Netaji Subhas University of Technology

CanSat 2019
Critical Design Review (CDR)

#3279

K.A.L.A.M.

Kinetic Autogyro Landing Aerospace Mission

Presentation Outline [1/6]

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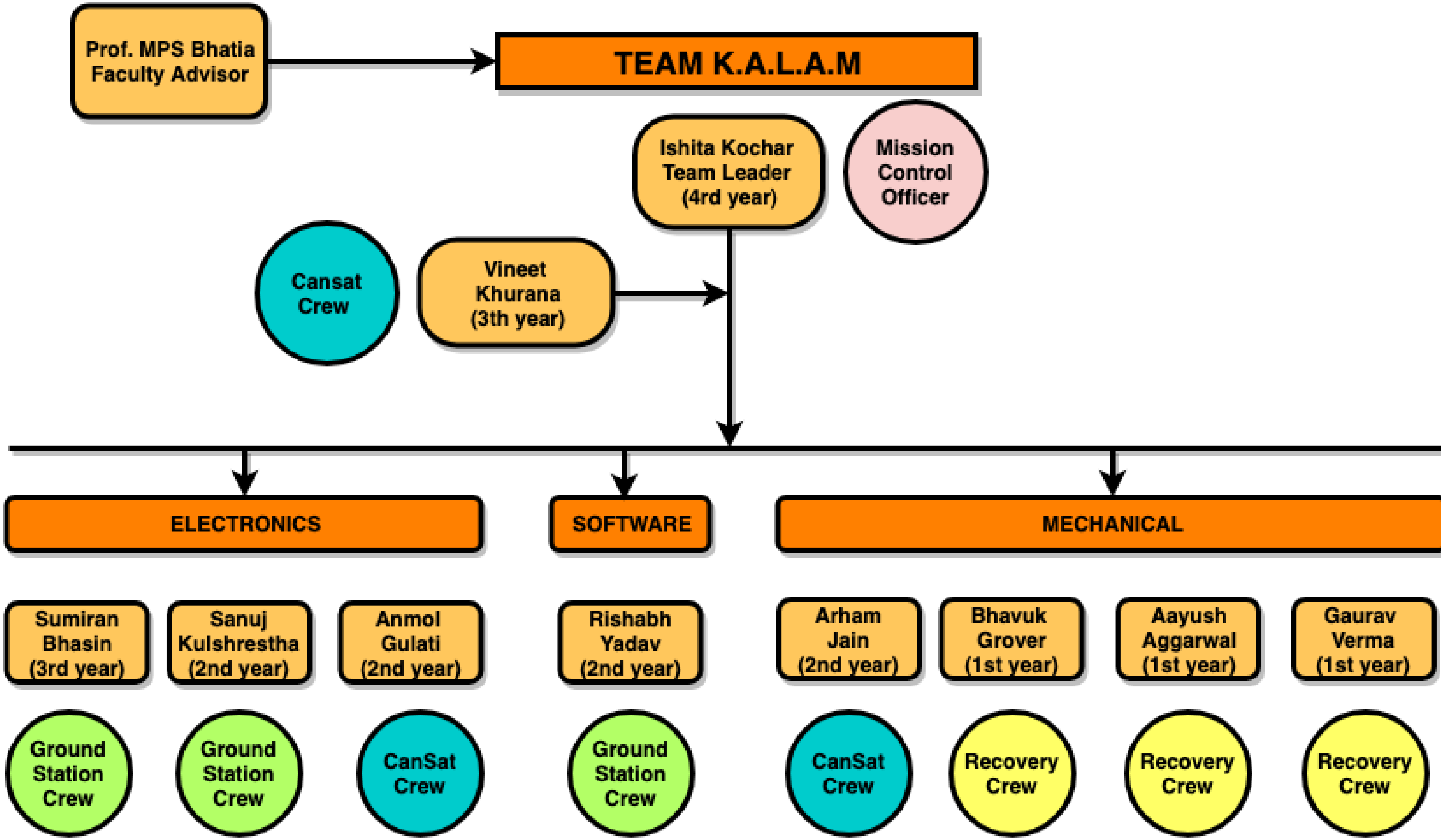
Section	Presenter
Systems Overview	**Sanuj Kulshrestha**
Sensor Subsystem Design	**Sumiran Bhasin**
Descent Control Design	**Aayush Aggarwal**
Mechanical Subsystem Design	**Arham Jain**
Communication and Data Handling (CDH) Subsystem Design	**Ishita Kochar**
Electrical Power Subsystem (EPS) Design	**Anmol Gulati**
Flight Software (FSW) Design	**Rishabh Yadav**
Ground Control System (GCS) Design	**Vineet Khurana**
CanSat Integration and Test	**Bhavuk Grover**
Mission Operations & Analysis	**Gaurav Verma**
Requirements Compliance	**Gaurav Verma**
Management	**Vineet Khurana**

Team Organization



Acronyms

A	Analysis
ADC	Analog to Digital Converter
Alt	Altitude
ARM	Advanced RISC Machines
CDH	Communication and Data Handling
CDR	Critical Design Review
CONOPS	Concept of Operations
DCR	Decent Control Requirements
D	Demonstration
EEPROM	Electrically Erasable Programmable Read Only Memory
EPS	Energy Power Subsystem
FSW	Flight Software
GCS	Ground control station

GPS	Global Positioning System
GUI	Graphical User Interface
HDPE	High Density Polyethylene
I	Inspection
I2C	Inter-Integrated Circuit (Two Wire Interface)
IDE	Integrated Development Environment
Li	Lithium
MCU	Microcontroller Unit
MSR	Mechanical Sub-System Requirements
P	Process
PANID	Personal Area Network Identification Number
VM	Verification Method
SR	System Requirements
T	Testing

System Overview

Sanuj Kulshrestha

Mission Summary [1/2]

Objectives

Build a CanSat that will use auto-gyro/passive helicopter recovery descent control of a science payload when released from the launch vehicle.

- The CanSat shall be launched to an altitude ranging 670 -725 meters above the launch site.
- Once the CanSat is deployed from the rocket, the CanSat shall descend using a parachute at a descent rate of 20 m/s.
- At 450 meters, the container shall release the science payload.
- The descent rate of science payload shall be 10 to 15 m/s.
- The science payload descends under auto-gyro/passive helicopter recovery control system.
- The payload shall transmit telemetry which shall include sensors to track altitude using air pressure, external temperature, battery voltage, GPS position, pitch and roll and blade spin rate
- The Ground Control Station shall receive and display CanSat data.
- When the science payload lands, all telemetry transmission shall stop and a located audio beacon shall activate.

Mission Summary [2/2]

Bonus Objective

- A video camera shall be integrated into the science payload to record the descent after being released from the container.
- Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second.
- The camera shall point downward 45 degrees from 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.
- Telemetry shall include the direction of camera that is relative to earth's magnetic north.

External Objectives

- Funding for project’s hardware and logistical needs through potential sponsors.
- We have already conducted workshops in our home city and we are planning to conduct CanSat-related workshops at the national scale.

Summary of Changes Since PDR

Sensor Subsystem Changes

- GPS BN220 has been replaced by GPS-NEO 6M.

Descent Control Subsystem Changes

- There have been no changes in Descent Control Subsystem since PDR.

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Mechanical Subsystem Changes

- Payload design has been modified.

Communication and Data Handling Subsystem Changes

- There have been no changes in Communication and Data Handling Subsystem since PDR

Summary of Changes Since PDR

Electrical Power Subsystem Changes

- A 9V – 12V booster has been used to power the buzzer so as to obtain a sound rated 100dB intensity.
- The container battery bas been updated to EBL Li-ion Battery as it performs equally well in low as well as in high rate of discharge

Flight Software Changes

- There have been no changes in the FSW since the PDR

Ground Control Station Changes

- There have been no changes in Ground Control Station since PDR

System Requirement Summary [1/4]

SRS#	Description	VM			
		A	I	T	D
SRS1	Total mass of CanSat (science payload and container) shall be 500grams +/- 10 grams	✓	✓	✓	✓
SRS2	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.	✓	✓	✓	✓
SRS3	The container shall not have any sharp edges to cause it to get stuck in the rocket payload section which is made of cardboard.	✓	✓		✓
SRS4	The container shall be a fluorescent color; pink, red or orange.	✓	✓	✓	✓
SRS5	The rocket airframe shall not be used as part of the CanSat operations.		✓		
SRS6	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.		✓		
SRS7	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.				✓
SRS8	The container shall release the payload at 450 meters +/- 10 meters.	✓	✓	✓	✓
SRS9	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.			✓	✓
SRS10	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.			✓	✓

System Requirement Summary [2/4]

SRS#	Description	Verification Method A	I	T	D
SRS11	All descent control device attachment components shall survive 30 Gs of shock.		✔	✔	
SRS12	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	✔	✔		
SRS13	The science payload shall measure altitude using an air pressure sensor.		✔	✔	✔
SRS14	The science payload shall provide position using GPS.		✔	✔	✔
SRS15	The science payload shall measure its battery voltage.		✔	✔	✔
SRS16	The science payload shall measure outside temperature.		✔	✔	✔
SRS17	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	✔	✔	✔	✔
SRS18	The science payload shall measure pitch and roll.		✔	✔	✔
SRS19	The payload shall transmit all sensor data in the telemetry		✔	✔	✔
SRS20	The Parachute shall be fluorescent Pink or Orange		✔		
SRS21	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.	✔	✔	✔	✔

System Requirement Summary [3/4]

SRS#	Description	Verification Method			
		A	I	T	D
SRS22	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.	✔	✔	✔	✔
SRS23	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	✔	✔	✔	✔
SRS24	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	✔	✔		
SRS25	Teams shall plot each telemetry data field in real time during flight.	✔	✔	✔	
SRS26	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.		✔	✔	✔
SRS27	No lasers allowed.		✔		
SRS28	The payload must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration	✔	✔		✔
SRS29	The payload 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.		✔		✔

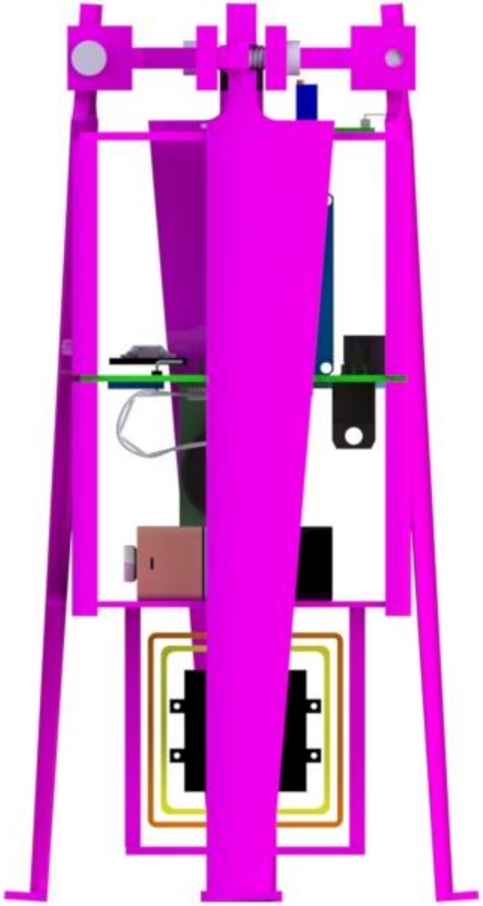
System Requirement Summary [4/4]

SRS#	Description	Verification Method			
		A	I	T	D
SRS30	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.		✔	✔	✔
SRS31	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.		✔	✔	
SRS32	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	✔	✔		✔
SRS33	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	✔	✔		
SRS34	The GPS receiver must use the NMEA 0183 GGA message format.	✔	✔	✔	
SRS35	Payload/Container shall operate for a minimum of two hours when integrated into rocket		✔		✔
BONUS	A video camera shall be integrated into science payload to record descent after being release from container. Camera must be color with a minimum resolution of 640x480 pixels and 30 frames per second. The camera shall point downward 45 degrees from nadir of the science payload.	✔	✔	✔	

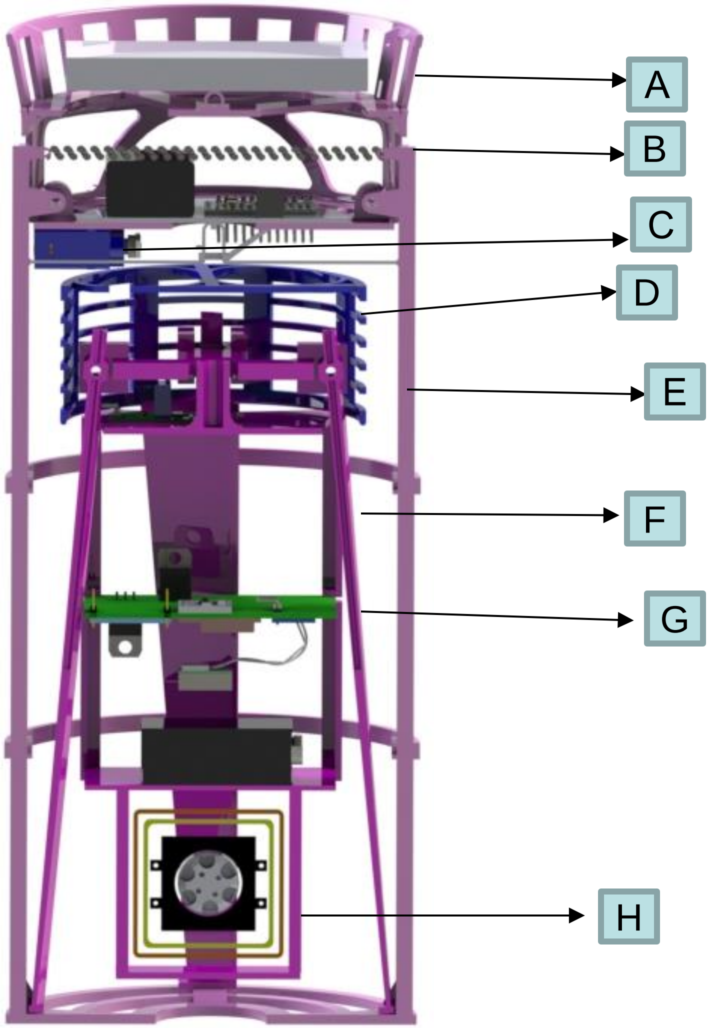
Payload Physical Layout [1/4]

CanSat

Payload



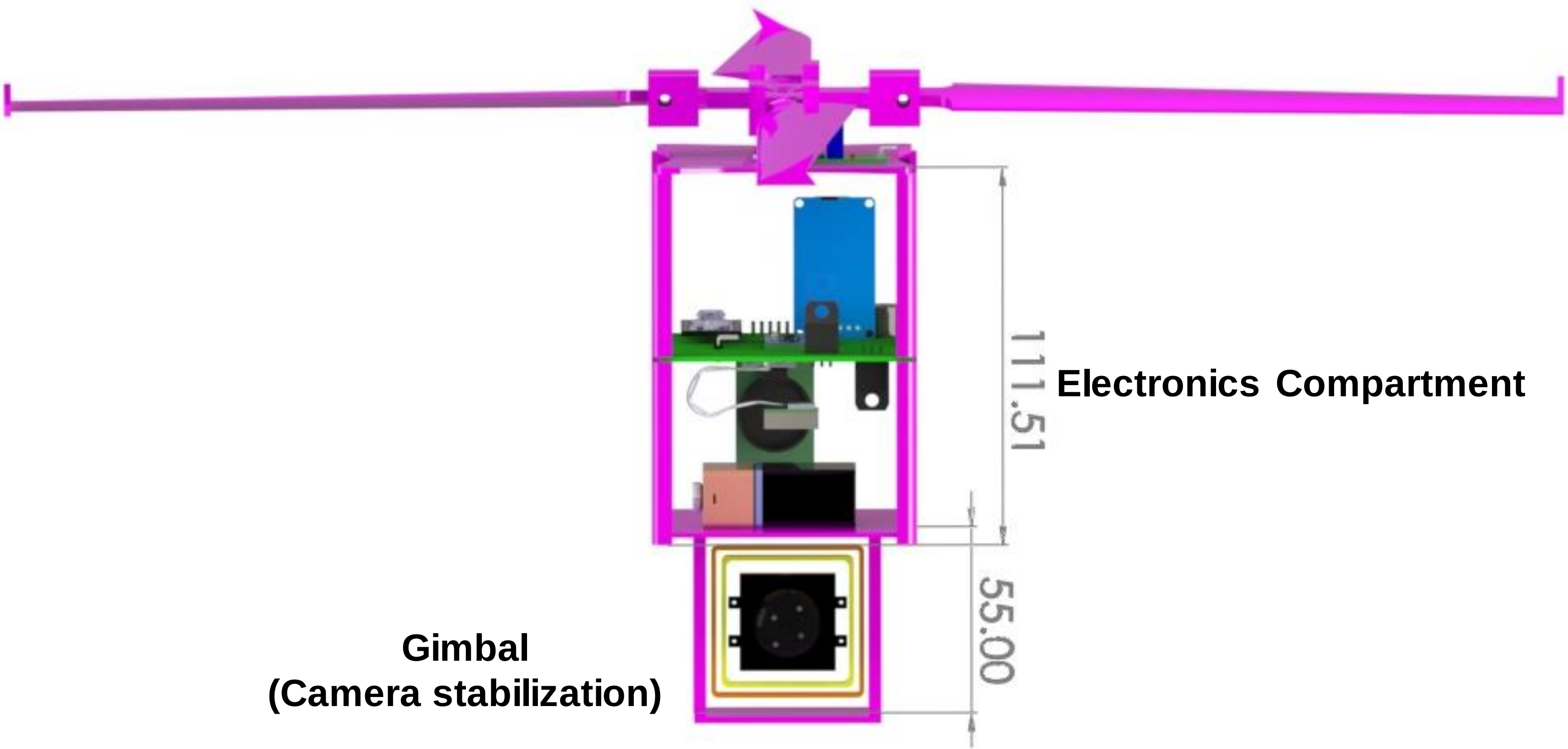
Payload Physical Layout [2/4]



Dimensioning

Symbol	Components	Dimensions
A	**Parachute**	Radius=**55mm**
B	**Spring**	Diameter=**4mm** , Length=**115mm**
C	**Servo Motor**	LengthxWidthxHeight = **31x24x12mm**
D	**Cage**	Diameter=**90mm** , Height=**51mm**
E	**Container Ribs**	Diameter=**110mm** , Height=**297.8mm**
F	**Blade**	LengthxWidthxHeight = **207x30x3mm**
G	**Electronic Component**	LengthxWidthxHeight = **75x75x110mm**
H	**Camera Stabilizer (Gimbal)**	LengthxWidthxHeight =**45x41x32mm**

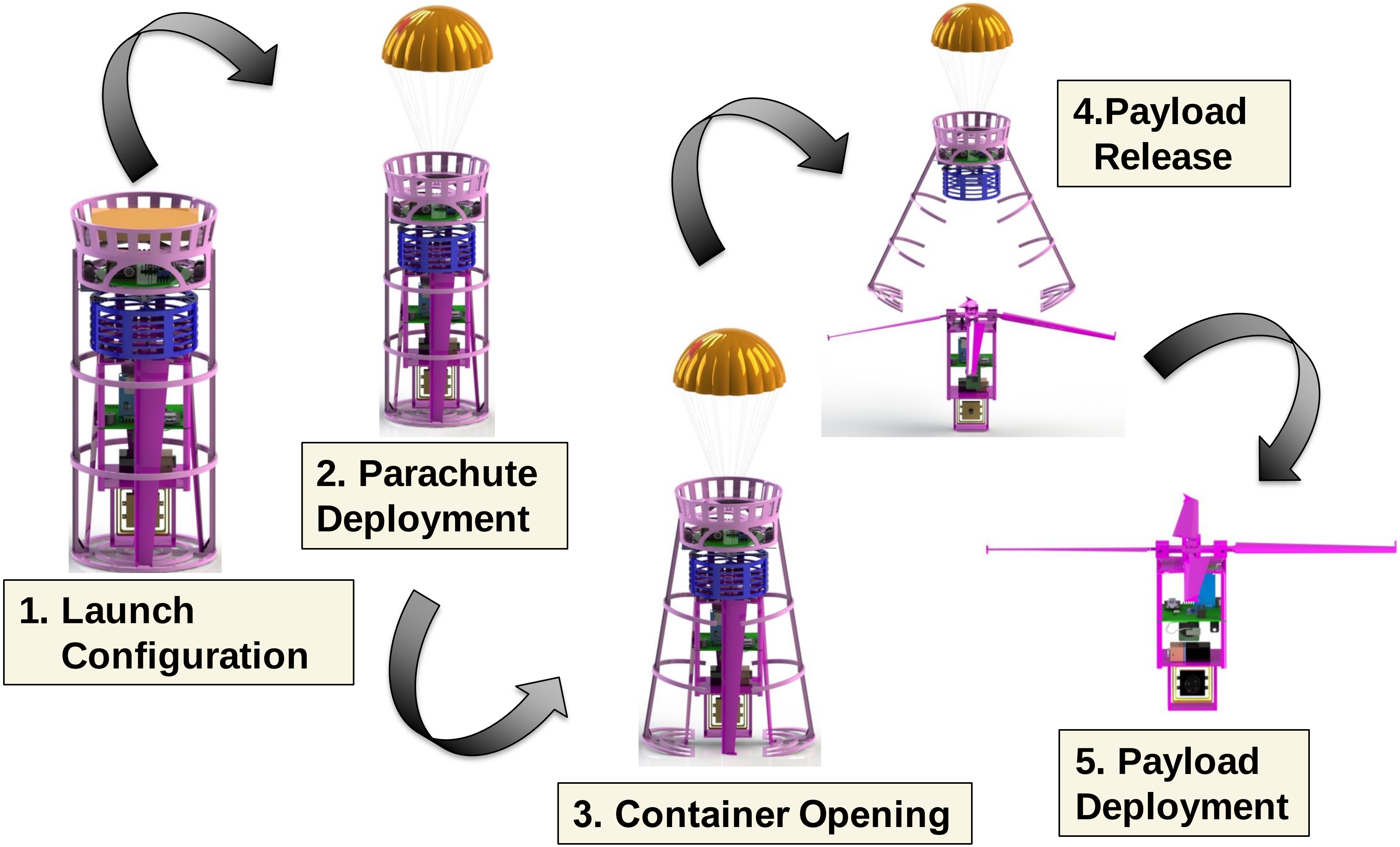
Payload Dimensioning



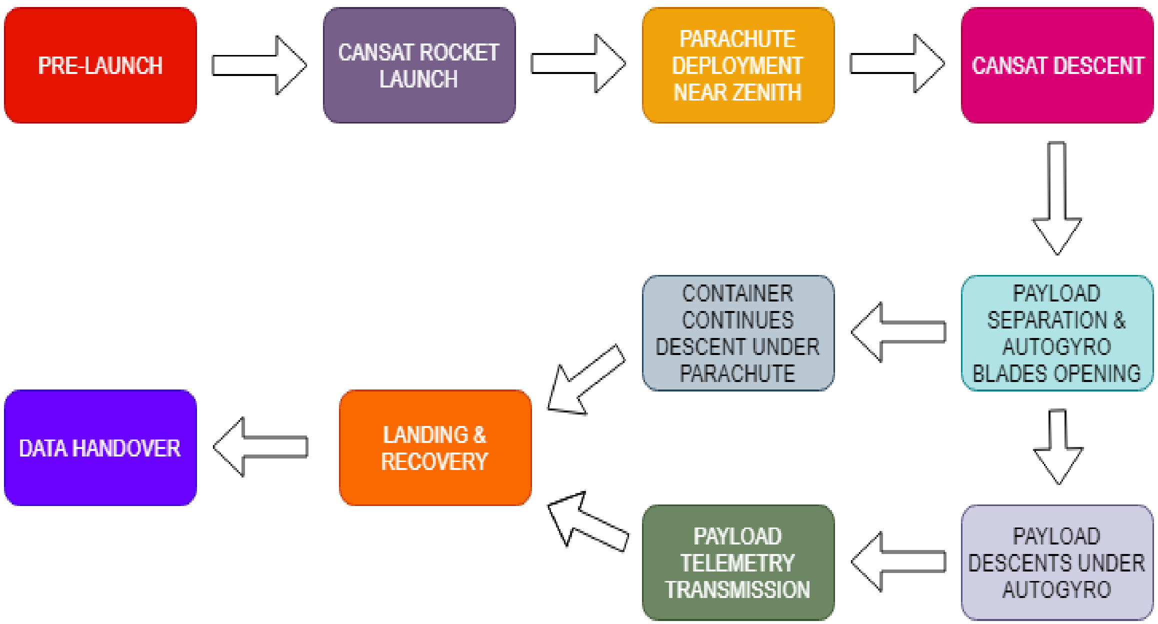
Electronics Compartment

Gimbal
(Camera stabilization)

Payload Physical Layout [4/4]



System Concept of Operations [1/5]



Name	Role/Responsibility
Ishita Kochar	Mission Control Officer
Vineet Khurana	CanSat Crew
Arham Jain	CanSat Crew
Anmol Gulati	CanSat Crew
Sanuj Kulshrestha	Ground Station Crew
Rishabh Yadav	Ground Station Crew
Sumiran Bhasin	Ground Station Crew
Bhavuk Grover	Recovery Crew
Gaurav Verma	Recovery Crew
Aayush Aggarwal	Recovery Crew

System Concept of Operations [2/5]

Pre-Launch

1. The CanSat integrity as a whole is checked thoroughly.
2. Environmental tests performed by the staff.
3. Communication and GCS checks completed.
4. CanSat is switched ON, and telemetry starts.
5. CanSat integrated in the launch rocket.

Launch

1. CanSat launched with the rocket.

CanSat Release & Parachute Deployment

1. CanSat released at apex at an altitude of around 700m.
2. The parachute of CanSat deploys right after the release.

System Concept of Operations [3/5]

CanSat Descent

1. The CanSat descents under parachute with velocity of 20 $\pm$ 5 m/s.

Payload Separation & Autogyro Blade Opening

1. At the altitude of 450m, the servo motor cuts the Kevlar thread.
2. The stretched/stressed spring gets compressed and pulls the container ribs open.
3. The payload slips down the container.
4. The stowed autogyro blades are deployed.

Payload Descent under Autogyro

1. The autogyro blades start rotating.
2. The payload descent under autogyro with velocity of 10m/s.

System Concept of Operations [4/5]

Container Descent

1. The container continues descent under the parachute.

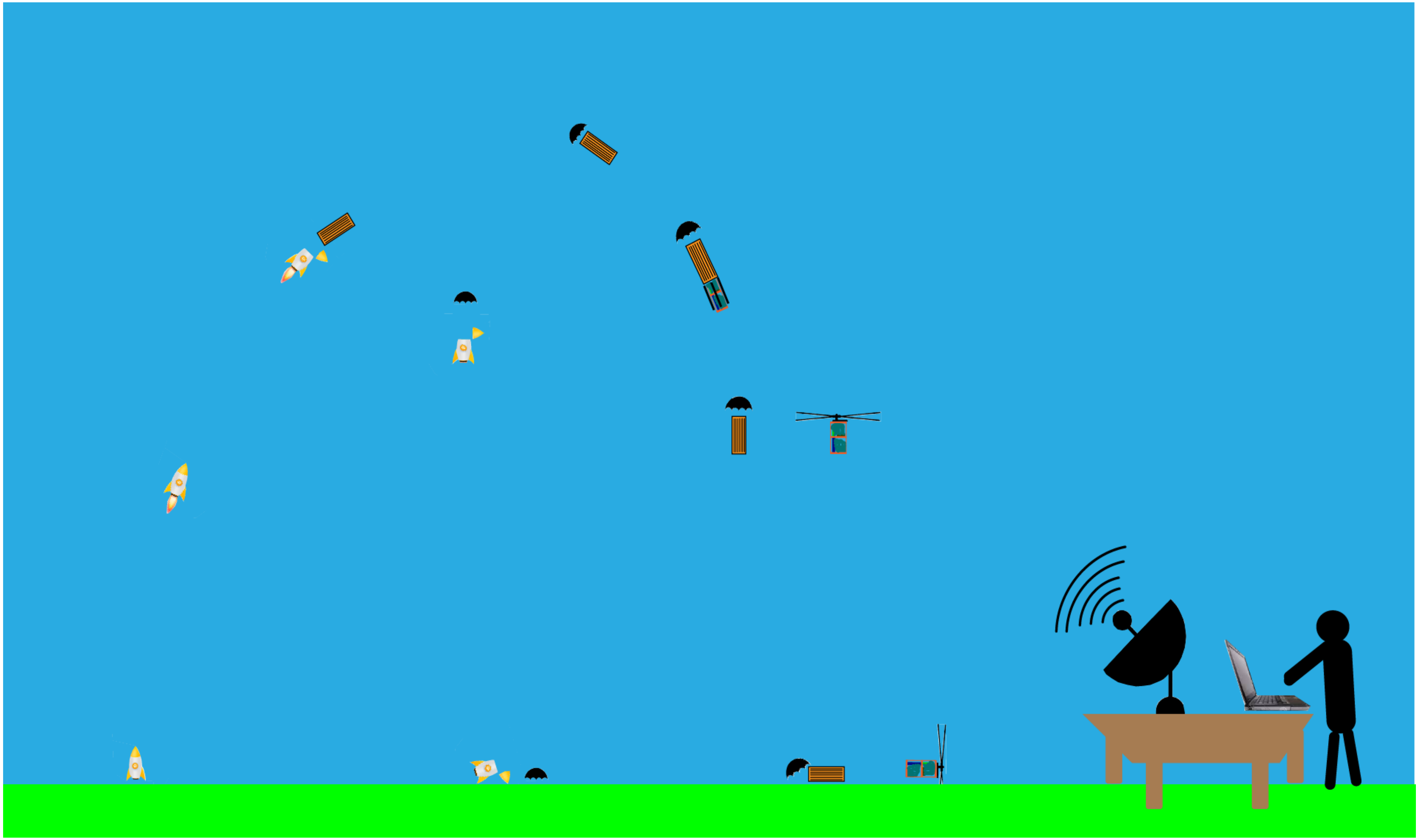
Landing & Recovery

1. The audio beacon on both container and payload starts after landing.
2. The telemetry transmission stops.
3. The last GPS location of payload is used to narrow down the location.
4. Bright pink colour on both payload and container for easy detection during landing.

Data Handover & PFR

1. The .csv file is copied to the thumb drive and handed over..
2. PFR preparations are started.

System Concept of Operations [5/5]



Launch Vehicle Compatibility [1/2]

Available Volume (as per Competition Requirements):

- Diameter 125 mm
- Height 310 mm

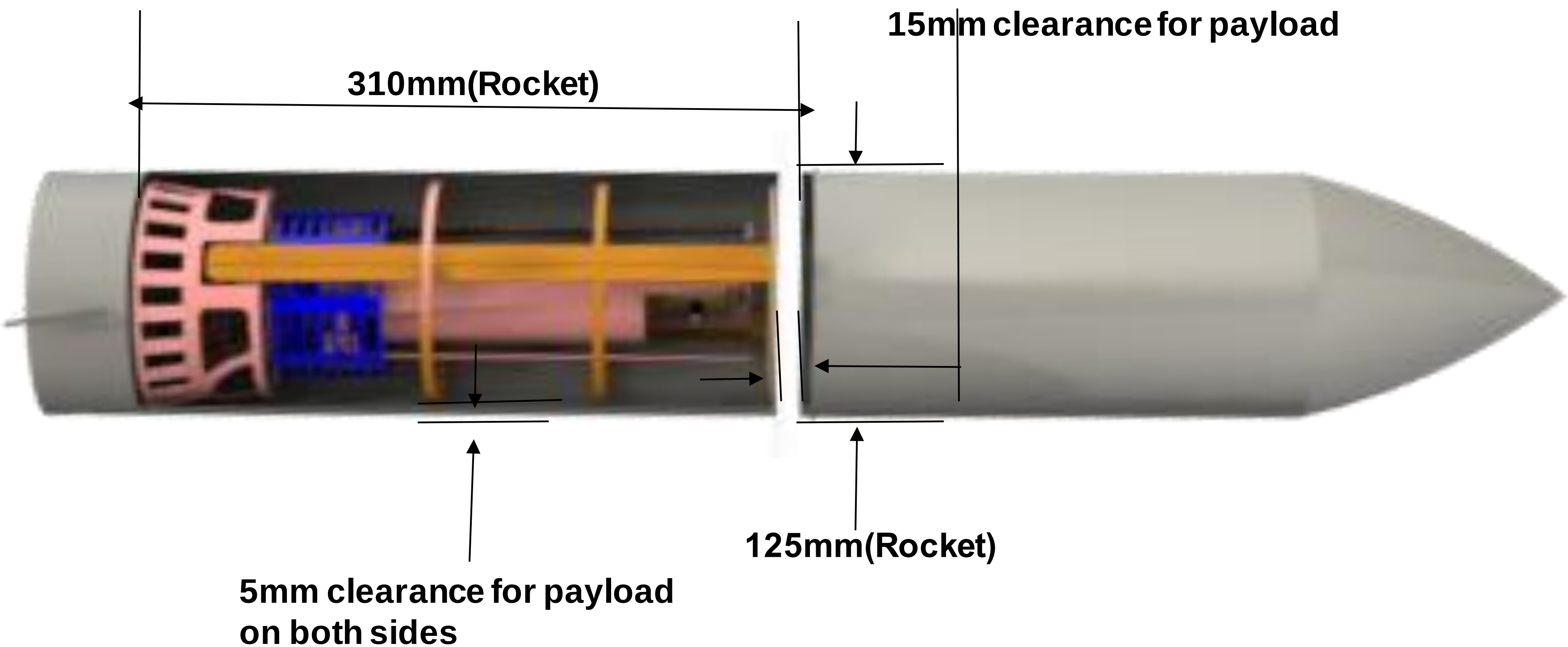
CanSat Volume:

- Diameter 115 mm
- Height 295 mm

Clearance:

- 10mm in diameter
- 15mm in Height

Launch Vehicle Compatibility [2/2]



No sharp protrusions

Sensor Subsystem Design

Sumiran Bhasin

Sensor Subsystem Overview

Where?	S.No.	Sensor	Device Name and its Model	How are they used?
Payload	1	**Air Pressure Sensor**	BMP-180	BMP-180 is used to measure pressure and temperature. We are using it to get the **altitude** of payload.
Payload	2	**Pitch and Roll Sensor**	MPU-6050	MPU-6050 is used to obtain acceleration and angular velocity in x, y and z axis. It gives **pitch** and **roll** of the Payload
Payload	3	**GPS**	UBLOX NEO 6M	Gives the **time, latitude, longitude, altitude, number of Satellite.**
Payload	4	**Temp. Sensor**	BMP-180	We are using it to get the temperature of the payload.
Payload	5	**Auto-Gyro blade spin Sensor**	Hall Sensor (AH44E Hall Effect Switch)	It detects Magnetic field of magnets on blade that is used to calculate the **RPM** of blades.
Payload	6	**Voltage**	Resistors	Voltage divider circuit to map actual voltage on ADC of Teensy. It Gives Battery **Voltage**
Payload	7	**Camera Sensor**	Turbowing Cyclops DVR 3	It is used for bonus task. Camera will start recording video at **640x480 30fps** when payload is released from Container.
Container	8	**Air Pressure Sensor**	BMP-180	BMP-180 is used to measure pressure and temperature. We are using it to get the **altitude** of container.

Sensor Changes Since PDR

Serial Number	Sensor Filed	From (In PDR)	To (In CDR)	Rationale
1.	**GPS Sensor**	**BN220**	**UBLOX NEO-6M**	**1.** **Non-availabily** of BN220 in Indian Market. The actual cost and overseas shipping charges would have increased the cost. 2. UBLOX NEO-6M, **most common GPS in Indian** was tested and hence used. 3. There are **no technical reasons** to switch to UBLOX NEO-6M

Sensor Subsystem Requirements [1/2]

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
SS-1	The payload shall measure air pressure, air temperature, altitude, pitch, roll, GPS position, battery voltage, mission time spin rate of auto-gyro blades during its descent through use of various sensors.	Competition Requirement	BR-20, BR-21, BR-22, BR-23, BR-24, BR-25	Very high	✔	✔	✔	
SS-2	All the sensor data shall be transmitted through telemetry to the ground station.	Competition Requirement	BR- 26 PCDH-01	Very high	✔		✔	
SS- 3	The sensor data shall also be stored in SD card for backup.	Competition Requirement		High	✔			

Sensor Subsystem Requirements [2/2]

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
SS-4	The GPS sensor shall use NMEA 0183 GGA format	Competition Requirement	BR- 53	Very high	✔	✔	✔	
SS- 5	The payload shall record its descent through a video camera integrated in it.	Bonus Objective		High	✔		✔	
SS- 6	The camera shall point 45 degrees from nadir. Also, the camera shall point in one direction from the earth's magnetic field with stability of 10 degrees in either direction. The direction from magnetic north shall be included in telemetry.	Bonus Objective		High	✔	✔		

Payload Air Pressure Sensor Summary

Sensor Selected :	BMP180

Source: Datasheet

Characteristics

- Low power: 5μA at 1 sample / sec. in standard mode
- Low noise: 0.06hPa (0.5m) in ultra low power mode 0.02hPa (0.17m) advanced resolution mode.
- Resolution of 0.01hPa.

