estimated
	Bolts	M4, Pan head	1	0.1	Actual
	Screws	ST4-20 cros head screws	16	0.61	Actual
	Elastic strands		-	2.14	Actual
	Miscellaneous			8	
			Total	**78.95**	

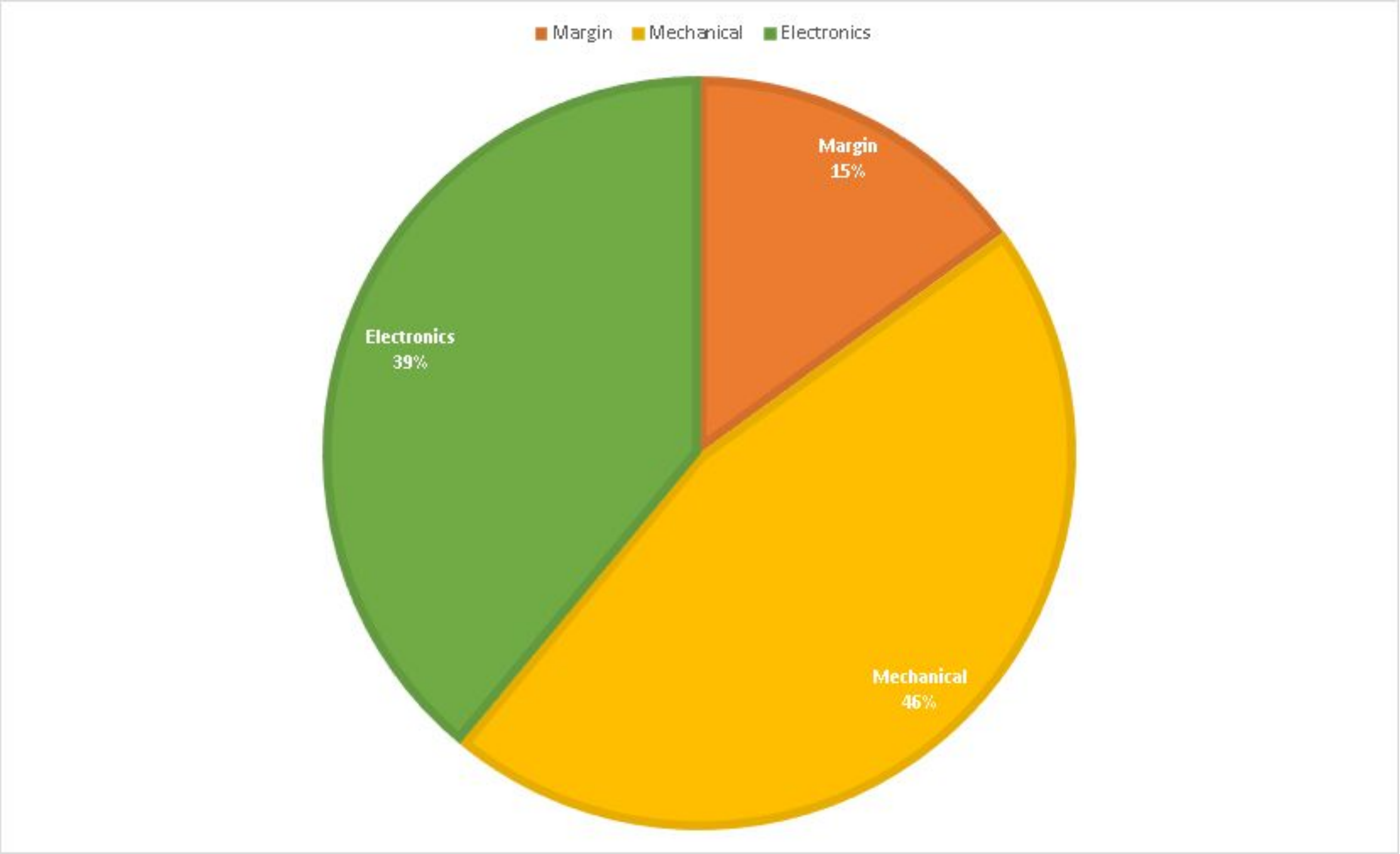
CanSat Budget – Hardware (6/7)

