Netaji Subhas University of Technology CanSat 2019

Preliminary Design Review (PDR)

#3279

K.A.L.A.M.

Kinetic Auto-gyro Landing Aerospace Mission

February 1, 2019

Presentation Outline [1/6]

Presentation Outline [2/6]

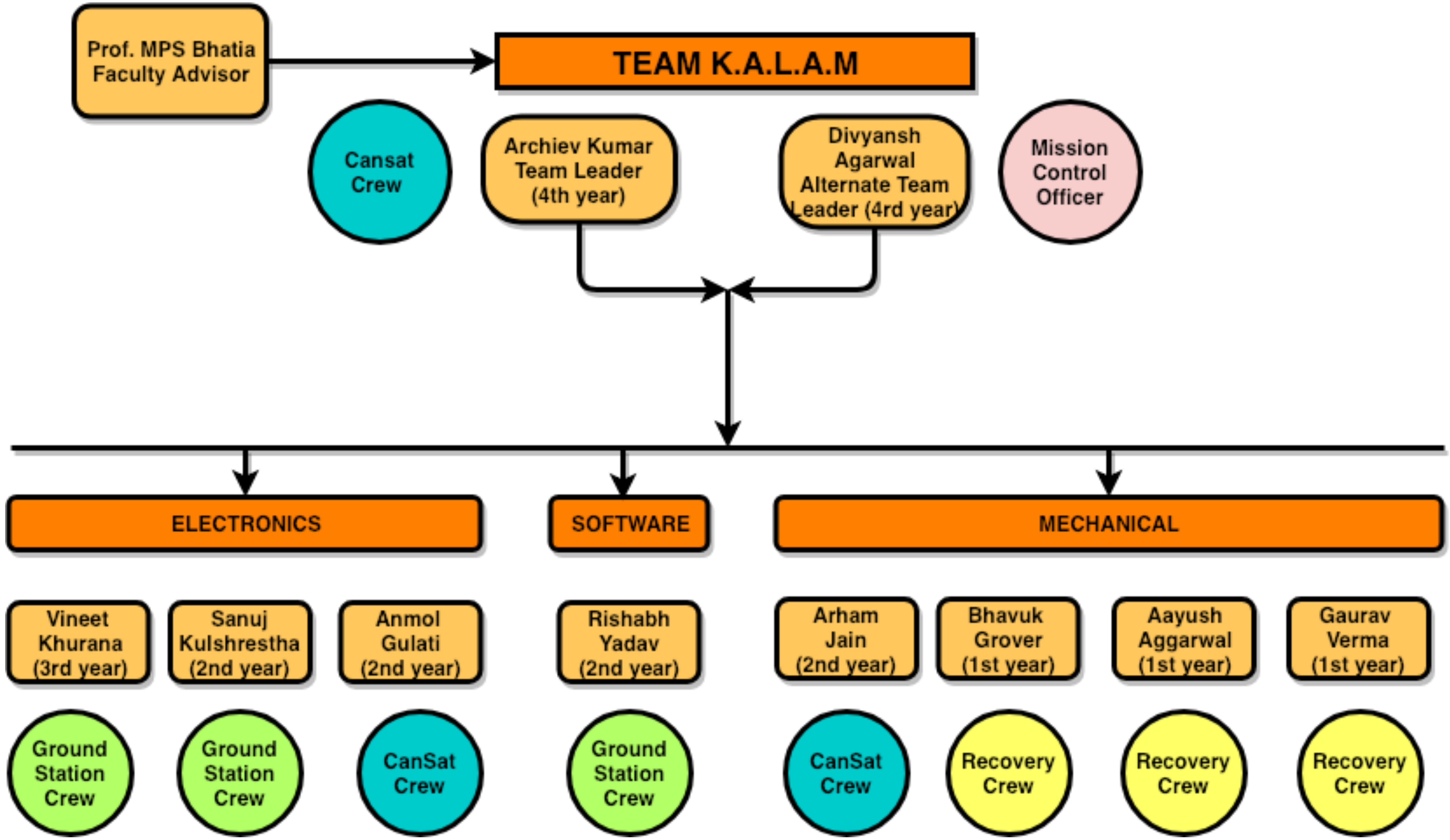
Presentation Outline [3/6]

Presentation Outline [5/6]

Presentation Outline [6/6]

Section	Presenter
Systems Overview	**Arham Jain**
Sensor Subsystem Design	**Sanuj Kulshrestha**
Descent Control Design	**Aayush Aggarwal**
Mechanical Subsystem Design	**Divyansh Aggarwal**
Communication and Data Handling (CDH) Subsystem Design	**Archiev Kumar**
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

Systems Overview

Arham Jain

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-gryo/ 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 logistic needs.

System Requirement Summary [1/4]

SRS#	Description	Verification Method 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]

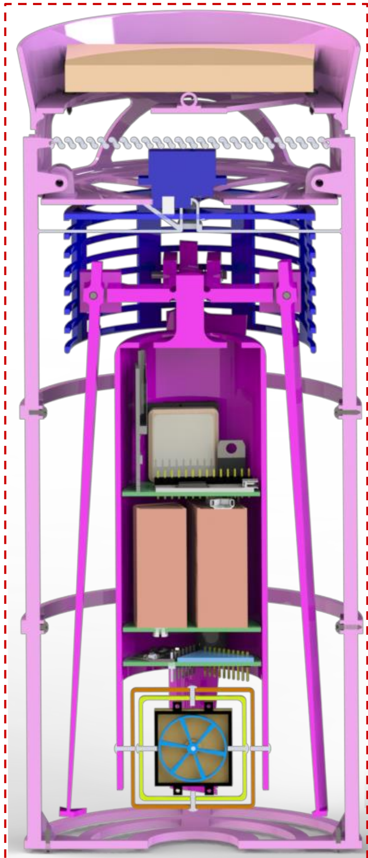
SRS#	Description	Verification Method A	I	T	D
SRS22	Telemetry shall include mission time with one second or better resolution. Mission time shall be maintained in the event of a processor reset during the launch and mission.	✔	✔		
SRS23	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are 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]

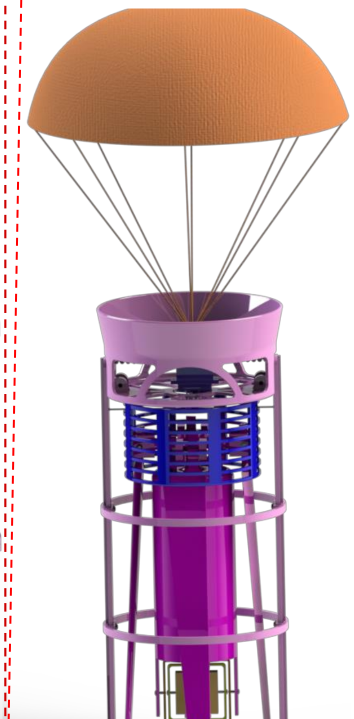
SRS#	Description	Verification Method A	I	T	D
SRS30	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.		✔		
SRS31	Battery source may be alkaline, Ni-Cad, Ni-MH or Lithium. Lithium polymer batteries are not allowed. Lithium cells must be manufactured with a metal package 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.	✔	✔	✔	

System Level CanSat Configuration Trade & Selection [1/3]

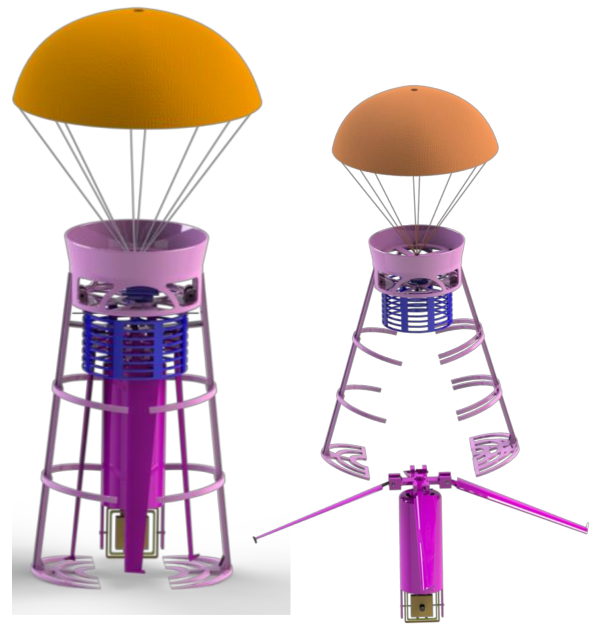
CONFIGURATION 1



Payload is stowed using cage



Two side halves of container open due to spring compression when the servo motor cuts the Kevlar string holding the halves.



Launch

Parachute Deployment

Payload Release

Payload Deployment

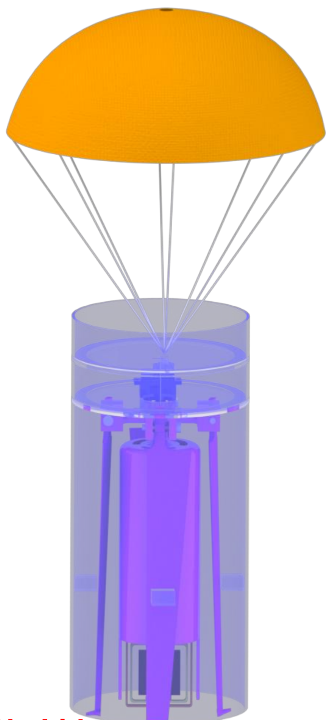
Blades open with the help of springs. Auto-Gyro is now operational. (Stable Configuration)

0 m | Post-Apex (670-725 m) | 460 m | 450 m | 250 m | 0 m

System Level CanSat Configuration Trade & Selection [2/3]

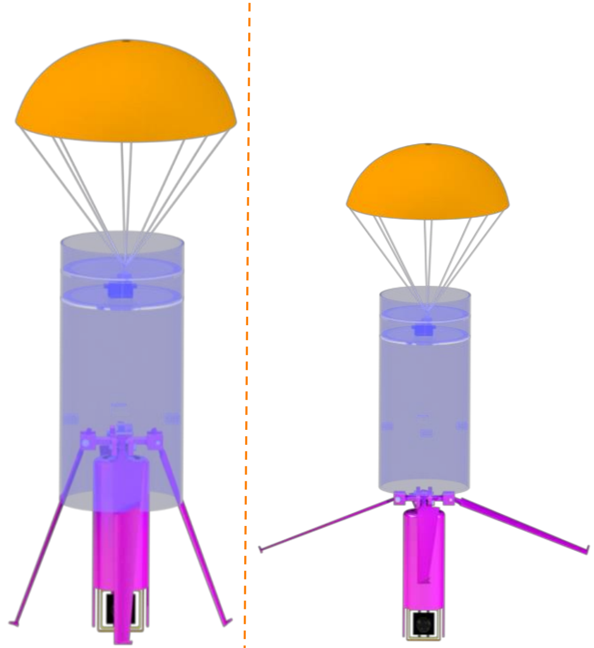
CONFIGURATION 2

Payload is attached to the container using a Kevlar thread.