Inter-face	Pressure Range (hPa)	Dimensions (mm)	Weight (g)	Working Current (mA)	Sensitivity (hPa)	Operating Voltage (V)
I2C	300-1100	14 x 12 x 0.93	0.92	1	±2	1.8 - 3.6

Data Processing

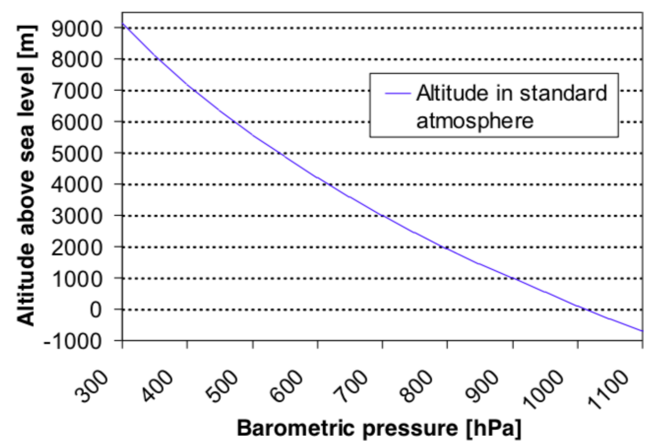
- It senses Pressure and then calculates Altitude using the given formula and this value of altitude is used to determine different FSW states.

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

where, p_0= Pressure at sea level (hPa) and p = Measured pressure (hPa)

- With the measured pressure p and the absolute altitude the pressure at sea level can be calculated:

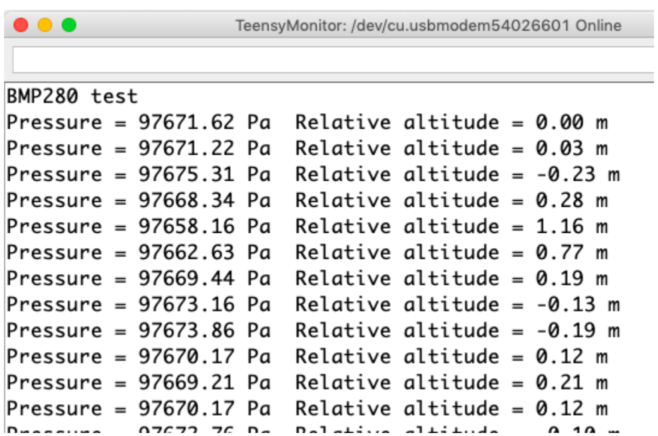
$$p_0 = \frac{p}{\left(1 - \frac{altitude}{44330}\right)^{5.255}}$$



Payload Air Pressure Sensor Summary

Data Format

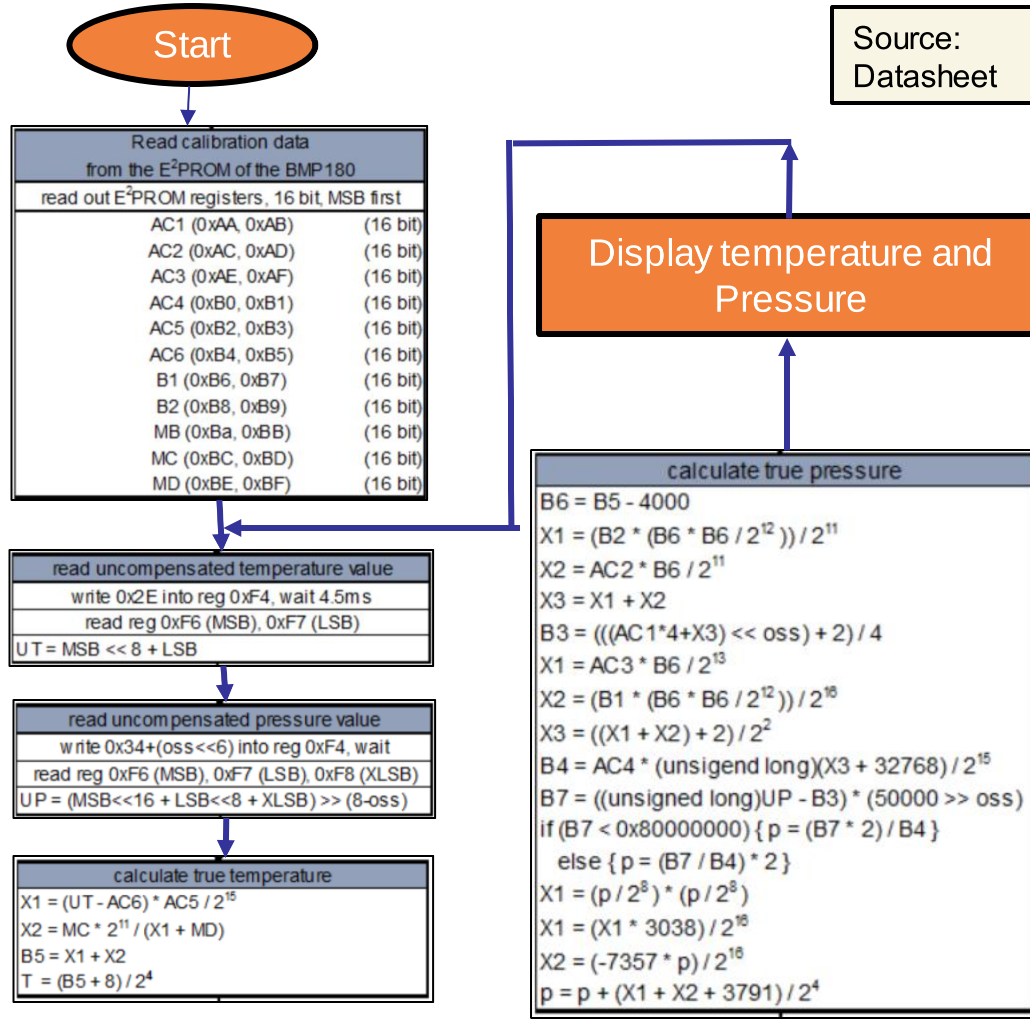
- Pressure will be displayed in Pascals because of the competition requirement of displaying each sensor value in engineering units with resolution of 1 pascals.
- Altitude will be displayed in meters and it will be a floating point number.



TeensyMonitor: /dev/cu.usbmodem54026601 Online

```
BMP280 test
Pressure = 97671.62 Pa  Relative altitude = 0.00 m
Pressure = 97671.22 Pa  Relative altitude = 0.03 m
Pressure = 97675.31 Pa  Relative altitude = -0.23 m
Pressure = 97668.34 Pa  Relative altitude = 0.28 m
Pressure = 97658.16 Pa  Relative altitude = 1.16 m
Pressure = 97662.63 Pa  Relative altitude = 0.77 m
Pressure = 97669.44 Pa  Relative altitude = 0.19 m
Pressure = 97673.16 Pa  Relative altitude = -0.13 m
Pressure = 97673.86 Pa  Relative altitude = -0.19 m
Pressure = 97670.17 Pa  Relative altitude = 0.12 m
Pressure = 97669.21 Pa  Relative altitude = 0.21 m
Pressure = 97670.17 Pa  Relative altitude = 0.12 m
```

Algorithm for pressure and temperature measurement



Payload Air Temperature Sensor Summary

Sensor Selected : **BMP180**

Source: Datasheet

Characteristics

- Low power: 5µA at 1 sample / sec. in standard mode
- Low noise: 0.06hPa (0.5m) in ultra low power mode 0.02hPa (0.17m) advanced resolution mode.
- Resolution of 0.1°C

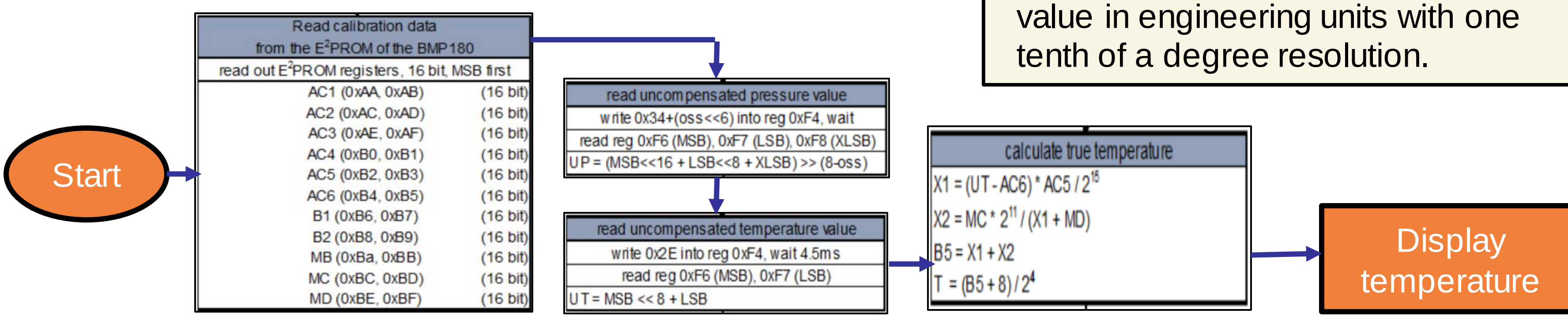
Inter-face	Temperature Range (hPa)	Dimensions (mm)	Weight (g)	Working Current (mA)	Sensitivity (hPa)	Operating Voltage (V)
I2C	-40 - +85	14 x 12 x 0.93	0.92	1	±2	1.8 - 3.6

Data Processing

- 16bit Temperature data is provided by the sensor.
- I2C Interface with Teensy 3.2

Data Format

Temperature will be displayed in °C because of the competition requirement of displaying each sensor value in engineering units with one tenth of a degree resolution.



GPS Sensor Summary

Sensor Selected :	UBLOX NEO 6M

Source: Datasheet

Characteristics

The 50-channel u-blox 6 positioning engine boasts a Time-To-First-Fix (TTFF) of under 1 second. The dedicated acquisition engine, with 2 million correlators, is capable of massive parallel time/frequency space searches, enabling it to find satellites instantly.

Inter-face	Weight (g)	Horizontal accuracy(m)	Sensitivity (Tracking)	Protocols	Voltage Supply (V)	Antenna Gain (dB)
UART, USB, SPI	12	2.5	-161 dBm	NMEA, UBX, RTCM	2.7 – 3.6	Max. 50

Data Processing

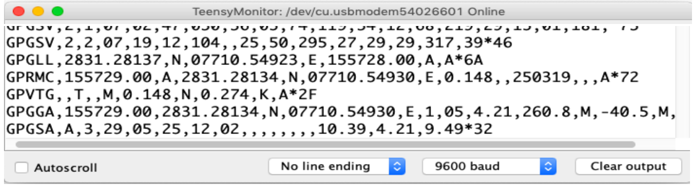
- We will be using UART Interface at baud rate set to 9600 to read NMEA sentences from UBLOX NEO 6M.

```
#define gps_uart Serial3
gps_uart.begin(9600);
```

- These NMEA sentences will be configured to obtain data such as Time, Altitude, Longitude, Latitude, number of satellites as per Telemetry Requirements (TinyGPS++ Library will be used that makes this process easier and efficient).

- Operation Limits:

Dynamics	≤ 4 g
Altitude[10]	50,000 m
Velocity[10]	500 m/s



GPS Sensor Summary

Data Format

As per competition requirements data will be in following scientific units and resolution:

- Time generated by the GPS receiver will be reported in UTC and will have a resolution of a second.
- Latitude generated by the GPS receiver will be in decimal degrees with a resolution of 0.0001 degrees.
- Longitude generated by the GPS receiver will be in decimal degrees with a resolution of 0.0001 degrees.
- Altitude generated by the GPS receiver in meters above mean sea level with a resolution of 0.1 meters.
- Number of GPS satellites being tracked by the GPS receiver. This must be an integer number.

TeensyMonitor: /dev/cu.usbmodem54026601 Online

Send

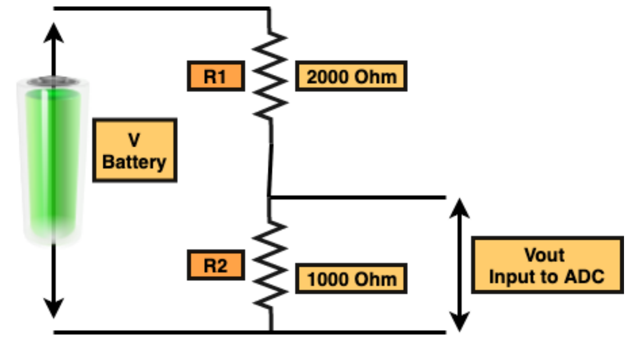
17:02:12	28.5214	77.1759	271.6	5
17:02:13	28.5214	77.1759	271.6	5
17:02:14	28.5214	77.1759	272.2	5
17:02:15	28.5214	77.1759	272.6	5
17:02:16	28.5214	77.1759	273.4	5
17:02:17	28.5214	77.1759	272.4	5
17:02:18	28.5214	77.1759	272.7	5
17:02:19	28.5214	77.1759	272.8	5
17:02:20	28.5214	77.1759	273.2	5
17:02:21	28.5214	77.1759	272.2	5
17:02:22	28.5214	77.1759	272.6	5
17:02:23	28.5214	77.1759	273.2	5
17:02:24	28.5214	77.1759	272.7	5
17:02:25	28.5214	77.1759	272.8	5
17:02:26	28.5214	77.1759	273.0	5
17:02:27	28.5214	77.1759	273.2	5

Payload Voltage Sensor Summary

Sensor Selected :	Voltage divider circuit

Characteristics

- A voltage divider can be used as a crude logic level shifter to interface two circuits that use different operating voltages.
- Easy to implement and flexible



Sensor	Interface	Sensitivity (%)	Resolution (bit)	Weight (g)	Size (mm^2)	Range (V)
Voltage divider circuit	ADC port	± 5 - ± 20	10	.8	Discrete Circuit	0 – 9.9V

Data Processing

- ADC Pin of Teensy is connected to the output of Voltage Divider Circuit.
- Accuracy is (5/210)V = 0.0049V because resolution of the ADC pin is 10bits.
- This will map 9 V Battery to 3 V on the ADC Teensy 3.2.

$$V_{out} = \frac{R2}{R1+R2} V_{battery} = \frac{1}{3} V_{battery}$$

WHERE
R1 = 2000 Ω
R2 = 1000 Ω

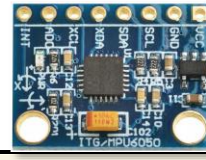
Data Format

Voltage will be displayed with resolution of 0.01 V because of the competition requirement.

```
float getBatteryVoltage() {
  int voltageDigital = analogRead(voltagePin);
  float voltageBattery = (voltageDigital)*(VCC/ADC_MAX)*VOLTAGE_DIV;
  return voltageBattery;
}
```

Pitch/Roll Sensor Summary

Sensor Selected :	MPU 6050



Source: Datasheet

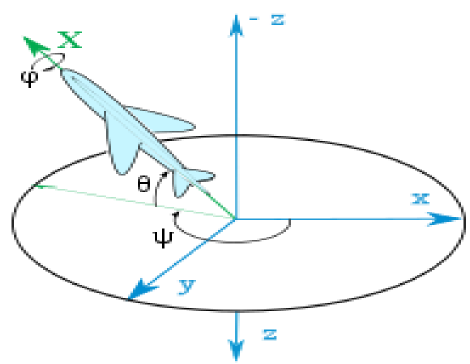
Characteristics

The MPU-60X0 is the world's first integrated 6-axis MotionTracking device that combines a 3-axis gyroscope, 3-axis accelerometer, and a Digital Motion Processor™ (DMP) all in a small 4x4x0.9mm package. With its dedicated I2C sensor bus, it directly accepts inputs from an external 3-axis compass to provide a complete 9-axis MotionFusion™ output.

Sensor	Model	Dimensions (mm^2)	Weight (g)	Resolution (bit)	Interfacing	Operating Current	Operating Voltage
InvenSense	GY 521 MPU 6050	30 x 20	2.1	16	I2C	3.9mA	2.375V–3.46V

Data Processing

- I2C Interface with Teensy 3.2
- Gyro Range :±250 500 1000 2000°/s
- Acceleration range:±2 ±4 ±8 ±16g
- Efficient and simple 6 degrees-of-freedom **SENSOR FUSION ALGORITHMS** are used to calculate pitch and roll of Payload.

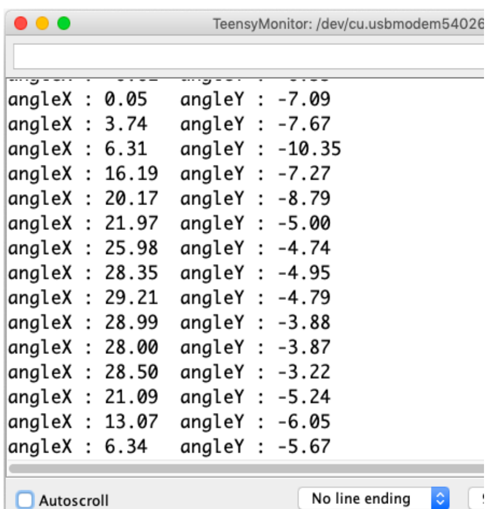


Pitch/Roll Sensor Summary

Data Format

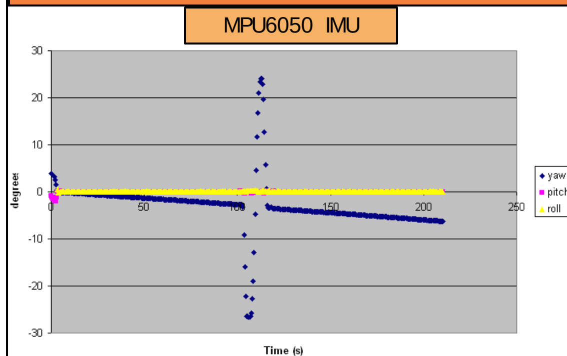
According to Competition requirements:

- <Pitch> is the tilt angle in the pitch axis in degrees. The resolution must be 1 degree.
- <Roll> is the tilt angle of the roll axis in degrees. The resolution must be 1 degree.



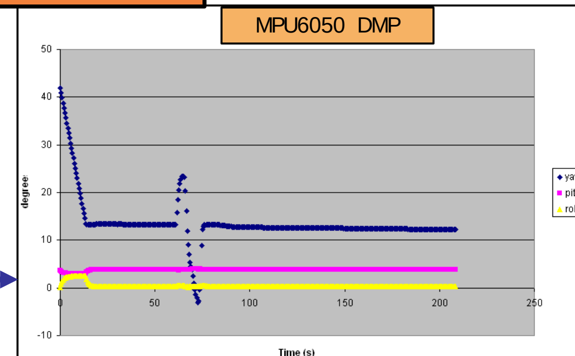
Sensor Fusion Algorithm

MPU6050 IMU



We see that the filtered Roll and Pitch are essentially zero for the sensor laying flat on the table and remain so for several minutes. The Yaw is slowly changing (about 1.8 degrees per minute here) due to gyro drift. Despite the drift, the Yaw returns to trend after slight rotations at the ~two minute mark. With only one axis as a frame of reference (gravity), we can specify two reference vectors (one parallel and one perpendicular) relative to the reference direction. That leaves one direction, the Yaw, undetermined.

MPU6050 DMP



Again, the Roll and Pitch are unchanging since there are two good reference axes. The Yaw is drifting although at a slower rate (~0.4 degrees per minute). This also responds quickly to changes in Yaw as seen at the ~one minute mark, returning to the previous Yaw drift trajectory after the excursion. We guess that there is a sensor fusion filter, similar to what is in the sketch above, as well as low- and high-pass filters to smooth the output. We can get a sense of this by noticing the ~ten seconds it takes to get to a stable value of the Yaw, which then drifts at a slow rate.

Start

determine the position of the gravity vector:
roll = atan2(y_Buff , z_Buff) * 57.3; pitch = atan2((- x_Buff) , sqrt(y_Buff * y_Buff + z_Buff * z_Buff)) * 57.3;

Obtain the angular position with the accelerometer by integrating the angular velocity as provided by the gyroscope: angle= angle + (gyr_angular_velocity*dt);

On the short term, we use the data from the gyroscope, because it is very precise and not susceptible to external forces.
On the long term, we use the data from the accelerometer, as it does not drift
angle = 0.98*(angle+gyr_data*dt) + 0.02*acc_data

Auto-Gyro Blade Spin Rate Sensor Summary

Sensor Selected :	Hall Effect Switch

Source: Datasheet

Characteristics

- A switch Hall sensor consists of voltage regulator, Hall element, differential amplifier, Schmitt trigger, and output terminal and it outputs digital values.
- High precision and good linearity , Adjustable sensitivity (accurate adjustment).With no contact, abrasion, shaking, or bound.

Model	Inter-face	Concept	Dimensions (mm^2)	Resolution (bit ADC or mm)	Power (mA-V)	Weight (g)
AH44E	GPIO	Hall effect module	32 x12	10 bit	3.5mA-5.0V	3

Data Processing

- When an energized conductor approaches the module, the output terminal SIG outputs low level; at the same time the corresponding LED lights up.
- Interrupts will be used to increase the counter when these low levels are detected.

```
attachInterrupt(digitalPinToInterrupt(HALLPIN), raiseCount, CHANGE);
```

- $No.of\ Rotations = {}^{Counts}/_{No.of\ Magnets*2}$
- $RPM = {}^{No.of\ Rotations}/_{time\ taken} \times 60$

Data Format

Blade spin rate is the rate the auto-gyro blades spin relative to the science payload. The units will be in revolutions per minute (rpm). The resolution will be 1 rpm as per competition requirements

Bonus Objective Camera Summary[1/2]

Sensor Selected : Turbowing cyclops dvr 3

Source: Datasheet

Characteristics

- Memory SD CARD CAPABLE: Cyclops 3 has a maximum capacity of 32g memory card that can usually record for 16 hours.
- Remarkable ultra light model with all the bells and whistles in a single coin size module.
- Provides transparent imagery, so that night traffic will not appear with excessive exposure.

Weight (g)	Power (mA V)	Resolution	Dimen-sions (mm^2)	FPS	Interface	Supply Voltage (V)
4.5	130 x 5	1280 * 720	18 x 18	30	GPIO	5V - 26V

Data Processing

- During descent, Teensy will send command to switch on the camera when height of 450 will be detected by BMP180. This command is send via nrf24l01 to camera subsection.
- Camera will be turned on by MCU by replacing the physical switch by and electronic switch.
- To obtain the Bonus camera direction, teensy will ping camera subsection and will receive the camera direction in return.

Data Format

The video is stored in sd card in the NTSC format

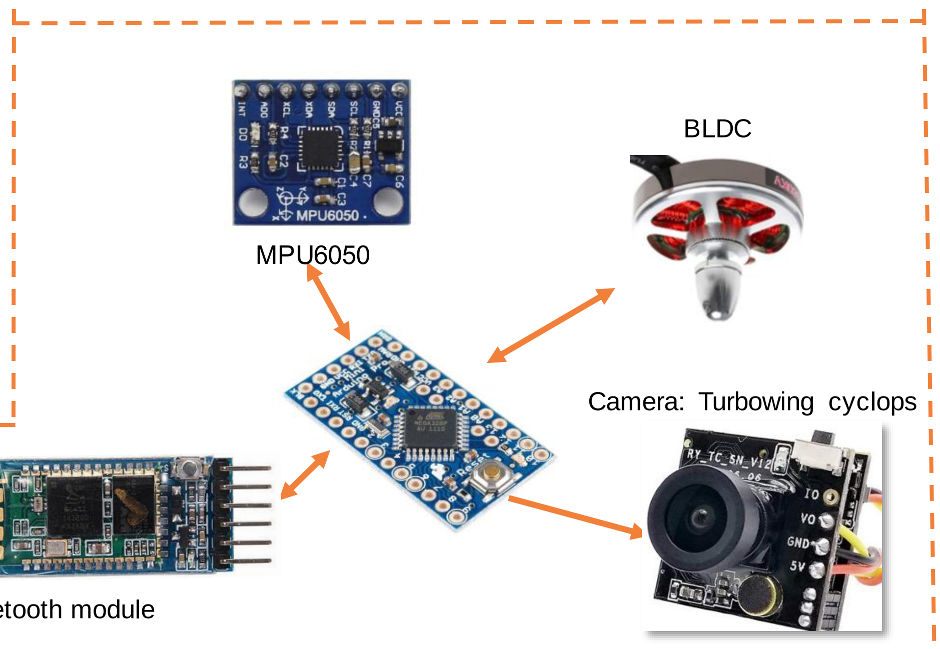
Bonus Camera Subsection

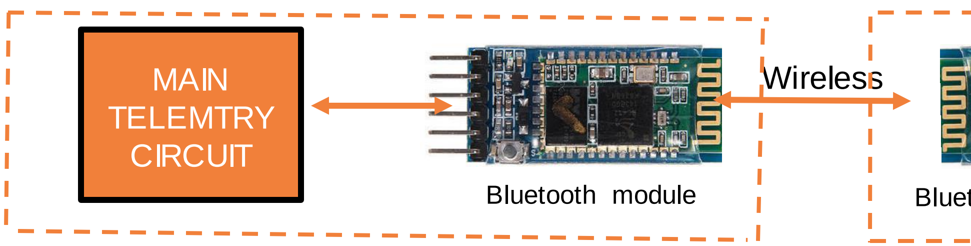
This subsection has following electronics and each of them have the specific purpose:

1. **Arduino Pro Mini:** Used as MCU to perform tasks such as camera stabilization and to start video recording and data transfer/receiver from Bluetooth.
2. **Bluetooth module**: Used for two-way communication between Main telemetry System and and the bonus camera stabilization sub-system.
3. **MPU6050:** Arduino uses MPU6050 to calculate Yaw that gives feedback to stabilize the camera.
4. **BLDC MOTOR**: is rotated in in opposite direction of payload to stabilize the camera direction.

Advantages

1. Different Subsection for the Bonus camera will ensure that our Payload's main telemetry section will keep functioning independently even if some problem occurs in the Bonus Task.
2. Servo is common choice for position control and thus it perfectly fits for direction control.





Container Air Pressure Sensor Summary[1/2]

Sensor Selected :	BMP180

Source: Datasheet

Characteristics

- Low power: 5µA at 1 sample / sec. in standard mode
- Low noise: 0.06hPa (0.5m) in ultra low power mode 0.02hPa (0.17m) advanced resolution mode.
- Resolution of 0.01hPa.

Inter-face	Pressure Range (hPa)	Dimensions (mm)	Weight (g)	Working Current (mA)	Sensitivity (hPa)	Operating Voltage (V)
I2C	300-1100	14 x 12 x 0.93	0.92	1	±2	1.8 - 3.6

Data Processing

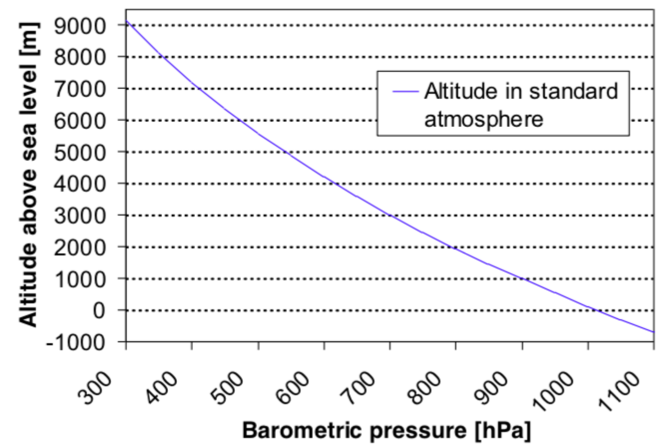
- It senses Pressure and then calculates Altitude using the given formula and this value of altitude is used to determine different FSW states.

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

where, p_0= Pressure at sea level (hPa) and p = Measured pressure (hPa)

- With the measured pressure p a the absolute altitude the pressu at sea level can be calculated:

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



Container Air Pressure Sensor Summary[2/2]

Data Format

- Pressure will be displayed in Pascals because of the competition requirement of displaying each sensor value in engineering units with resolution of 1 pascals.
- Altitude will be displayed in meters and it will be a floating point number.

TeensyMonitor: /dev/cu.usbmodem54026601 Online

```
Pressure = 97671.62 Pa  Relative altitude = 0.00 m
Pressure = 97671.22 Pa  Relative altitude = 0.03 m
Pressure = 97675.31 Pa  Relative altitude = -0.23 m
Pressure = 97668.34 Pa  Relative altitude = 0.28 m
Pressure = 97658.16 Pa  Relative altitude = 1.16 m
Pressure = 97662.63 Pa  Relative altitude = 0.77 m
Pressure = 97669.44 Pa  Relative altitude = 0.19 m
Pressure = 97673.16 Pa  Relative altitude = -0.13 m
Pressure = 97673.86 Pa  Relative altitude = -0.19 m
Pressure = 97670.17 Pa  Relative altitude = 0.12 m
Pressure = 97669.21 Pa  Relative altitude = 0.21 m
Pressure = 97670.17 Pa  Relative altitude = 0.12 m
```

Algorithm for pressure and temperature measurement

Source: Datasheet

Start

Read calibration data from the E²PROM of the BMP180

read out E²PROM registers, 16 bit, MSB first

AC1 (0xAA, 0xAB)	(16 bit)
AC2 (0xAC, 0xAD)	(16 bit)
AC3 (0xAE, 0xAF)	(16 bit)
AC4 (0xB0, 0xB1)	(16 bit)
AC5 (0xB2, 0xB3)	(16 bit)
AC6 (0xB4, 0xB5)	(16 bit)
B1 (0xB6, 0xB7)	(16 bit)
B2 (0xB8, 0xB9)	(16 bit)
MB (0xBa, 0xBB)	(16 bit)
MC (0xBC, 0xBD)	(16 bit)
MD (0xBE, 0xBF)	(16 bit)

read uncompensated temperature value

write 0x2E into reg 0xF4, wait 4.5ms

read reg 0xF6 (MSB), 0xF7 (LSB)

UT = MSB << 8 + LSB

read uncompensated pressure value

write 0x34+(oss<<6) into reg 0xF4, wait

read reg 0xF6 (MSB), 0xF7 (LSB), 0xF8 (XLSB)

UP = (MSB<<16 + LSB<<8 + XLSB) >> (8-oss)

calculate true temperature

X1 = (UT - AC6) * AC5 / 2^{15}

X2 = MC * 2^{11} / (X1 + MD)

B5 = X1 + X2

T = (B5 + 8) / 2^{4}

calculate true pressure

B6 = B5 - 4000

X1 = (B2 * (B6 * B6 / 2^{12})) / 2^{11}

X2 = AC2 * B6 / 2^{11}

X3 = X1 + X2

B3 = (((AC1*4+X3) << oss) + 2) / 4

X1 = AC3 * B6 / 2^{13}

X2 = (B1 * (B6 * B6 / 2^{12})) / 2^{16}

X3 = ((X1 + X2) + 2) / 2^{2}

B4 = AC4 * (unsigend long)(X3 + 32768) / 2^{15}

B7 = ((unsigned long)UP - B3) * (50000 >> oss)

if (B7 < 0x80000000) { p = (B7 * 2) / B4 }

else { p = (B7 / B4) * 2 }

X1 = (p / 2^{8}) * (p / 2^{8})

X1 = (X1 * 3038) / 2^{16}

X2 = (-7357 * p) / 2^{16}

p = p + (X1 + X2 + 3791) / 2^{4}

Display temperature and Pressure

Descent Control Design

Aayush Aggarwal

Descent Control Overview

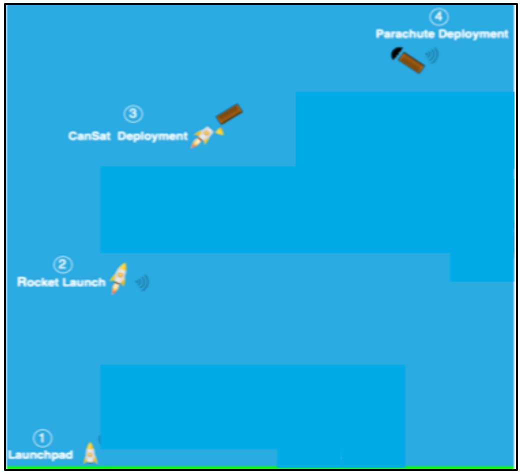
DESCENT CONTROL SYSTEM

- Consist of a parachute and the science payload descends under auto gyro/ passive helicopter recovery control.

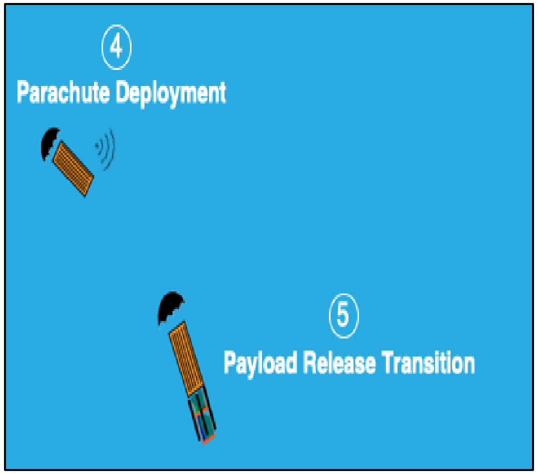
DEPLOYMENT AND RELEASE ORDER

- Payload is deployed at an altitude of 670 – 725 meters and the parachute is deployed which results in a descent rate of 20 ± 5m/s.
- At 450 meters the science payload is released, airfoils will be deployed and the payload descends at a rate of 10-15 m/s.

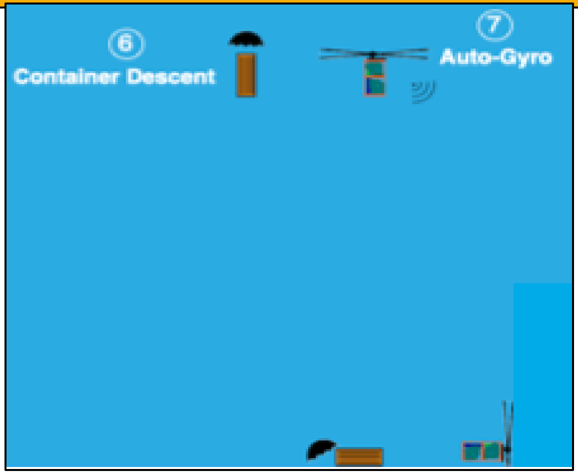
1st Stage – Rocket Launch to Apex



2nd Stage – Apex to Payload Release till 450 m



3rd Stage – Container and Payload Descent from 450 m to ground



Descent Control Changes Since PDR

S. No.	Change	Requirement	Rationale
	No change		

Prototype Testing

Descent Control Requirements [1/3]

Number	Description	Rationale	Priority	Verification Method			
				A	I	T	D
DCR1	The CanSat shall deploy from the rocket payload	Competition Requirement	HIGH	✔			
DCR2	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Competition Requirement	HIGH			✔	✔
DCR3	The container shall release the payload at 450 meters +/- 10 meters.	Competition Requirement	HIGH			✔	✔
DCR4	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system	Competition Requirement	HIGH	✔	✔		
DCR5	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Competition Requirement	HIGH			✔	✔

Descent Control Requirements [2/3]

Number	Description	Rationale	Priority	Verification Method			
				A	I	T	D
DCR6	All descent control device attachment components shall survive 30 Gs of shock.	Competition Requirements	HIGH		✔	✔	
DCR7	All structures shall be built to survive 30 Gs of shock.	Competition Requirements	HIGH		✔	✔	
DCR8	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition Requirements	HIGH		✔	✔	
DCR9	Mechanisms shall not use pyrotechnics or chemicals.	Competition Requirements	HIGH	✔	✔	✔	✔
DCR10	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.	Competition Requirements	HIGH	✔	✔	✔	✔

Descent Control Requirements [3/3]

Number	Description	Rationale	Priority	Verification Method			
				A	I	T	D
DCR11	The Parachute shall be fluorescent Pink or Orange.	Competition Requirements	HIGH	✔			
DCR12	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Competition Requirements	HIGH	✔	✔	✔	✔
DCR13	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Competition Requirements	HIGH	✔	✔		✔

Payload Descent Control Hardware Summary [1/3]

Active Components

Component	Sensor Accuracy	Data Format	Overview of sensor Data Processing	
			Control Action	Command Rate
BMP180 (Air Pressure and Temperature Control)	• Quite high accuracy of 0.01hPa • Temperature Coefficient of 0.01hPa per degree Celsius. • Temperature resolution of 0.1°C	I2C	Triggers the audio beacon(continuous mode) at an altitude less than 5m.	<1 Hz as the telemetry rate requirement is 1Hz.
Hall Sensor (			-	<1 Hz as the telemetry rate requirement is 1Hz.
MPU6050 (Tilt Sensor)	• Fixed 10 bit resolution • High resolution is up to 13 bit	I2C	-	<1 Hz as the telemetry rate requirement is 1Hz.
GPS	Time Pulse accuracy is 30 ns.	UART	-	<1 Hz as the telemetry rate requirement is 1Hz.