	Payload ($)	Container ($)
Mechanical	220.10	78.95
Electronics	202.39	51.78

	Total ($)
Mechanical	299.05
Electronics	254.17
Margin (15%)	98
Total	**655.22**

	Total ($)
Mechanical	424.49
Electronics	256.17
Margin (15%)	98
Total	**655.22**

CanSat Budget – Hardware (7/7)



CanSat Budget – Other Costs(1/3)

Component	Model No.	Quantity	Total price($)	Determination
Ground Station Antenna	TPLINK- TL-ANT2415D	1	140.39	Actual
Radio Module	XBEE Pro S2C RPSMA	1	43	Actual
Connector	N-female to RPSMA Male	1	4.87	Actual
Laptop	MAC Book Air	1	1408.45	Actual
Miscellaneous Setup (Umbrella, Binoculars and other components)	-		70	Estimated
		Total	**1666.71**	

Note: No component has been reused from previous year.

CanSat Budget – Other Costs (2/3)

Side Expenditures

	Quantity	Total Price($)	Determination
CanSat registration fee	1	100	Actual
Model shipment	1	180	Estimated
Flight tickets + US VISA	10	12600	Estimated
Food and Accommodation	10	1800	Estimated
Container and Payload Prototyping	2	320	Estimated
Drone and Rocket Testing	-	150	Partially Sponsored
	Total	**15150**	

	Cost ($)
Hardware	655.22
GCS	1666.71
Side Expenditures	15150
Overall Cost of Mission	**17471.93**

Sponsorship

Sponsorship speeds

We aspire to bring technological advancement in the design of satellites, rockets and rovers. Our team has been working on various research-related projects in the field of aeronautics and astronautics. Currently, we stand in the top teams in India but for achieving the target and making a state-of-the-art CanSat, we require your valuable financial support. Your contribution will help the team in emerging successful and to raise the Indian flag high on the international ground.

SUBSONIC (Rs 10k+)

- You are entitled to everything in the Subsonic reward title.
- Your logo/name will be printed on our team apparels.
- You will receive a personalized thank-you mail.
- Your support will be acknowledged and thanked through a Special Mention in all our NASA presentations.

TRANSONIC (Rs 30k+)

- You are entitled to everything in the Transonic reward title.
- Our exclusive team merchandise will be sent to you.
- An e-certificate will be sent to you via mail.
- Your name will be featured in exclusive team video which will be featured on our YouTube channel, website, and social media.

SUPERSONIC (Rs 50k+)

- You are entitled to everything in the Supersonic reward title.
- Your logo/name will be printed on our CanSat banner.
- Your pitch video/personal video will be displayed during the final rocket launch in the USA.

HYPERSONIC (Rs 100k+)

- You are entitled to everything in the Hypersonic reward title.
- Your decal will be printed on CanSat and you will become our official title sponsor.
- You will be given a special Memento of our prototype as a