No Lid

Servo motor cuts the thread for the release of payload.



Launch

Parachute Deployment

Payload Release

Payload Deployment

Blades open due to air pressure. Auto-Gyro is now operational. (Unstable Configuration)

0 m | Post-Apex (670-725 m) | 460 m | 450 m | 250 m | 0 m

System Level CanSat Configuration Trade & Selection [3/3]

CONFIGURATION 1

Merits	Demerits
• Easy payload integration • Eleventh hour changes, possible due to simplicity of overall design • Lightweight • More reliable blade opening • Sturdy built and less CONOPS stages • Maintenance of nadir direction (Stable)	• Excessive stress on the joints • Complex payload release mechanism due to dependence on hinges and springs

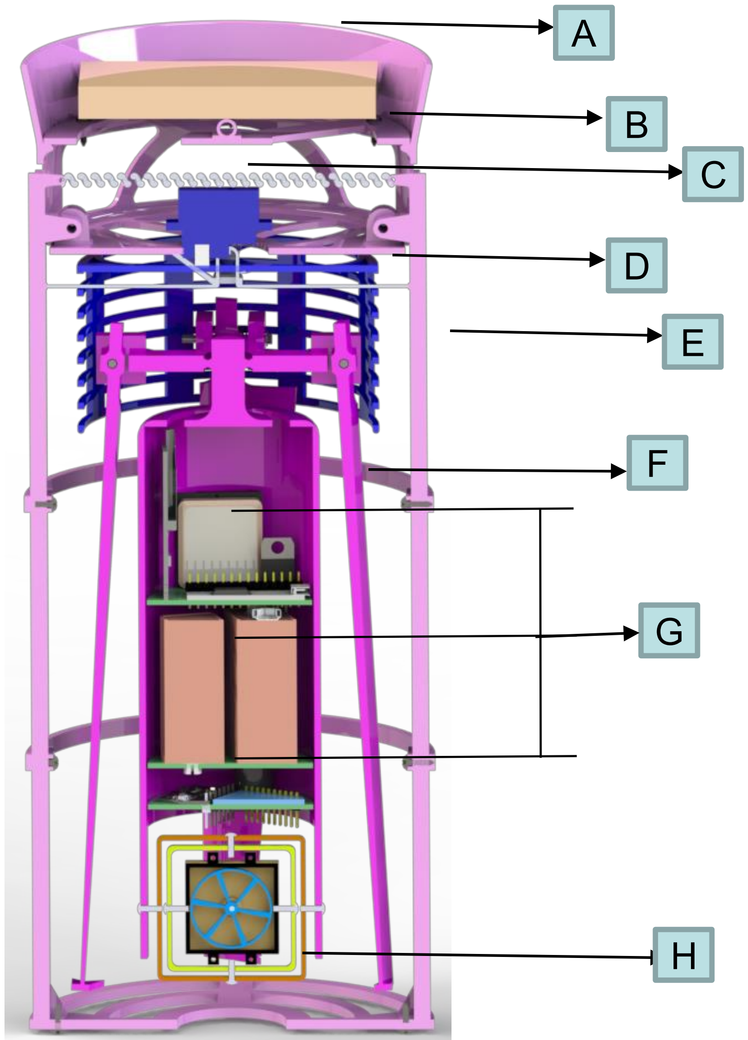
CONFIGURATION 2

Merits	Demerits
• Ease of manufacturing. • Less structural forces • No warping possible . • Simpler payload release mechanism	• Comparatively bulkier • Container opening mechanism is extremely unreliable as there is no lid. • More CONOPS stages • Unstable payload as blades are opening due to air pressure. A problem incurred during our testing phase revealed that the model incurred instability and unreliable spin

System Level Configuration Selection

Concept Chosen	Rationale
Configuration1	• More stable (less disturbance) • Ease to fabricate • Easy to integrated • More Shock Durability

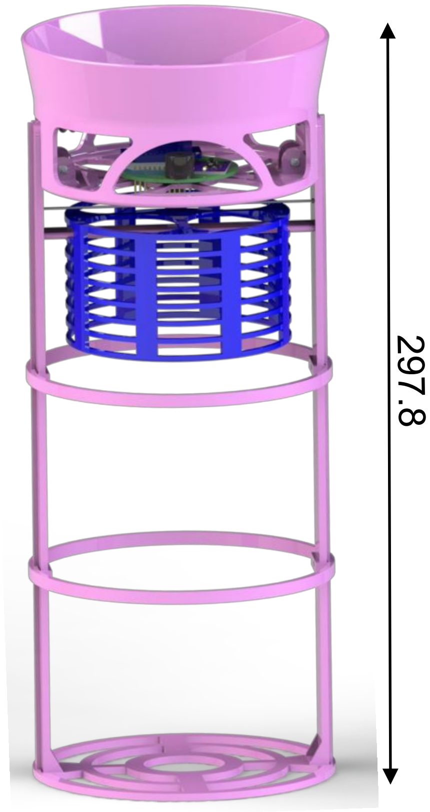
Physical Layout [1/8]