Payload Descent Control Hardware Summary [2/3]

Passive Components

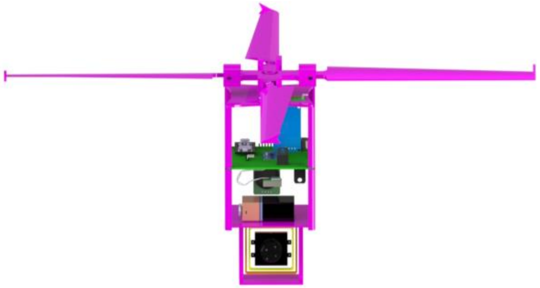
Component/concept	Component Size	Color	Key Design Considerations
Payload Body	Length = 161.51mm	Pink	• Must be lightweight and made from strong material. • Should include all the electronics components and descent smoothly under autogyro recovery descent control system.
Blades	Length = 207mm Width = 30mm Height = 3mm	Pink	• Must be lightweight and able to open after payload release at 450 meters. • Should give a descent rate of 10 - 15m/s for the payload.
Gimbal (Camera stablization)	Length = 45mm Width = 41mm Height = 32mm	_	• Takes little space, volume • For Camera stabilization at an angle of 45° from nadir of the science payload
Center of Buoyancy is above center of Gravity	_	_	• Center of buoyancy was found to be above the center of gravity due to which a self-aligning torque will nullify any forces acting to produce **TUMBLING.**

Payload Descent Control Hardware Summary [3/3]

Payload Configurations

Stowed Configuration

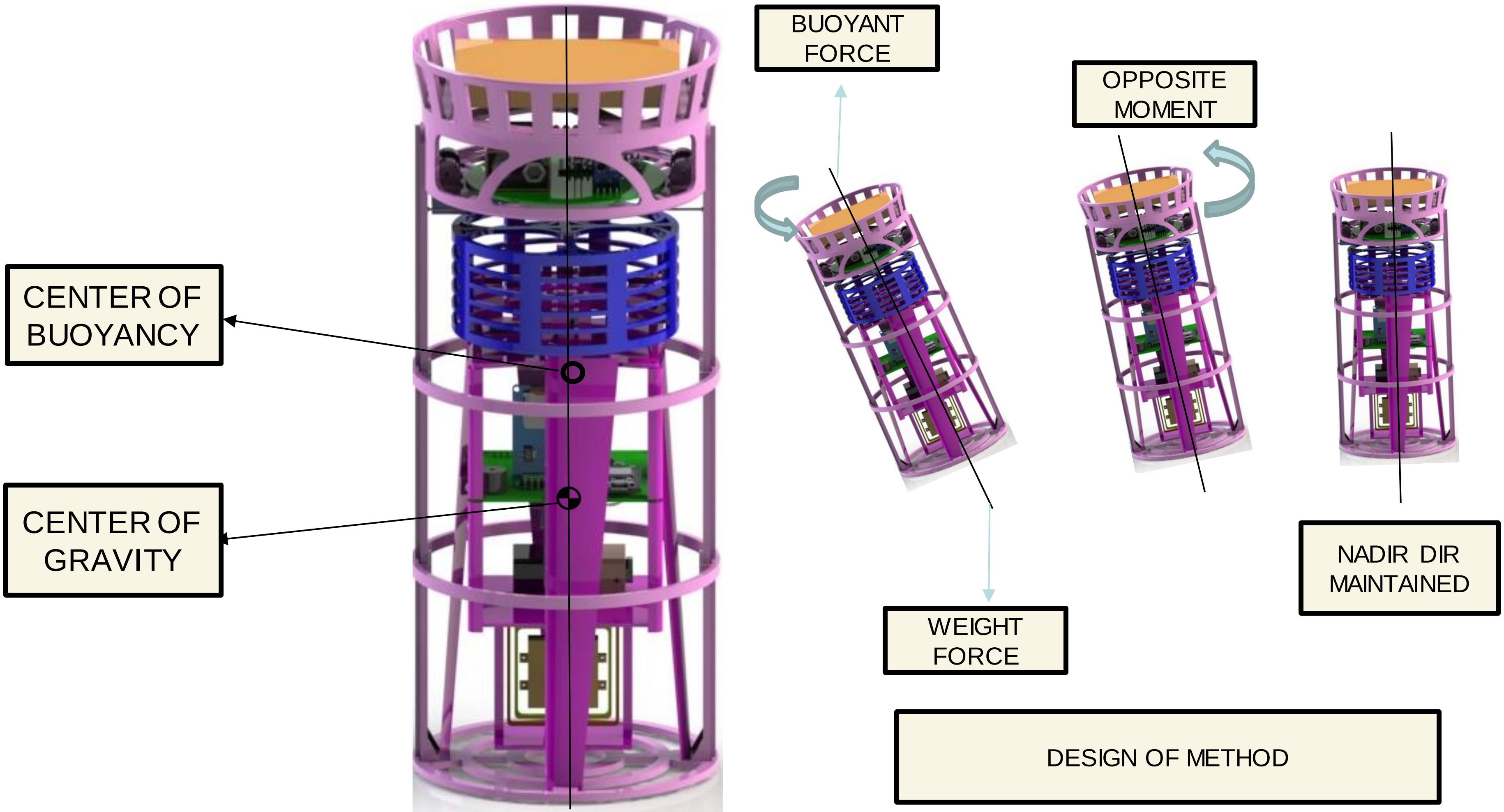
Transition



Deployed Configuration

Descent Stability Control Design [1/2]

Passive: Descent Stability Control Design

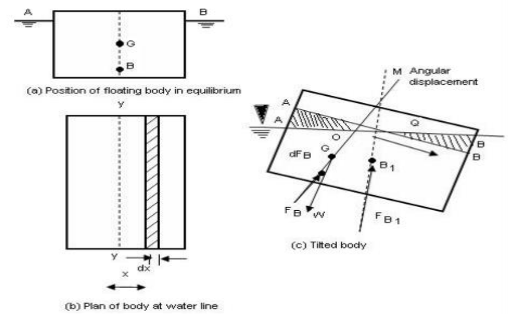


Passive: Descent Stability Control Design For Payload

- Center of buoyancy was found to be above the center of gravity due to which a self-aligning torque will nullify any forces acting to produce **TUMBLING.**

- Since both the points are very far away based on our calculations, it will form a very **STABLE Equilibrium.**

- The inference drawn from above proves that it will always remain in the downward direction (**NADIR direction).**



Design of Method

KM = KB + BM

BM = I/V

Where **KB** is the center of buoyancy (height above the keel)**, I** is the second moment of area of the waterplane in meters and **V** is the volume of displacement in meters . **KM** is the distance from the keel to the metacenter.

Stable floating objects have a natural rolling frequency, just like a weight on a spring, where the frequency is increased as the spring gets stiffer. In a boat, the equivalent of the spring stiffness is the distance called "GM" or "metacentric height", being the distance between two points: "G" the center of gravity of the boat and "M", which is a point called the metacenter

Container Descent Control Hardware Summary [1/3]

Active Components

Component	Sensor Accuracy	Data Format	Overview of sensor Data Processing	
			Control Action	Command Rate
BMP180 (Air Pressure and Temperature Control)	• Quite high accuracy of 0.01hPa • Temperature Coefficient of 0.01hPa per degree Celsius. • Temperature resolution of 0.1°C	I2C	Triggers the servo motor at an altitude of 450m and audio beacon(continuous mode) at an altitude less than 5m.	<1 Hz as the telemetry rate requirement is 1Hz.
Voltage Divider Circuit	Accuracy is (5/210)V = 0.0049V because resolution of the ADC pin is 10bits	ADC	-	<1 Hz as the telemetry rate requirement is 1Hz.

Container Descent Control Hardware Summary [2/3]

Passive Components

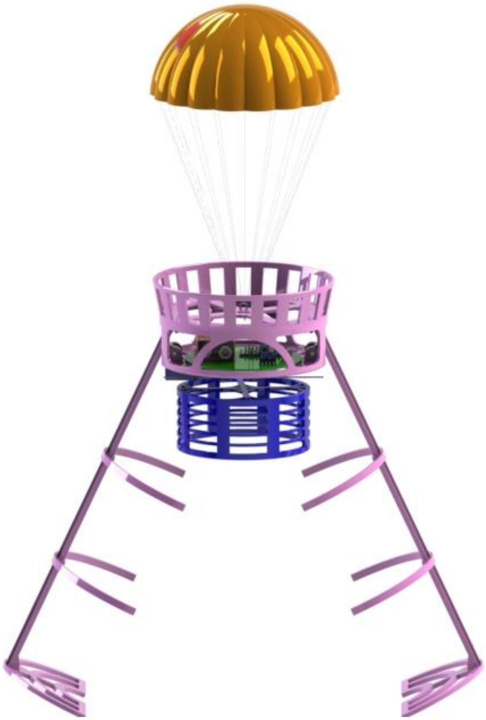
Component	Component Size	Color	Key Design Considerations
Parachute	**8 inch Diameter hexagonal chute**	Red and White	• Takes little packing space, volume • Lightweight, sufficient drag force. • Can withstand brutal openings easily. • Gives us the desired descent rate of 20m/s for the CanSat and a smooth landing.
Cage	**Diameter = 90mm Height = 55mm**	Blue	• Cage has to be designed in such a way so that there are less chances of blades getting stuck.

Container Descent Control Hardware Summary [3/3]

Container Configurations

Stowed Configuration

Transition



Deployed Configuration

Descent Rate Estimates [1/11]

Assumptions

- Weight of the falling object is equal to drag when it travels with constant velocity (terminal velocity).
- Density of air is assumed to be 1.225 kg/m^3
- No wind or air currents.
- Mass of the CanSat (container + payload) = 0.5kg
- Mass of container = 0.15kg
- Drag coefficient of parachute = 0.75

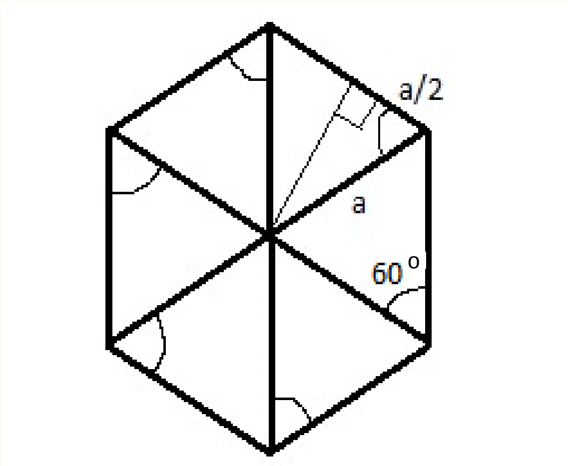
CanSat's (Container + Payload) Parachute landing Calculations

- The parachute will be used to control the speed of the payload's descent.

$$F_d = \frac{1}{2}\rho\, C_d\, A\, V^2 \qquad \text{(i)}$$

$$F_d = \text{mg} \qquad \text{(ii)}$$

$$\text{Area} = \frac{3\sqrt{3}}{2}\, a^2$$



Hexagon made of 6 equilateral triangles

From (i) and (ii)

$$\text{mg} = \frac{1}{2}\rho\, C_d\, A\, V^2$$

Diameter = 7.34 inches (desired value of diameter)

$$(0.5)(9.8)\ \text{kg m}/s^2 = \frac{1}{2} \times 1.225\ \text{kg}/m^3 \times 0.75 \times \frac{3\sqrt{3}}{2} \times a^2 \times 400\ m^2/s^2$$

Descent Rate Estimates (Container & Payload) [3/11]

CanSat (Container + Payload) Parachute Landing calculation For 8 inch Hexagonal Parachute

mg $= \frac{1}{2}\rho\, C_d\, A\, V^2$

Area = $\frac{3\sqrt{3}}{2}a^2$

For our parachute a = 0.11284m

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

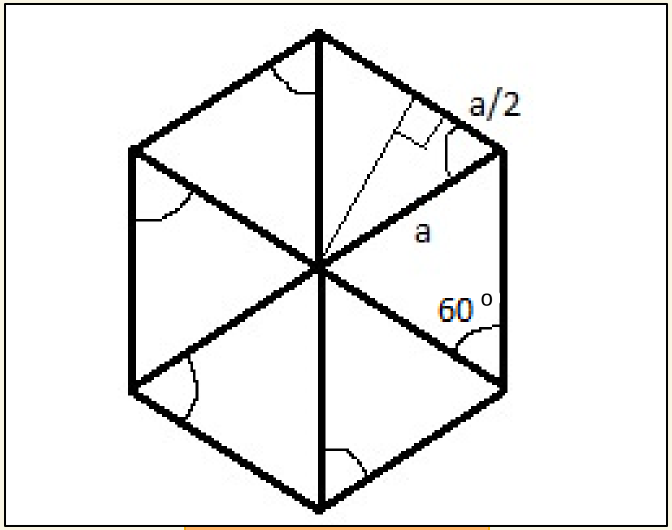
v = $\sqrt{\frac{2(0.5)(9.8)(2)}{1.225(0.75)(3\sqrt{3})(0.11284)^2}}$ m/s

v = $\sqrt{366.39}$m/s

v = 19.14 m/s

T = 32.12 s

Our Parachute will land with this velocity.



Hexagon made of 6 equilateral triangles.

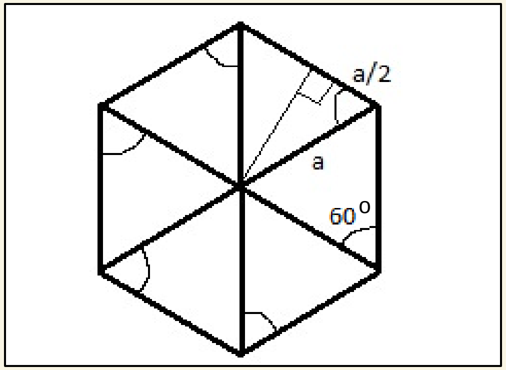
Descent Rate Estimates (Container) [4/11]

Container: Container parachute landing calculation after payload is released

$F_d = \frac{1}{2}\rho\, C_d\, \mathrm{A}\, V^2$ (i)

F_d = mg (ii)

A = $\frac{3\sqrt{3}}{2}\, a^2$



From (i) and (ii)

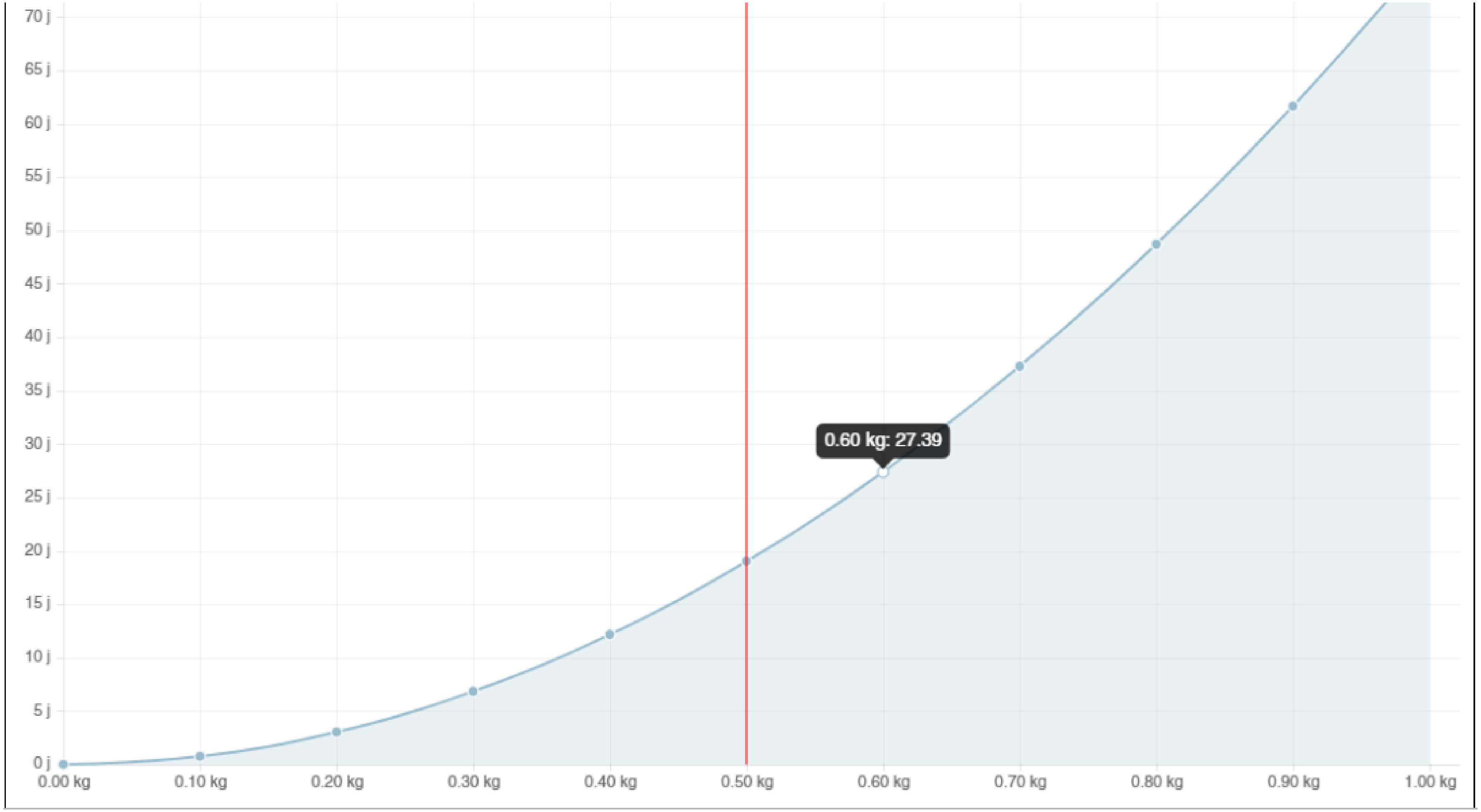
mg = $\frac{1}{2}\rho\, C_d\, \mathrm{A}\, V^2$

(0.15)(9.8) kg m/s^2 = $\frac{1}{2}$(1.225 kg/m^3)(0.75)($\frac{3\sqrt{3}}{2}$)(0.11284 x 0.11284m^2)V^2

v = $\sqrt{\frac{5.88}{0.0607}}$ m/s = 9.84m/s , T = 54.88s

Descent Rate Estimates (Container) [5/11]

Impact Energy Joules vs Weight



Descent Rate Estimates[6/11]

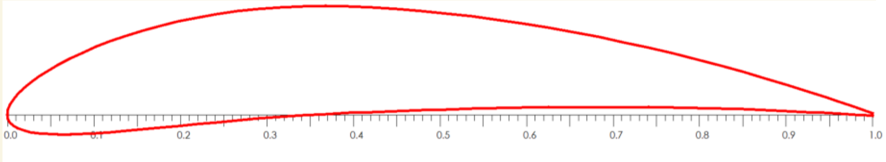
Parachute Specifications

Chute Style:	Hexagonal Lightweight with shroud lines
Canopy Shape:	Hexagonal
Canopy Diameter(inches):	8.00
Number Gores:	6.00
Weight(oz):	0.243
Weight(grams):	6.9
Parachute Area(sq. Ft.):	0.28
Cd Projected:	0.75
Shroud Line Length(inches):	8.00
Material:	1 mil thick polyethylene plastic
Reinforcement rings:	6.00
Manufacturer:	Apogee components

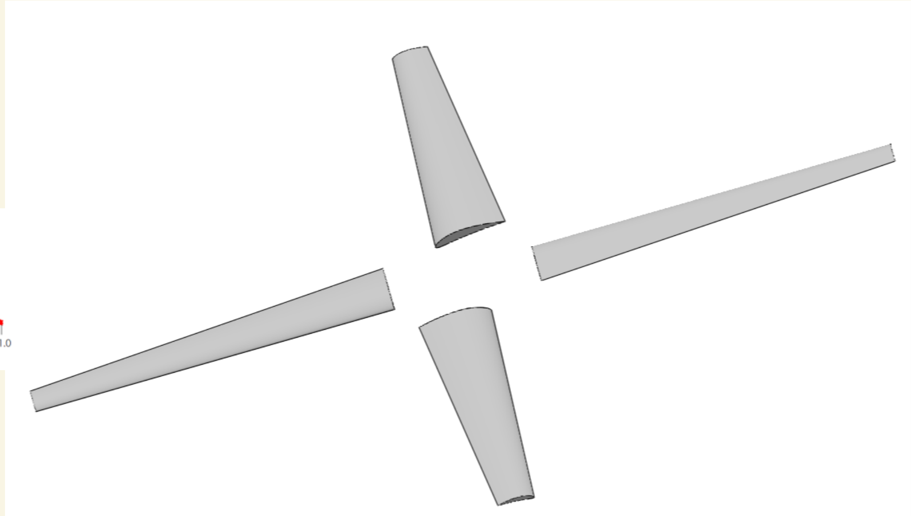
Payload: Autogyro Blade Selection

We have selected NACA 6412 airfoil at pitch angle of 5°.

QBlade software was used to calculate the various parameters of the descent.



Airfoil geometry

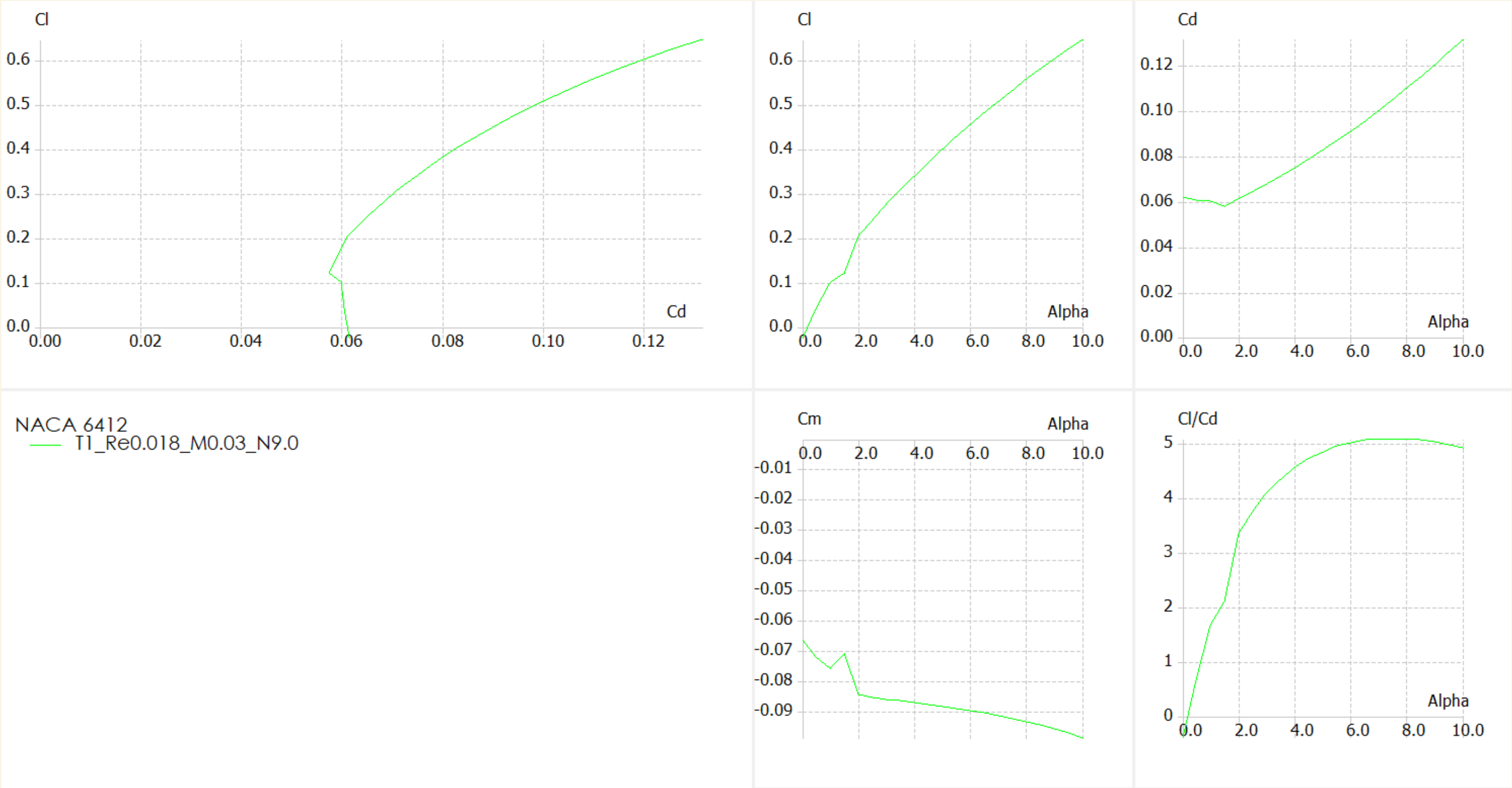


Blade geometry

Descent Rate Estimates (Payload) [8/11]

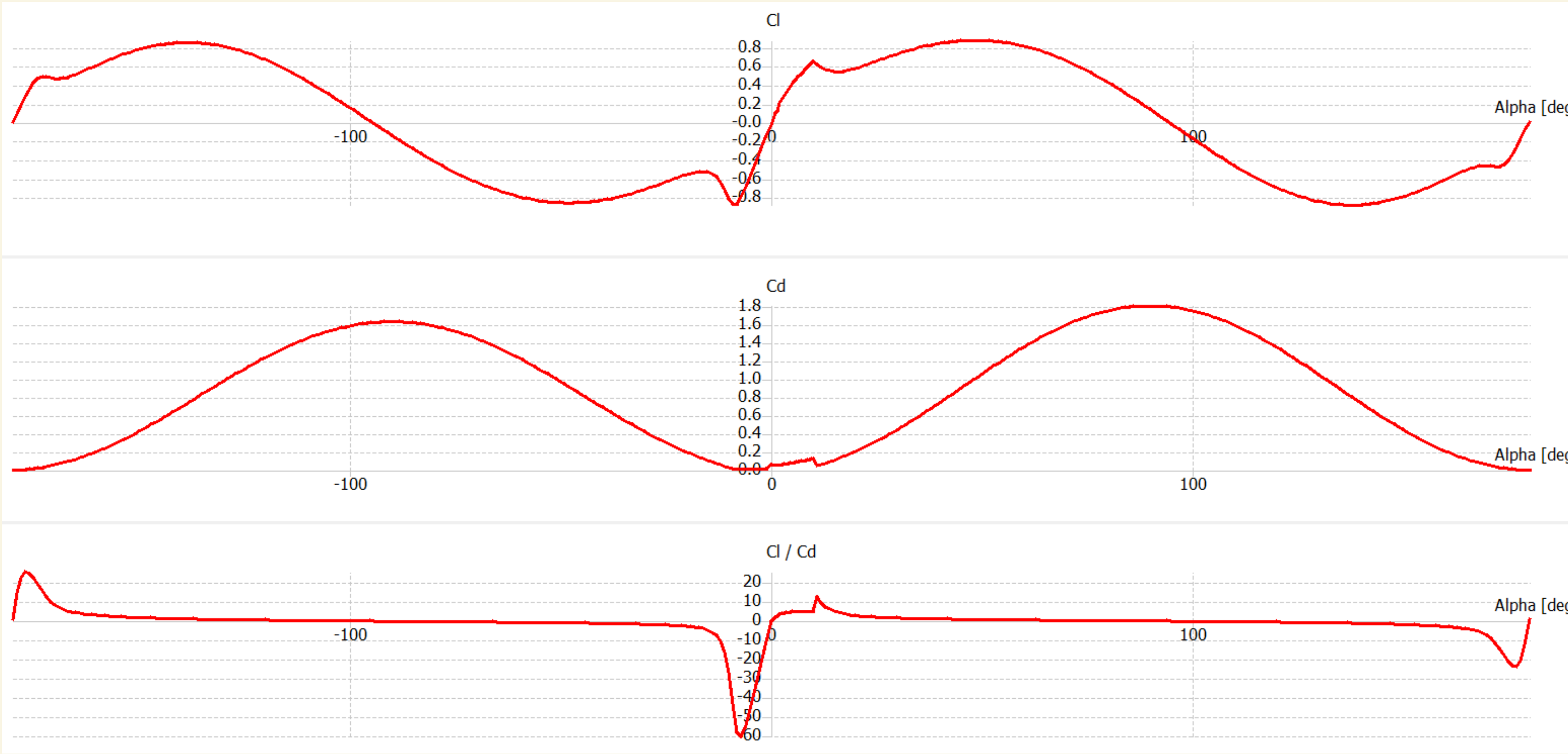
Payload: Autogyro Blade Selection

The coefficient of lift and drag graphs with pitch angle are given.



Payload: Autogyro Blade Selection

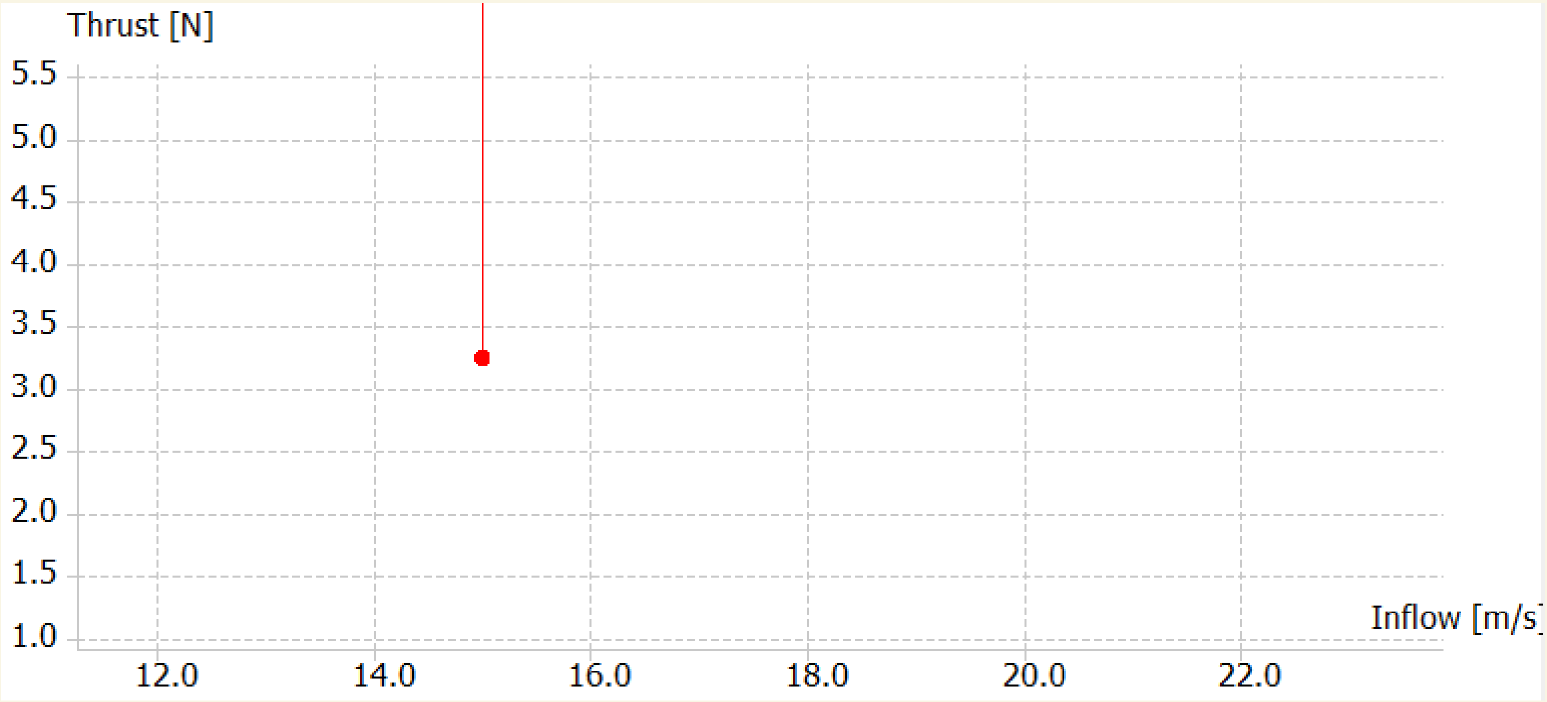
The extrapolated graphs of coefficients of lift and drag are as follows.



Descent Rate Estimates (Payload) [10/11]

Payload: Autogyro Blade Selection

The tip speed ratio was approximated to 1 and the resulting thrust at 15 m/s inflow velocity comes out to be between 3 and 3.5 N, resulting in a velocity of about 11.8 m/s and total time of flight = 45.11 s



Descent Rate Estimates [11/11]

FINAL DESCENT RATES		
Parameter	**Calculated Value**	**Flight Time (s)**
Descent rate of Container + Payload	19.14 m/s	32.12
Descent rate of only Container	9.84 m/s	54.88
Descent rate of the Payload	11.8 m/s	45.11

Mechanical Subsystem Design

Arham Jain

Mechanical Subsystem Overview[1\2]

Major Structural elements

Payload	Container
Payload Body	Parachute Section
Rotating Hub	Ribs
Propeller	Cage
Gimbal	Parachute

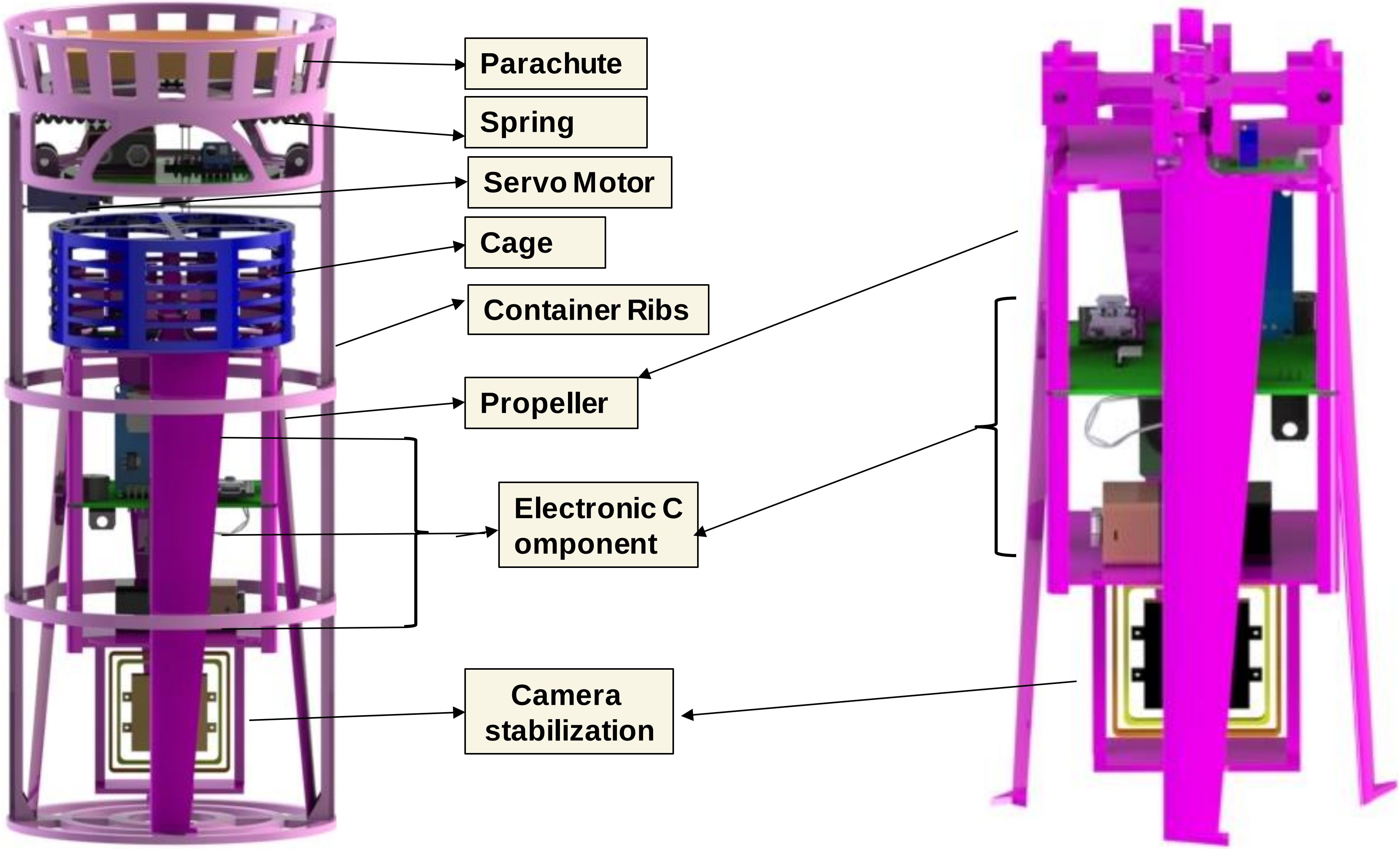
Material Selection

Payload	Container
3 D printed Nylon PA-2200	CNC HDPE
3 D printed HDPE	3 D printed ABS
Vacuum Formed Polycarbonate	Nylon Parachute

Interface Definitions

Payload	Container
Connected through cage in stowed config.	2 symmetrical hinged parts connected through a torsional spring
Springs in auto-gyro propellers for deployment	Motor mounted on container electronics module bottom to cut thread

Mechanical Subsystem Overview[2/2]



Mechanical Subsystem Changes Since PDR

S. No	Change	Requirement	Rationale
1	Modified payload design	All the electronics were not getting fit inside existing design	The current design easily accommodates all the electronic components required.