Team B.A.G.S.
Ballistic Auto-Gyro Satellite

Our Current Sponsors

NSIT Motorsports

Nakshatra

DN Aerospace

Space Development Nexus

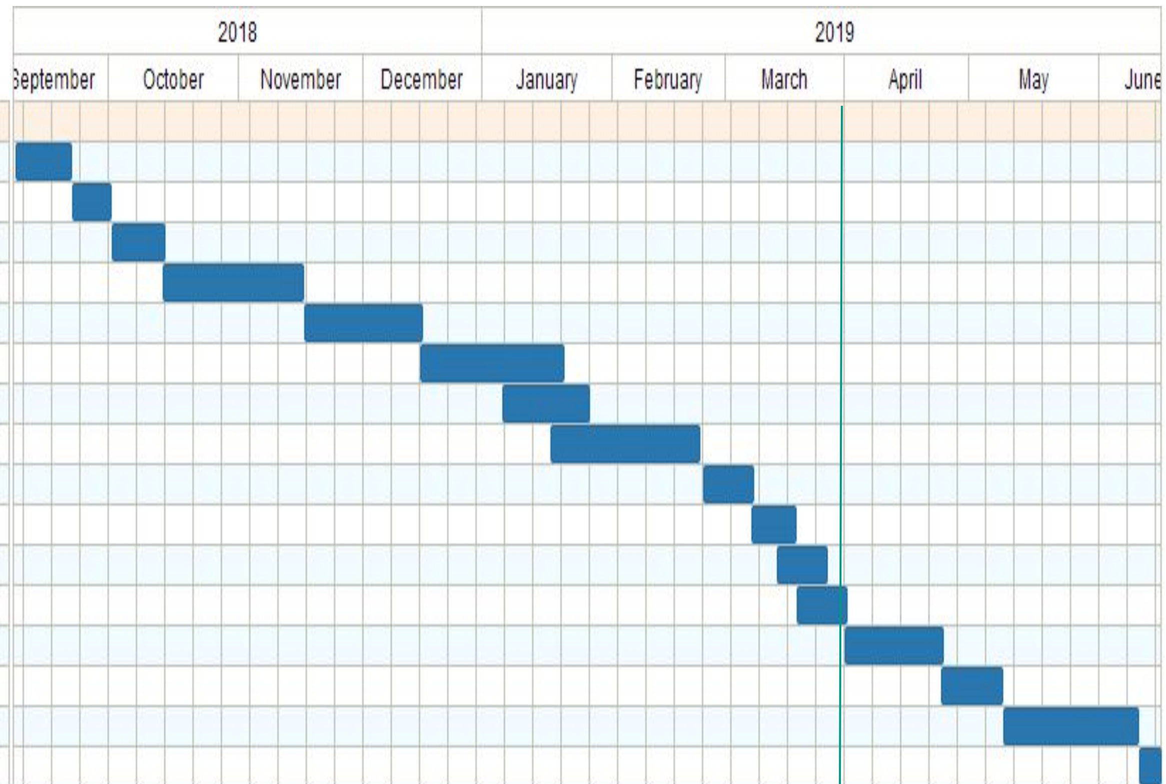
Morphedo

Heramb Maker Lab

Program Schedule Overview (1/4)