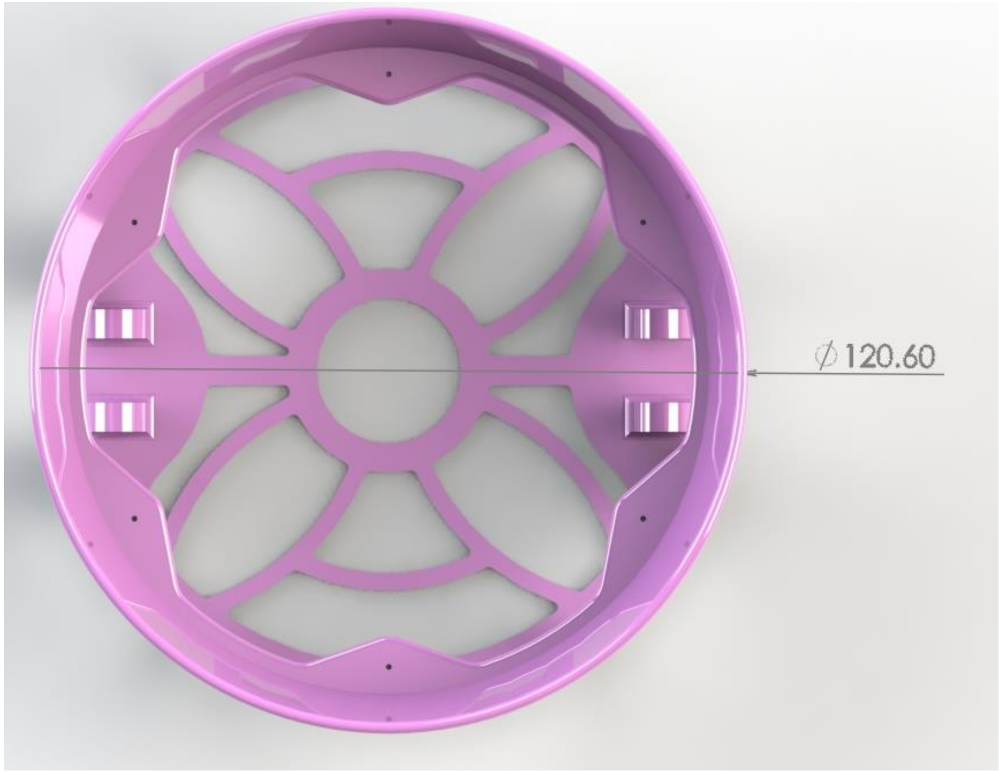


CanSat Dimensioning

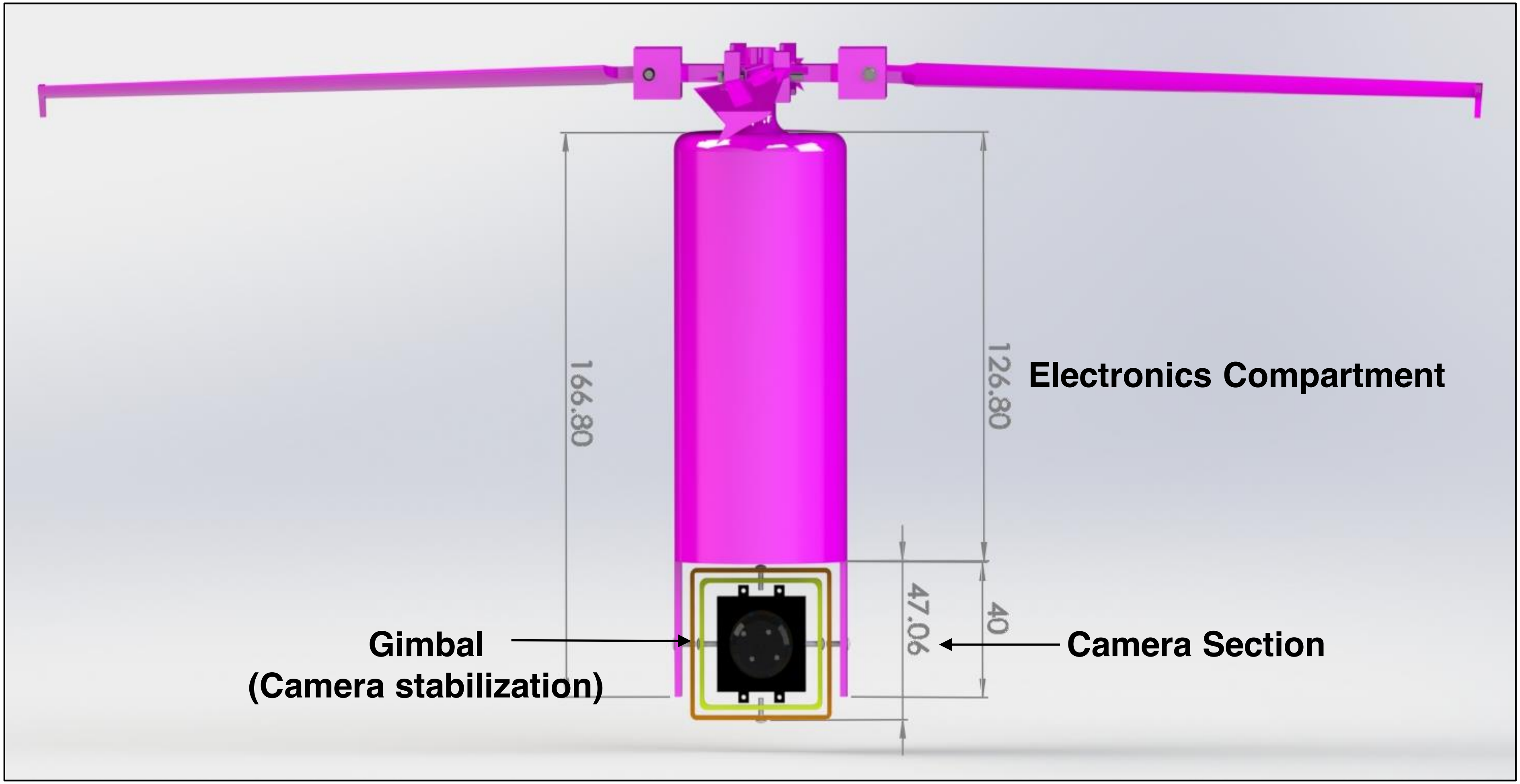
Symbol	Components	Dimensions
A	**Parachute**	Radius=**55mm**
B	**Spring**	Diameter=**4mm ,** Length=**115mm**
C	**Servo Motor**	LengthxWidthxHeight = **31x24x12mm**
D	**Cage**	Diameter**=90mm ,** Height=**51mm**
E	**Container Ribs**	Diameter=**110mm ,** Height=**297.8mm**
F	**Blade**	LengthxWidthxHeight = **207x30x3mm**
G	**Electronic Component**	Diameter=**50mm ,** Height=**120mm**
H	**Camera Stabilizer**	LengthxWidthxHeight =**45x41x32mm**