Mechanical Sub-System Requirements

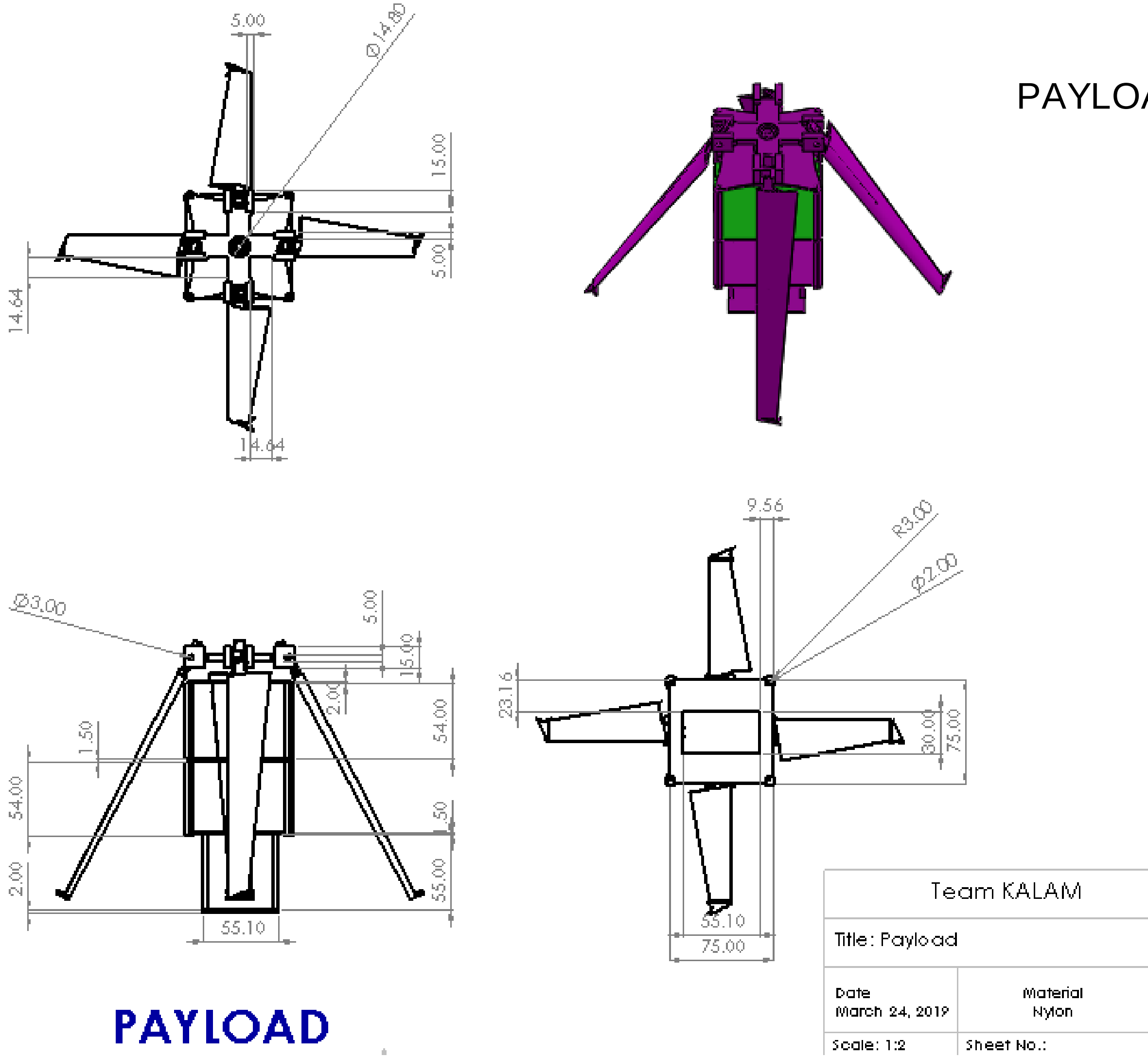
ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
MSR-1	Total mass of CanSat (science payload and container) shall be 500grams +/- 10 grams	Competition Requirement			High	✔	✔	✔	
MSR-2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition Requirement			High	✔	✔	✔	
MSR-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.	Competition Requirement			High	✔	✔		
MSR-4	Mechanisms shall not use pyrotechnics or chemicals.	Competition R equirement			High	✔			
MSR-5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement			High	✔			

Mechanical Sub-System Requirements

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
MSR-6	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Competition Requirement			High		✓	✓	✓
MSR-7	All structures shall be built to survive 15Gs of launch acceleration.	Competition Requirement			High		✓	✓	
MSR-8	All structures shall be built to survive 30 Gs of shock.				High		✓	✓	
MSR-9	Tolerances are to be included to facilitate container deployment from the rocket fairing.	Competition Requirement			High	✓	✓		

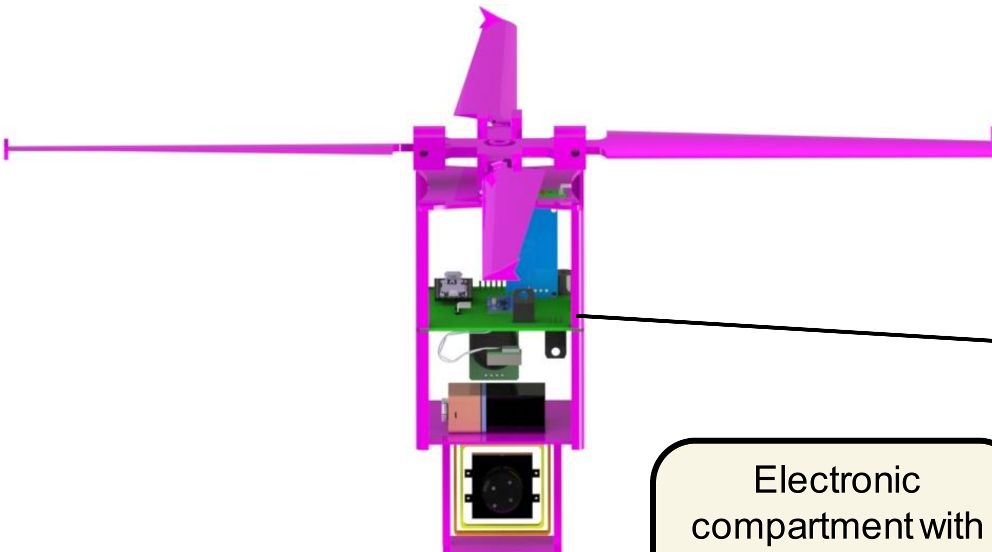
Payload Mechanical Layout of Components [1/6]

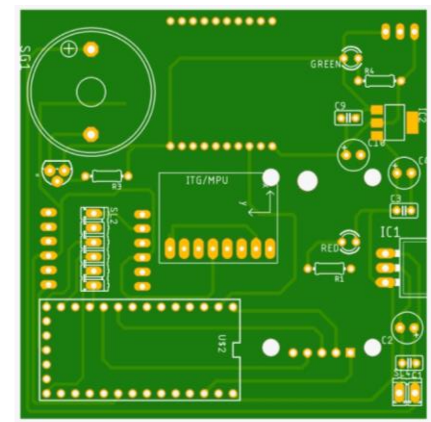
PAYLOAD CAD DRAWING

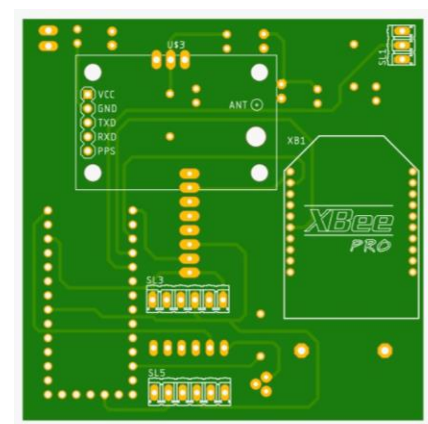


Payload Mechanical Layout of Components [2/6]

Location of Electrical Components







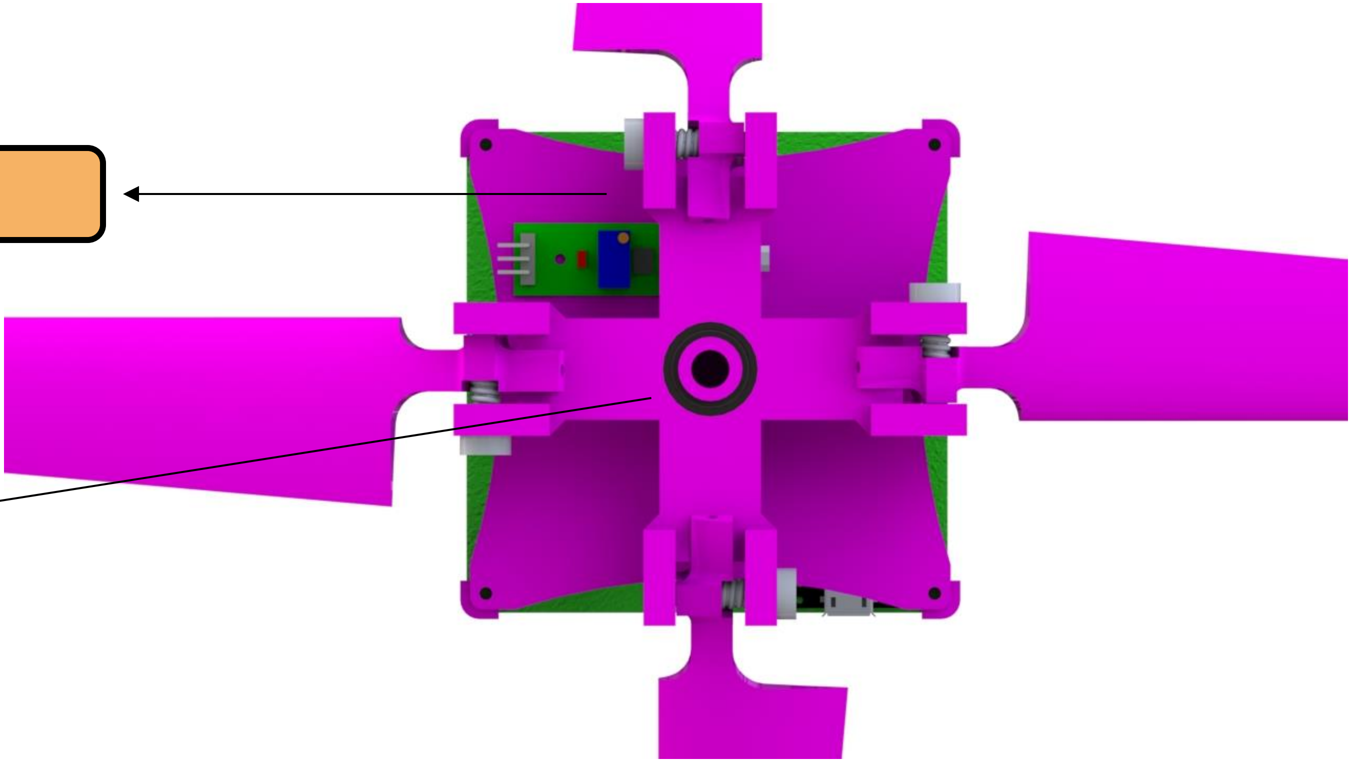
Electronic compartment with all the sensors on printed circuit boards

Payload Mechanical Layout of Components [3/6]

Autogyro Attachment Points

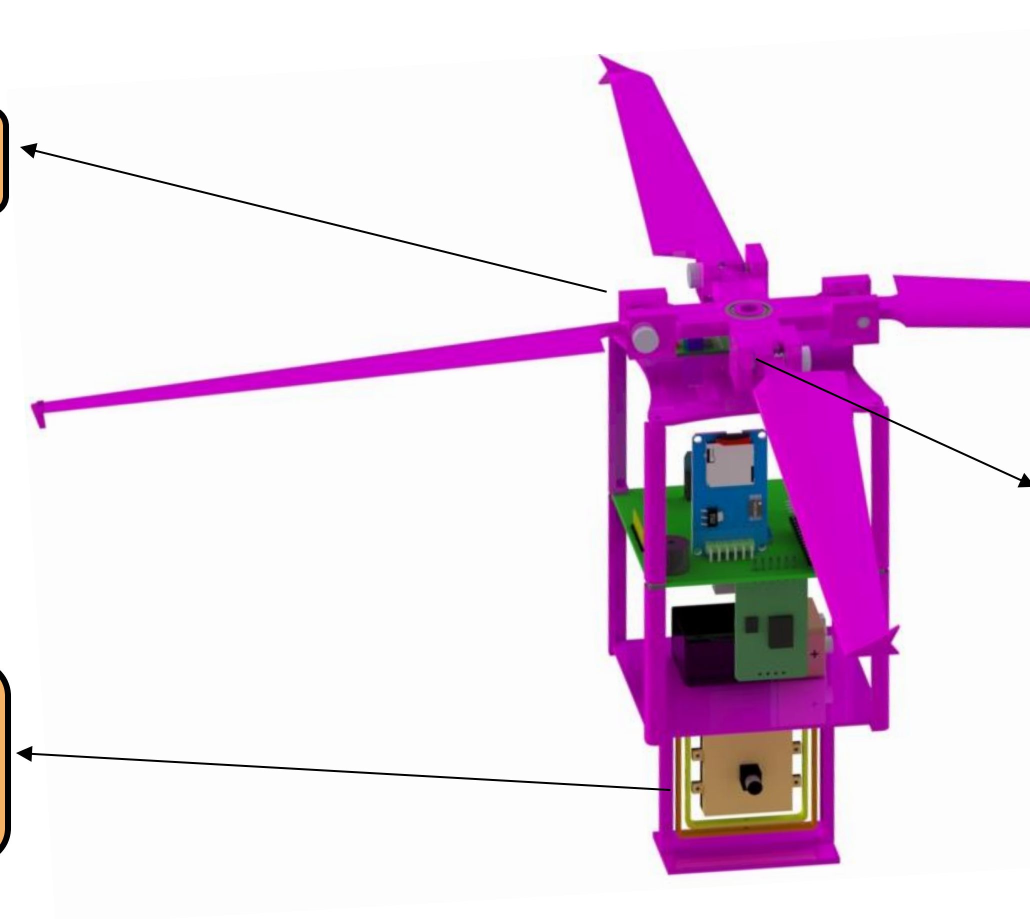
Hinge

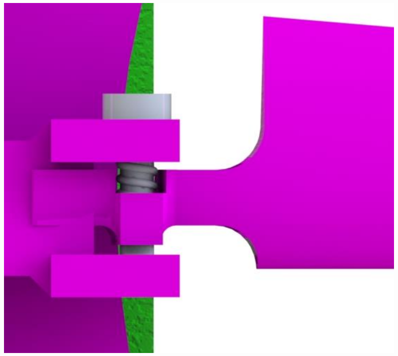
Bearing



Major Mechanical Parts

Hinge

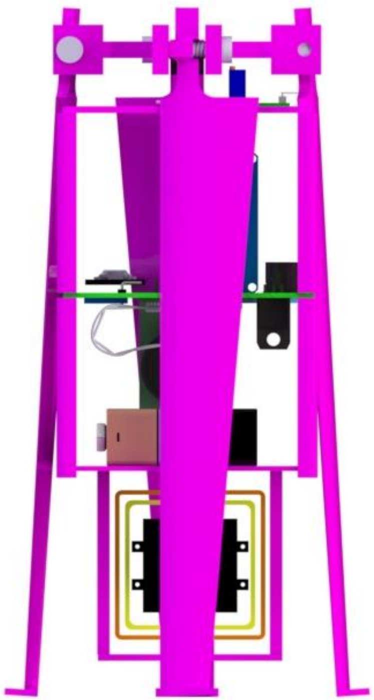




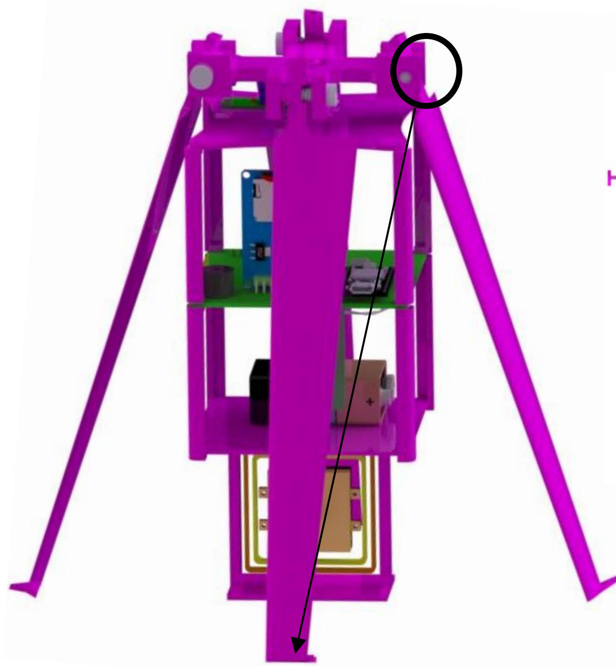
Gimbal (Camera Stabilization)

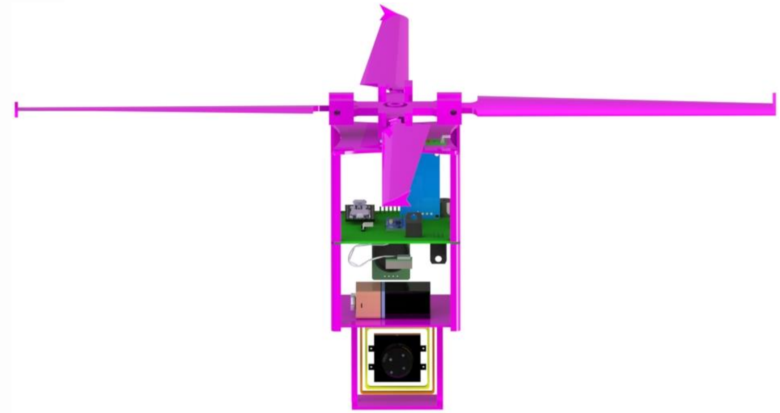
Torsional spring

Payload Mechanical Layout of Components [5/6]



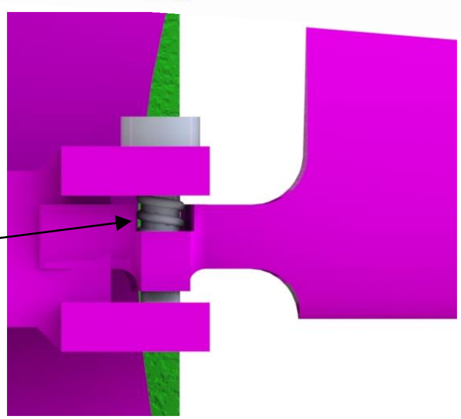
Stowed



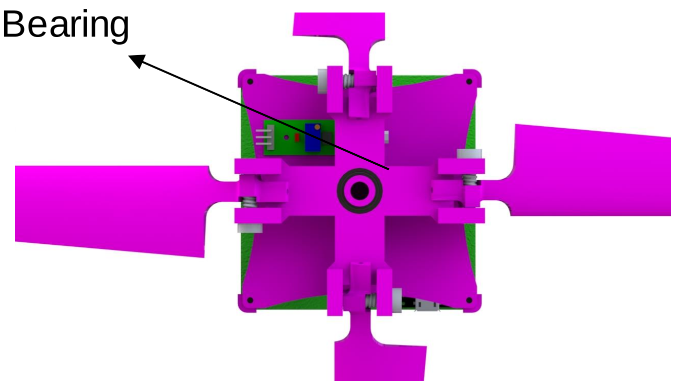


Deployed

Screw + Torsional Spring



Bearing

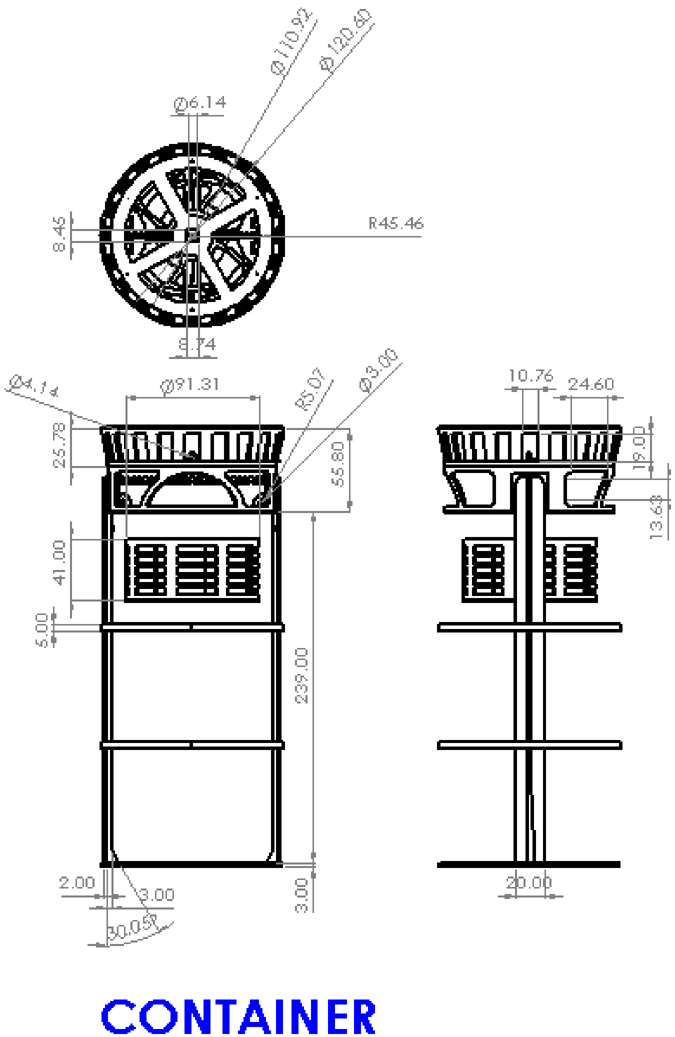


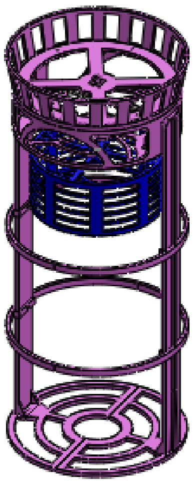
Payload Mechanical Layout of Components [6/6]

Component(s)	Material	Density (g/cm^3)	Tensile strength (MPa)	Cost per kg	Advantages	Disadvantages
Payload Body	**HDPE -** CNC (machined)	0.97	32	$30	• Strong and durable. • Relatively light weight.	• Stress cracking
• **Rotating Hub** • **Gimbal (Camera Stabilizer)**	**NYLON PA 2200 -** 3D PRINTING (FDM)	0.93	48	$25-65	• Flexible and strong • UV and chemical resistant	• Constantly meant to keep dry • It can shrink
Payload Propeller	**POLYCARBONATE -** 3D PRINTING (MJ)	1.2	72	$40-75	• Flexible and Durable • High Tensile Strength	• Needs Warm environment for optimum quality • High price

Container Mechanical Layout of Components [1/5]

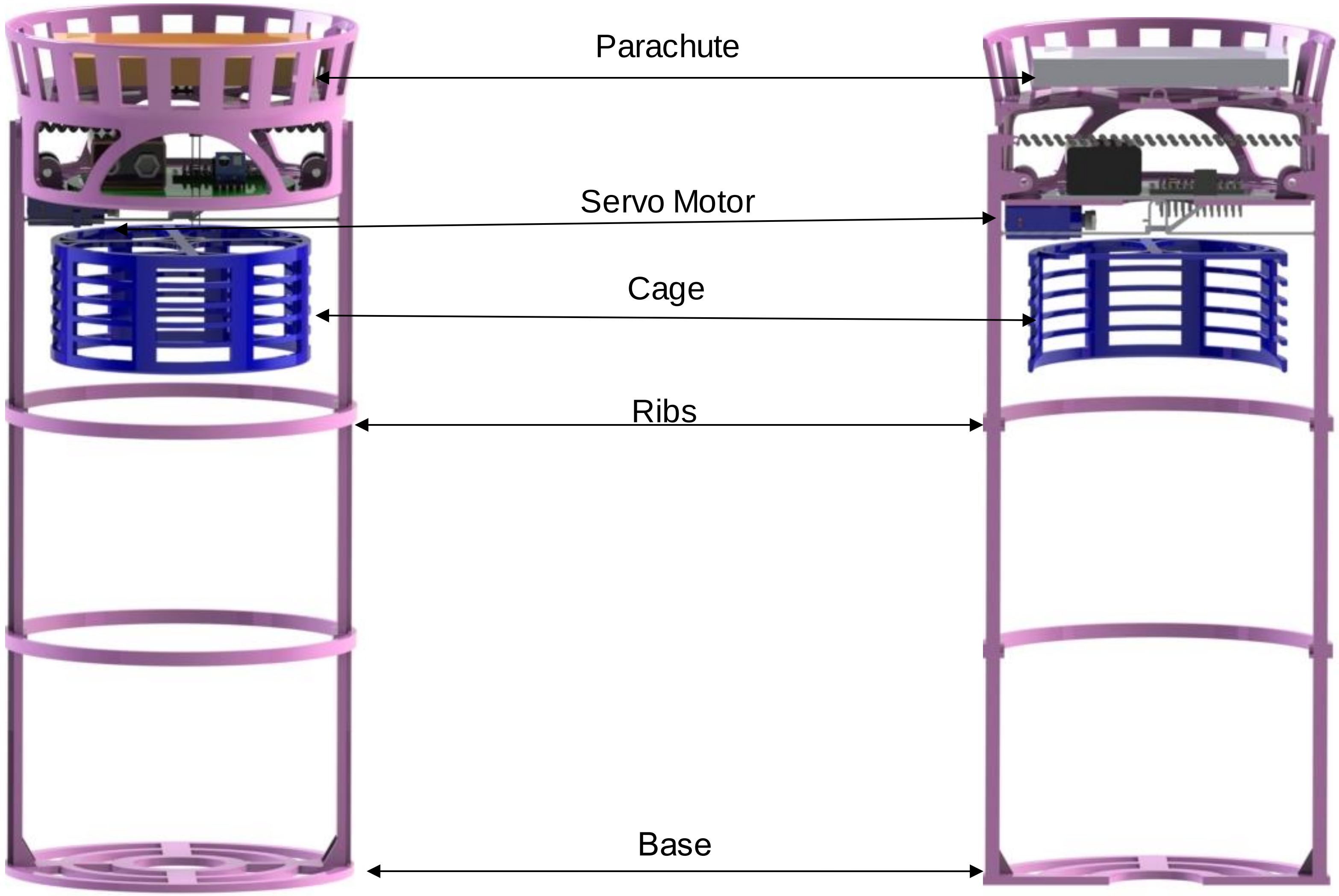
CONTAINER CAD DRAWING



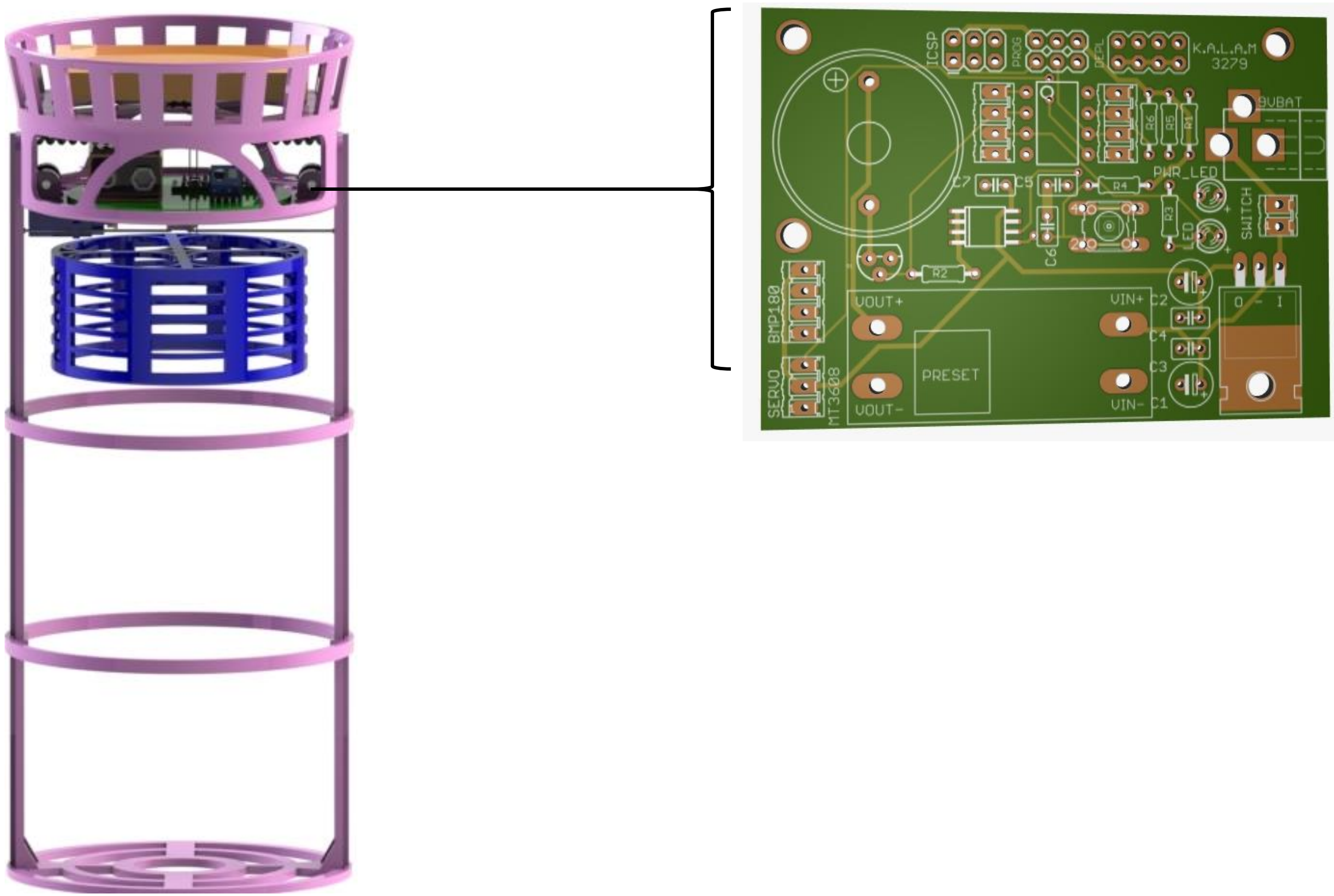


Team KALAM	
Title: Container	
Date March 24, 2019	Material Nylon
Scale: 1:2	Sheet No.:

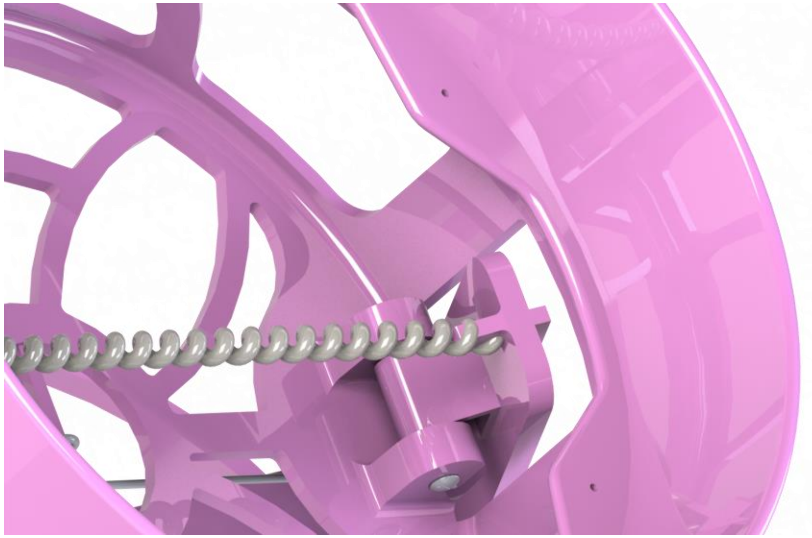
Container Mechanical Layout of Components [2/5]



Container Mechanical Layout of Components [3/5]



Container Mechanical Layout of Components [4/5]



Spring for container opening

Hinge for container ribs opening

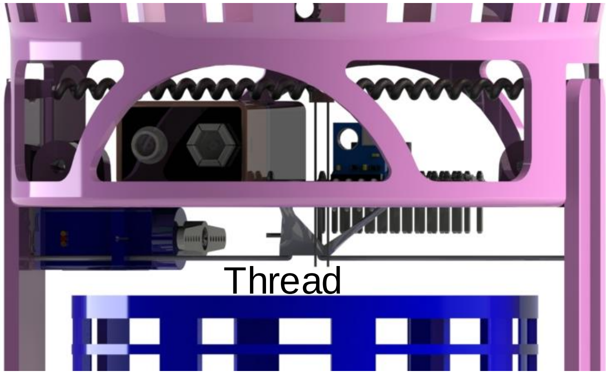
3D printed parachute compartment

Container Mechanical Layout of Components [5/5]

Component(s)	Material	Density (g/cm^3)	Tensile strength (MPa)	Cost per kg	Advantages	Disadvantages
• **Parachute Mounting Lid** • **Container Cage**	**ABS -** 3D PRINTING (FDM)	1.06-1.08	27-46	$10-40	• Mechanically strong and long life span	• Toxic and required heated bed
• **Container Rib (Body)** • **Container Ribs** • **Container Base** • **Container Parachute Section**	**HDPE -** CNC (machined)	0.97	32	$30	• Strong and durable. • Relatively light weight.	• Stress cracking

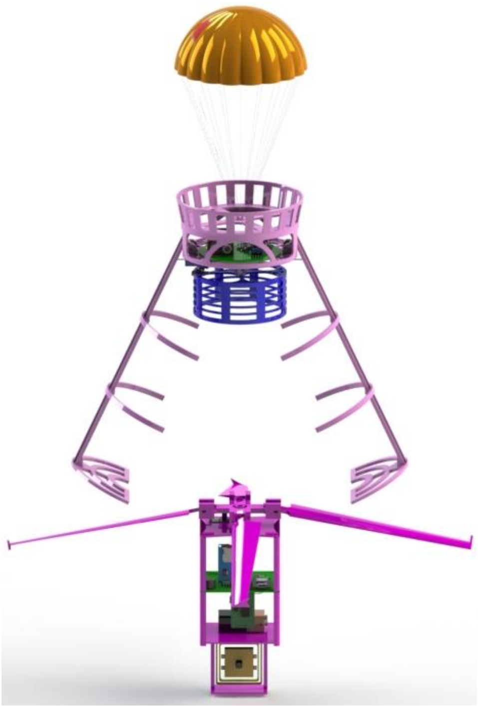
Payload Release Mechanism [1/2]

The payload rests on the container base and the cage stops the blades from opening, while the CanSat descents.



The servo motor cuts the Kevlar thread as the altitude reaches 450m.

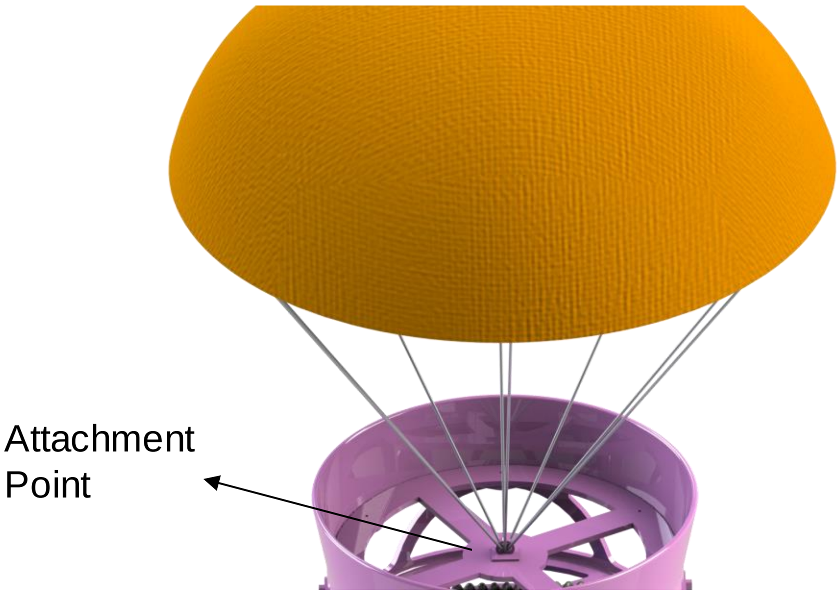
As a result of the thread cutting, the spring pulls the ribs of the container open. The payload starts to slip down the container.



The payload gets free from the cage and container. The autogyro blades start opening.

The autogyro blades open fully and the payload descents with 20m/s velocity.

Container Parachute Release Mechanism



Parachute is folded and placed in a compartment having diameter of 110mm and height 24mm. The compartment is open from above.

The attachment threads of the parachute are tied to the hook at the middle of the container. The parachute opens due to air pressure as soon as the CanSat is deployed from the rocket.

Structure Survivability

Silicon glue will be used for final mounting of all the components to ensure that nothing falls loose

PCB is screwed to the mainframe using Philips screws

Servo motor used for parachute opening will be clamped on the curved surface.

Hot glue is used to clamp jumpers to the wall for BMP180.