Overall Gantt Chart

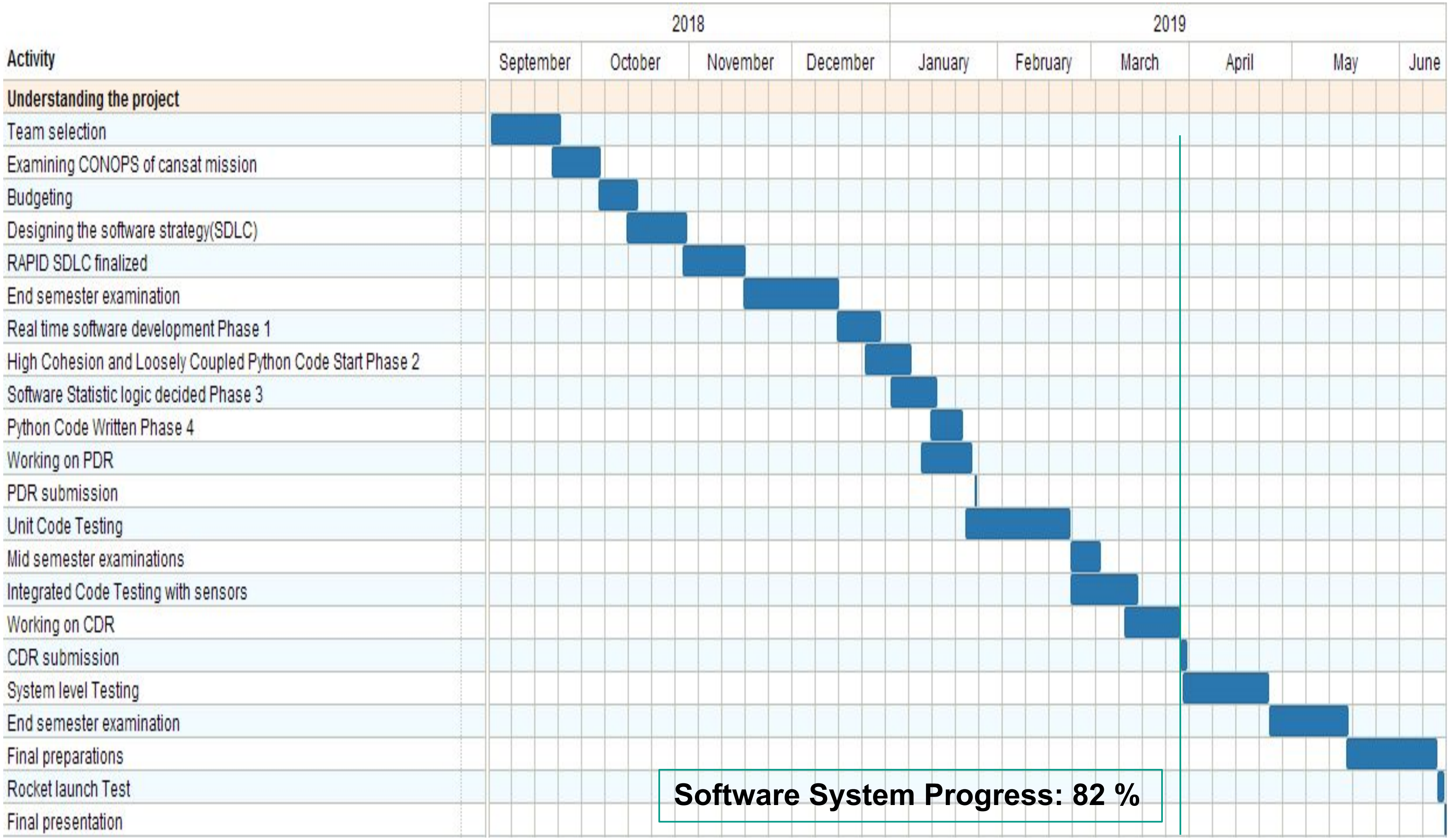
Activity	Start date	End Date
Understanding the project	**Start date**	**End date**
Team Selection	10-Sept-201..	20-Sept-201..
Examining CONOPS of cansat mission	21-Sept-201..	30-Sept-2018
Budgeting	1-Oct-2018	14-Oct-2018
Concept development	15-Oct-2018	14-Nov-2018
End semester examination	15-Nov-2018	15-Dec-2018
Procurement of facilities and materials	16-Dec-2018	20-Jan-2019
Working of PDR	5-Jan-2019	25-Jan-2019
CanSat integration	17-Jan-2019	22-Feb-2019
Mid semester examination	23-Feb-2019	7-Mar-2019
Design finalisation	8-Mar-2019	18-Mar-2019
Various testing	13-Mar-2019	20-Mar-2019
Working of CDR	3-Mar-2019	29-Mar-2019
Last modifications	30-Mar-2019	24-Apr-2019
End semester examination	25-Apr-2019	7-May-2019
Final preparations	8-May-2019	11-May-2019
Final Competition	12-Jun-2019	17-Jun-2019