Container Dimensioning

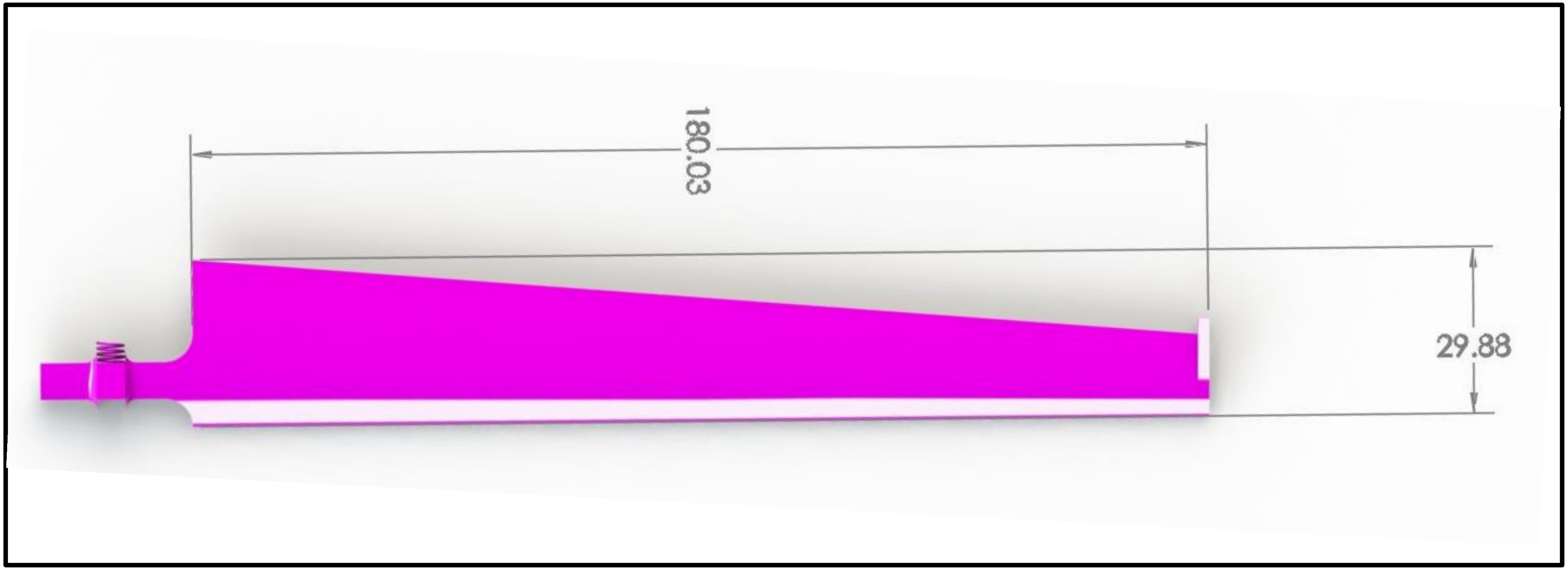




Payload Dimensioning

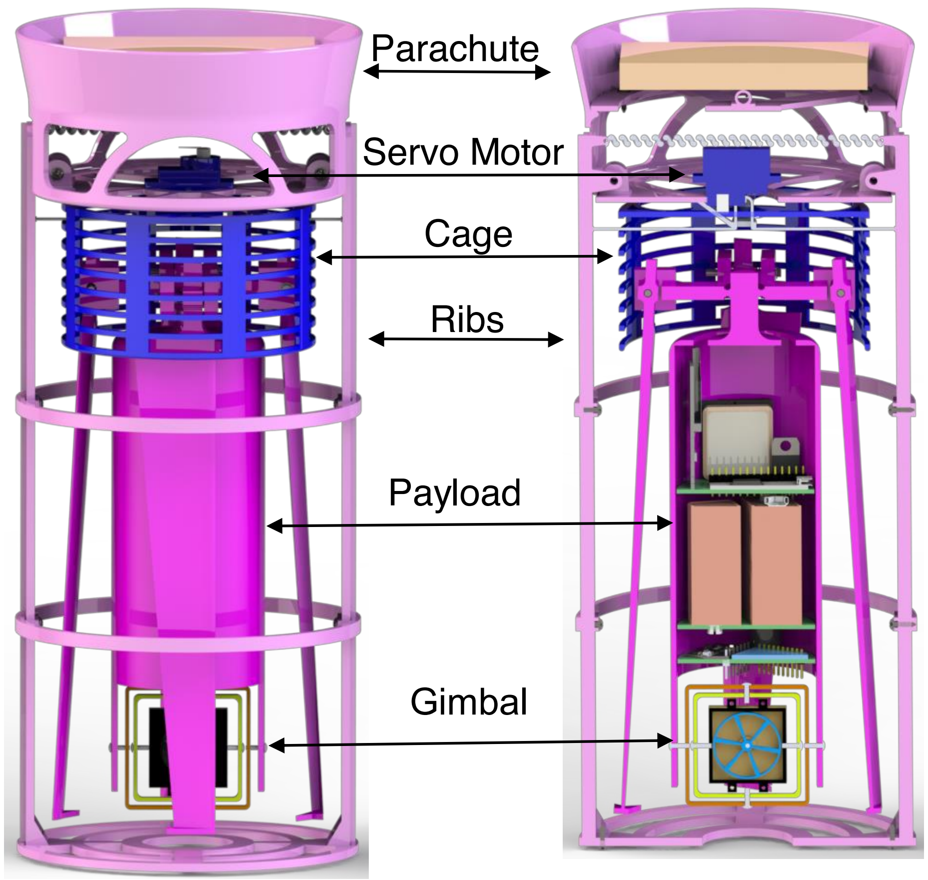


Blade Dimensioning



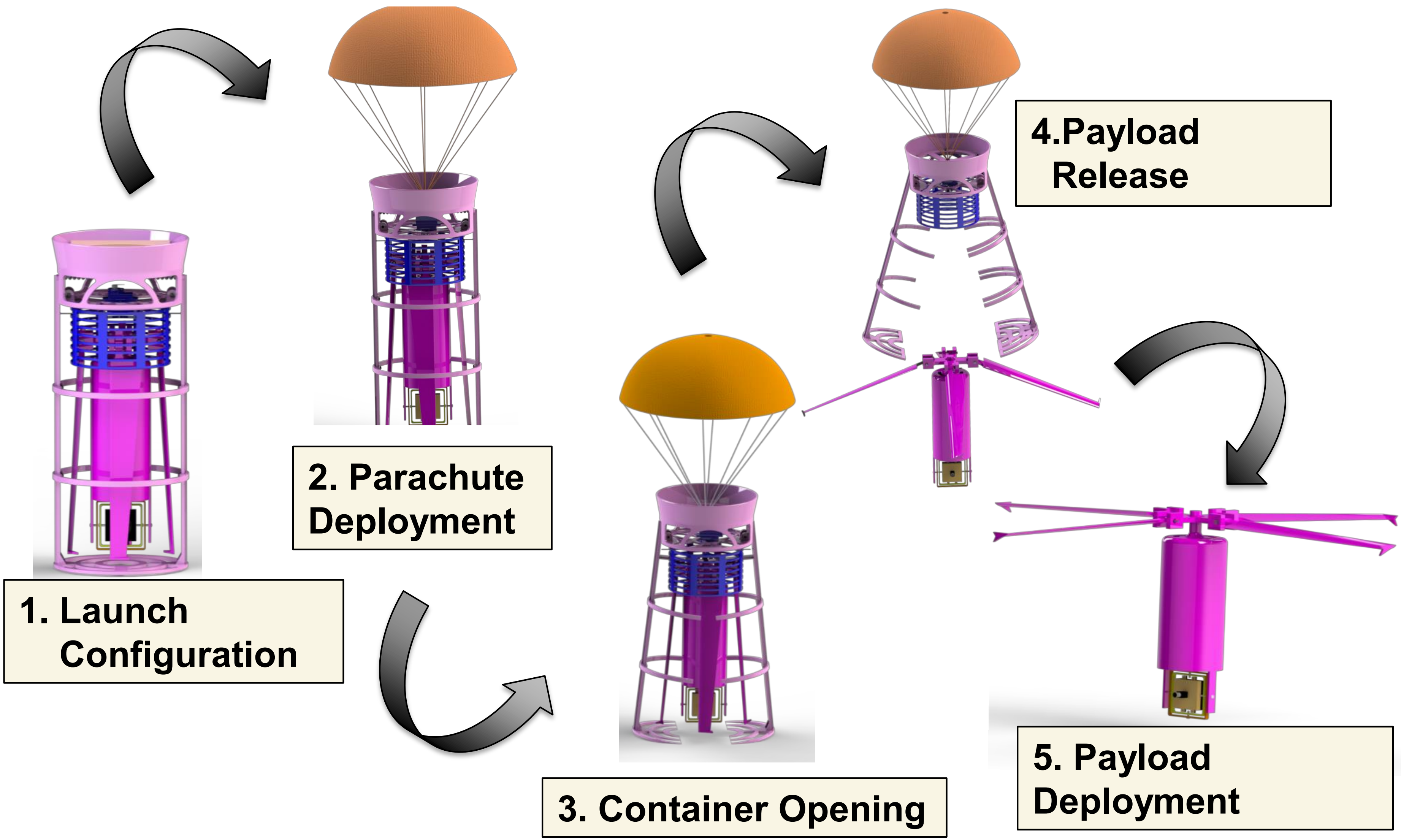
Physical Layout [5/8]

PAYLOAD STOWED CONFIGURATION

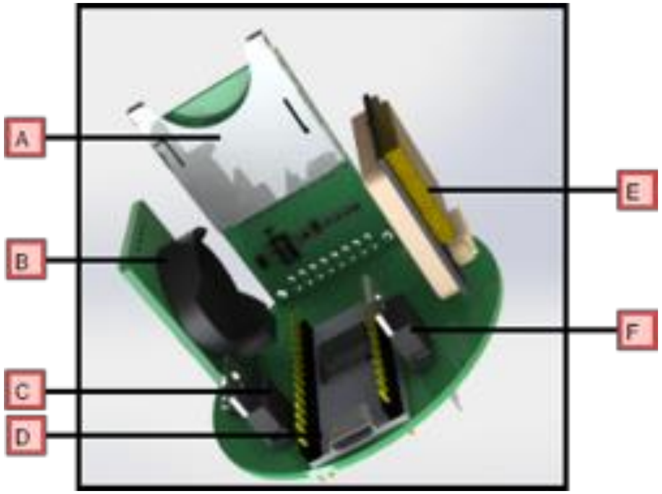


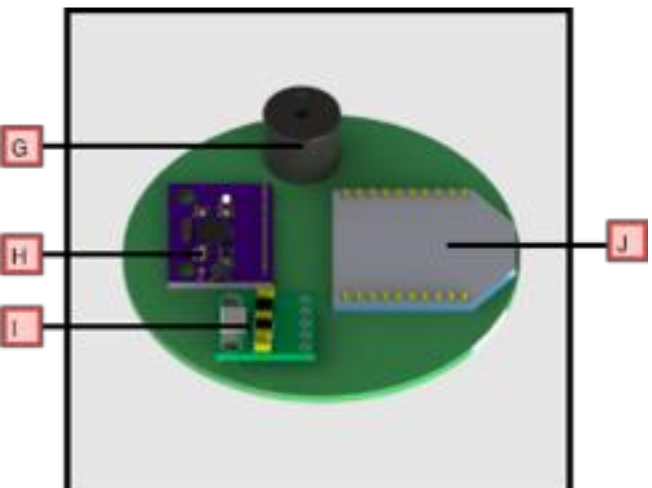
The blades are stowed with the help of a cage that is connected to the container.

Physical Layout [6/8]



Physical Layout [7/8]

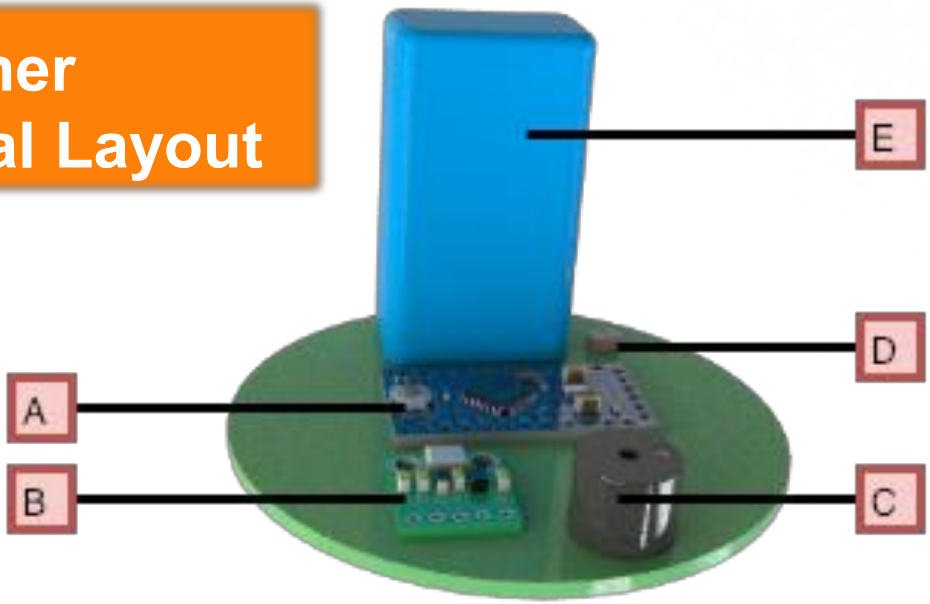




Payload Physical Layout

Symbol	Electronic Components	Dimensions
A	SD Card Logger	LengthxWidth = **20x28mm**
B	RTC DS3231	LengthxWidth = **44x22mm**
C	9-5V LDO	LengthxWidth = **4x26mm**
D	Teensy 3.2	LengthxWidthxHeight = **29.9x17.8x4.5mm**
E	GPS BN220	LengthxWidthxHeight = **22x20x6mm**
F	5-3.3V LDO	LengthxWidth = **4x26mm**
G	Buzzer 95dB	Radius = **20mm** & Height = **24mm**
H	MPU6060 (Tilt and Roll sensor)	LengthxWidthxHeight = **21.2mmx16.4mmx3.3mm**
I	BMP180 (Pressure Sensor)	Length x width x height = **3.6 x 3.8 x 0.93 mm**
J	XBEE PRO S2C	LengthxWidth = **32.94x25.8mm**

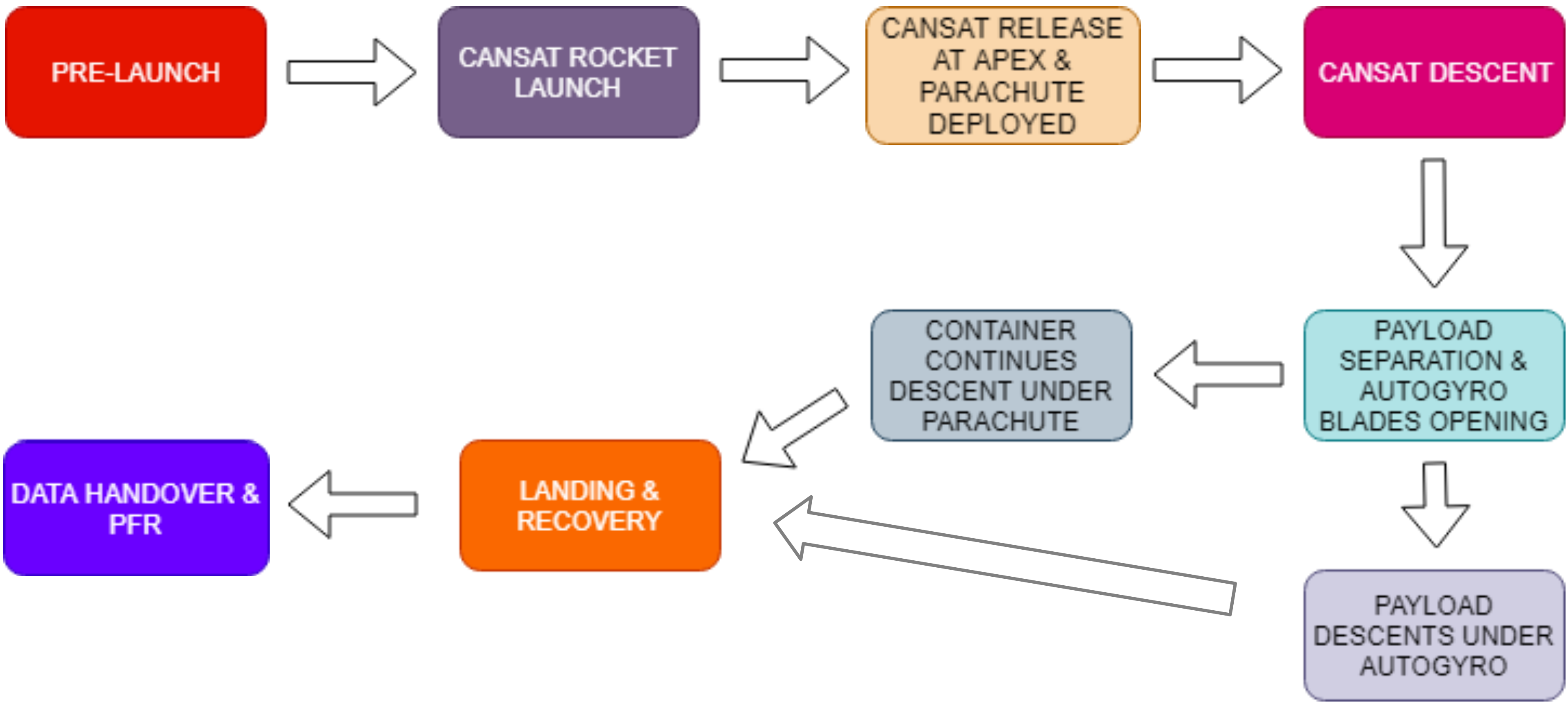
Container Physical Layout



Symbol	Electronics
A	Arduino Pro Mini
B	BMP 180
C	Buzzer
D	Light dependent Resistor
E	Battery (9v)