Mass Budget [1/8]

ELECTRONICS – PAYLOAD (1/2)									
Part		Component Name	Quantity	Mass (g)	Ext. Mass (g)	Uncertainty (Tolerance)	Uncertainty (g)	Sources	Method of Correction
Microcontroller		Teensy 3.2	1	5.2	5.2	0.1	0.005	Actual	-
Sensors	Air Pressure Temperature	BMP180	1	0.9	0.9	0.1	0.0009	Actual	-
Tilt Sensor		MPU-6050	1	2.1	2.1	0.1	0.002	Actual	-
Autogyro Blade spin Sensor		AH44E	1	2.9	2.9	0.1	0.003	Actual	-
GPS Sensor		GPS NEO 6M	1	12	5.4	0.01	0.0005	Datasheet	-
Power Voltage Sensor		Voltage Divider Circuit	1	0.8	0.8	0.1	0.0008	Actual	-
XBEE Radio		XBEE Pro S2C	1	4.3	4.3	0.1	0.004	Actual	-
CanSat Antenna		FXP70 Freedom (Patch Antenna)	1	1.2	1.2	0.1	0.001	Actual	-
Audio Beacon		MCKPI-G2437	1	1.86	1.9	0.01	0.0002	Datasheet	-
Battery		9V Li-Ion	2	33.00	66.0	0.01	0.003	Datasheet	-
BLDC Motor		82212/13T	1	40.7	40.7	0.1	0.051	Actual	-
Camera Stabilization		TurboWing Cyclops DV	1	4.5	4.5	0.1	0.004	Datasheet	**M1**
		ESC	1	15.0	15.0	0.1	0.015	Actual	Metallic portion on the wires will be stripped off

Mass Budget [2/8]

ELECTRONICS – PAYLOAD (2/2)								
Part	Component Name	Quantity	Mass (g)	Ext. Mass (g)	Uncertainty (Tolerance)	Uncertainty (g)	Sources	Method of Correction
SD Card Module	Generic SD Card Module	1	5.79	5.8	0.01	0.0005	Datasheet	-
SD Card	SanDisk Class 10	1	0.5	0.5	0.1	0.0005	Actual	-
RTC	DS 3231	1	7.8	7.8	0.1	0.007	Actual	-
Voltage Regulator	LM 7805(5V)	1	1.84	1.8	0.01	0.0001	Datasheet	-
Voltage Regulator	LM1117(3.3V)	1	0.98	1.0	0.01	0.0001	Datasheet	-
PCB	-	2	14	28.0	-	-	Estimated	**M2**
External Switch	SPDT Switch	1	1	1.0	-	-	Estimated	**M3**
Misc.	Jumpers, LEDs	-	10	10.0	-	-	Estimated	**M4**

METHODS OF CORRECTION	
M1(Camera)	The complete casing of the ca
M2 (PCB)	Making circular pcb
M3(External Switches)	Using SPST switches instead of SPDT
M4(Misc.)	Using mini-jumper wires/ single-core wires instead of normal Jumpers wires

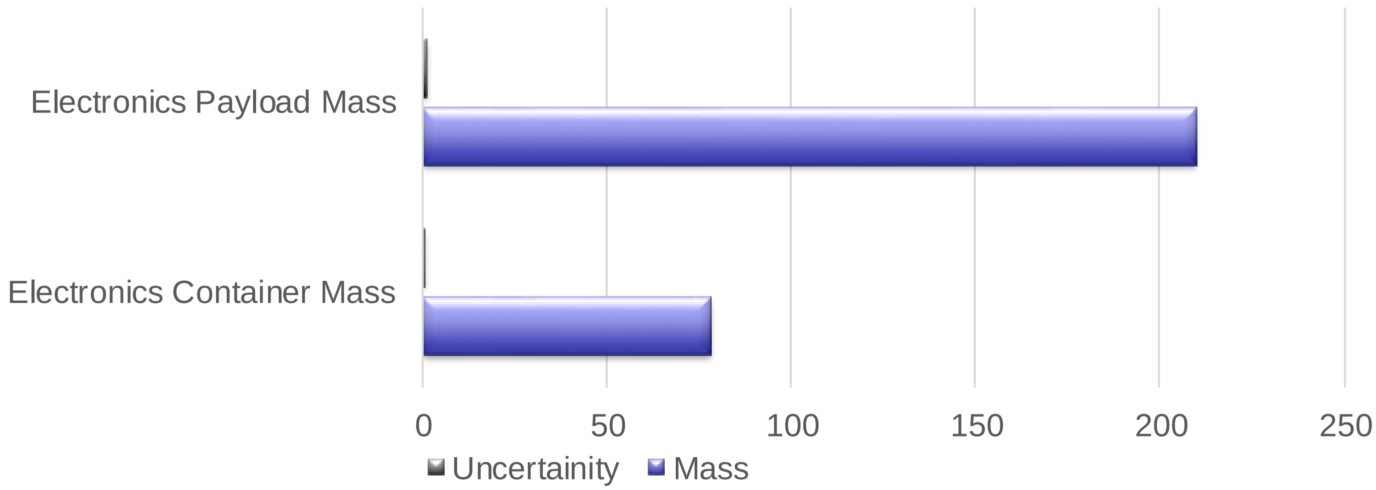
Mass Budget [3/8]

ELECTRONICS – CONTAINER								
Part	**Component Name**	**Quantity**	**Mass (g)**	**Ext. Mass (g)**	**Uncertainty (Tolerance)**	**Uncertainty (g)**	**Sources**	**Method of Correction**
Servo Motor	Micro Servo (9g)	1	11.7	11.7	0.1	0.01	Actual	
Air Pressure Sensor	BMP180	1	0.9	0.9	0.1	0.0009	Actual	-
Voltage Regulator	LM1117(3.3V)	1	0.98	1.0	0.01	0.0001	Datasheet	-
Voltage Regulator	LM 7805(5V)	1	1.84	1.8	0.01	0.0001	Datasheet	-
Audio Beacon	MCKPI-G2437	1	1.86	1.9	0.01	0.0001	Datasheet	-
Battery	9V Li-Ion	1	40.00	40.0	0.01	0.004	Datasheet	
Microcontroller	Arduino Pro Mini	1	4.00	4.0	0.01	0.0004	Datasheet	
External Switch	SPDT Switch	1	1	1.0	-	-	Estimated	M2
PCB		1	7	7.0	-	-	Estimated	M1
Misc.	Jumpers, LEDs	-	6	6.0	-	-	Estimated	M3

METHODS OF CORRECTION	
M1 (PCB)	Making circular pcb
M2(External Switches)	Using SPST switches instead of SPDT
M3(Misc.)	Using mini-jumper wires/ single-core wires instead of normal Jumpers wires

TOTAL ELECTRONICS MASS BUDGET

Electronics Payload Total Mass	204.8 ± 1.26g
Electronics Container Total Mass	75.28 ± 0.25g
TOTAL	**280.08 ± 1.51g**



Mass Budget [5/8]

MECHANICAL – PAYLOAD									
	Part	Material	Quantity	Mass (g)	Ext. Mass (g)	Uncertainty (Tolerance)	Uncertainty (g)	Sources	Method of Correction
Structural Elements	Payload Body	3D printed HDPE	1	18.26	18.3	0.1	0.03	Actual	-
	Rotating Hub	3D printed nylon PA-2200	1	11.02	11.0	0.01	0.001	Actual	**M5**
	Propeller	Vacuum formed polycarbonate	4	16.37	45.5	0.01	0.002	Simulated	-
	Gimbal (Camera Stabilization)	3D printed nylon PA-2200	1	16.0	16.0	-	-	Estimated	-
Misc.Components	Misc.	Adhesives, nuts, bolts, screws etc.	-	8	8.0	-	-	Estimated	**M6**
	TOTAL			108.65	98.78	0.12	0.033		

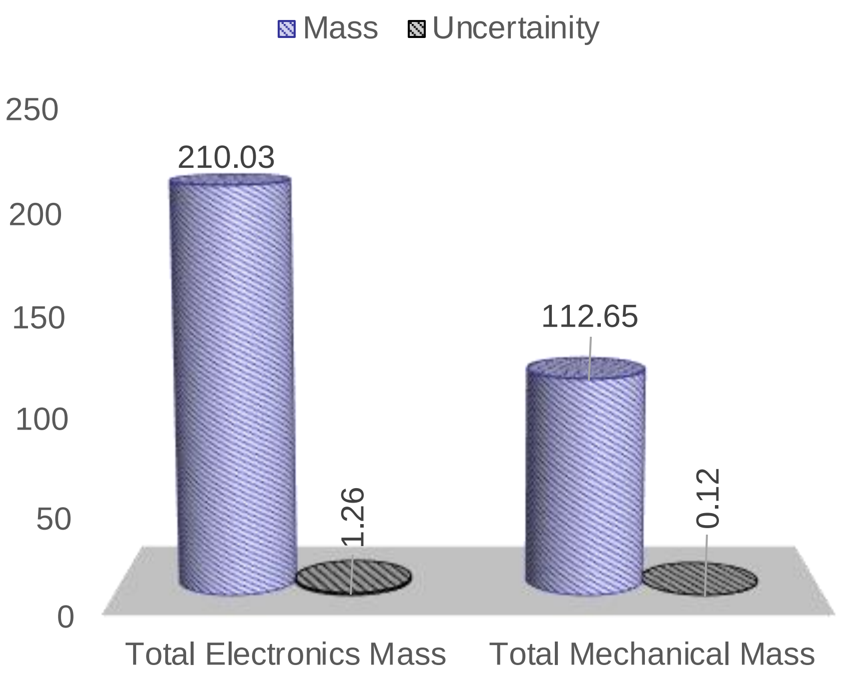
METHODS OF CORRECTION	
M5	Replacing the nylon PA-2200 material with the HDPE material as HDPE is lighter than nylon PA-2200.Although we'll have to compromise on some properties, but HDPE will survive the **high impact strength.**
M6	Ensuring that Adhesives are used in limited quantity.

Mass Budget [6/8]

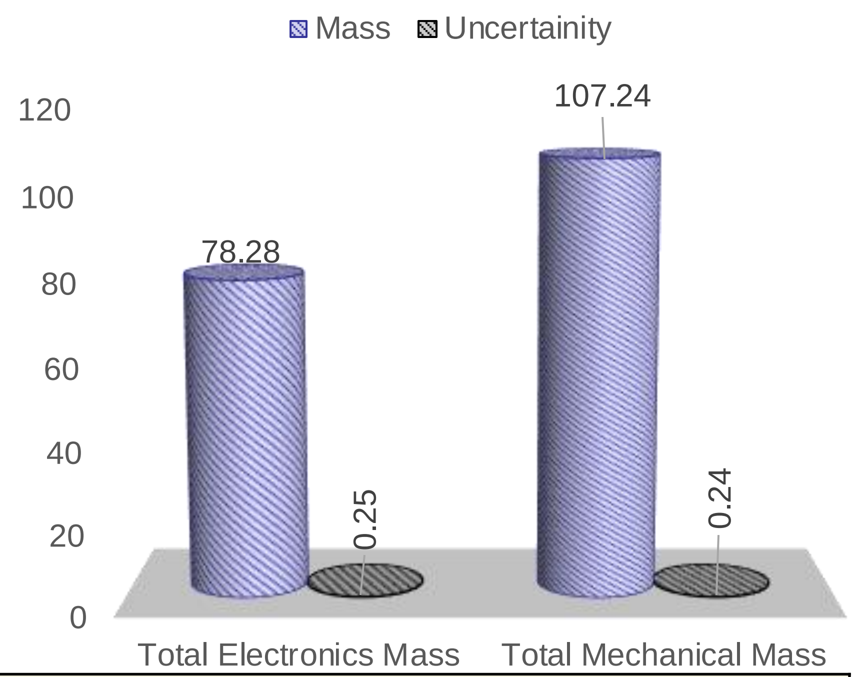
MECHANICAL – CONTAINER										
	Part		Material	Quantity	Mass (g)	Ext. Mass (g)	Uncertainty (Tolerance)	Uncertainty (g)	Sources	Method of Correction
Structural Elements	Parachute Section		CNC machined HDPE	1	22.26	22.26	0.01	0.004	Simulation	
	Ribs	Main Body	CNC machined HDPE	2	11.82	23.64	0.01	0.003	Simulation	
		Supporting Body	CNC machined HDPE	4	9.52	38.1	0.01	0.001	Simulation	
		Base	CNC machined HDPE	2	9.54	18.1	0.01	0.001	Simulation	
	Cage		3D printed ABS	1	11.2	11.2	0.1	0.01	Actual	
Components	Parachute		TFR Thin Mill Chutes	1	12.8	12.8	0.1	0.01	Datasheet	
Misc. Components	Misc.		Adhesives, nuts, bolts, Kevlar thread, screws, torsional spring etc.		8	8.0			Estimated	**M6**(Ensuring that Adhesives are used in limited quantity)
TOTAL					99.24	130.14	0.24	0.029		

TOTAL MASS BUDGET

PAYLOAD



CONTAINER



TOTAL MASS OF STRUCTURAL ELEMENTS	201.09 ± 0.26g
TOTAL MASS OF OTHER COMPONENTS	307.11 ± 1.61g

Mass Budget [8/8]

TOTAL MASS BUDGET	
TOTAL MASS OF THE CANSAT	508.86 ± 1.87g

MARGIN	
510.73g – 500g = 10.73g	10.73g
506.99g – 500g= 6.99g	6.99 g

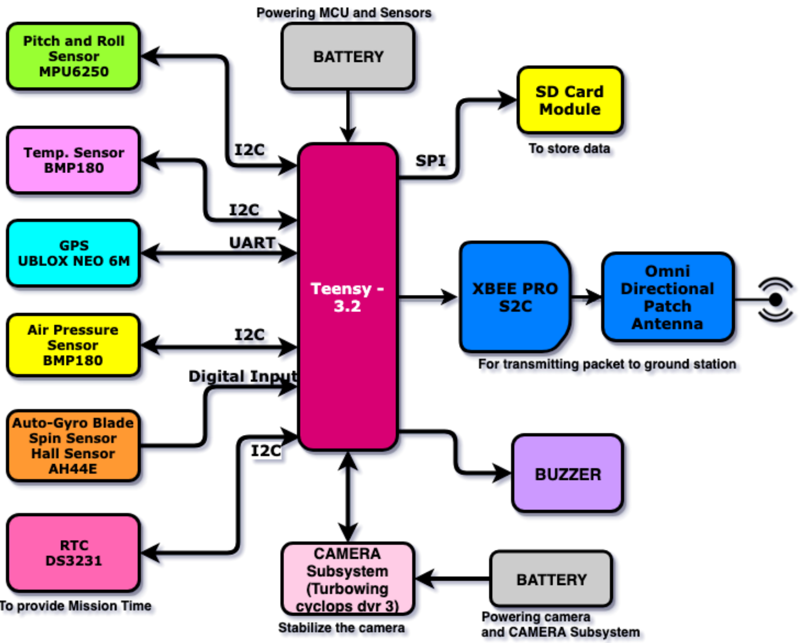
METHODS OF CORRECTION	
In case total mass of the CanSat measured at the launch site is different than expected, the following methods of correction will be followed:	
MASS < 490g	MASS > 510g
The container made of Nylon PA-2200 will be used.	**The container made of HDPE will be used.**

Communication and Data Handling (CDH) Subsystem Design

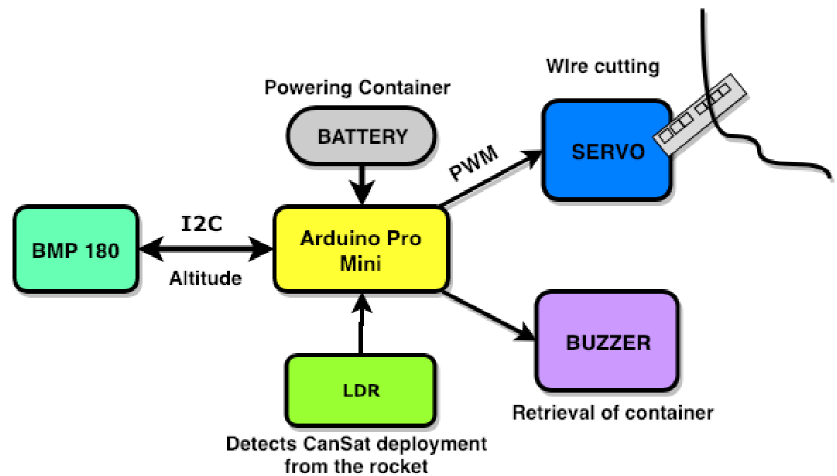
Ishita Kochar

CDH Overview

Payload CDH Overview



Container CDH Overview



CDH Requirements[1/3]

ID	Requirement	Rationale	Parent	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.	Competition 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		Very High	✔		✔	
PCDH-03	Telemetry shall be accomplished using XBee radios. 2.4GHz radios are used. 900MHz radios are also allowed.	Competition Requirement	BR- 31	Very High	✔		✔	
PCDH-04	XBees shall operate in unicast mode only.	Competition Requirement	BR- 33	Very High	✔	✔	✔	

CDH Requirements[2/3]

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
PCDH-05	The NETID/PANID of XBee radios should be same as the team number.	Competition Requirement	BR- 32	High	✓	✓	✓	
PCDH-06	Telemetry data of all sensors shall be displayed in real time in a csv file.	Competition Requirement	BR- 29	Very High	✓	✓	✓	✓
PCDH 07	The telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Competition Requirement	BR- 37	High		✓	✓	
PCDH-08	Telemetry data shall also be plotted wrt time.	Competition Requirement	BR- 38	Very High	✓		✓	
PCDH-09	Once the payload lands, all telemetry shall stop and an audio beacon shall activate.	Competition Requirement	BR- 47	Very High		✓	✓	✓

CDH Requirements[3/3]

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
CCDH-1	Container shall comprise of pressure sensor to calculate height, battery, microcontroller and servo motor.	By calculating altitude, the servo would be commanded to move at 450m.		Very high	✔	✔	✔	
CCDH-2	Container electronics is responsible for the payload separation mechanism at 450m.	Competition requirement	BR9	Very high		✔		
CCDH-3	The payload shall be separated from container by cutting a cotton thread from a servo once the altitude becomes 450m.	Safe and reliable mechanism, effective when a sharp blade is attached on it to cut the thread.	BR9	Very high	✔		✔	
CCDH-4	The software state shall change when altitude of CanSat is 450m.	To indicate that the container has opened at 450m altitude.	BR9	Very high		✔		

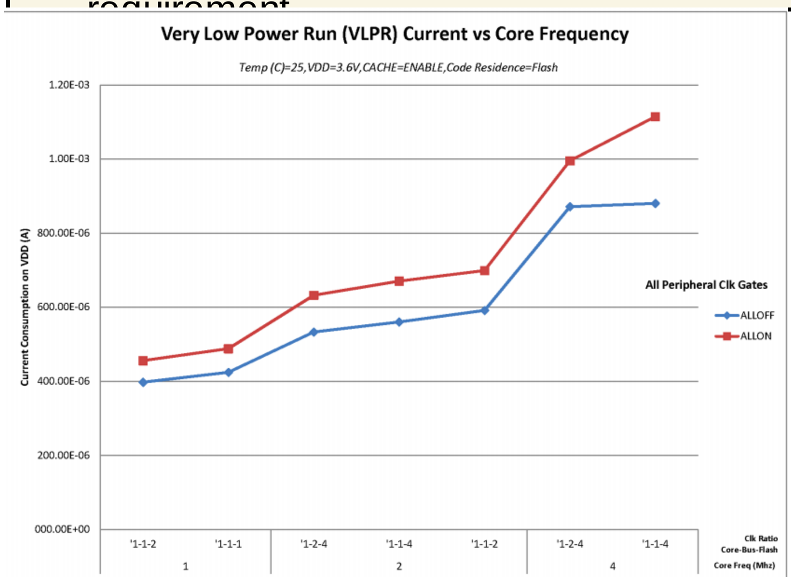
Payload Processor & Memory Selection

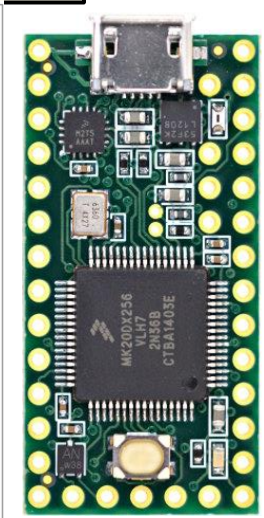
Source: Datasheet

SELECTED MCU :	Teensy 3.2

Characteristics

- Up to 50 MHz ARM Cortex-M4 core with DSP instructions delivering 1.25 Dhrystone MIPS per MHz
- Large number of communication interfaces.
- Multiple low-power modes to provide power optimization based on application requirement





Input Voltage (V)	3.3-12
Processor and	MK20DX256VLH 7 Cortex-M4
CPU Speed (MHz)	72
Boot Time (seconds)	1
Flash Memory (kB)	256
SRAM (kB)	64
EEPROM (kB)	3
Weight (g)	5
CAN Bus	1

<u>Intefaces</u>:
Digital I/O – 34
Analog Input – 22
Analog Output – 1
UART – 3
SPI – 1
I2C – 2

Payload Processor & Memory Selection

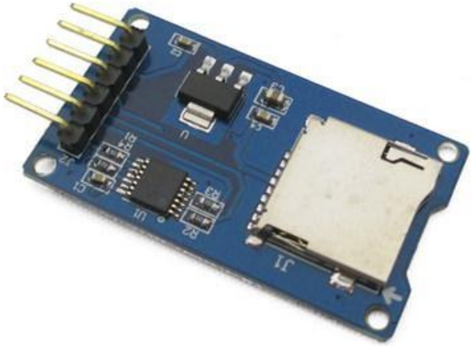
SELECTED: **Arduino SD Card Module**

Source: Datasheet

Characteristics

- The module (MicroSD Card Adapter) is a Micro SD card reader module for reading and writing through the file system and the SPI interface driver, SCM system can be completed within a file MicroSD card
- Support Micro SD Card, Micro SDHC card (high speed card)
- Level conversion circuit board that can interface level is 5V or 3.3V
- Power supply is 4.5V ~ 5.5V, 3.3V voltage regulator circuit board
- Communications interface is a standard SPI interface.
- Level conversion circuit: Micro SD card to signal the direction of converts 3.3V, MicroSD card interface to control the direction of the MISO signal is also converted to 3.3V, general AVR microcontroller systems can read the signal;
- Micro SD card connector: self bomb deck, easy card insertion.

Model	Weight (g)	Interface	Memory Space (GB)	Price ($)
Arduino SD Card Module	6	SPI	16 (expandable)	1.81



Payload Processor & Memory Selection

SELECTED:	SanDisk 16 GB

Source: Datasheet

Characteristics

- Password protection
- Built-in write protection features (permanent and temporary)
- Supports card detection (insertion and removal)
- Application-specific commands
- Up to 25 MB/sec data transfer rate (using four parallel data lines)
- Variable clock rate 0-25 MHz (standard), 0-50 MHz (high performance)

Model	Features	Memory Space (GB)	Cost
SanDisk 16 GB	25 MB/sec data transfer rate SD - protocol compatible Supports SPI Mode Read speed : 96 MB/s	16	$3.5

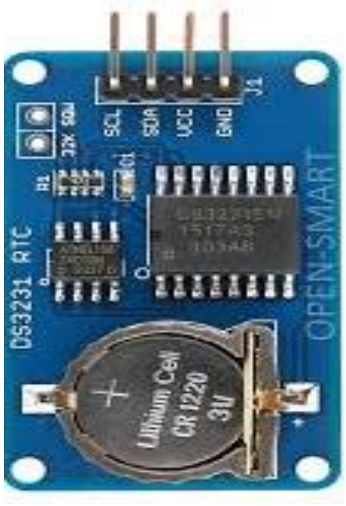
Payload Real-Time Clock

SELECTED RTC: **Hardware RTC DS3231**

Source: Datasheet

Characteristics

- Low Power Operation Extends Battery-Backup Run Time.
- Fast (400kHz) I2C Interface.
- Highly Accurate RTC Completely Manages All Timekeeping Functions
  - Real-Time Clock Counts Seconds, Minutes, Hours, Date of the Month, Month, Day of the Week, and Year, with Leap-Year Compensation Valid Up to 2100
  - Accuracy ±2ppm from 0°C to +40°C
  - Accuracy ±3.5ppm from -40°C to +85°C
  - Digital Temp Sensor Output: ±3°C Accuracy
  - Register for Aging Trim
  - Two Time-of-Day Alarms
  - Programmable Square-Wave Output Signal



MODEL	HARDWARE/ SOFTWARE	WEIGHT/ SIZE	RESET TOLERANCE	COST	V-SUPPLY	ACCURACY	INTER-FACE
DS3231	HARDWARE	8g	After reset condition external clock still keeps the mission time	$ 1.4	2.3 to 5.5 V (Coin Cell Battery)	±2 ppm from 0°C to +40°C	I2C

Payload Antenna Selection

SELECTED Antenna:	FXP70 Freedom

Source: Datasheet

Characteristics

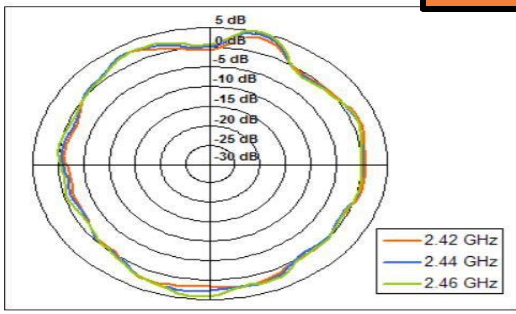
- The FXP70 Freedom 2.4GHz Antenna works on WiFi, ZigBee, Bluetooth and ISM band at 2.4GHz.
- Efficiency : 80%
- Free Space Peak Gain: 1.5dBi
- Impedance: 50 Ohms
- Polarization: Linear

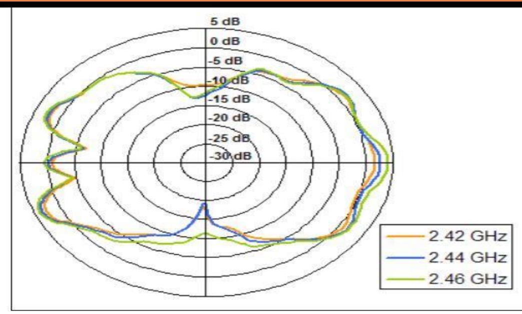
Model	Peak Gain	Dimensions	Directivity	Weight	Connector	Range (Frequency range)	VSWR	Range
FXP70 Freedom	5dBi	27mm*25 mm* 0.08 mm	Omni	1.2g	MHFI (U.FL Compatible)	2.4GHz	<1.5-1	2 km

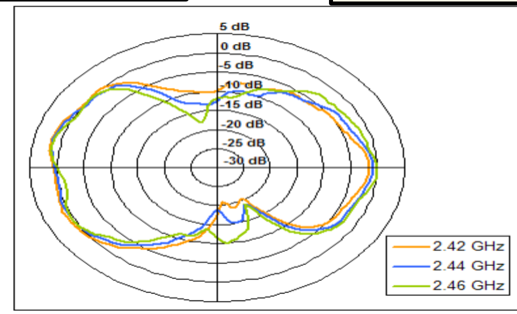
Payload Antenna Selection

Radiation Pattern of FXP70 Freedom

Source: Datasheet





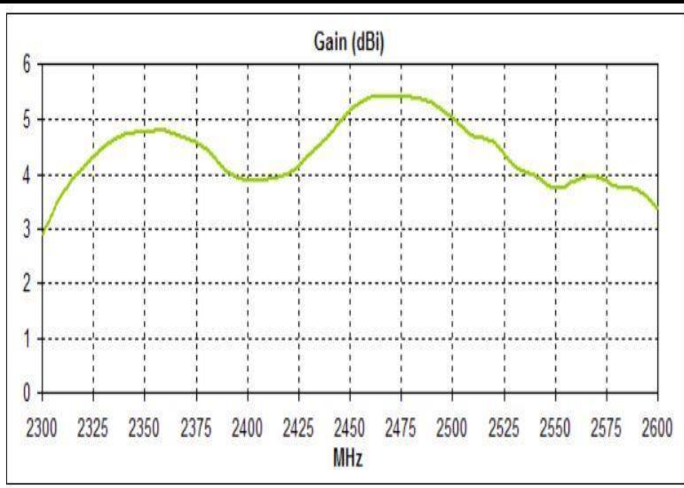


Radiation pattern XZ Plane

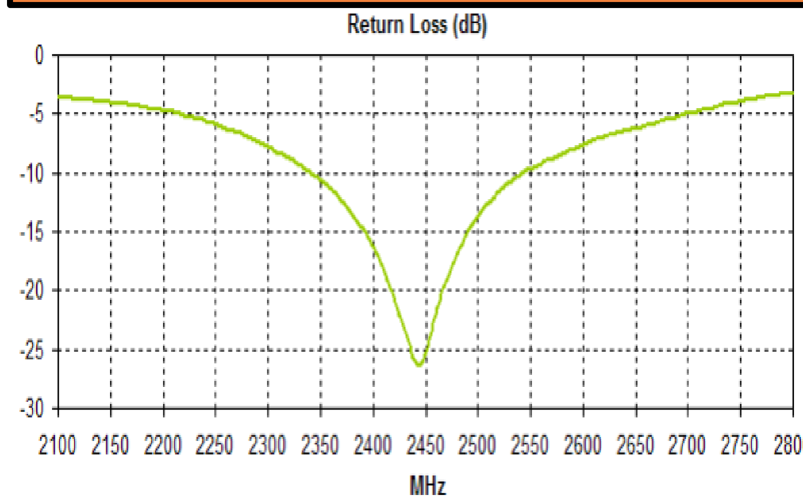
Radiation pattern YZ Plane

Radiation pattern XY Plane

GAIN of FXP70 Freedom Patch Antenna



S11(Return Loss) of FXP70 Patch Antenna



Payload Radio Configuration

SELECTED Radio: **XBEE PRO S2C**

Source: Datasheet

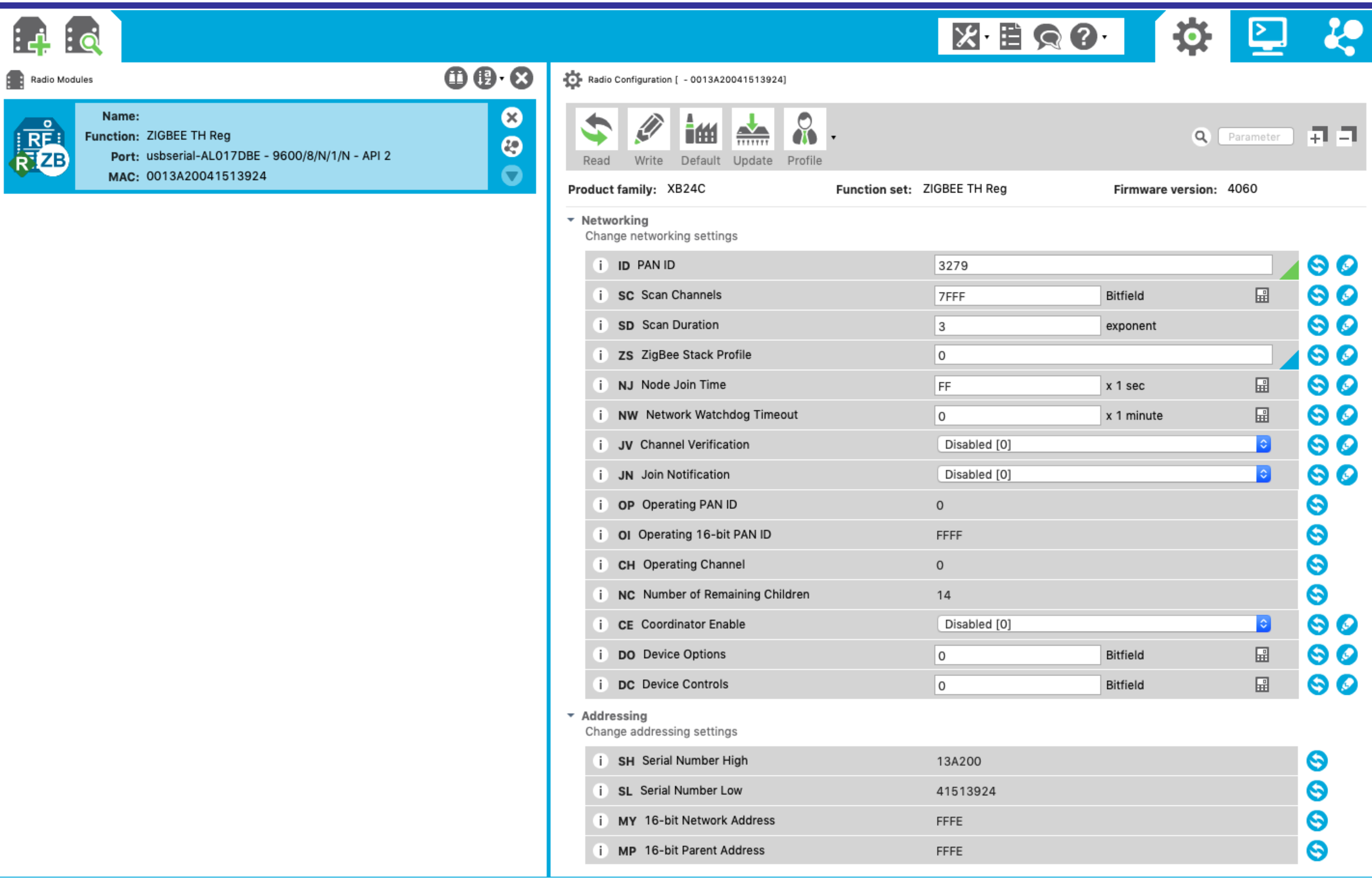
Characteristics

- Low Operating Current and Range is within our Requirements with very good Margins.
- XBee Radio Module is interfaced to the Teensy3.2 through USART Communication Protocol.
- PAN ID will be set to Team Number 3279.
- The XBEE Radio is configured using AT Mode (Ground Station being Coordinator AT & payload Xbee as Router AT).
- Successful testing upto receiving packets at range of 1km with parabolic antenna

Line of Sight Range	Transmit Power output	Receiver Sensitivity (dBm)	Supply Voltage (V)	Weight (g)	Operating Frequency	Power down Current
Up to 2 miles.	63mW (+18dBm)	-101	2.1-3.6	4.3	ISM 2.4GHz	<1μA

Transmission Control: Transmission begins as and when CanSat is powered and sends data to ground station during each mission phase. Telemetry stops when payload is below 5m during decent state

Payload Radio Configuration



Payload Telemetry Format

The Telemetry consists of :

1. All the Sensory data must be in Engineering Units(meters, meters/sec, Celsius, etc.)

2. Data transmitted at default Baud Rate of 9600 in ‘Continuous Mode’.

3. Data is transmitted in ASCII Format with values separated by a comma(,) .

4. Example telemetry given above is provided with system prototype.

5. Example telemetry matches with competition guide requirements.

6. Telemetry is saved on the ground station computer as CanSat_TEAM_KALAM.csv .

Telemetry Format and Data Included :

<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>

Example :

3279,5,5, 0.2, 101465, 24.3,8.96, 17:47:36.0, 53.2734, 77.0389,7, 273,0,36,2,1.2

```
3279,2,2,0.00,565.00,12.00,2.00,2,28.97,77.90,273.00,7,83,7,129,0,2
3279,3,3,0.00,369.00,29.00,7.00,3,28.97,77.90,273.00,0,33,69,278,1,5
3279,4,4,0.00,626.00,32.00,7.00,4,28.97,77.90,273.00,0,63,19,349,4,1
3279,5,5,0.00,272.00,33.00,6.00,5,28.97,77.90,273.00,5,65,38,91,4,7
3279,6,6,0.00,353.00,28.00,4.00,6,28.97,77.90,273.00,8,50,84,196,0,3
3279,7,7,0.00,266.00,29.00,4.00,7,28.97,77.90,273.00,1,73,27,208,3,3
3279,8,8,0.00,581.00,35.00,3.00,8,28.97,77.90,273.00,5,4,23,136,0,9
3279,9,9,0.00,94.00,29.00,1.00,9,28.97,77.90,273.00,7,5,15,4,1,8
3279,10,10,0.00,323.00,25.00,2.00,10,28.97,77.90,273.00,2,26,16,337,3
3279,11,11,0.00,97.00,31.00,8.00,11,28.97,77.90,273.00,7,8,37,397,4,4
3279,12,12,0.00,631.00,25.00,5.00,12,28.97,77.90,273.00,5,68,52,399,3
```

Container Processor & Memory Selection

SELECTED MCU	Arduino Pro Mini

Source: Datasheet

Characteristics

- The Arduino Pro Mini is an ATmega168 based microcontroller board.
- High performance, low power AVR® 8-bit microcontroller
- Advanced RISC architecture . 131 powerful instructions – most single clock cycle execution
- Two 8-bit Timer/Counters with separate prescaler and compare mode
- Low power consumption
  Active mode: 4MHz, 3.0V: 1.8mA
  Power-down mode: 5μA at 3.0V

Intefaces:
Digital I/O – 14
Analog Input – 6
Hardware UART-1
SPI – 1
I2C – 1

Input Voltage (V)	3.3-12
Processor and	ATmega168
CPU Speed (MHz)	8
Boot Time (seconds)	8
Flash Memory (kB)	32
SRAM (kB)	2
EEPROM (kB)	1
Weight (g)	4
Data Bus	8 bit