Overall Progress: 76 %

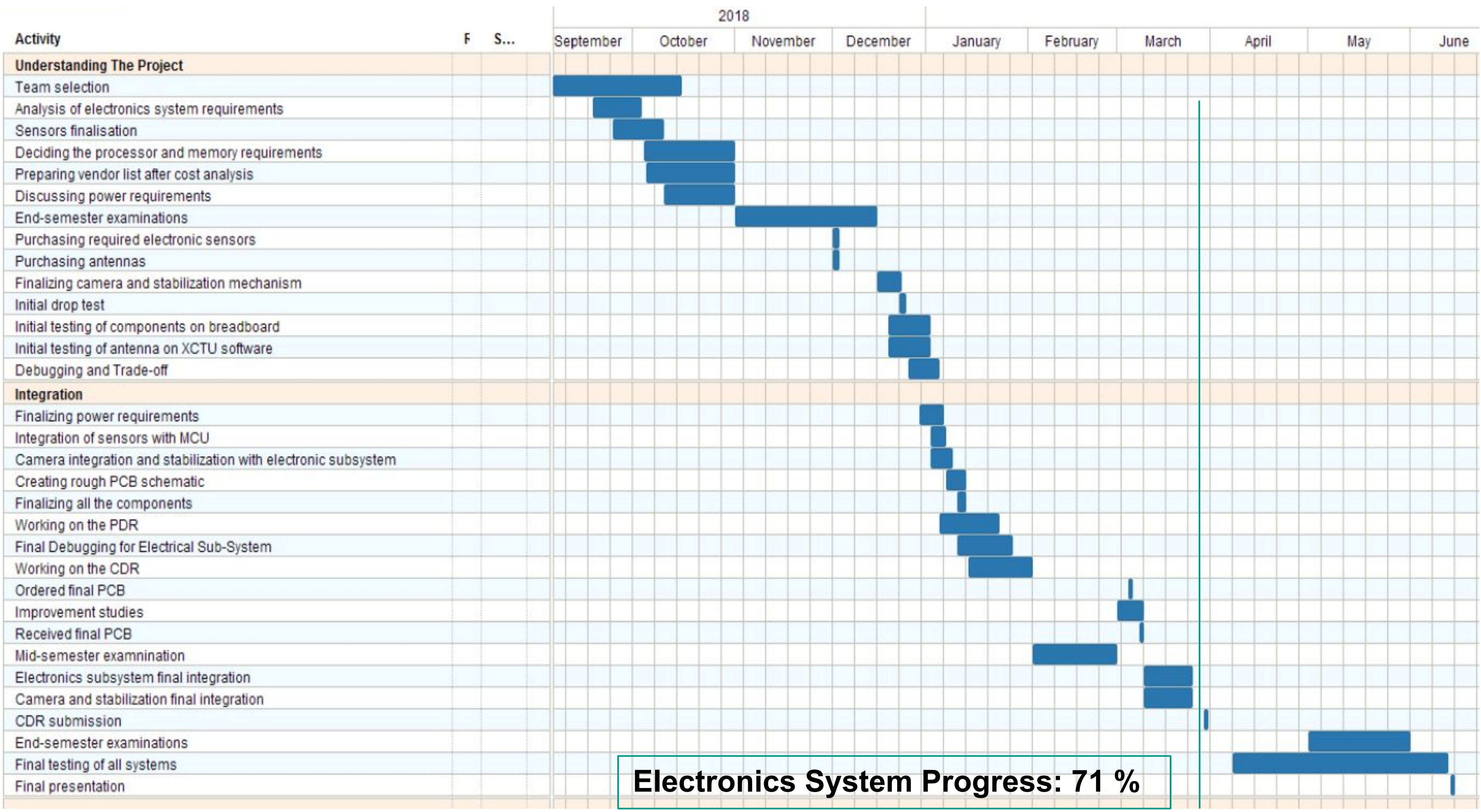
Program Schedule(Cont.) (2/4)