Electronics Component	Dimensions
Arduino Pro Mini	length x width = **18 x 33mm**
BMP 180	length x width x height = **3.6 x 3.8** x **0.93 mm**
Buzzer	Radius = **20mm** & Height = **24mm**
Light dependent Resistor	length x width x height = **2 x 4 x 5mm**
Battery (9v)	length x width x height = **10 x 9 x 8 cm**

System Concept of Operations [1/5]



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

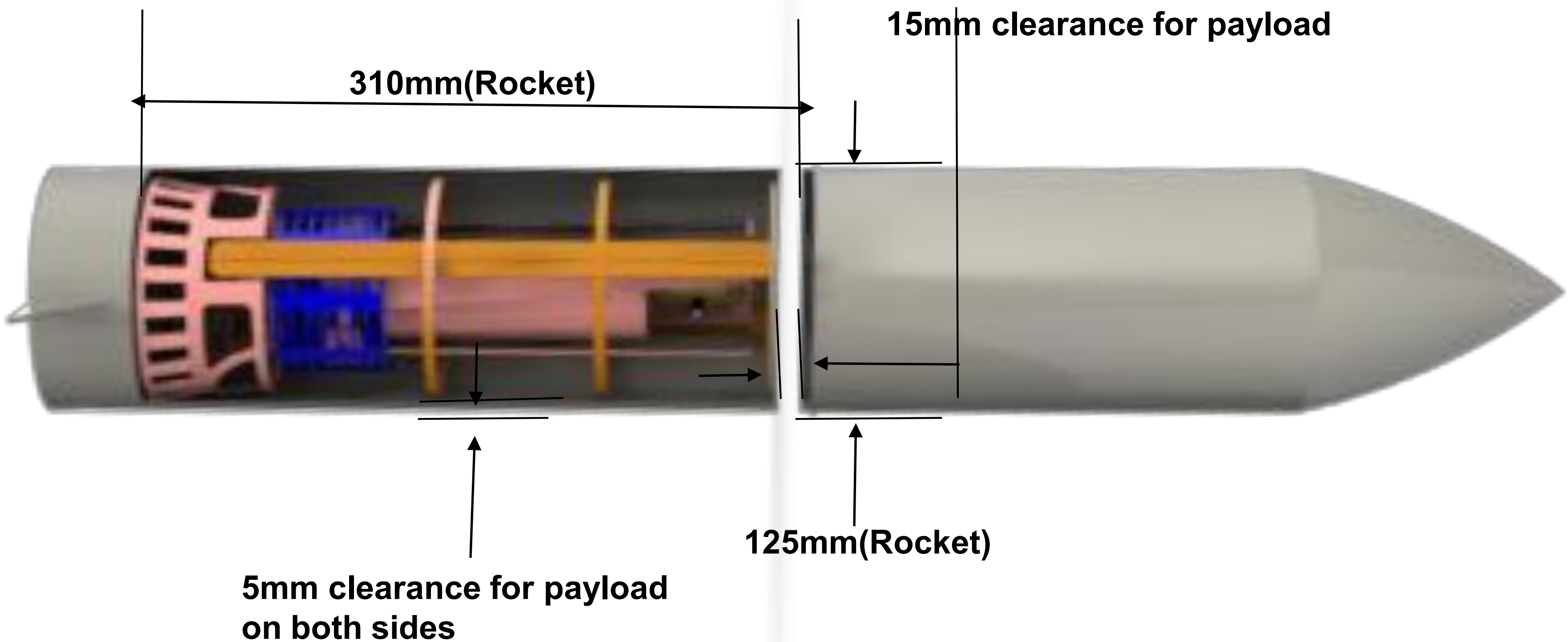
CanSat Volume:

- Diameter 115 mm
- Height 295 mm

Clearance:

- 10mm in diameter
- 15mm in Height

Launch Vehicle Compatibility [2/2]



No sharp protrusions

Sensor Subsystem Design

Sanuj Kulshrestha

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**	BN220	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 **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 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 Trade & Selection

Air Pressure Sensor	Interface	Pressure Range (hPa)	Dimensions (mm)	Weight (g)	Working Current (mA)	Accuracy (hPa)	Operating Voltage (V)	Cost ($)
BMP180	**I2C**	**300-1100**	**14 x 12 x 0.93**	**0.92**	**1**	**±2**	**1.8 - 3.6**	2.66
DHT22	1-wire bus	300-1100	31 x 25.1 x 7.7	2.4	1.5	±0.5	3.3 - 5.5	1.39
BME280	I2C and SPI	300-1100	19 x 18 x 3	1	1.2	±1	1.6 - 3.6	1.85

SELECTED	REASONS
BMP180	• **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.** • **Temperature measurement** • **Fully calibrated** • **Pb-free, halogen-free and RoHS compliant.**

Payload Air Temperature Sensor Trade & Selection

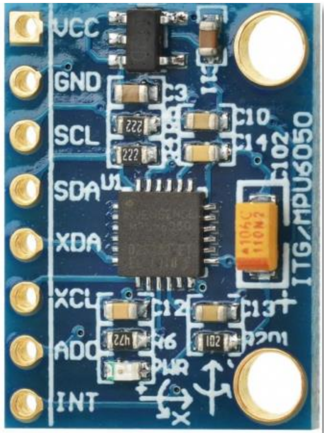
Model Number	Connection Type	Temperature Range (℃)	Size (mm^2)	Weight (gram)	Accuracy (C)	Supply Voltage (V)	Price
DS1621	I2C	-55 - +125	9.47 x 7.62	4	±0.5	2.7-5.5	2.7
Temperature Sensor LM35	ADC	-50 - +150	3 x 2	2	±1	4 – 30	1
BMP180	**I2C**	**-40 - +85**	**5 x 5**	**0.92**	**±0.1**	**1.8-3.6**	**2.66**

SELECTED	REASONS
BMP180	• **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.** • **Temperature measurement** • **Fully calibrated** • **Pb-free, halogen-free and RoHS compliant.**

Pitch and Roll Sensor Trade & Selection

Manufac turer	Model	Dimen sions (mm^2)	Weight (g)	Resolution (bit)	Inter-facing	Specifications	Cost ($)
InvenSense	GY521 MPU 6050	30 x 20	2.1	16	I2C	9-Axis MotionFusion Operating current : 3.9mA Gyro Range:±250 500 1000 2000°/ s Acceleration range:±2 ±4 ±8 ±16g	1.5
Adafruit	MMA 8451	14.5 x 20.5	1	14	I2C	3-Axis accelerometer Acceleration range:±2 ±4 ±8 ±16g	7.95

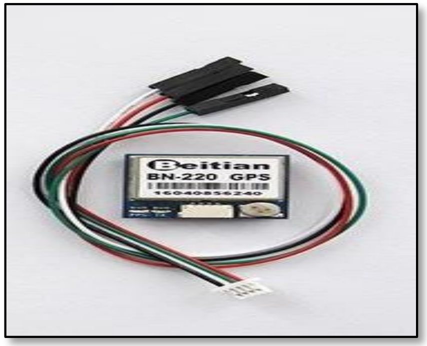
SELECTED	REASONS
InvenSense GY521 MPU6050	• **3-axis gyroscope and a 3-axis accelerometer on the same with an onboard Digital Motion Processor.** • **Increased reliability using sensor fusion of both MPU-6050 gyro and accelerometer .** • **Cost efficiency** • **Efficient Resolution for measuring tilt**



GPS Sensor Trade & Selection

Model	Commu-nication	Size (mm^3)	Weight (g)	Horizontal accuracy (m)	Timing Accuracy (ns)	Resolu-tion (bit ADC)	Proto-cols	Voltage Supply (V)	Cost ($)
BN 220	I2C	22x20x6	5.3	2	1000	10	NMEA-0183, Default NME-0183	3.0 - 5.5	9.11
SIM808 GSM	UART	24x24x2.6	48	2.5	10	10	GPS NMEA protocol	3.0 - 5.0	33.62

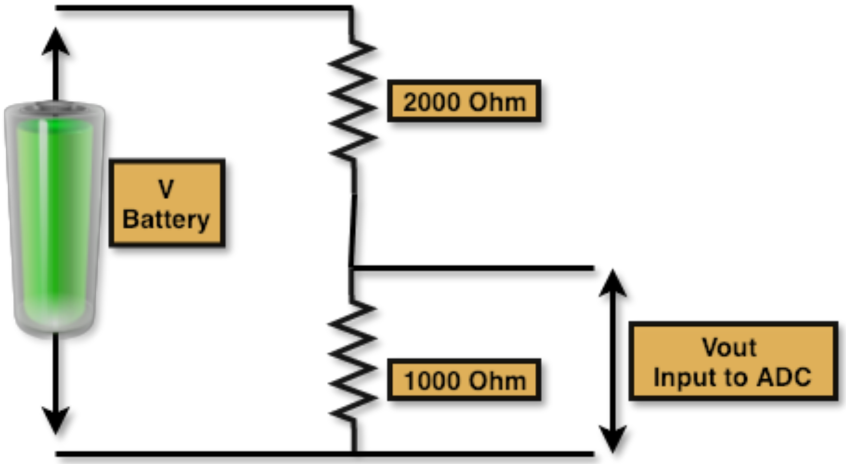
SELECTED	REASONS
BN 220	• <u>**High Accuracy:**</u> **Position Horizontal: 2.0 m CEP 2D RMS SBAS Enable (Typical Open Sky) Velocity: 0.1m/sec 95% (SA off)** • **Timing: 1us synchronized to GPS time** • **Low Acquisition Time: Cold start: 26s, Warm start: 25s, Hot start: 1s**