Electrical Power Subsystem Design

Anmol Gulati

EPS Overview

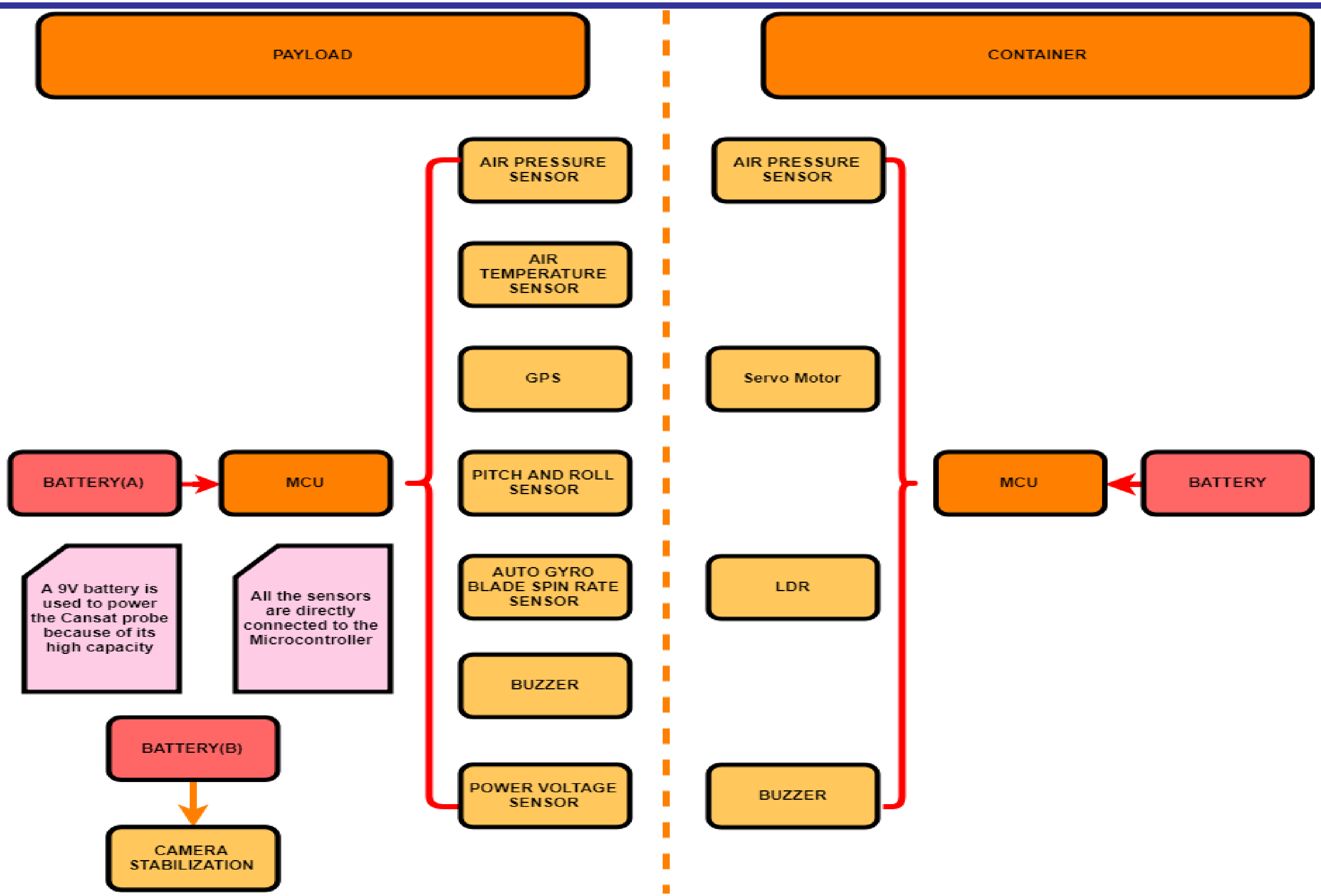
Payload EPS

Component Type	Model	Description
Battery(A)	EBL 9V Li-ion battery	Main power source
Battery(B)	EBL 9V Li-ion battery	Powers Camera Sub-System
Voltage Divider	---	Measuring Battery Voltage
3.3V Regulator	LM1117V Regulator	Regulates voltage for 3.3V specific sensors.
5V Regulator	L7805CV Regulator	Regulates voltage for 5V specific sensors.
Tertiary battery	CR2032	Power for RTC
Switch	SPDT Switch	Controls power on/off
DC-DC Voltage Convertor	MT3608	9V – 12V booster for buzzer

Container EPS

Component Type	Model	Description
Battery	EBL 9V Li-ion battery	Main power source
3.3V Regulator	LM1117V Regulator	Regulates voltage for 3.3V specific sensors and MCU.
Switch	SPDT Switch	Controls power on/off
DC-DC Voltage Convertor	MT3608	9V – 12V booster for buzzer

EPS Overview



EPS Changes Since PDR

PAYLOAD

What	In PDR	In CDR	Rationale
12V booster for buzzer	--	MT3608	1. Buzzer gives desired output only when operated at maximum rated voltage

CONTAINER

What	In PDR	In CDR	Rationale
Container battery	APT-HW9V10	EBL Li-ion	1. Higher battery capacity 2. Lesser weight 3. Performs equally well in low and as well as high rate of discharge.
12V booster for buzzer	--	MT3608	1. Buzzer gives desired output only when operated at maximum rated voltage

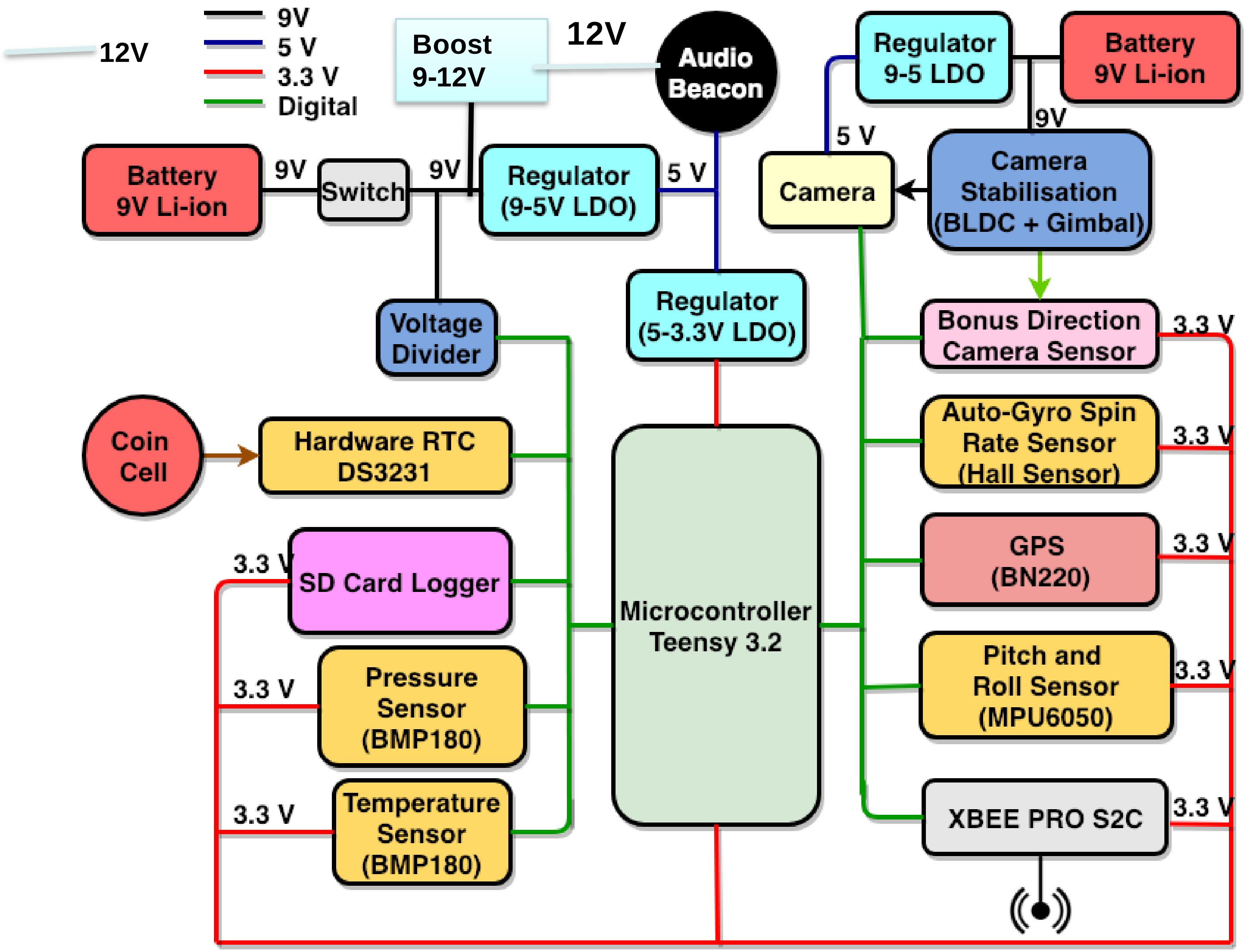
EPS Requirements

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
EPS-1	The payload must include an easily accessible power switch.	Competition Requirement	BR- 45	Very high		✔		
EPS-2	The payload must include a power indicator such as an LED that can be easily seen without disassembling the CanSat.	Competition Requirement	BR- 46	Very high		✔	✔	
EPS-3	Battery source may be alkaline, Ni-Cad, Ni-MH, Lithium or Lithium-ion. Lithium polymer batteries are not allowed.	Competition Requirement	BR- 49	Very high	✔	✔		
EPS-4	An audio beacon is required for the payload. It may be powered after landing or operate continuously and the sound level should be minimum 92dB unobstructed.	Competition Requirement	BR- 47	Very high			✔	✔

EPS Requirements

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
EPS-5	All electronic components shall be shielded from the environment except sensors.	Competition Requirement	BR- 13	Very high		✔		
EPS-6	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Competition Requirement	BR- 55	High	✔			
EPS-7	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Base Requirement	BR- 51	High	✔	✔		

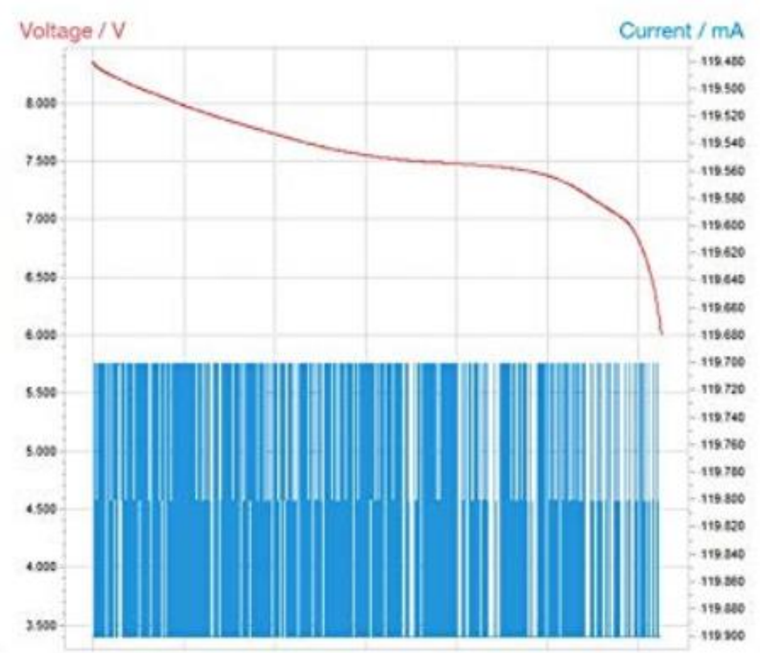
Payload Electrical Block Diagram



Payload Power Source

Model	Weight	Type	Voltage	Capacity	Cost
EBL Li-ion battery	37g	Li-ion	9V	600mAh	$10.18

The rated Voltage of the battery is 9V and the Current capacity is 600mAh. The experimental values show that the battery can provide a current of 580mA for one hour before being dead.



Payload Power Budget

S.No	Component	Voltage (V)	Current(mA)	Error (mA)	Power(W)	Operation time	Wh Requirements	Duty Cycle	Source/ Uncertainty
1.	**BMP 180**	3.3	0.65	0.5	0.002145	2 hours	0.00429	100%	Datasheet
2.	**TEENSY 3.2**	3.3	45	0.5	0.1485	2 hours	0.297	100%	Datasheet
3.	**UBLOX NEO 6M**	3.3	10	1.0	0.033	2 hours	0.066	100%	Datasheet
4.	**RTC-DS3231**	3.3	0.08	0.5	0.00026	2 hours	0.00052	100%	Datasheet
5.	**LM1117**	5	10	0.0	0.05	2 hours	0.066	100%	Datasheet
6.	**MPU 6050**	3.3	1.74	0.5	0.0057	2 hours	0.01148	100%	Datasheet
7.	AUTO GYRO SPIN RATE SENSOR **AH49E**	3.3	3.5	0.0	0.0115	2 hours	0.0231	100%	Datasheet
8.	MICRO-**SD CARD MODULE**	3.3	25	0.5	0.0825	2 hours	0.165	100%	Datasheet
9	BUZZER**(MCKPI-G2437-3671)**	5	8.3	0.5	0.041	1 hour	0.041	50%	Estimated
10.	**MT3608**	9	1.8	0.4	0.016	1 hour	0.016	50%	Estimated
11	XBEE **PRO S2C**	3.3	60	0.5	0.198	2 hours	0.396	100%	Datasheet
12	LM7508	9	10	0.0	0.09	2 hours	0.18	100%	Datasheet
13	CAMERA	5	130	0.5	0.65	2 minutes	0.0216	75%	Datasheet
14	BLDC MOTOR(ON GIMABL FOR BONUS CAMERA STABILIZATION) **A2212/13T**	9	136	0.5	1.2	2 minutes	0.0408	75%	Datasheet
15	BLDC CONTROLLER H-BRIDGE **– L298**								

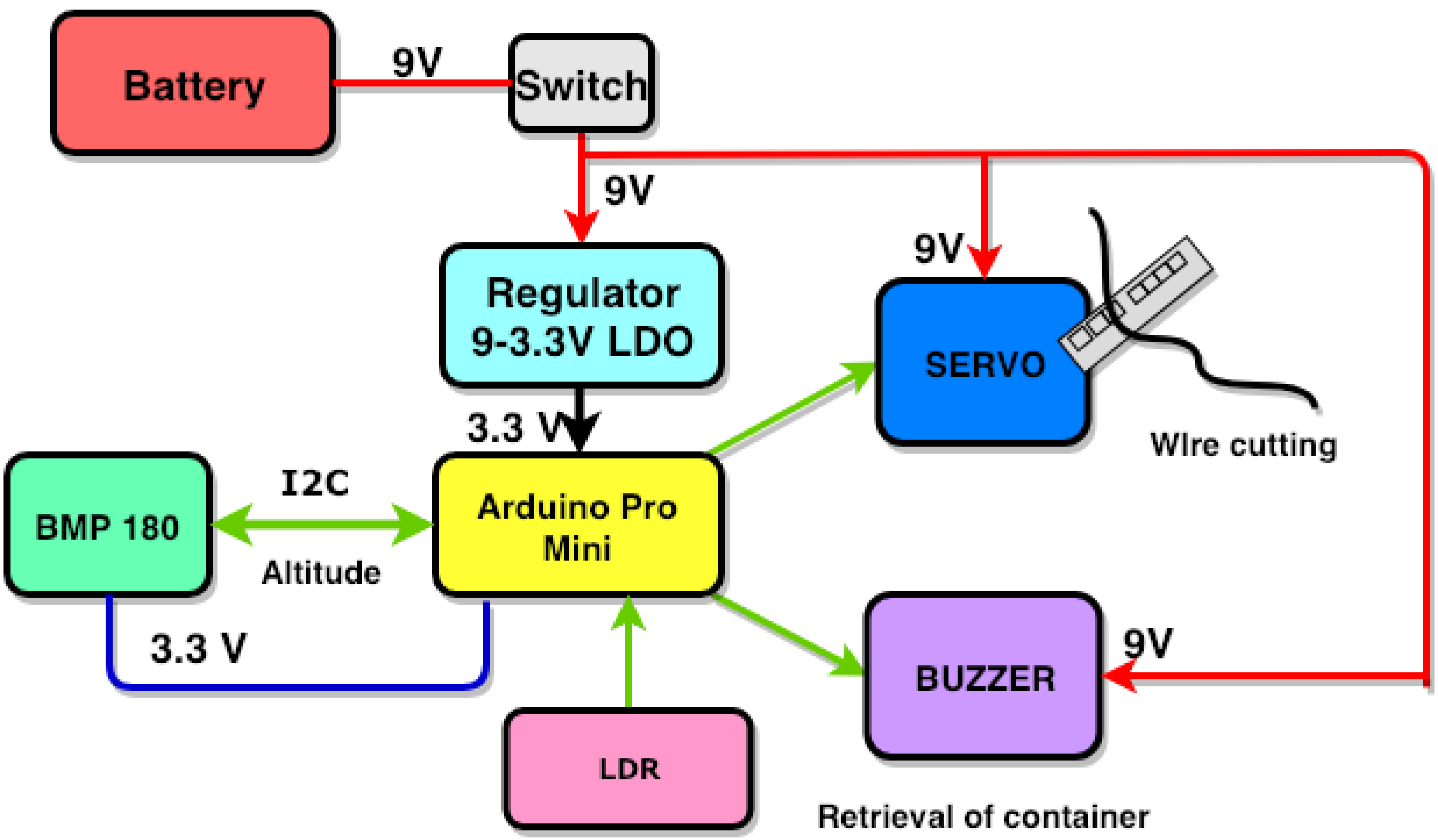
Payload Power Budget

Power Calculations (Without Camera System)		
Total Power(W)	0.67661	Total Duration for the mission = 2 Hour Wait + Mission Time (2 minutes)
Wh Requirements	1.2664	
Error(Wh)	0.0321	
Total Wh Requirements	1.2664 ± 0.0321	
Battery Rating(Wh)	5.4	
Margin(Wh)	4.104	

Power Calculations (Camera System)		
Total Power(W)	1.94	The total duration for which we need to operate the camera is 75% of 2 minutes = 1.5 minutes. We Only require 266mA current for 2 minutes
Wh Requirements	0.2426	
Error(Wh)	0.0332	
Total Wh Requirements	0.2426 ± 0.0332	
Battery Rating(Wh)	5.4	
Margin(Wh)	5.1242	

We have used separate batteries for the sensor subsystem and the camera to ensure that the high instantaneous current requirement of the camera does not kill the sensor subsystem.

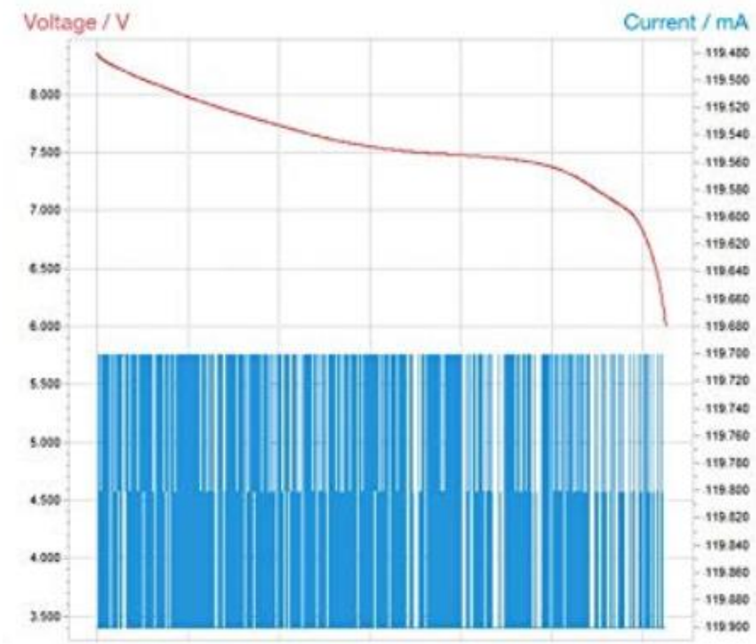
Container Electrical Block Diagram



Container Power Source

Model	Weight	Type	Voltage	Capacity	Cost
EBL Li-ion battery	37g	Li-ion	9V	600mAh	$10.18

The rated Voltage of the battery is 9V and the Current capacity is 600mAh. The experimental values show that the battery can provide a current of 580mA for one hour before being dead.



Container Power Budget

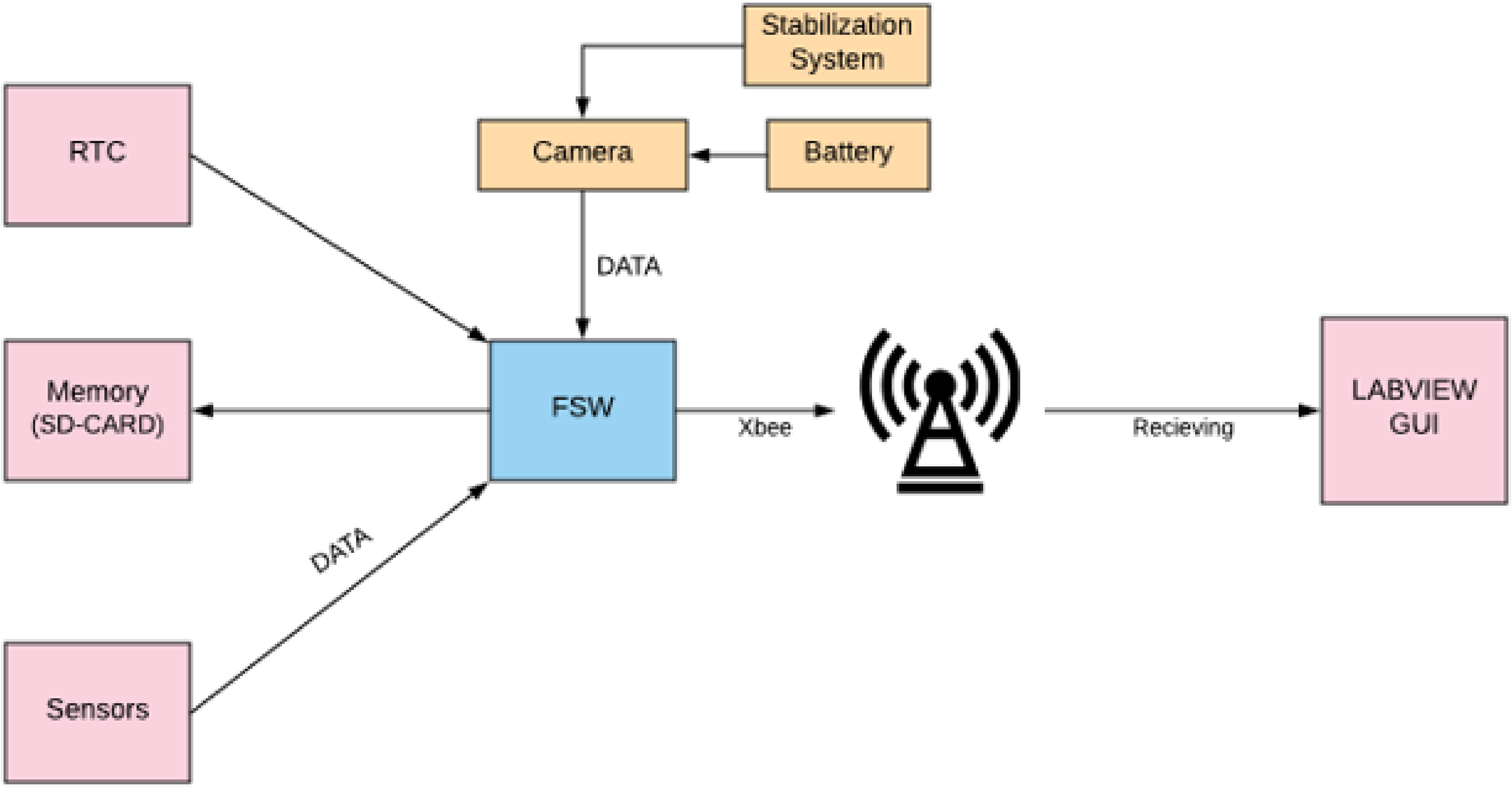
S.No	Component	Current (mA)	Voltage(V)	Error (mA)	Power (W)	Operating time	Wh Requirements	Duty Cycle	Source/ Uncertainty
1.	BMP 180	0.5	3.3	0.5	0..00165	2 hours	0.0033	100%	Datasheet
2.	Arduino Pro Mini	0.2	3.3	0.5	0.00066	2 hours	0.00132	100%	Datasheet
3.	Audio Beacon	0.2	5	0.5	0.001	1 minutes	0.0005	50%	Datasheet
4.	Servo Motor	120	5	1	0.600	2 minutes	0.020	5%	Datasheet

Power Calculations (Without Camera System)			
Total Power(W)		0.603	Total Duration for the mission = 2 Hour Wait + Mission Time (2 minutes). We Only require 121mA current for 120 minutes.
Wh Requirements		0.02512	
Error(Wh)	3.3V Watt Hour	0.0066	
	5V Watt Hour	0.000208	
Total Wh Requirements		0.02512 ± 0.00688	
Battery Rating(Wh)		5.4	
Margin		5.368	

Flight Software (FSW) Design

Rishabh Yadav

FSW Overview[1/2]



FSW Overview[2/2]

Development Environment

Arduino IDE – Easy to use with clear programming environment

Software overview:

1. Calibration of sensors.
2. Sensor data updated every second.
3. Creating telemetry and storing the data in SD card and also sending to the ground station using Xbee.
4. Video recording.
5. Maintenance of transmitted packet counts
6. Saving data in a .CSV file.
7. Activation of Auto-Gyro and Camera at 450 m and storing video to the SD-CARD.

FSW Changes since PDR

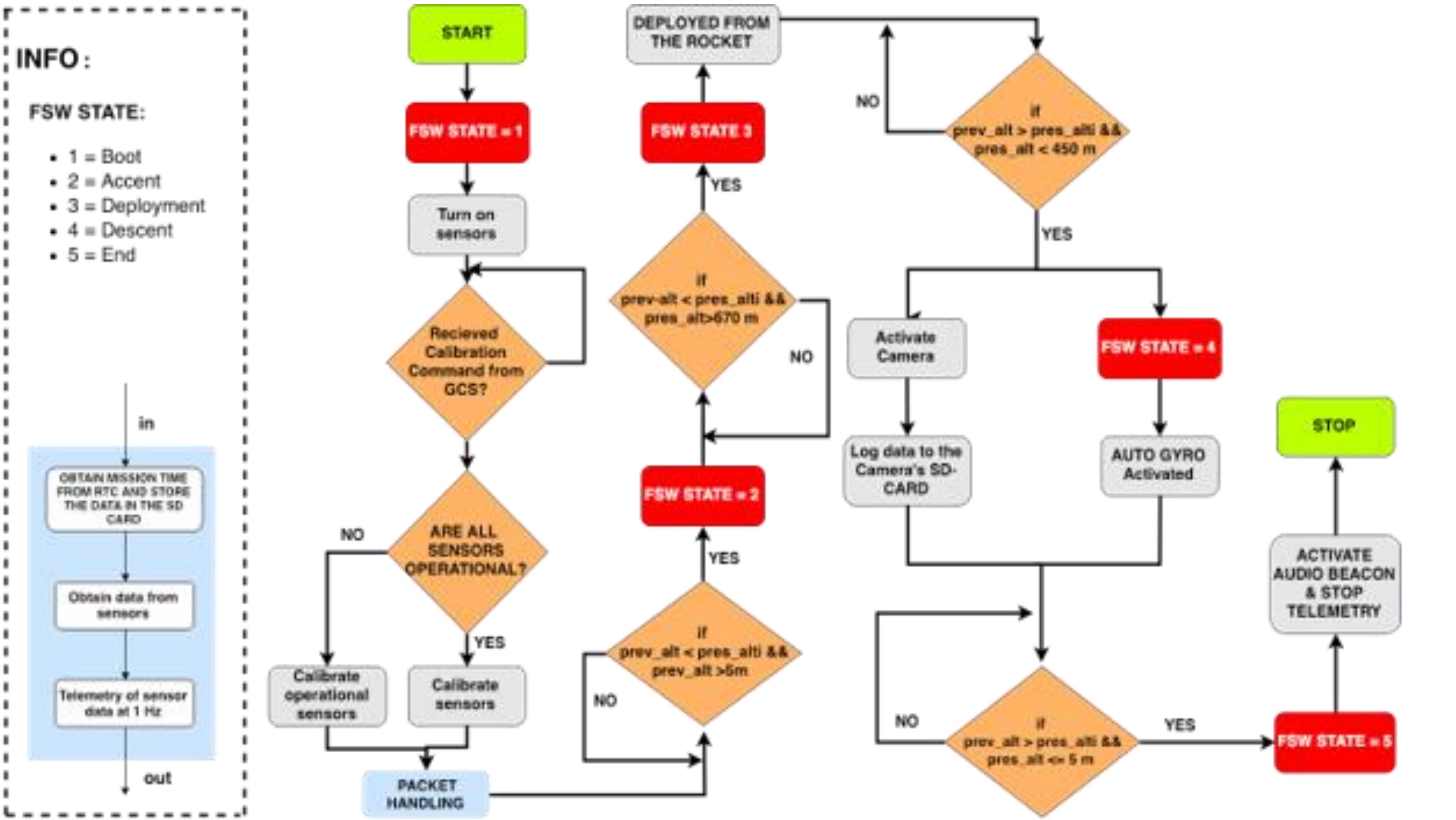
No changes since PDR

FSW Requirements[1/2]

ID	Requirement	Rationale	Priority	Parent	Varification Method			
					A	D	I	T
GCS-1	Each team shall develop their own ground station.	Mission Requirement	High	SRS- 21			✔	
GCS-2	All telemetry shall be displayed in real time during descent.	Mission Requirement	High	SRS- 13	✔		✔	✔
GCS-3	All telemetry shall be displayed inengineering units (meters, meters/ sec, Celsius, etc.)	Mission Requirement	High	SR-34	✔		✔	
GCS-4	Teams shall plot each telemetrydata field in real time during flight.	Mission Requirement	High	SRS- 13			✔	

FSW Requirements[2/2]

ID	Requirement	Rationale	Priority	Parent	Varification Method			
					A	D	I	T
GCS-5	The ground station shall include one laptop computer with a minimum of two hours of batteryoperation, XBEEradio and a handheld antenna.	MissionRequirement	High	SRS- 21			✔	
GCS-6	The ground station must beportable so the team can bepositioned at the ground stationoperation site along the flight line. AC power will not be available at the ground station operation site.	MissionRequirement	High	SRS- 22	✔		✔	


INFO :
FSW STATE:
1 = Boot
2 = Accent
3 = Deployment
4 = Descent
5 = End
in
OBTAIN MISSION TIME FROM RTC AND STORE THE DATA IN THE SD CARD
Obtain data from sensors
Telemetry of sensor data at 1 Hz
out
START
FSW STATE = 1
Turn on sensors
Recieved Calibration Command from GCS?
ARE ALL SENSORS OPERATIONAL?
NO
YES
Calibrate operational sensors
Calibrate sensors
PACKET HANDLING
if prev_alt < pres_alti && prev_alt >5m
NO
YES
FSW STATE = 2
if prev-alt < pres_alti && pres_alt>670 m
NO
YES
FSW STATE 3
DEPLOYED FROM THE ROCKET
if prev_alt > pres_alti && pres_alt < 450 m
NO
YES
Activate Camera
Log data to the Camera's SD-CARD
FSW STATE = 4
AUTO GYRO Activated
if prev_alt > pres_alti && pres_alt <= 5 m
NO
YES
FSW STATE = 5
ACTIVATE AUDIO BEACON & STOP TELEMETRY
STOP

Payload CanSat FSW State Diagram[2/2]

- Sampling Rate of 1 Hz for all sensors
- Telemetry is done with the help of XBEE modules available at both payload and ground station.
- Telemetry is done in every FSW state at 1Hz.
- Storage of all telemetry data in SD card in case of failure
- Retrieval of SD card data in case the processor resets, errors identified and necessary corrections made.

Processor Reset Control :

- In the unlikely event of temporary power failure because of the battery, some measures have to be taken.
- These measures help to control the irregular pattern of the telemetry count.

- The value ‘1’ is pre written in the EEPROM.
- The processor takes this value from the EEPROM.
- The current state value is written in the processor.
- Data is transmitted along with the packet count in the telemetry.
- Received value is incremented by 1.
- This value is over written on the EEPROM. Back to step 2.

Container CanSat FSW State Diagram[1/2]

INFO :

FSW STATE:

- 1 = Boot
- 2 = Accent
- 3 = Deployment
- 4 = Descent
- 5 = End

Processor Reset Control:

- The value '1' is pre w ritten in the EEPROM.
- The processor takes this value from the EEPROM.
- The current state value is w ritten in the processor.
- Data is transmitted along w ith the packet count in the telemetry.
- Received value is incremented by 1.
- This value is over w ritten on the EEPROM. Back to step 2

Container CanSat FSW State Diagram[2/2]

Sampling of sensors (including rates)	Altitude is calculated from BMP180, the only sensor in container, every time loop repeats itself. Sampling of BMP180 stops as and when container deploys the payload
Communications (command and telemetry)	Calibration command is used to calibrate sensors from a distance and telemetry is sent at 1 Hz .
Data storage	Data is stored in the EEPROM
Mechanism activations	When the payload is to be deployed , the servo is activated which cuts the wire and separates it from the payload.
Major decision points in the logic	1. Store the height in EEPROM when CanSat is deployed from rocket. 2. Activate wire cutting mechanism at height of 450m.
Power management	Battery voltage is being continously monitored

FSW can be recovered to correct state after processor reset during flight, in the unlikely event of temporary power failure because of the battery, by using the data written to EEPROM .

Software Development Plan[1/2]

To Avoid Late Software Development :

1. Proper schedule followed according to Gantt Chart
2. Work divided in accordance with Waterfall Model.
3. First prototype of FSW is ready , has been successfully tested on a breadboard and is currently being improved

Prototyping and prototyping environments :

1. Each sensor is tested separately on breadboard and proper operation is ensured .
2. An electronic system prototype containing all sensors is created on a breadboard to ensure that all sensors and microcontrollers are working in accordance with each other.
3. Sensor subsystems are designed in accordance with the competition and system requirements
4. The results obtained from the prototype are used to make the PCB which is further tested and improved by the software

Software Development Plan[2/2]

✓ Software subsystem development sequence:

- Waterfall Software Development Life Cycle Model with a well-defined Risk Management System
- Defining FSW functions, states, interactions and requirement.
- Proper interfacing of sensors with processor and unit testing
- Integrated Sensor sub-system module will be made
- Applying different algorithms to check various FSW states and implementation Sandwich Integrated Testing will be performed and review of logic
- Risk Management System will identify bugs and their subsequent removal
- Final system testing

✓ Test Methodology:

1. Drop Test from tallest building in campus
2. Communication Test for patch antenna
3. Integration of all sensors to analyze frequency of telemetry and appropriate optimization algorithm used.