Software



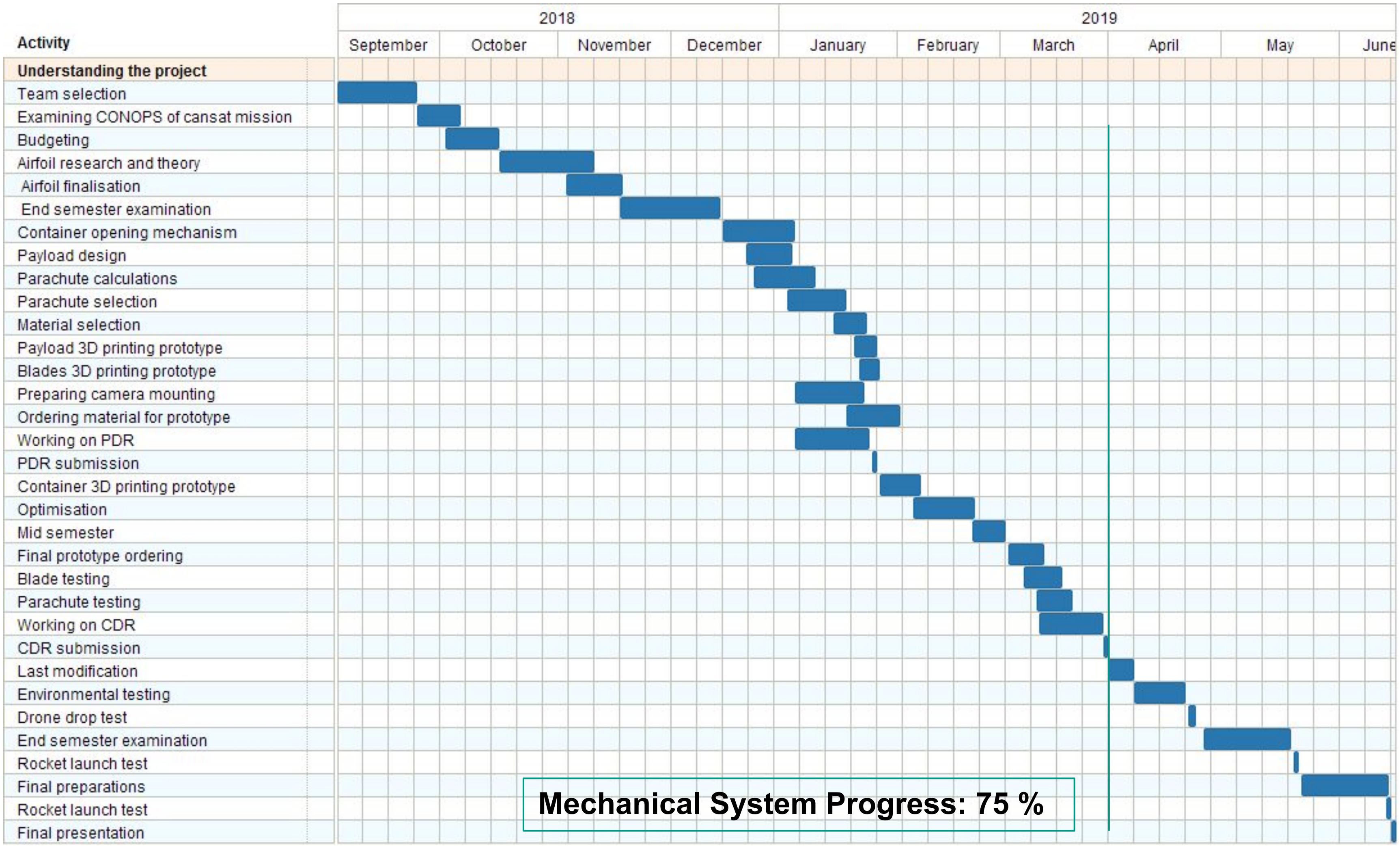
Program Schedule(Cont.) (3/4)

Electronics



Program Schedule(Cont.) (4/4)

Mechanical



Detailed Program Schedule (1/4)