Payload Power Voltage Sensor Trade & Selection

Sensor	Interface	Resolution (mV)	Weight (g)	Size (mm^2)	Cost ($)
Voltage divider circuit	**ADC port**	**23.4**	**.8**	**Discrete Circuit**	**0.2**
Generic Voltage Sensor Module	3P connector to ADC	4.89	4	28 x 14	1.39

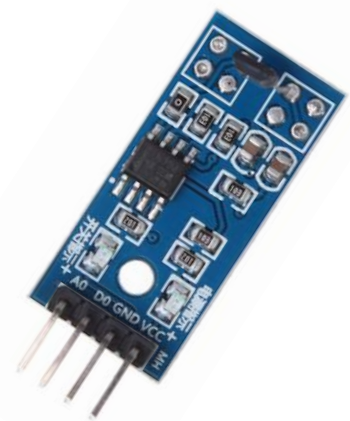
SELECTED	REASONS
Voltage divider circuit	• **Easy to implement and flexible** • **Compact and Light weight** • **Cheaper**



Auto-gyro Blade Spin Rate Sensor Trade & Selection

Model	Inte-rface	Concept	Dimensions (mm^2)	Resolution (bit ADC or mm)	Power (mA-V)	Weight (g)	Cost ($)
AH44E	GPIO	Hall effect module	32 x12	10 bit	3.5mA-5.0V	3	1
TCRT5000	GPIO	IR Sensor	10.2 x 5.8	10 bit	20mA-5.0V	30	1.2
ECHO-PRO	GPIO	Ultrasonic Sensor	43 x 20	1 mm	20mA-5.0V	14	1

SELECTED	REASONS
AH44E Hall Effect Switch	• **Open-Collector 25 mA Output … Compatible with Digital Logic** • **Reverse Polarity Protection** • **Activate with Small, Commercially Available Permanent Magnets** • **Solid-State Reliability** • **Small Size** • **Resistant to Physical Stress**



Bonus Camera Trade & Selection

Name	Weight (g)	Power (mA V)	Resolution	Dimen-sions (mm^2)	FPS	Interface	Supply Voltage (V)	Price
Miniature TTL Serial Camera	3	75 x 5	640 x 480	32 x 32	30	TTL	3.3V	$15.82
Pixy CMUCam5	27	140 x 5	1280 x 800	43 x 39	50	I2C, SPI, UART	5V	$40.85
Turbowing cyclops dvr 3	4.5	130 x 5	1280 * 720	18 x 18	30	GPIO	5V - 26V	$22.4

SELECTED	REASONS
Turbow-ing cyclops dvr 3	• **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 wistles in a single coin size module.** • **Provides transparent imagery, so that night traffic will not appear with excessive exposure. In the event there is a lack of light, it offers a low light exposure.**

Container Air Pressure Sensor Trade & Selection

Air Pressure Sensor	Interface	Pressure Range (hPa)	Dimensions (mm)	Weight (g)	Working Current (mA)	Accuracy (hPa)	Operating Voltage (V)	Cost ($)
BMP180	**I2C**	**300-1100**	**14 x 12 x 0.93**	**0.92**	**1**	**±2**	**1.8 - 3.6**	2.66
DHT22	1-wire bus	300-1100	31 x 25.1 x 7.7	2.4	1.5	±0.5	3.3 - 5.5	1.39
BME280	I2C and SPI	300-1100	19 x 18 x 3	1	1.2	±1	1.6 - 3.6	1.85

SELECTED	REASONS
BMP180	• **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.** • **Temperature measurement** • **Fully calibrated** • **Pb-free, halogen-free and RoHS compliant.**

Descent Control Design

Aayush Aggarwal

Descent Control Overview [1/2]

DESCENT CONTROL SYSTEM

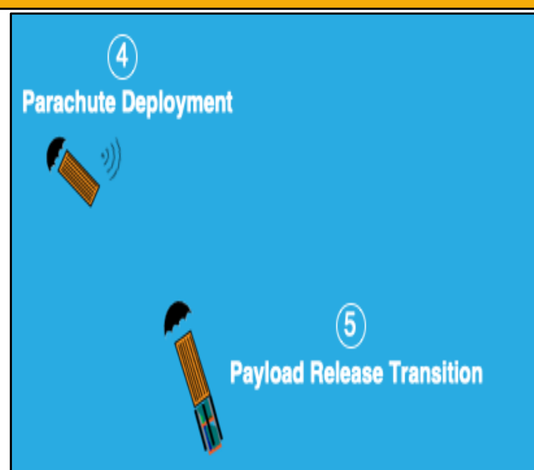
- Consist of a parachute and the science payload descends under auto gyro/ passive helicopter recovery control.

DEPLOYMENT AND RELEASE ORDER

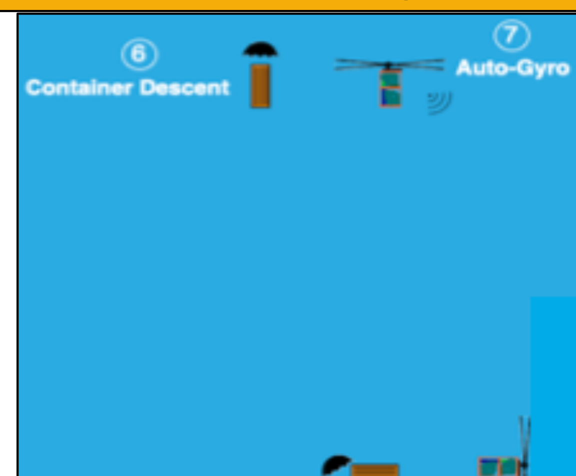
- Payload is deployed at an altitude of 670 – 725 meters and the parachute is deployed which results in a descent rate of 20 ± 5m/s.
- At 450 meters the science payload is released, airfoils will be deployed and the payload descends at a rate of 10-15 m/s.

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 Overview [2/2]

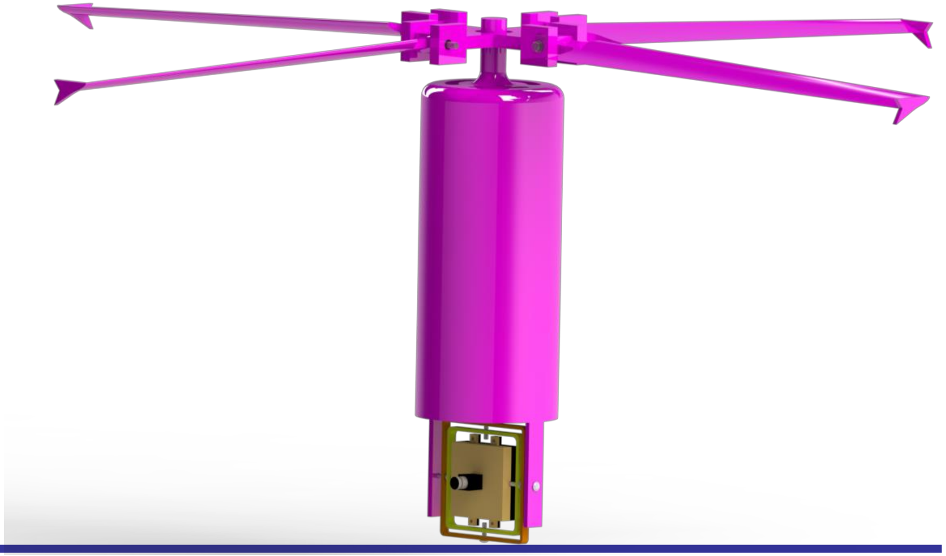
DESCENT COMPONENTS

Parachute

Hexagon Parachute of diameter 8 inch made of 1- mill thick polyethylene plastic will be used

Auto-Gyro

Pitch-Angle = + 5 degrees



Nadir Configuration

Centre of Buoyancy is above Centre of Gravit. Hence, CanSat remains in Nadir configurations

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 Strategy Selection and Trade [1/7]

Payload Descent Control Strategy For Container and Payload

Shape	Diameter (inches)	Drag Coefficient	Mass(g)	Price($)	Descent Rate (m/s)
Cruciform Parachute	12	1.5	20	6.9	9.8
Hexagonal Parachute	8	0.75	5.2	3.39	19.14

Cruciform Parachute

Hexagonal Parachute

Descent Descent Control Strategy Selection and Trade [2/7]

Cruciform Parachute

Hexagonal Parachute

Shape	Merits	Demerits
Cruciform Parachute	1. Balanced load distribution	1. High probability of drift in the air. 2. Faster landing
Hexagon parachute	1.They are much stronger than the traditional plastic chutes. 2.Can withstand brutal openings easily.	1. Balanced load adjustment is more disadvantageous.

Parachute 2 is chosen because build is easier than 1. We chose the hexagonal one because we wanted something **STRONG** that would survive a violent deployment during launch from rocket.