✓ Development Team:

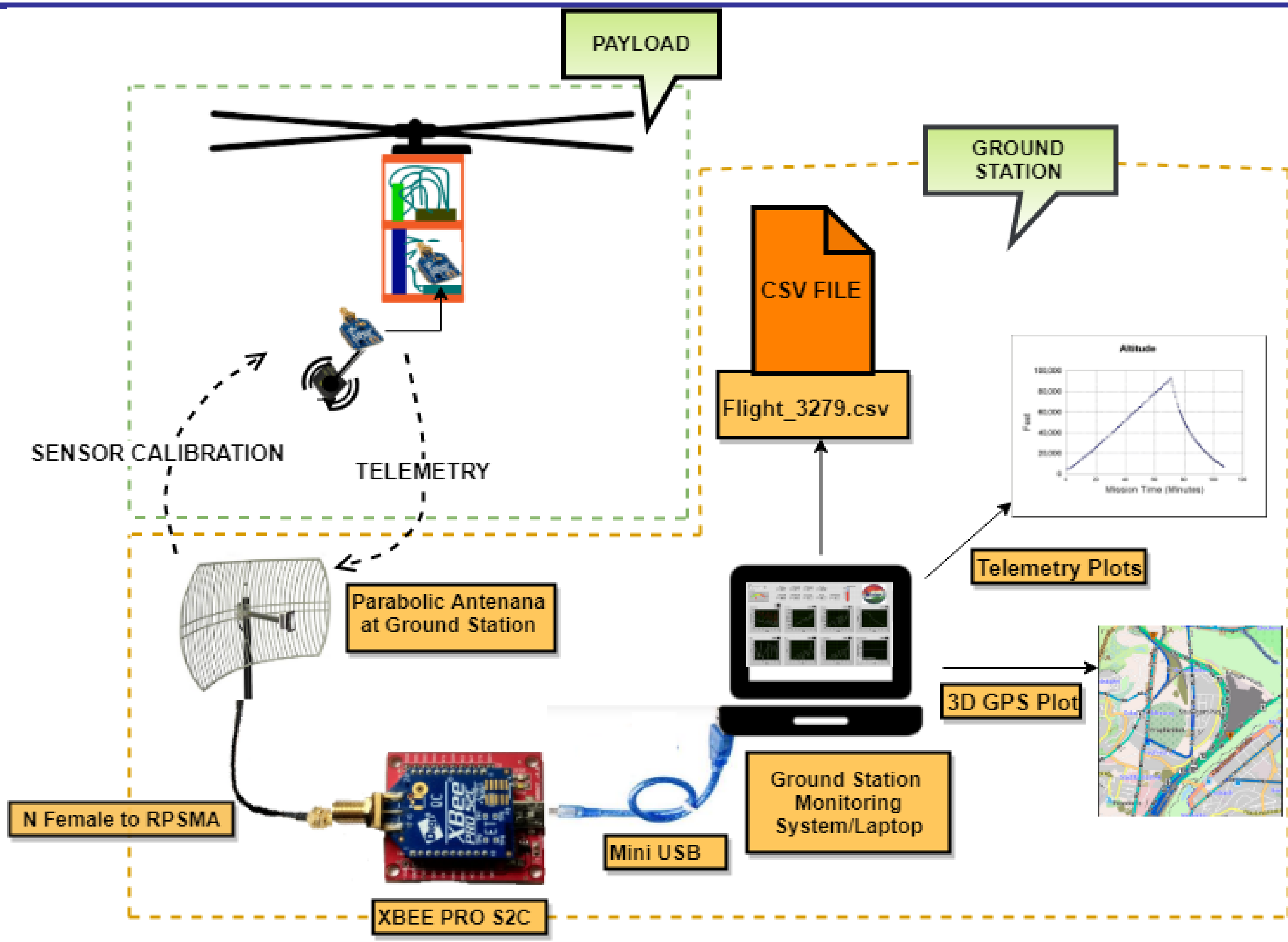
Sanuj Kulshrestha, Anmol Gulati, Vineet Khurana, Rishabh Yadav

PROGRESS SINCE PDR: FSW states have been decided and finalized and code has been written and packet testing has been achieved over 2 km

Ground Control System (GCS) Design

Vineet Khurana

GCS Overview



GCS Changes since PDR

No changes in GCS since PDR

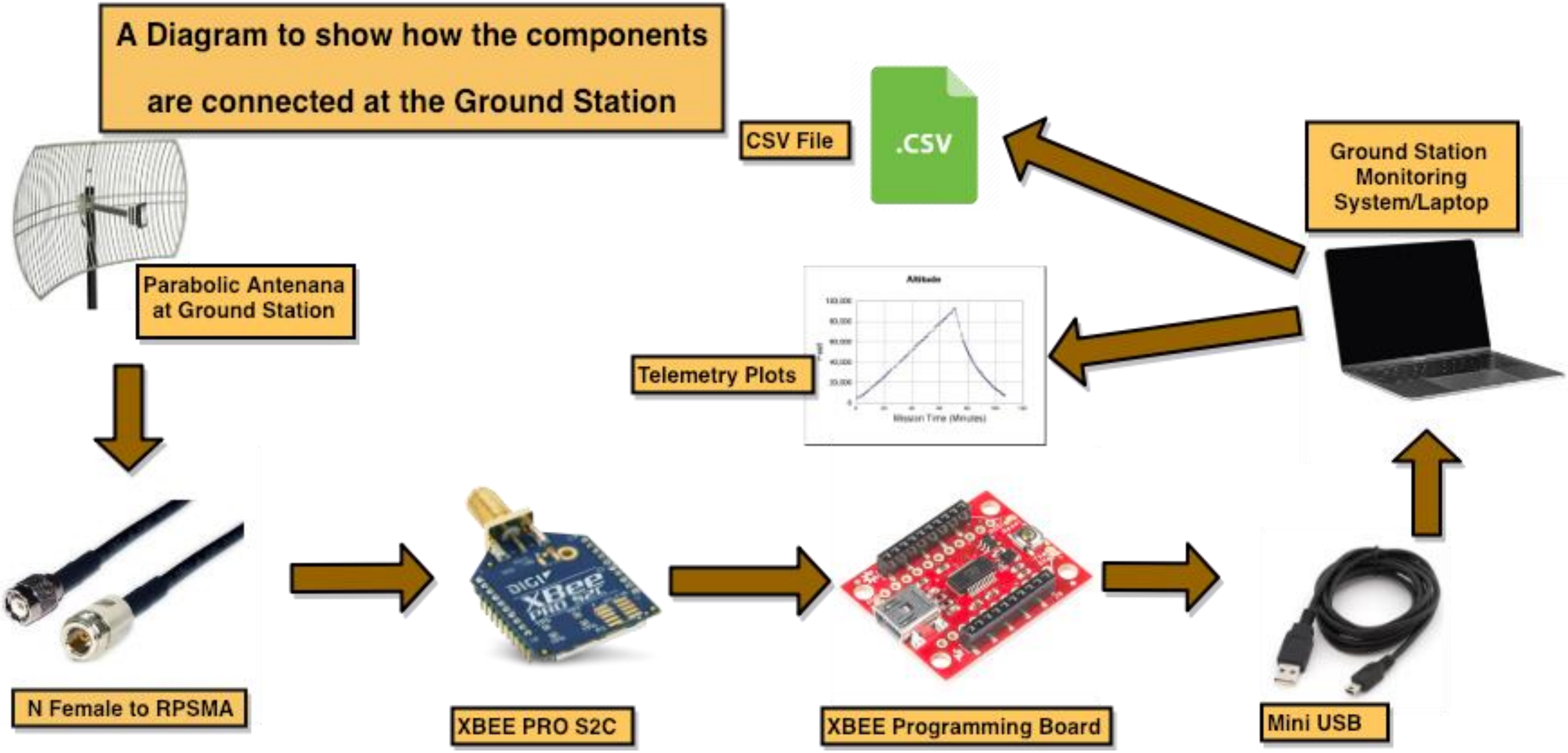
GCS Requirements[1/2]

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
GCS- 01	Ground station shall be developed by each team	Competition requirement	BR- 35	Very High		✔	✔	
GCS- 02	The ground station shall comprise of a laptop with at least 2 hours of battery operation, an XBee radio and an antenna	Competition requirement	BR- 39	Very High		✔	✔	
GCS- 03	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line.	Competition requirement	BR- 40	Very High		✔	✔	

GCS Requirements[2/2]

ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
GCS- 04	The ground station shall command the science vehicle to calibrate to calibrate altitude, pitch and roll to zero as it sits on the launchpad i.e. communication between payload and ground station is half-duplex.	Competition requirement	BR- 28	Very High	✔		✔	✔
GCS- 05	A csv file of all the sensor data shall be generated at the ground station.	Competition requirement	BR- 29	Very High	✔	✔	✔	
GCS- 06	All the sensor data shall be plotted in real time.	Competition requirement	BR- 38	Very High	✔	✔	✔	

GCS Design[1/3]



GCS Design[2/3]

Connector Name	Frequency	Application	Cost
N- Female Connector (i.e male headed)	<11GHz	Antennas, Base stations, Instrumentation, Satellite systems, WLAN, Radar systems, Broadcast, Surge protection	$ 2.1

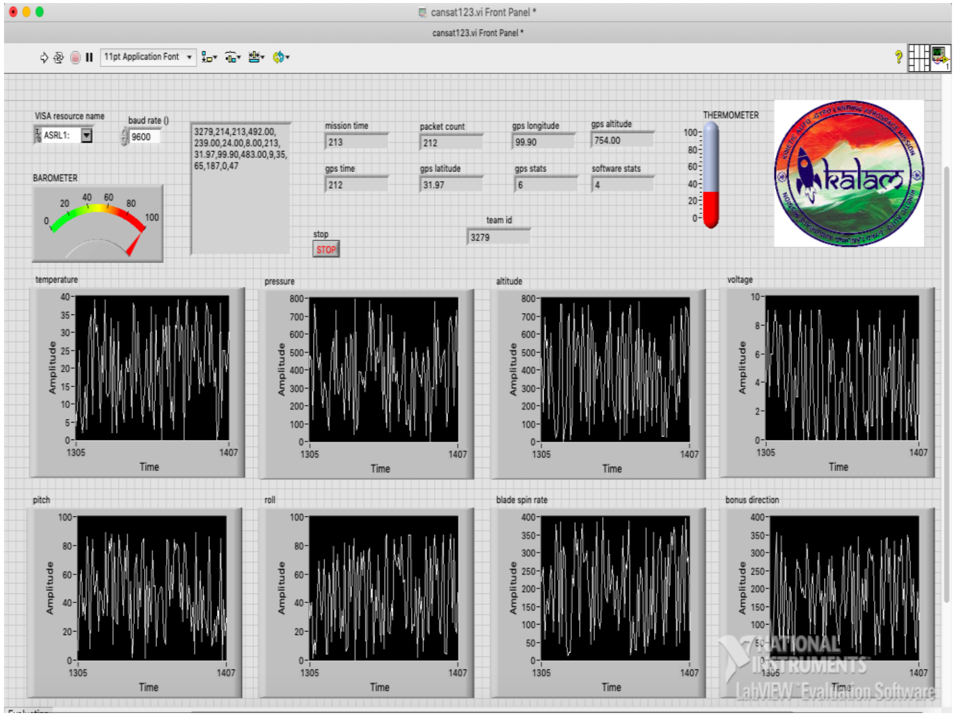
Ground Station Antenna is connected to GS XBEE Module (Co-ordinator Mode) using N Female connector to RPSMA coaxial cable.

GCS Design[3/3]

Specifications

- GCS will have at least two hours of battery life. Apple MacBook will easily have battery life more than 2 hours.
- To prevent over-heating, unwanted Load will be minimized and a portable umbrella along with arrangements for a cooling pad shall be set up to prevent GCS from the overhead sun.
- Required Configuration GCS will be used for the required software .
- Data will be logged to a plain text file with a .CSV extension and read from same file for plotting. Plotting and serial data monitoring occur in parallel.

GCS Software[1/3]



3279	1	1	152.63898536645132	90001.10525172668	30.324301543499956	3.3	29.7041	78.12	11.54257332117443	10	0	0.1589168131523243	0.0028623154059624523	31.965927116504886	BOOT	0
3279	2	2	154.50080043903668	90002.70153737822	29.249364760596126	3.015959230121885	30.7041	79.12	11.20088797911094	10	0	0.5200939749823714	0.03424107745795203	33.39147290019323	BOOT	0
3279	3	3	151.01530663904143	90005.89047004821	29.953847046231886	2.582536381147395	31.7041	80.12	18.59366549442714	10	0	0.6307132380423504	0.00813104115202276	34.55516782762305	BOOT	0
3279	4	4	156.2766727786975	90006.3986104475	24.58691767185332	2.0656259918888913	32.7041	81.12	16.435373567065078	10	0	0.05022445937904507	0.04026309456642913	34.53153035955111	BOOT	0
3279	5	5	156.16728475388447	90005.36172259826	31.76244966648121	2.0171346827023893	33.7041	82.12	18.36663862144317	10	0	0.09622164517110399	0.06631389858035244	32.98006075667116	BOOT	0
3279	6	6	152.35649975470454	90006.9360190904	28.44293931583886	1.5148401693224676	34.7041	83.12	24.742068057684598	10	0	0.3968693149515783	0.005116328445478144	32.16281488180192	BOOT	0
3279	7	7	172.03679785733408	90012.96942001837	19.528871826327684	1.394451775129687	35.7041	84.12	13.488574780798723	10	0	0.1299949573321012	0.06921249435104539	35.36192880742551	BOOT	0
3279	8	8	177.6589898488897	90013.54755095135	23.366459109700024	1.179076670949906	36.7041	85.12	13.7910374516669	10	0	0.9608978614710475	0.036213666880072035	36.09132772543765	BOOT	0
3279	9	9	185.81822659084162	90017.05150286052	14.776579468534734	0.9823242210218949	37.7041	86.12	11.616182374384918	10	0	0.1410044275465785	0.14472685222857112	46.980635874841624	BOOT	0
3279	10	10	166.4598914785792	90011.25171679852	28.64676568324115	0.4844376005539913	38.7041	87.12	11.539110142163896	10	0	0.20919411624474882	0.16185288209778373	46.409239332237576	BOOT	0
3279	11	11	174.86553679606803	90017.9859433859	19.7432822429657	-0.3813670767107451	39.7041	88.12	14.538329728648458	10	0	0.037974826922617444	0.18266910367881764	46.72760129447079	BOOT	0
3279	12	12	163.7481320257691	90012.56245546578	11.284969444999135	-1.295695997397571	40.7041	89.12	42.498959685534054	10	0	0.4340319018930614	0.07142808358001607	34.08462833813715	BOOT	0
3279	13	13	150.38987034430616	90023.3191958977	7.029242181468259	-2.149290750538301	41.7041	90.12	47.18662427764484	10	0	0.4190835198402013	0.03272872151682069	51.11803265047611	BOOT	0
3279	14	14	191.80651947333666	90024.76179261075	4.483218997769832	-3.1266381303073487	42.7041	91.12	37.69492249002734	10	0	0.40516922675463163	0.06629296171808027	35.468658720025246	BOOT	0
3279	15	15	205.58710582272303	90023.65587066117	18.239425989039383	-4.049851509927696	43.7041	92.12	35.162560909903185	10	0	0.3872719117910003	0.24434397014847073	40.533495938433084	BOOT	0
3279	16	16	209.34239422156392	90028.88846282635	26.67730385086038	-4.362686075452339	44.7041	93.12	10.754079405210929	10	0	0.642618229856097	0.03171025204814068	40.7109878556721	BOOT	0
3279	17	17	163.34397415690626	90022.16320496173	6.057399322250273	-4.923298637062253	45.7041	94.12	55.77040929487413	10	0	0.04453926638643513	0.10343381087279684	58.19518102079246	BOOT	0
3279	18	18	207.41864856894043	90022.25982438859	30.431182712896963	-5.058110013921221	46.7041	95.12	61.417896801282424	10	0	0.8779554089750229	0.003573817327580162	58.727813208875574	BOOT	0
3279	19	19	220.4662847374669	90032.54931762954	22.650542321444174	-5.439680254328407	47.7041	96.12	44.450251859519256	10	0	0.7691216459239026	0.2981271338499338	45.3655983575668	BOOT	0
3279	20	20	156.55013853051494	90022.29022585985	-1.117349858505932	-6.195111129701285	48.7041	97.12	30.66464102801917	10	0	0.7262162594129097	0.20081959848369002	38.57715579986211	BOOT	0
3279	21	21	199.64908808294183	90022.37096182033	12.580441198154066	-6.9574595397879415	49.7041	98.12	18.189596188578	10	0	0.8084065107693108	0.2830218043551858	58.87492410851756	BOOT	0
3279	22	22	225.5359470669147	90028.66711428703	28.03484080847216	-7.019693424509661	50.7041	99.12	49.79609921743238	10	0	0.1814409948201553	0.2852483825570002	60.55656788472547	BOOT	0
3279	23	23	179.68308107463832	90023.34438081515	-5.58915045933778	-7.0788794570612765	51.7041	100.12	50.383915471673184	10	0	0.7629899322845292	0.11612715450341686	66.225247294772	BOOT	0
3279	24	24	190.25727753056114	90034.44505818986	-3.1595520547355846	-7.5585285867388325	52.7041	101.12	75.13559093532785	10	0	0.5946996676668976	0.24407957774739625	54.85894036728614	BOOT	0
3279	25	25	193.99577617995834	90043.72537645175	19.101497362035246	-8.007942522209383	53.7041	102.12	24.208547999493536	10	0	0.41415437254271614	0.12460957783321841	36.37749873238155	BOOT	0
3279	26	26	224.64549047687404	90029.8927321999	-7.306598161310788	-8.038825558708103	54.7041	103.12	31.734391490639613	10	0	0.5613996375736674	0.4444181354503001	68.06155146550873	BOOT	0
3279	27	27	198.40487251333295	90040.73672117299	24.572692471839154	-8.060093666549713	55.7041	104.12	35.18351957861168	10	0	0.755538275271331	0.526819185916453	63.48261628204295	BOOT	0
3279	28	28	259.42367604999527	90047.97986942815	-11.691611727425304	-8.676023431532194	56.7041	105.12	78.82332485675788	10	0	0.057615633513594555	0.265260700510842	63.18910906597106	BOOT	0
3279	29	29	257.9024481735962	90034.86761129748	30.91679453251569	-9.050181376150539	57.7041	106.12	64.88941422491712	10	0	0.9298922388799974	0.21287633108907308	79.2045714066357	BOOT	0
3279	30	30	241.15362405140024	90050.66465268527	12.301432386323604	-9.958036859978606	58.7041	107.12	34.74085077161298	10	0	0.7707295815576751	0.29032831638570317	85.74661979710099	BOOT	0

LABVIEW GUI

Flight_3279.csv FILE

GCS Software[2/3]

- ✓ **LABVIEW Software** is used for displaying our Telemetry in a very Appropriate and Easy Manner.
- ✓ A Push Button will be added so that when the button is pushed it sends the commands via serial through **XBEE Pro S2C.**
- ✓ Telemetry data recording and testing is done in the Software called **X-CTU software** and it's main purpose is to configure and test the XBEE Pro S2C. Arduino IDE will be the language used for Board Programming.
- ✓ All the Data will be saved in .csv format (in MS-Excel)

- ✓ **Barometric sensor and row/pitch angles sensors will be calibrated according to the ground conditions when CANSAT is placed in rocket. It will be done by sending char 'c' from the ground station which will be detected by XBEE UART on Teensy to execute calibration functions.**
  To verify the calibrated values, Telemetry packet should have '0' for those sensors values.

GCS Software[3/3]

✓Telemetry Prototype

<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>

✓ Commercial off the shelf (COTS) software

1. XCTU (XBEE Program Software)

✓ PROGRESS SINCE PDR

Real time testing of LabVIEW is complete and results have been verified .

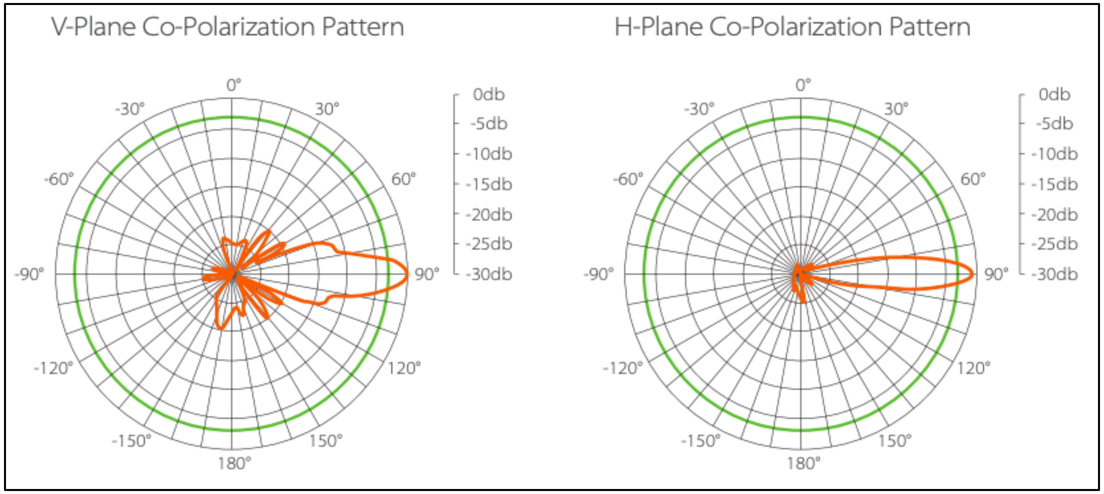
GCS Antenna(1/5)

SELECTED ANTENNA	TP-Link Grid Parabolic Antenna: TL-ANT2424B

Characteristics

- 24dBi directional operation, ideal for extraordinary long distance point to point connection
- Weather proof design, suitable for all weather conditions.
- High Survival wind Speed
- Ideal storage and operating temperatures.

Frequency	Gain	Directivity	VSWR	Range	Weight	Mounting
2.4GHz-2.5GHz	24dBi	Directional	1.5:1 (MAX)	Approximate Range at 1 Mbps is 56km	4.8Kg	Table Top and adjusted Manually



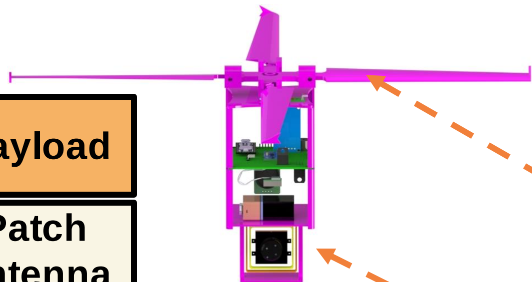
Parabolic Antenna Radiation Pattern

GCS Antenna(2/5)

MOUNTING:

Payload

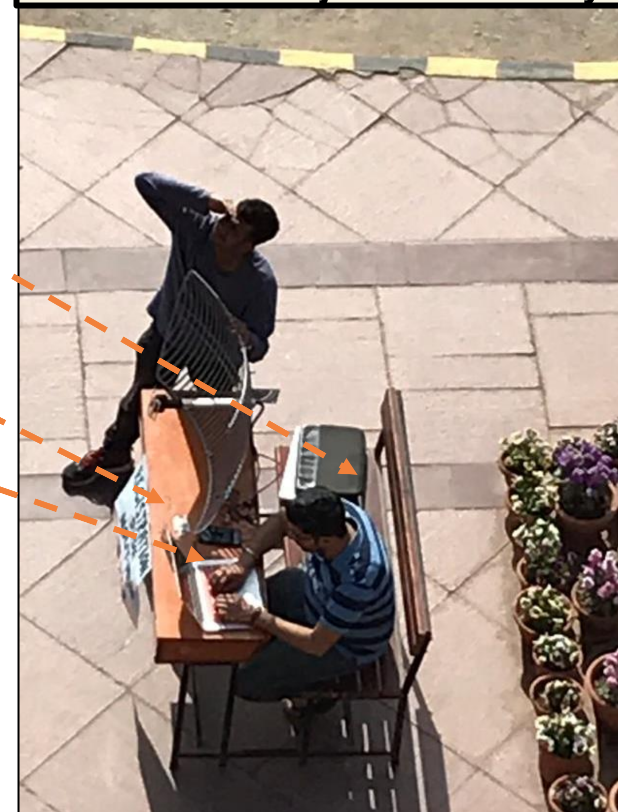
Patch Antenna inside Payload



RF Signals

Team KALAM Ground Station

Table top Parabolic Grid antenna and adjusted manually

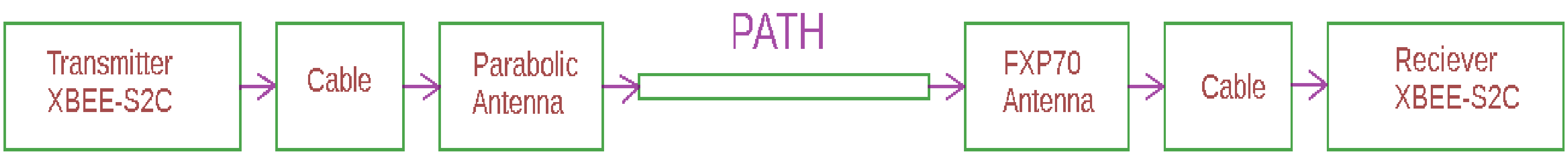


Parabolic grid antenna will be placed on Table and will be directed towards the payload by one of Ground Station Crew

GCS Antenna(3/5)

Distance link predictions and margins

Ground to Satellite Communication System



Power Equation is:

Received Power = Transmitted Power - Cable loss + Antenna Gain - Cable loss - Path Loss + Antenna Gain

Distance link predictions and margins

Received Power = Transmitted Power - Cable loss + Antenna Gain - Cable loss - Path Loss + Antenna Gain

The above is the equation to calculate the received power of the antenna.
By using the values given in the datasheet we have:
1) XBEE Transmitted Power : 5dB
2) Cable loss : 2dB
3) Parabolic Antenna Gain : 24dB
4) FXP7O Antenna Gain : 5dB
5)Path loss is given by the equation : $20\log_{10}(4\pi df/c)$ where d is the distance , f is its frequency and c is the speed of electromagnetic wave.
For d= 1000m and f = 2.4Ghz , path loss = 100dB

Therefore, Received power then = 5-2+24-100+5-2
= 70dB

Link Margin = Received Power - Receiver Sensitivity
= [-70 - (-100)] dB
= 30 dB

This value is enough for a reliable link

GCS Antenna(5/5)

Testing

Sno	Topic	Specifications/Results
1.	Antenna Construction	a) 2.4 GHz 24 dBi Parabolic Antenna has been purchased from TP-Link. b) The antenna was assembled by screwing all the parts together. c) Successful antenna Testing with XBEE radio has been done.
2.	Antenna Portability	a) Easy to point towards CanSat as it is lightweight and and has the smallest form factor for it's gain.
3.	Antenna Coverage	a) Affirmative results of testing up to 2 kms with LOS. b) Directional antenna at ground station and omni-directional at payload are ideal conditions for maximum coverage

CanSat Integration and Test

Bhavuk Grover

CanSat Integration and Test Overview

Mechanical

Shock simulations and stress-strain curve plotting. Strength test during drop from 200m.

Descent

Descent rates calculated when CanSat is dropped from 200m. Deployment of parachute and payload checked.

Environmental

Thermal, Vibration, Drop & Fit check performed.

CanSat

Software

Real time plotting with dummy data checked.

Electronics

Individual testing of sensors and telemetry. Range testing for antenna.

Payload

The blade opening mechanism and autogyro checked.

CanSat Integration and Test Overview

Test Overview

- **Unit Level Testing**
  - Mechanical
  - Electronics
- **Subsystem level Testing**
  - Sensors
  - CDH
  - EPS
  - Communication
  - Mechanism
  - FSW
- **Integrated Level Testing**
  - Descent
  - Communication
  - Mechanisms
  - Deployment
- **Environmental Testing**
  - Vibration Test
  - Thermal Test
  - Drop Test
  - Fit Check

Subsystem Level Testing Plan [1/9]

Sensor sub system integration and testing (1/4)

During testing phase, we realized we were working in a very high turbulence environment and hence individual sensor values could not be trusted . To overcome this , we implemented a versatile low pass filter for all sensors , the details of which are outlined below

Specifications : Cutoff frequency , α = 10Hz ;Sampling frequency , β = 500Hz ; Order = 11

=> For low pass filter we obtained the response , H(n)= sinc(π(n-5)/25)/25

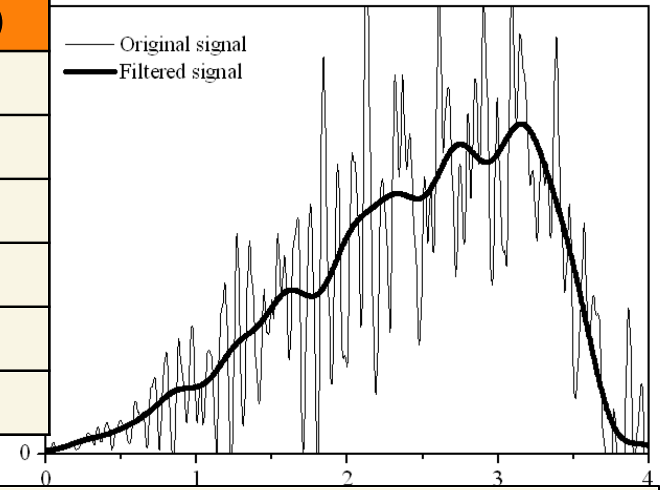
We chose causal Blackman window , which in our case evaluated to be ,
W(n)= 0.42 -0.5cos(πn/5)+0.08cos(2πn/5)

n	H(n)	W(n)	h(n)=H(n)xW(n)
0	0.0374	0	0
1	0.0383	0.0401	0.00153
2	0.0390	0.2005	0.00781
3	0.0395	0.5092	0.02011
4	0.0398	0.8466	0.03377

Subsystem Level Testing Plan [2/9]

Sensor sub system integration and testing (2/4)

n	H(n)	W(n)	h(n)=H(n)xW(n)
5	0.04	0.9999	0.03999
6	0.0398	0.8486	0.03377
7	0.0395	0.5092	0.02011
8	0.0390	0.2005	0.00781
9	0.0383	0.0401	0.00153
10	0.0374	0	0



Σh(n)=0.20642
We scale up the filter by {(1/Σh(n))=4.844} to decrease convergence time .

We end up with the final filter response ,

X[n] = 0.0074*X[n-1] + 0.0378*X[n-2] + 0.0974*X[n-3] + 0.1635*X[n4] + 0.1937*X[n-5] + 0.1635*X[n-6] + 0.0974*X[n-7] + 0.0378*X[n-8] + 0.0074*X[n-9]

Subsystem Level Testing Plan [3/9]

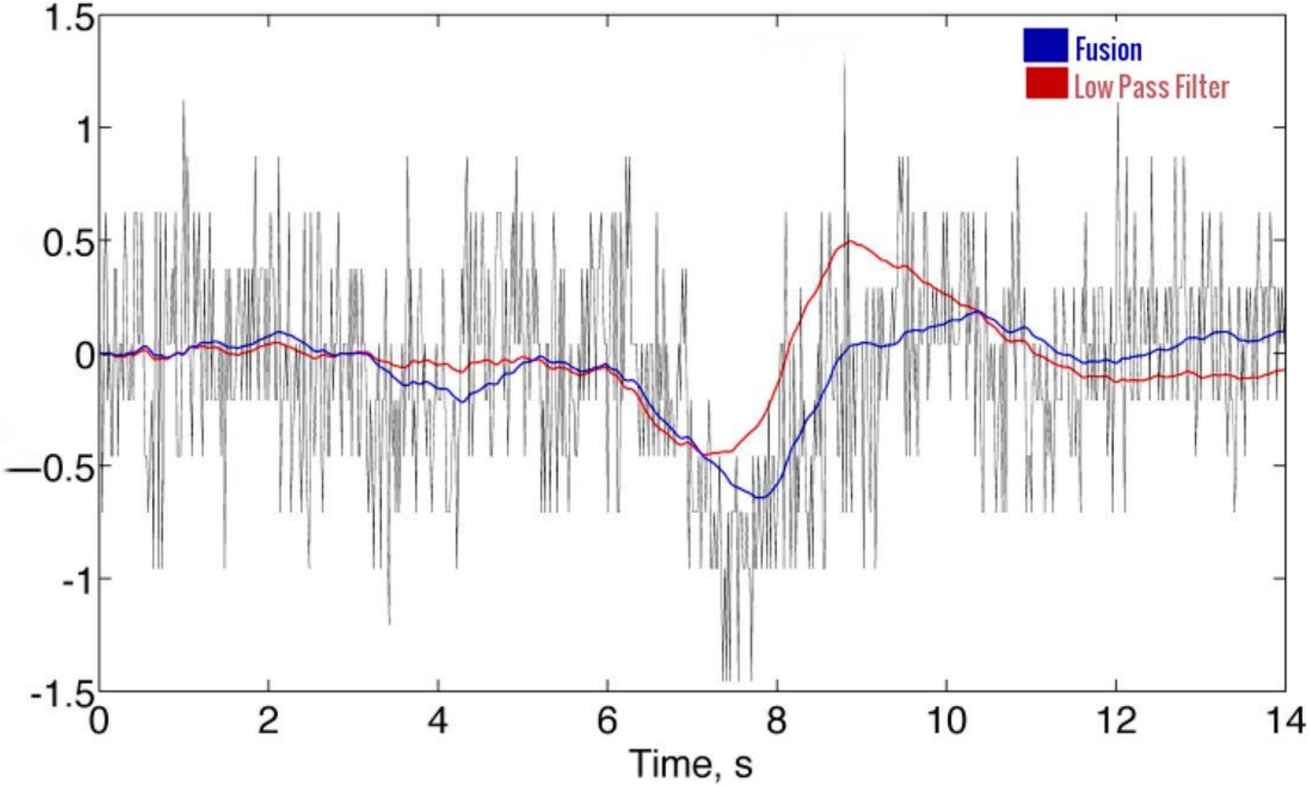
Sensor sub system integration and testing (3/4)

Since altitude estimation is a mission critical task and payload deployment depends on it , we decided to make the estimation extremely accurate by fusing data from both the accelerometer and the barometer .

The Proposed Algorithm

1. Measurement of barometric pressure, vertical acceleration and temperature.
2. Temperature drift compensation of the barometer.
3. Tilt compensation of Accelerometer.
4. Estimation of altitude using both Barometer and Accelerometer(Fusion).

Sensor sub system integration and testing (4/4)

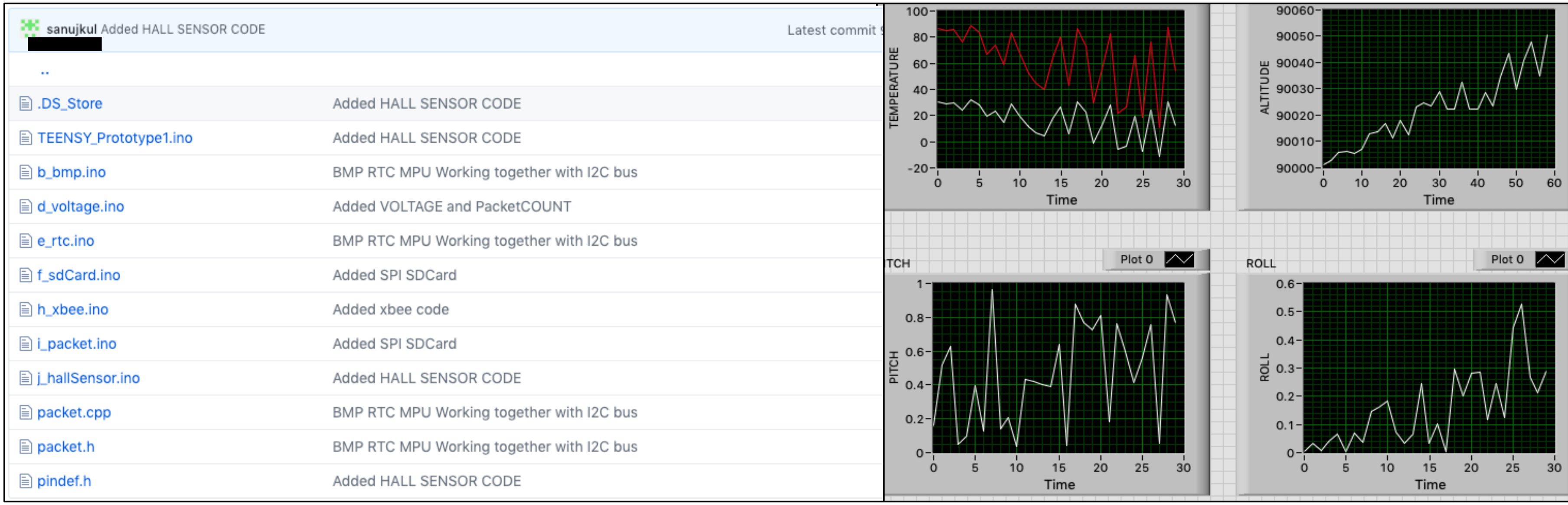


The fusion of accelerometer and barometer data gave even better results than a low pass filter with the barometer alone and hence we adopted this approach.

Subsystem Level Testing Plan[5/9]

1. Sensors

- All sensors were interfaced according to their interfaces(I2C,UART,etc).
- The sensors were tested by taking their readings and plotting the measurements.



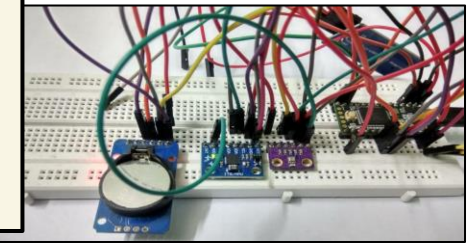
2. Communication and Data Handling

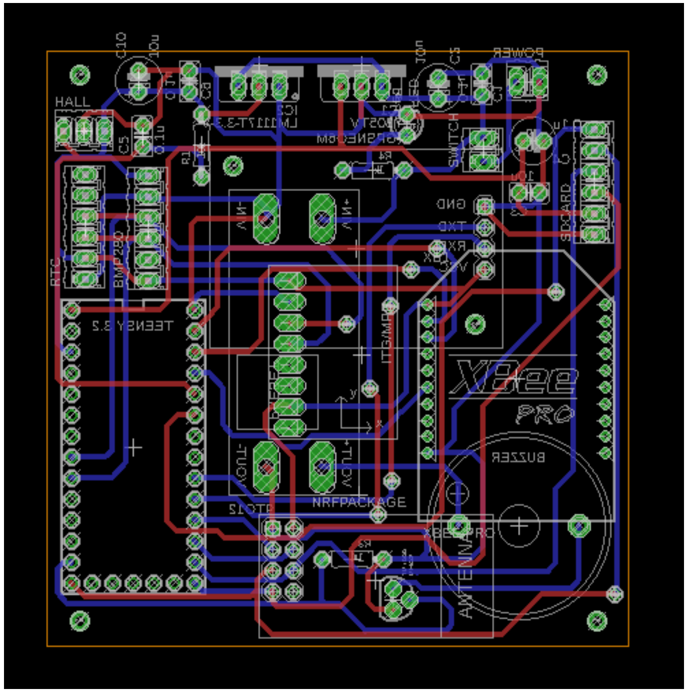
- The telemetry of the radio modules was tested by transmitting data and plotting it.
- Communication with every component was tested.
- The data was collected from the sensors at the required rate of 1Hz.

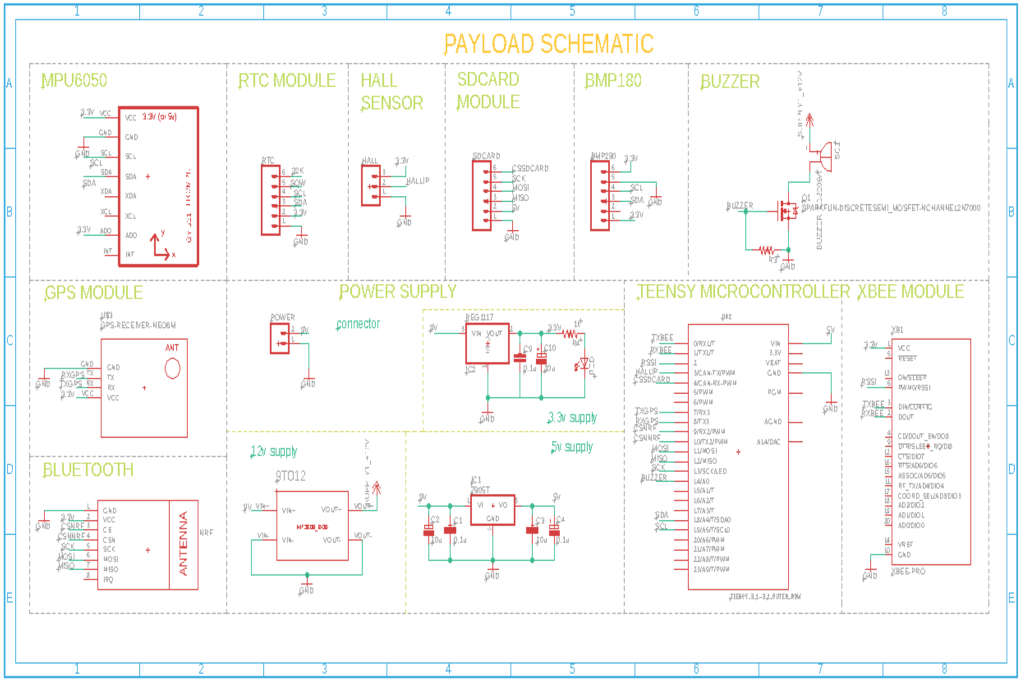
3. Electrical Power System

The power required by each component was calculated.

The Battery and required regulators were chosen accordingly to match the power requirements.







Subsystem Level Testing Plan[7/9]

4. Radio Communications

- The antenna shall be tested for its range from different distances and positions.
- Integration with the XBEE modules shall also be tested.

5. FSW

- The different software states were tested and the system functioning was checked after reset.
- Software state after various conditions was tested.
- Software state after payload deployment from container at different altitudes was checked.
- Software state after landing was checked.