Milestone	Start Date	End Date	Duration	Assigned to
A team of 10 members was formed by taking interviews. Based on how much they have learned from the study session held.	10 Sept 2018	20 Sept 2018	11 Days	❖ Bhavya Arya ❖ Sourav Bhattacharjee
Understanding the mission, and studying every aspect of the CanSat guide for 2019. The mission statement was analyzed and preparation for the competition was begun.	21 Sept 2018	30 Sept 2018	10 Days	❖ Entire team
Sensor finalization was done. Analysation of processor and memory requirement and discussion on power requirement was done.	25 Sept 2018	3 Nov 2018	10 Days	❖ Sourav Bhattacharjee ❖ Shikhar Makhija
Started working on airfoils and their configurations and started deciding the processor and memory requirements.	31 Sept 2018	13 Oct 2018	14 Days	❖ Snigdha Singh ❖ Bhavya Arya
Designing the software strategy.	12 Oct 2018	31 Oct 2018	20 Days	❖ Raunit Singh
Prototypes were made of ideas which were theoretically perfect, from things used in our homes on daily basis of the container opening mechanisms and tested.	14 Oct 2018	14 Nov 2018	31 Days	❖ Riyanshu Motalaya ❖ Kshitij Shekhar
Finalisation of RAPID SDLC	31 Oct 2018	15 Nov 2018	16 Days	❖ Raunit Singh
End term examinations	15 Nov 2018	15 Dec 2018	32 Days	❖ Entire team

Detailed Program Schedule (2/4)

Milestone	Start Date	End Date	Duration	Assigned to
Purchasing for required electronic sensors and antennas was done	1 Dec 2018	5 Dec 2018	6 Days	❖ Shikhar Makhija ❖ Sourav Bhattachar jee
Several preliminary designs and ideas for possible container and payload were brainstormed and discussed.	16 Dec 2018	5 Jan 2019	21 days	❖ Riyanshu Motalaya ❖ Bhavya Arya
Real time software development Phase 1 and High Cohesion and Loosely Coupled Python Code Start Phase 2 was done	14 Dec 2018	7 Jan 2018	25 Days	❖ Raunit Singh
Initial testing of components on breadboard and testing of antennas on XCTU software was carried out.	22 Dec 2018	17 Jan 2019	27 Days	❖ Shaonak Dayal ❖ Advait Paithankar
Our team research's materials which satisfies our needs like low weight , high strength , which can be 3D printed , etc. We selected materials by seeing constraints like shipping , availability and cost.	1 Jan 2019	23 Jan 2019	24 days	❖ Riyanshu Motalaya ❖ Snigdha Singh ❖ Kshitij Shekhar
Worked on Software Statistic logic decided Phase 3	3 Jan 2019	14 Jan 2019	12 Days	❖ Raunit Singh
Integration of sensors with MCU. Camera integration and stabilisation with electronic subsystem	5 Jan 2019	21 Jan 2019	17 Days	❖ Shaonak Dayal ❖ Divya Tiwari
Worked on Python Code Written Phase 4	11 Jan 2019	22 Jan 2019	12 Days	❖ Raunit Singh
Finalizing of material was done from various options available to us according to our needs.	11 Jan 2019	23 Jan 2019	13 Days	❖ Entire Team

Detailed Program Schedule (3/4)

Milestone	Start Date	End Date	Duration	Assigned to
Finalized design for CanSat , after rejecting various designs on the basis of flaws in their mechanism. And selected the most suitable that fulfills our needs and is in accordance with the guidelines provided by CanSat competition.	3 Jan 2019	11 Jan 2019	9 Days	❖ Sourav Bhattacharjee ❖ Bhavya Arya
After all the work, we documented it and finally concocted the PDR.	18 Jan 2019	29 Jan 2019	12 Days	❖ Entire Team
Creating rough PCB schematic and then finalizing all components	22 Jan 2019	26 Jan 2019	5 Days	❖ Advait Paithankar ❖ Divya Tiwari
Final debugging for electronics system	26 Jan 2019	12 Feb 2019	18 Days	❖ Divya Tiwari ❖ Sourav Bhattacharjee ❖ Shikhar Makhija
PDR presentation will be given by our team.	8 Feb 2019	15 Feb 2019	8 Days	❖ Entire Team
Mid semester examination	15 Feb 2019	2 Mar 2019	16 days	❖ Entire Team
Post presentation, improvisation of designs for the CDR will be done for making it in best accordance with the guidelines.	3 Mar 209	13 Mar 2019	23 Days	❖ Entire Team
Integrated Code Testing with sensors will be done	3 Mar 2019	14 Mar 2019	12 Days	❖ Shaonak Dayal ❖ Advait Paithankar
Design will be passed after final analysis, by our team which is to be 3D printed and will be sent to printer.	5 Mar 2019	19 Mar 2019	15 Days	❖ Riyanshu Motalaya ❖ Snigdha Singh ❖ Kshitij Shekhar