Payload Descent Control Strategy Selection and Trade [3/7]

Payload Descent Control Strategy For Container and Payload

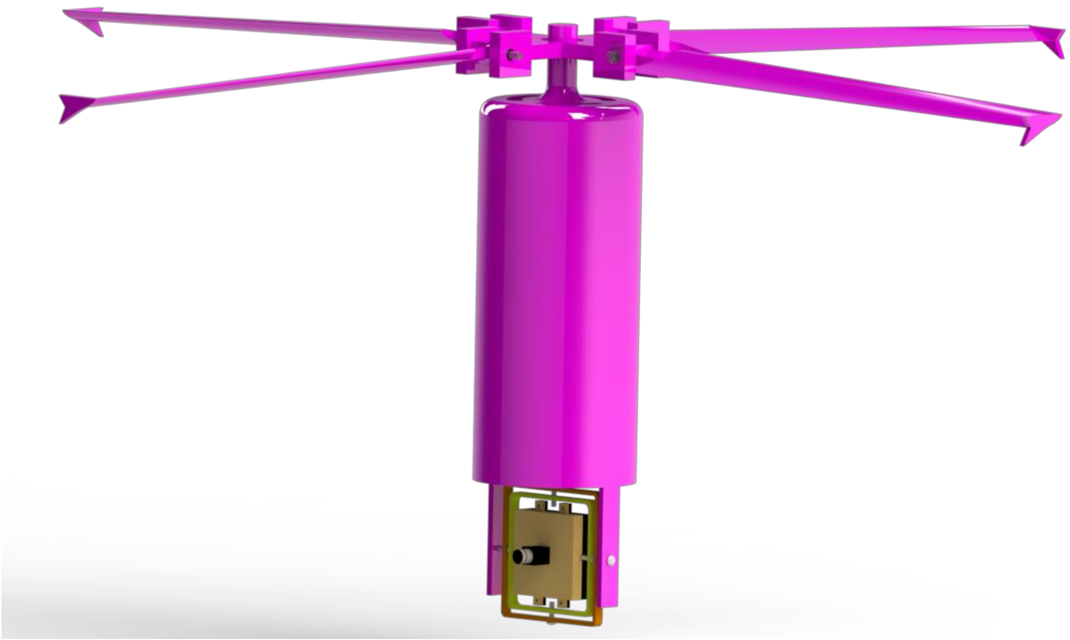
- ✓ Our Parachute is hexagon in shape.
- ✓ Made from 1- mil thick polyethylene plastic.
- ✓ It is a 8 inch diameter hexagonal chute and comes with thick cotton string for the shroud lines, and tear resistant hole reinforcement rings.
- ✓ Parachute radius is 8 inches. (Detailed Competition are provided in the following slides).
- ✓ This Parachute is much stronger than traditional Plastic chutes.
- ✓ It can also withstand brutal openings easily.

Payload Descent Control Strategy Selection and Trade [4/7]

Post Payload: Payload Descent Control Strategy For Payload

GYROPLANE

The rotor hub is mounted on the payload via a ball bearing to which the blades are hinged.



Post-Payload: Payload Descent Control Strategy For Payload

GYROCHASER

Rotor hub is connected to the payload via a Kevlar thread.

Payload Descent Control Strategy Selection and Trade [6/7]

	Merits	Demerits
Gyro-chaser	• Optimized to fly higher into the sky due to both its lightweight components and low drag aerodynamic shape. • It cuts down an aerodynamic drag, which means the rocket can zoom higher into the air. • Designed to rotate freely, due to which it limits the rotational drag of the spinning rocket, which could slow down the spinning of blades.	• It goes such high in the air and hangs in the air so long leading to less stability and poor descent. • Since it has such a lightweight nose and hub. It has a very little inertia, which means the hub slows down very fast when it ejects out of the tube. • At the tip of rotor blades , the blade is thinner, because of which the angle of attack is less, keeping the rocket in air for more time.
Gyroplane	• Better structural integrity since the rotor hub is attached to the payload via a bearing thus maximizing the area of applied thrust. • Under strong crosswinds the payload would stay comparatively stable since the central axis of payload is always coincident to the central axis of the rotor hub.	• Adding a bearing makes it comparatively bulkier.

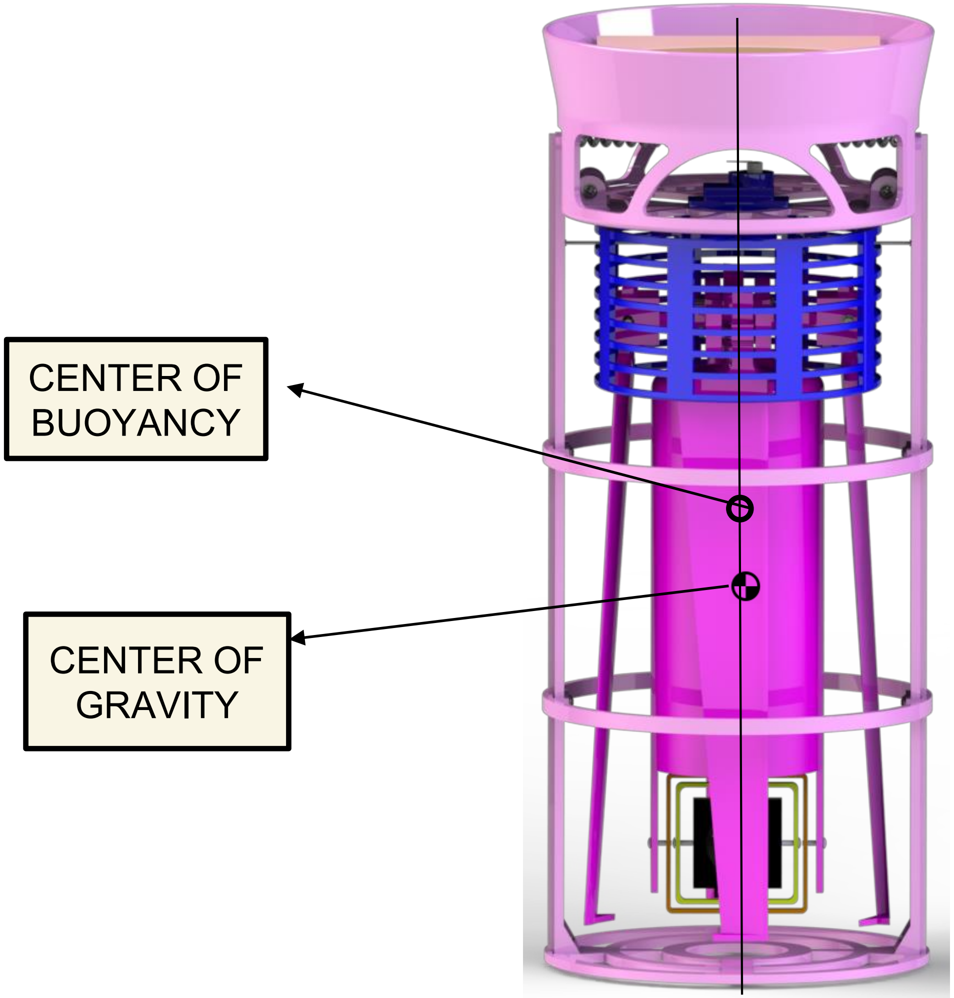
RATIONALE

- Under strong crosswind in Gyrochaser, the payload would deviate more from the normal trajectory than the rotor hub which, would may lead payload to oscillate about the rotor hub, thus, disbalancing the whole descent.
- In Gyroplane, since the rotor hub is directly connected to the payload, any effect of the crosswind caused would be equal on the rotor hub and the payload, thus would comparatively be more stable.
- Gyrochaser turns out to be clumsier when compared to the Gyroplane.

Hence, **Gyroplane is selected**.

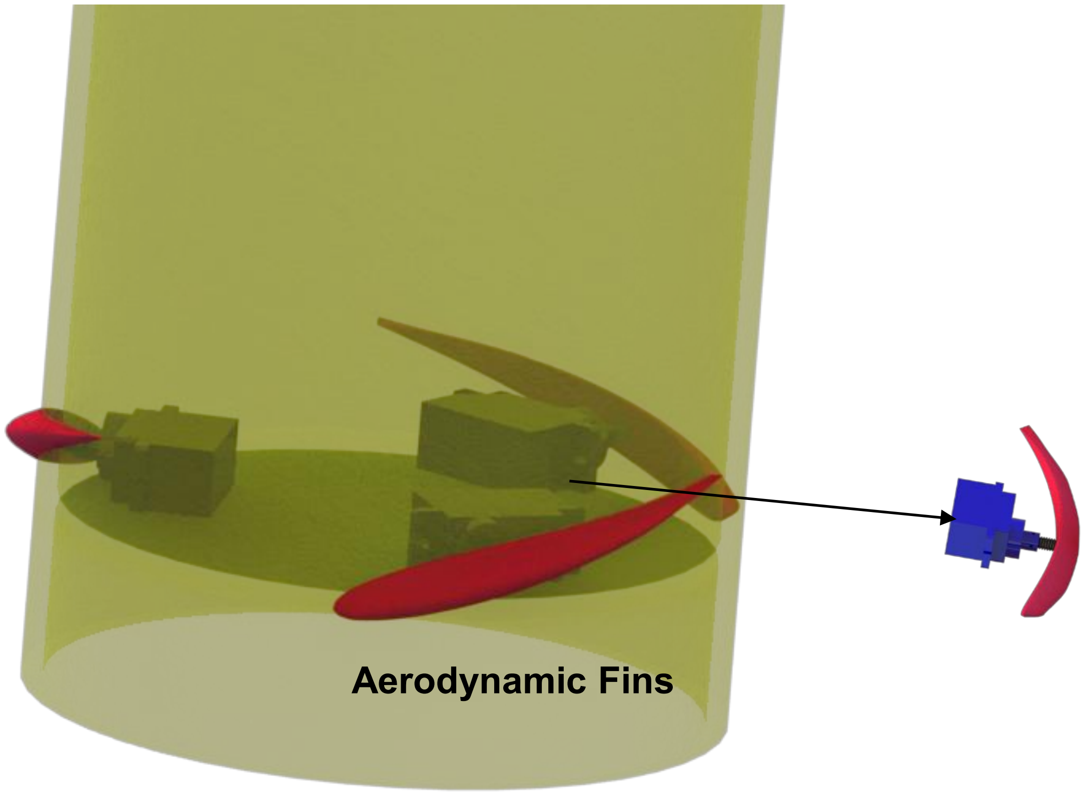
Payload Descent Stability Control Strategy Selection and Trade [1/4]

Passive: Payload Descent Stability Control Strategy For Payload



Payload Descent Stability Control Strategy Selection and Trade [2/4]

Active: Payload Descent Stability Control Strategy For Payload



Payload Descent Stability Control Strategy Selection and Trade [3/4]

Technique	Description	Merits	Demerits
Active Stabilization through aerodynamic fins	• During the state of unstable equilibrium the three motors will receive the feedback from the gyroscope and will move the CanSat accordingly with the help of three outer fins which will provide aerodynamic drag	• If there is less delay in the feedback to the motors, this will lead to a much stable system when compared to the passive stability design	• Spinning the CanSat would also lead to entanglement of the parachute shroud lines and also effect the patch antenna directivity. • This mechanism will bring more weight • Delay in stabilization since it is electronically managed and the motors can receive late feedback, hampering the stability instead.
Passive Stabilization	• Since Payload is a fully submerged body in fluid(air) and HyperWorks analysis has calculated the center of buoyancy point above center of gravity, it will produce a torque in the opposite direction during its oscillations about the center of buoyancy point, thus leading to a state of stable equilibrium and point in nadir direction. This analysis has been done taking into assumption the zero velocity of air	• No extra parts required • Lightweight • Cheap, simple	• On the day of launch however if there are high velocity winds the center of buoyancy point will shift and metacenter point will come into action but it will change with time. Thus stable equilibrium is dependent on the launch day wind conditions.