FSW state 1=Boot
FSW state 2=Ascent
FSW state 3=Deployment
FSW state 4=Decent
FSW state 5=End

6. Mechanical

- Check mass of CanSat such that it lies in the mentioned range.
- Plotting the stress-strain curves for the container and payload. Performing shock tests on the container and payload.
- Using ANSYS for simulations of the auto-gyro mechanism

7. Descent Control

The parachute was tested by dropping the CanSat body. The parachute was a hexagonal parachute.

Integrated Level Functional Test Plan[1/4]

1. Descent Testing

- The model CanSat body was dropped with the sensors, and parachute attached . The telemetry was received on the ground station and plotted. The descent rates were also measured.

- In our final testing, the entire CanSat system along with the electronics will be tested using a rocket and perform descent test from a height of up to 700m. Since the altitude of deployment will be the similar to the altitude during the actual launch, we will be able to test our telemetry, sensors, descent rate and deployment of Auto-Gyro very well.

Integrated Level Functional Test Plan[2/4]

2. Communications

- The electronic components were integrated on a PCB, to be attached inside the CanSat body. The data sent by the XBEE module to the ground station during our testing was be plotted and checked with the known data values.
- In our final test, since we are going to conduct the launch at an altitude similar to the actual launch, both our antennas at the ground station and inside the CanSat will be tested perfectly.

3. Mechanisms

- To test the deployment mechanism as well as the blade opening mechanism of the auto-gyro, we made a prototype which was tested on ground.
- It will be tested again during our descent test to check whether the deployment mechanism works as required at the correct position i.e. at a height of 450m.

Blade opening mechanism

by servo cutting the nylon thread

4. Deployment

- Initially Auto-Gyro deployment will be tested using a quad copter or releasing from top of a tall building. Auto-Gyro deployment height will be set to around 50m in our code for testing purposes.
- In our final testing, the entire CanSat system along with the electronics will be tested using a rocket and perform descent test from a height of up to 700m. Since the altitude of deployment will be the similar to the altitude during the actual launch, we will be able to test our Auto-Gyro deployment very well.

1. Drop Test

A cord is used for the drop tests. The following methodology is used.

- Attach one end of the cord to the parachute attachment point and the other end to the ceiling.
- Raise the CanSat to a height such that it is in line with the cord.
- Release the cord to allow the CanSat to fall freely.
- Check the container and payload for damage

Environmental Test Plan[2/4]

2. Thermal Test

The following methodology is used.

- Turn on the CanSat and place it into a sealed thermal chamber.
- Maintain a temperature of 65°C for 2 hours and then inspect the CanSat thoroughly.
- All mechanisms and structures are inspected to make sure structural integrity is preserved.
- All epoxy joints and composites are inspected and all results are noted.

3. Vibration Test

The following methodology is used.

- A functional test of the CanSat is carried out.
- Mount the CanSat on the vibration machine.
- Allow the machine to vibrate for a minute and then check for the CanSat.
- A full functional test is performed and the results are noted.

4. Dimensions Verifications

The following methodology is used.

- A 125mm hole is CNC machined in an aluminium sheet.
- Proceed to pass the fully integrated Can Sat through the hole and confirming it is clearance fit.

Test Procedures Descriptions

Test Proc	Purpose	Test Description	Requirements	Pass/Fail Criteria
1. SENSORS				
1.a	Verifying all sensors are working	All Sensors were individually tested for their readings and then sensors were integrated to Teensy 3.2	20,21,22,23,24,25,26	**PASS** Verified with actual readings
1.b	Verifying all interfaces (UART, I2C, SPI) of Teensy are functioning	1. Testing of several sensors to one Single I2C Bus. 2. Testing of all 3 UART of Teensy. 3. Testing SPI with with 2 different sensors with different “Chip Select“ pins	26	**PASS:** All I2C interfaced sensors working with single bus, all UART working, SPI verified with SD Card and nrf
1.c	Verifying Calibration of sensors for more accurate readings	1. Testing of sensors like BMP and MPU after calibration command is send from ground Station	25,26	**PASS** Sensors giving more accurate readings after calibration command

Test Procedures Descriptions

2. Communication and Data Handling				
2.a	Verifying receiving of data to ground station with frequency of 1Hz	1. Testing whether packet is being transmitted by XBEE at Teensy after every 1 second.	28,29	**PASS** Verified with mission time equals packet count
2.b	Verifying the GUI of packets received during telemetry at Ground station	1. Testing if a packet is successful received at ground station's Laptop's serial port. 2. Testing of fetching data from serial port to plot the GUI.	29,30	**PASS:** All the graphs/numbers were showed expected changes when conditions around payload sensors were changes
3. Electrical Power System				
3.	Verifying if Battery is capable of giving desired power	1. The battery is connected to the completed electronic circuit. 2. Power supply is checked in all components by using an LED. 3. The voltage provided by the battery is checked regularly for eight hours.	49	**PASS** Battery, with sufficient margin, was fulfilling all EPS requirements.

Test Procedures Descriptions

4. Radio Communication				
4.a	Verifying if XBEE's are programmed correctly with XCTU	1. Testing with the XCTU software to test full duplex communication between the two XBEEs	31,32,33	**PASS** Data was transmitted from one and received to other and vice versa
4.b	Range test between two Antennas of Payload and Ground Station	1. Testing the telemetry for up to LOS distance of 1 km.	36,37	**PASS** Verified with all packets being received at Ground station
5. FSW				
5.	Verifying smooth switching between al FSW state	1. The designed logic is implemented using BMP180(altitude sensor) and Teensy 3.2. 2. Initial testing is done in college building with all height scaled to 0 to 10 meters. 3. Final testing will be done during quadcopter test from a height of 300m(then the conditions for change of state is scaled down to 0-300m)	42	**PASS** Verified as FSW switches its state as and when expected.

Test Procedures Descriptions

6. Deployment				
6	To test the payload release mechanism	1. The servo motor is activated using Arduino pro mini at a specified height	10,11	**PASS** the container must open at the specified height
7. Drop test				
7.	To check that the parachute attachment point would survive the deployment shock.	1. Secure one end of the cord to the eye-bolt and other end of the parachute attachment point to the container. 2. Raise the cansat to 80cm in line with the cord. 3. Release the cansat and let it undergo free fall. 4. Observe for any physical damage.	12, 13, 15	**PASS** **there should be no physical damage**
8. Thermal Test				
8.	To check the cansat could operate under high temperatures	1. Place the cansat in a thermal chamber. 2. Turn on the heat source till the time cansat reaches 60oC		**PASS** **the electronic component must work properly**

Test Procedures Descriptions

9. Vibration Test				
9.	Verify the mounting integrity of all components, battery connections, etc.	1. Mount the CanSat on the vibration machine. 2. Turn the vibration machine on for 1 min to power up to full speed and then turn it off and inspect the cansat. 3. A full functional test is performed and the results are noted.	12, 14, 15	**TO BE PERFORMED**: Structural integrity of the CanSat must be maintained
10. Dimensions Verification				
10.	Verifying if the CanSat will properly fit in the rocket payload section and slide out at deployment time.	1. Cut a hole in aluminium sheet of 125mm. 2. Moved the CanSat container through the hole.	2	**PASS:-** The fully integrated CanSat must pass through the hole and confirming it is clearance fit.

Mission Operations & Analysis

Gaurav Verma

Overview of Mission Sequence of Events

ARRIVAL	PRE-LAUNCH CHECKS	ASSEMBLY AND INTEGRATION
• Specific roles are assigned to all team members. • Ground station is set up including antenna assembly and ground station settings. • Initial start-up of the program is done and GCS is configured. • Communication with GCS is confirmed.	• Payload separation mechanism is checked. • All PCB connections are verified. • Working of sensors and the triggers are verified. • CanSat is checked for any physical damage. • CanSat landing zone is estimated. • CanSat is weight and fit checked.	• Parachute is folded and placed into its designated compartment. • The payload is secured into the container. • The CanSat electronics are switched ON. • Communications are verified. • The CanSat assembly is fitted into the rocket.
GROUND STATION CREW	**GROUND STATION & CANSAT CREW**	**CANSAT CREW**

Overview of Mission Sequence of Events

LAUNCH SEQUENCE

- Rocket launches with the CanSat inside.
- Rocket releases the CanSat at 700m altitude.
- The CanSat descents with parachute at 20m/s.
- Telemetry transmission for the descent begins
- At 450m, the payload is released and starts the auto-gyro descent.
- Audio beacon activates just before landing.
- Telemetry stops.

RECOVERY

- Recovery crew goes into the field to find the container and payload.
- Container and payload are retrieved by the crew.
- The last GPS location of the payload helps to narrow down the area.
- The active audio beacon and orange color also aid in recovery.
- Both are inspected for any damage.

RECOVERY CREW

ANALYSIS AND PFR

- The payload and camera SD card are acquired.
- The received telemetry data and camera video are analyzed.
- The data is utilized for mission assessment and PFR preparation.
- The PFR presentation is given on the following day.

ENTIRE TEAM

Overview of Mission Sequence of Events[3/3]

ROLES & RESPONSIBILITIES

Name	Role/Responsibility
Ishita Kochar	Mission Control Officer
Vineet Khurana	CanSat Crew
Arham Jain	CanSat Crew
Anmol Gulati	CanSat Crew
Sanuj Kulshrestha	Ground Station Crew
Rishabh Yadav	Ground Station Crew
Sumiran Bhasin	Ground Station Crew
Bhavuk Grover	Recovery Crew
Gaurav Verma	Recovery Crew
Aayush Aggarwal	Recovery Crew

Field Safety Rules Compliance

Mission Operations Manual: Content

Checklist	Electronics Testing	Structural Components Testing
✓ Pre-Launch Checklist	Sensor Check	Parachute Visual Check
	PCB Connections Check	Payload Release Check
	Servo Motor Check	Auto-gyro Blade Opening Check
	Camera Stabilization Check	Auto-Gyro Mechanism Check

✓ CanSat Preparation

1. Initial Start
2. Unit Testing of all sub-systems
3. Assembly and Hybrid Integration Testing

✓ GCS Setup Checklist

1. GCS Configuration and Operation
2. Testing and starting data receiving

✓ Rocket Integration Checklist

1. Integrating CanSat into rocket and stand mounting

✓ Launch

1. Rocket Preparation

✓ Recovery

1. Retrieval of CanSat
2. Data Handling

Field Safety Rules Compliance

Mission Operations Manual: Development

Development Process

The following sections in the Manual have been developed

- Defining Team Member Roles
- CanSat assembly
- Pre-Launch Checks
- Ground Station Assembly
- Troubleshooting Procedures for any on-site problems prior to launch and after landing
- Safety Check Method

Development Status

- The basic template of the Mission Operations Manual has been made.
- Team roles, troubleshooting mechanisms and the functions each subsystem have been included.
- In the safety check procedure section, the results of various tests will be included in the manual when performed. The results of environmental tests like fit check, thermal test, vibration test and drop test have been included since we have performed them and they will be revised till the final draft.
- Final draft will be ready by mid-May.

The manual will be assembled in 3 ring binders and 2 copies will be submitted at the FRR, the day before launch and one copy will be submitted to the flight coordinator.

CanSat Location and Recovery

Structural Element	Recovery
Payload	• GPS sensor • Audio Beacon when it lands • Bright color (Red) of the container to increase visibility
Container	• Bright color (Red) of the container to increase visibility • Audio Beacon when it lands

Following information will be written on Container and Payload:

Team Leader Name
Team Name
Team Number
Email Address
Contact Number

Mission Rehearsal Activities

Activity	Date	Description
Ground system radio link check procedures	20/03/2019	Rehearsed during Parabolic and Patch antenna testing by establishing communication between the two via XBEE Pro S2C over a range of 1 km.
Powering on/off the Payload and the container	10/03/2019	Easily accessible power source on the top of the Container and Payload was tested.
Telemetry processing, archiving, and analysis	17/03/2019	Packets were transmitted and received and stored in a .csv file
Launch configuration preparations	27/03/2019	Rehearsed the assembly of the Payload and the container
Loading the CanSat in the launch vehicle	27/03/2019	A rocket test will be performed. Fit Check has been performed.
Recovery	27/03/2019	The recovery team will be responsible for recovery of container and payload. For these reasons, RED color has been chosen to increase visibility and several tests are done to improve loudness of audio beacon.

The procedures written in the Manual so far are used for all the rehearsal activities and accordingly revised.

Requirements Compliance

Gaurav verma

Requirements Compliance Overview

All departments (Electronics, Mechanics and Software) have designed and nearly completed the first prototype of CanSat and mission requirements have been fulfilled and treated as high priority.

This includes:

- **Electronics Subsystem requirements for**
- **Data collection, storage and Telemetry transmission**
    - FSW
    - GCS communications
- **Mechanical Subsystem requirements for**
    - Mass
    - Container opening
    - Auto-Gyro deployment and activation.
    - Dimensions and Tolerance for easy deployment from rocket.

Bonus objective task will be performed with BLDC motor and gimbal for camera stabilization. We have obtained satisfactory results till now , although the development is not complete yet .

Environmental tests have been performed with prototype 1 according to the guide and the results obtained are included in the CanSat Integration and Testing section.

Requirements Compliance[1/5]

Rqmt Num	Requirement	Comply / No Comply / Partial	X-ref slides demonstrating compliance	Team Comments or Notes
1	Total mass of the CanSat (science payload and container) shall be 500 grams +/- 10 grams.	Comply	101	
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	176	
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	29	
4	The container shall be a fluorescent color; pink, red or orange.	Comply	55	
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply		
6	The rocket airframe shall not be used as part of the CanSat operations.	Comply		
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Comply	92	
8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Comply	62-72	
9	The container shall release the payload at 450 meters +/- 10 meters.	Comply	137	
10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Comply	83	
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Comply	62-72	
12	All descent control device attachment components shall survive 30 Gs of shock.	Comply	174	

Requirements Compliance[2/5]

13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	75	
14	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	93,173,175	
15	All structures shall be built to survive 30 Gs of shock.	Comply	93,173,175	
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	93,173	
17	All mechanisms shall be capable of maintaining their configuration or states under all forces	Comply	94	
18	Mechanisms shall not use pyrotechnics or chemicals.	Comply	-	
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	-	
20	The science payload shall measure altitude using an air pressure sensor.	Comply	35,36	
21	The science payload shall provide position using GPS.	Comply	38,39	
22	The science payload shall measure its battery voltage.	Comply	40	
23	The science payload shall measure outside temperature.	Comply	37	
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Comply	43	
25	The science payload shall measure pitch and roll.	Comply	41,42	
26	The payload shall transmit all sensor data in the telemetry	Comply	113	
27	The Parachute shall be fluorescent Pink or Orange	Comply	56	

Requirements Compliance[3/5]

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	152	
29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Comply	151,152	
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	112	
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	113, 114	
32	XBEE radios shall have their NETID/PANID set to their team number.	Comply	113, 114	
33	XBEE radios shall not use broadcast mode.	Comply	114	
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	204	
35	Each team shall develop their own ground station.	Comply	146, 153	
36	All telemetry shall be displayed in real time during descent	Comply	149	
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	149,151	
38	Teams shall plot each telemetry data field in real time during flight.	Comply	149	
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	148	

Requirements Compliance[4/5]

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	**147**	
41	Both the container and payload shall be labeled with team contact information including email address.	Comply	189	
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	137	
43	No lasers allowed.	Comply	-	
44	The payload must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration.	Comply	125	
45	The payload 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	124	
46	An audio beacon is required for the payload. It may be powered after landing or operate continuously.	Comply	124	
47	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Comply	124	
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	125	
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	

Requirements Compliance[5/5]

50	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	-	
51	The auto-gyro descent control shall not be motorized. It must passively rotate during descent.	Comply	57	
52	The GPS receiver must use the NMEA 0183 GGA message format.	Comply	39	
53	The CanSat must operate during the environmental tests laid out in Section 3.5.	Comply	174-177	
54	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Comply	125	
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. Direction does not matter as long as it is in one direction. The payload can pick the direction. 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	45	

Management

Vineet Khurana

Status of Procurements[1 of 2]

Components	Procurement Status (y/n)	Arrival Status ETA-Ordered Date
Flight Hardware		
BMP180	Y	Before PDR- 10/01/19
Camera	N	Ordered- 24/02/18, Expected Arrival by 2/04/19
UBLOX NEO-6M	Y	Before PDR- 10/01/19
MPU6050	Y	Before PDR- 20/02/19
XBee-PRO(S2C)	Y	After PDR- 20/02/19
Teensy	Y	Before PDR-15/01/19
Patch antenna	Y	Before PDR-18/01/19
SD card module	Y	Before PDR-18/01/19
EEPROM	Y	Before PDR-18/01/19
Sandisk 16GB Class 10	Y	Before PDR-20/01/19

Status of Procurements[2 of 2]

Components	Procurement Status (y/n)	Arrival Status ETA- Ordered Date
RTC: DS3231	Y	Before PDR-20/01/19
3D Printed Container	Y	After PDR- 25/02/19
3D Printed Payload	Y	After PDR- 25/02/19
GCS Hardware		
Parabolic Antenna	Y	Received and tested
XBEE Pro S2C	Y	After PDR- 20/02/19
Others	Y	

CanSat Budget – Hardware(Electrical)[1/2]

Part		Model	Quantity	Total Cost ($)	Determination
PAYLOAD					
Microcontroller		Teensy 3.2	1	$29.5	Actual
Sensors	Air Pressure	BMP180	2	$3.8	Actual
	Temperature				
Tilt Sensor		MPU-6050	1	$1.8	Actual
Auto-gyro Blade spin Sensor		AH44E	1	$1.6	Actual
Camera Sensor		Turbowing cyclops dvr	1	$15.4	Actual
GPS Sensor		NEO-6M	1	$10.13	Actual
Power Voltage Sensor		Voltage Divider Circuit	1	$1	Actual
XBEE Radio		XBEE Pro S2C	1	$33.8	Actual
CanSat Antenna		FXP70 Freedom (Patch Antenna)	1	$4.52	Actual
Audio Beacon		MCKPI-G2437	1	$1	Actual
Battery		9V Li-Ion	3	$15	Actual
Servo Motor		Micro Servo (9g)	1	$6.96	Actual
BLDC Motor		82212/13T	1	$5.4	Actual

CanSat Budget – Hardware(Electrical)[2/2]

Part	Model	Quantity	Total Cost ($)	Determination
SD Card	SanDisk Class 10	1	$3.5	Actual
SD Card Module	Generic SDCard Module	1	$4.7	Actual
RTC	DS3231	1	$5.97	Actual
Voltage Regulator	LM 7805(5V)	1	$2.5	Actual
	LM7111(3.3V)	1	$2.5	Actual
Communication Module	XBEEPro S2C	1	$33.8	Actual
Base Circuit Boards	P.C.B.	1	$10	Actual
Others			$20	Estimate
TOTAL			$258.84	

CanSat Budget – Hardware(Mechanical)[1/2]

Part		Model	Quantity	Total Cost ($)	Determination
Container					
Parachute and Electronics Section		CNC machined HDPE	1	$45	Actual
Parachute mounting lid		CNC machined HDPE	1	$8	Actual
Ribs	Main body	CNC machined HDPE	2	$30	Actual
	Supportin g structure	CNC machined HDPE	4	$30	Actual
	Base	CNC machined HDPE	2	$15	Actual
Cage		3D printed ABS	1	$15	Actual

CanSat Budget – Hardware(Mechanical)[2/2]

Payload				
Main body	3D printed HDPE	1	$43	Actual
Rotor	3D printed nylon PA-2200	1	$15	Actual
Blades	Vacuum formed p olycarbonate	4	$115	Actual
Miscellaneous				
Gimbal	3D printed nylon PA-2200	1	$71	Estimated
Torsional Springs, Screw, Nuts, Bolts, Thread, Blade, Adhesive s etc.	N.A.	N.A.	$20	Estimated
			Total=$407	

CanSat Budget – Hardware(Total)

System	Cost($)
Electrical	$258.84
Mechanical	$407
Margin	$100
Total Cost	$775.84

Our total estimated cost is well within the prescribed limit of $1000

CanSat Budget – Other Costs [1/4]

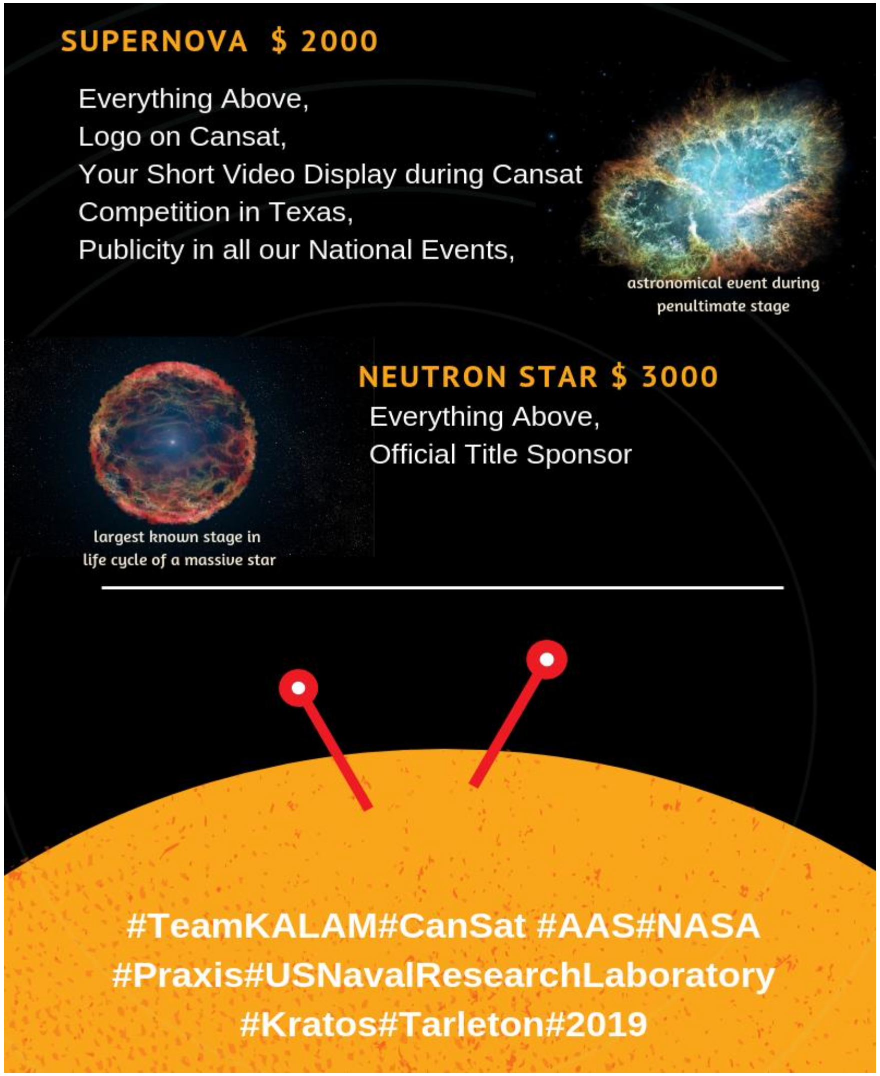
Part	Model	Quantity	Total Cost ($)	Determination
Ground Station Antenna	Parabolic Antenna	1	$46.04	Actual
Communication Module	XBEE Pro S2C	1	$41.61	Actual
Base Circuit Boards	PCB	1	$10	Actual
Laptop	Apple MacBook Air	1	$999	Actual
Others			$20	Estimate
Total			$1096.65	

CanSat Budget – Other Costs [2/4]

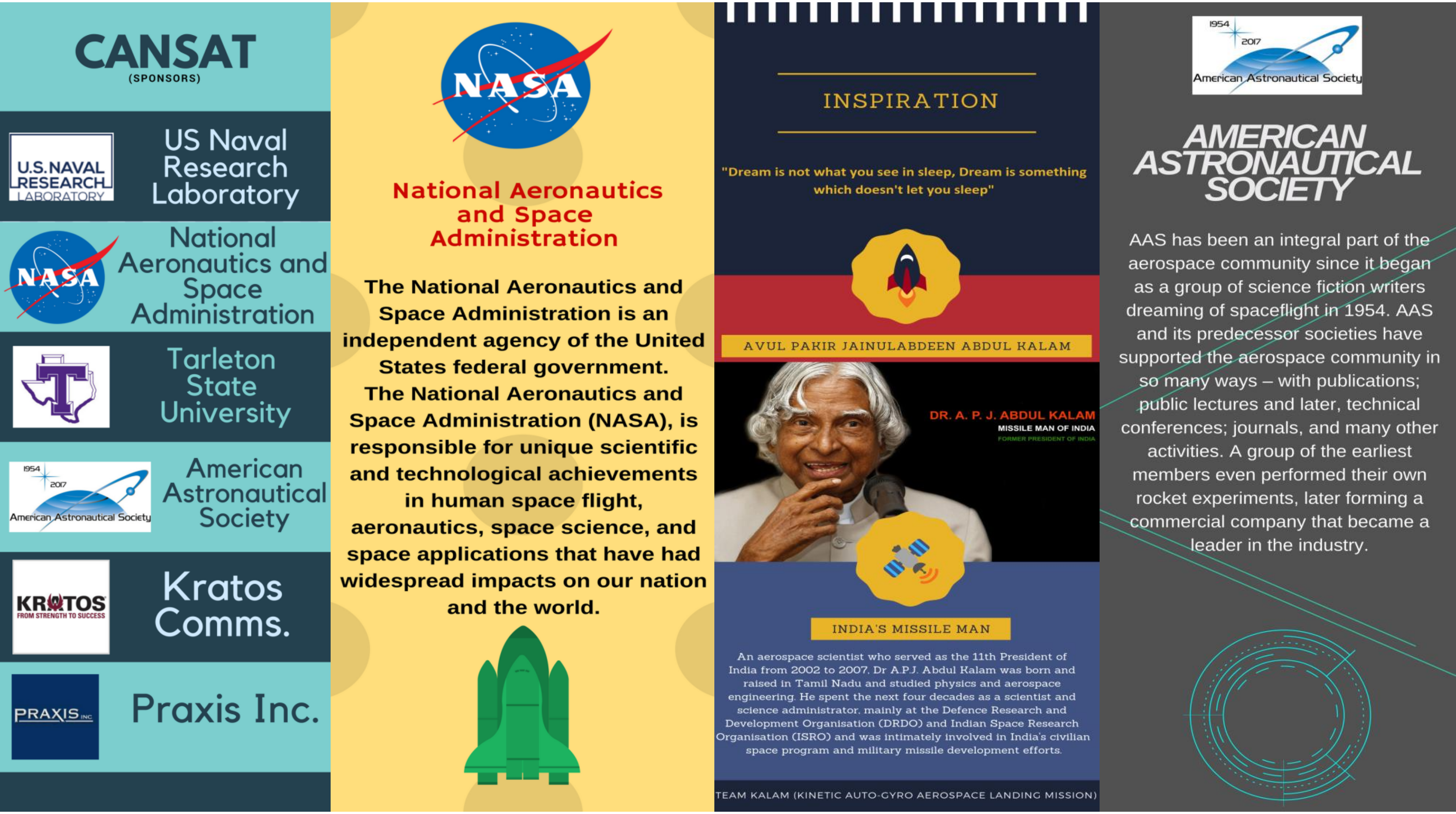
Part	Quantity	Total Cost ($)	Determination
CanSat Fee	1	$100	Actual
Food	12	$900	Estimated
Transport	10	$1500	Estimated
Flight Tickets	10	$15000	Estimated
Accommodation	2	$700	Estimated
Prototyping	-	$3000	Estimated
	Total	$21200	Estimated

Budget	
College	$500
Amount from Sponsors needed	$3000

CanSat Budget – Other Costs [3/4]

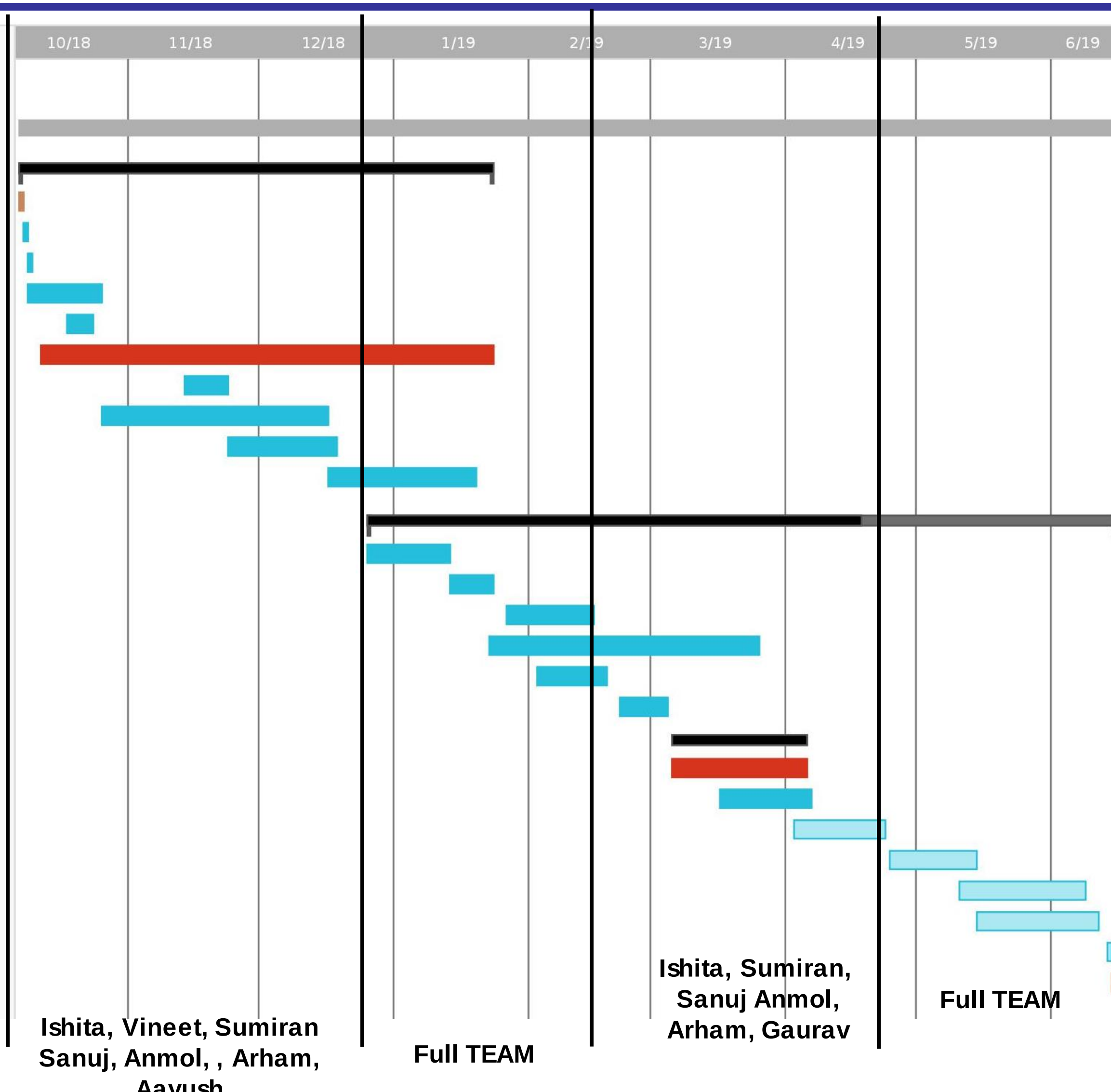


CanSat Budget- Other Costs [4/4]



Detailed Program Schedule[1 of 5]

CANSAT	**82%**
1st Educational Phase	**100%**
First Meeting	100%
Finalizing team	100%
CANSAT Project started	100%
Analyzing Mission Guidelines	100%
Budget Formation	100%
Prelimnary Design	100%
University End Term Examinations	100%
Prototyping	100%
Material Ordering	100%
Finalizing Material	100%
2nd Educational Phase	**66%**
Finalizing Design	100%
Preparing PDR	100%
Presenting PDR	100%
Final Designing	100%
Placing Final Order	100%
University Mid Term Examinations	100%
Preparing for CDR	**100%**
Preparing for CDR	100%
Prepare CDR	100%
Present CDR	0%
University End Term Examinations	0%
Final Deprations	0%
Final Testing	0%
Demo Flight	0%
PFR	0%



Task Assignment

Detailed Program Schedule[2 of 5]

Start Date	End Date	Major Milestones/Activities
7 Oct 2018	31 Dec 2018	**Phase - I : 1st Educational Phase**
7 Oct 2018	25 Oct 2018	The mission statement was analysed and preparation for the competition was begun. The team was formed by selecting the 10 most interested and able students
25 Oct 2018	25 Oct 2018	A presentation was prepared based on the CanSat mission requirements and competition guide, and presented to the faculty in-charge
26 Oct 2018	20 Nov 2018	Several designs were brainstormed and discussed. Sensors were researched
14 Nov 2018	23 Nov 2018	End Semester Theory Examinations
24 Nov 2018	18 Dec 2018	Electronic components were selected and ordered.
18 Dec 2018	18 Dec 2018	Revisions in competition guide were taken into account and subsystems were allocated to team members

Detailed Program Schedule[3 of 5]

Start Date	End Date	Major Milestones/Activities
17 Dec 2018	19 Jan 2019	A working prototype for the payload was built and tested. The heat shield model was built on Solidworks and simulations were begun
1 Jan 2019	15 May 2019	**Phase - II : 2^{nd} Educational Phase**
11 Jan 2019	15 Jan 2019	The GCS software and FSW was tentatively designed.
15 Jan 2019	20 Jan 2019	The final materials and trade selections were done and ordered. CFD calculations and simulations were completed and verified
20 Jan 2019	1 Feb 2019	The **PDR** was compiled and mailed
25 Jan 2019	6 Feb 2019	Coding of the GCS software and FSW, and the design of all CanSat components shall be finalised. Antenna and Xbee testing done
7 Feb 2019	16 Feb 2019	The fabrication for the CanSat began.

Detailed Program Schedule[4 of 5]

Start Date	End Date	Major Milestones/Activities
3 Feb 2019	18 Feb 2019	Final ordering of the components.
17 Feb 2019	1 Mar 2019	Drop test conducted.
22 Feb 2019	5 Mar 2019	Mid Semester Theory Examinations
10 Mar 2019	25 Mar 2019	Final testing of all EPS circuits, electronics and sensors, mechanisms, softwares (including GCS integration) was done.
17 Mar 2019	30 Mar 2019	The **CDR** shall be compiled and mailed. Team members shall apply for U.S. visas
30 Mar 2019	11 June 2019	**Phase - III : Mission Planning and Preparation**
1 Apr 2019	30 Apr 2019	All final tests shall be performed and any absolutely necessary changes shall be made. The final design of the CanSat shall be fabricated with precision

Detailed Program Schedule[5 of 5]

Start Date	End Date	**Major Milestones/Activities**
25 April 2019	15 May 2019	End Semester Theory Examinations. Mission planning for the on-site competition shall be done.
11 May 2019	8 June 2019	Final preparations will be done.
1 June 2019	11 June 2019	Margin for any unforeseen problems. Any other miscellaneous needs shall be taken care of CanSat shall be carefully packaged for the journey to Stephenville, TX. The team shall depart on 12 Jun 2019

Transportation plans:

1. We have decided to carry the CanSat and other required equipment as cabin baggage with us in the flight. This will rule out the question of the CanSat getting lost.
2. The CanSat will be disassembled to make it easy to carry with us in the flight.
3. We have discussed/will discuss the CanSat with the airline authorities as certain components may not be allowed on board and during the security check. All doubts have been resolved/will be resolved. We will also be carrying necessary documents from our college to prove our credibility whenever required.
4. For transportation to the launch site, we will be using the transport provided by the competition organizers to carry our CanSat. The CanSat will then be assembled at the launch site.

Shipping and Transportation[2 of 2]

Carry on restrictions:

1. There is a weight limit for travel by air. For extra luggage, a payment has to be made to the airline.
2. Certain components of the CanSat may not be allowed on board the flight.
3. Special permission may have to be obtained.

Transportation of tools and equipment:

1. All required tools and equipment will be carried with us. Special permission may have to be obtained to carry certain equipment.
2. The Parabolic antenna will be disassembled as it is inconvenient to carry the fully assembled antenna because of its size.

Conclusions[1 of 3]

Major accomplishments:

1. 3D models of container, CanSat structure and deployment mechanisms have been obtained in SolidWorks software.
2. Thorough testing of the electrical power subsystem has been done.
3. The PCB has been fabricated again after incorporating all changes. Electronic components have been integrated on the PCB and tested.
4. Descent calculations have been redone after incorporating all design changes.
5. Communication system has already been tested extensively.
6. The problems identified by the respected judges during the presentation and in our scoresheet have been addressed and solved.

Conclusions[2 of 3]

Major unfinished work:

1. Camera sensor is yet to arrive.

Testing to complete:

1. Quadcopter and Weather Balloon testing are yet to be done.
2. Camera testing is to be done.
3. Final test using a rocket provided by our sponsors is to be done.

Flight software status:

1. All flight software states have been tested.
2. Testing of the flight software at the actual altitudes will be done during the rocket testing.

Conclusions[3 of 3]

“If you want to shine like a sun, first burn like a sun.”

-Dr APJ Abdul Kalam

Given the sleepless nights, busy weekends , non-existent vacations and the exhaustion that came along ; we strongly believe that it is now our time to shine !!

We believe our dedication and prior hands-on experience with model aerodynamic systems and electronics will help us carve a niche for ourselves in the competition. Our preliminary design with unique and innovative features is up and running . With ambition , hard work and team spirit, we are absolutely ready for the competition .