Detailed Program Schedule (4/4)

Milestone	Start Date	End Date	Duration	Assigned to
Various tests will be performed on CanSat to check that we are meeting the requirements or not. Different tests are vibration, drop, environment, etc.	**10 Mar 2019**	**25 Mar 2019**	16 Days	❖ Entire Team
Ordering PCB. Final integration of electronics subsystem and camera.	**15 Mar 2019**	**27 Mar 2019**	13 Days	❖ Divya Tiwari ❖ Shaonak Dayal ❖ Advait Paithankar
CDR will be concocted after adding on the necessary improvisations on the CanSat.	**15 Mar 2019**	**29 Mar 2019**	15 Days	❖ Entire Team
Preparations as team will be giving presentation of the CDR before the experts (competition organizers).	**29 Mar 2019**	**4 Apr 2019**	6 Days	❖ Entire Team
Final preparations will be done	**5 Apr 2019**	**20 Apr 2019**	16 Days	❖ Sourav Bhattacharjee ❖ Shikhar Makhija ❖ Bhavya Arya
End semester Examinations	**21 Apr 2019**	**7 May 2019**	17 Days	❖ Entire Team
Everything will be tested for a one last time and then will be packed for competition.	**8 May 2019**	**20 May 2019**	13 Days	❖ Entire Team
Every item will be checked and packed and will be tick marked.	**16 May 2019**	**13 Jun 2019**	29 Days	❖ Entire Team

Shipping and Transportation

- We will be providing safety to the CanSat (like through bubble wraps,etc.) and pack them in special containers customized for this purpose only.
- We have contacted different courier service and have chosen DHL Express service for the purpose of shipping.
- We have been proposed an approximate cost of 3900 INR ($ 56.37) for an approximate weight of 2kg box.
- This box would be containing whole cansat model (excluding batteries and bulb) and spares to manage any last minute system failure or damage during transportation.
- The courier would be reaching the USA in two days from India. So we are planning to send the courier by 8th of June, to avoid any kind unforeseen delay.

All components will be bubble wrapped and taped and then placed inside a big box

1 Box for Mechanical components, 1 box for Electronics hardware and 1 box for GCS

Stephenville **Shipped through DHL**

Conclusions

MAJOR ACCOMPLISHMENTS

- All sensors tested with SAMD21 on breadboard.
- Telemetry has been tested
- Descent rate estimations have been done using numerical methods
- Mechanism for payload deployment and container opening have been tested
- Material selection and basic material testing has been done

MAJOR UNFINISHED WORK

- Camera stabilization mechanism to be tested.
- Validation of descent rate estimation with experimental values through rocket testing in April end.
- Validation of FSW states/logics

TESTING TO COMPLETE

We have spent an appropriate amount of time prototyping, developing, testing, troubleshooting and refining all our systems, and will continue to do so. Hence we feel we can face the challenges ahead. Our rocket testing as sponsored by Space Development NEXUS (SDNX) is scheduled on 28 April, 2019 in a rural area in Haryana, India.

FLIGHT SOFTWARE STATUS

The FSW logic has been written down and all of its major components have been tested individually. The full integrated test will be performed on the second week of April.