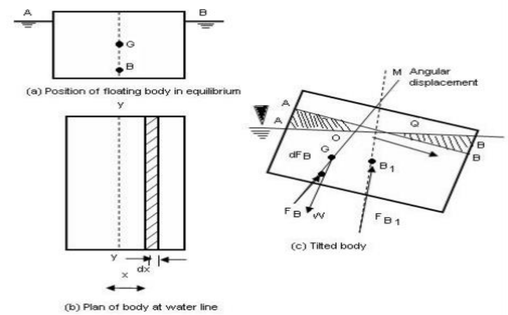
Therefore, active stability control is not possible and our passive stability control system worked quite well in stabilizing our CanSat last year

Passive: Payload Descent Stability Control Strategy 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).**



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

Descent Rate Estimates [1/13]

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

Descent Rate Estimates (Container & Payload) [2/13]

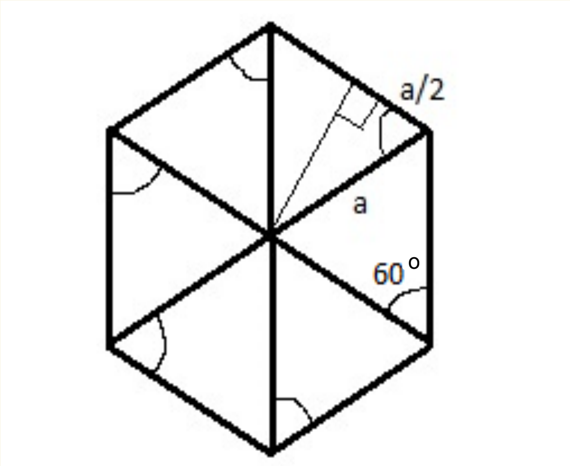
CanSat's (Container + Payload) Parachute landing Calculations

- 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)

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

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

Descent Rate Estimates (Container & Payload) [3/13]

CanSat's (Container + Payload) Parachute landing Calculations

$$a = \sqrt{\frac{5(2)(2)\ kg\ m/s^2}{(\ 1.225\frac{kg}{m^3})(3\sqrt{3})(400\frac{m^2}{s^2})(0.75)}}$$

$$a = \sqrt{\frac{20\ m^2}{1909.58}} = \sqrt{0.010473}\ \text{m} = 0.10234\ \text{m}$$

$\sqrt{3}a$ = 0.1770482 m = **7.34 inches**

(This is the desired diameter of the parachute)

Where, a = length of side of parachute

C_d = drift coefficient

V = Landing speed (m/s)

ρ = Air density at +15°c from sealevel

Descent Rate Estimates (Container & Payload) [4/13]

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

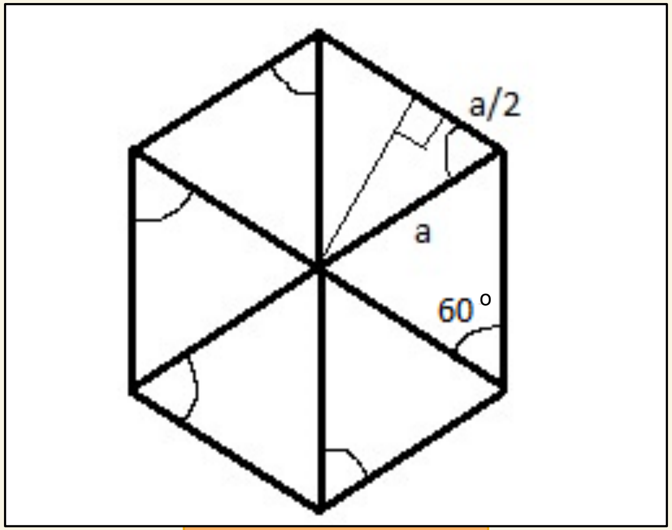
v = $\sqrt{\frac{2(0.5)(9.8)(2)}{1.225(0.75)(3\sqrt{3})(0.11284)^2}}$ m/s

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

v = 19.14 m/s

T = 32.12 s

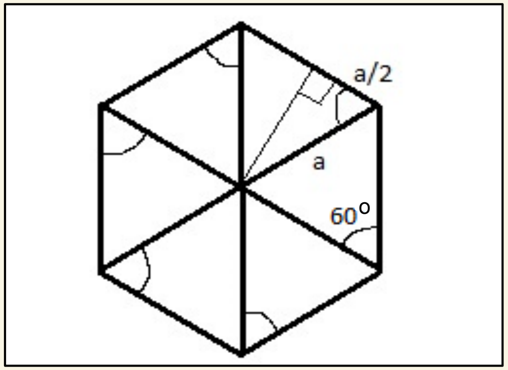
Our Parachute will land with this velocity.



Hexagon made of 6 equilateral triangles.

Container: Container parachute landing calculation after payload is released

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



F_d = mg (ii)

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

From (i) and (ii)

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

(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

$V = \sqrt{96.86}$ m/s

= **9.84 m/s**

T = 54.88 S

- This is the velocity of the container after it releases the science payload at an altitude of 450 metres.
- In the above equation,

  F_d = Drift coefficient

  $\rho =$ Air density at +15℃ from sea level

  v = landing speed in m/s

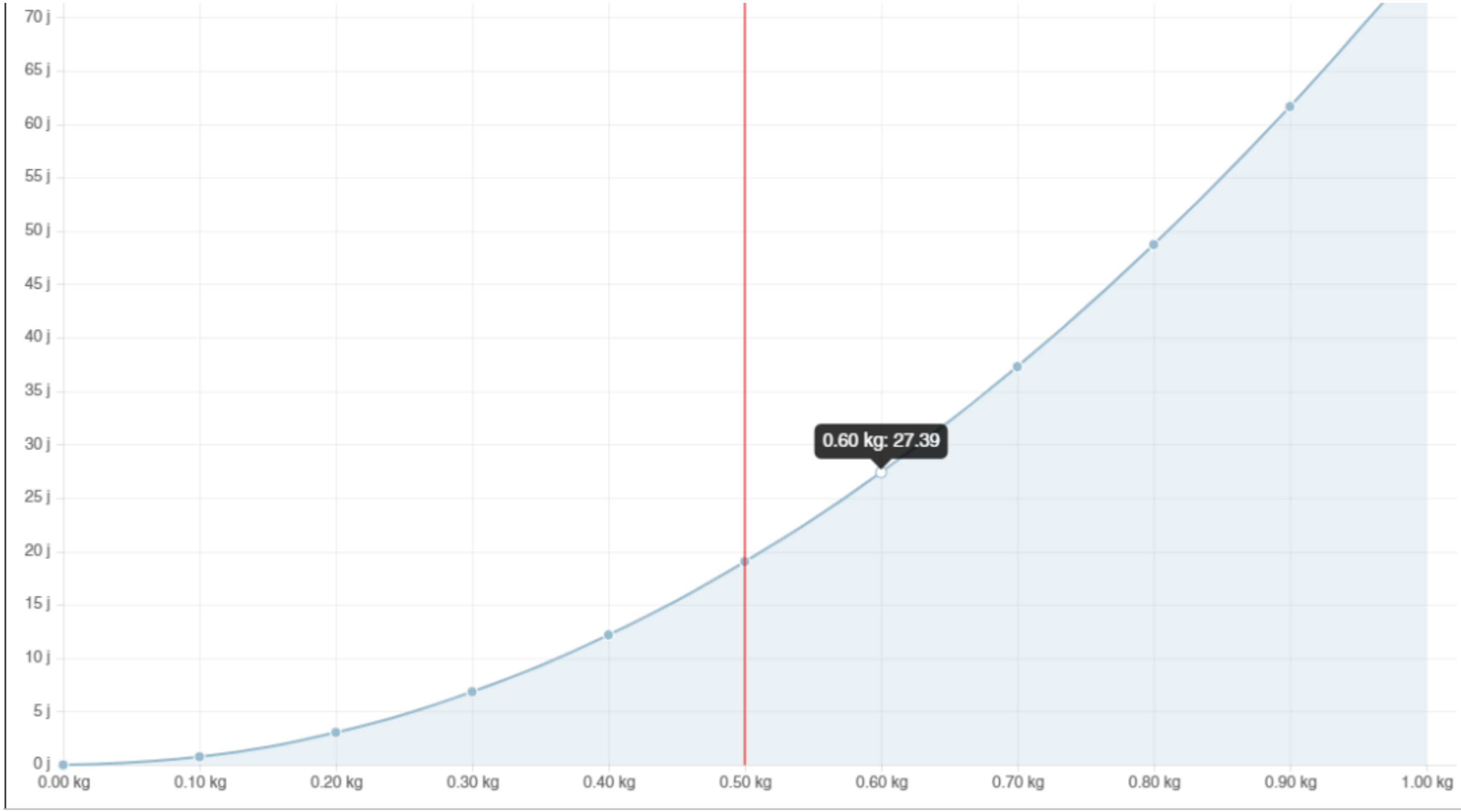
  a = length of side of parachute

Assumptions – 1. Density of air = 1.225 kg/m^3.

2. Weight of the falling object is equal to drag when it travels with constant terminal velocity.
3. No wind or air currents.

Descent Rate Estimates (Container) [7/13]

Impact Energy Joules vs Weight



Descent Rate Estimates [8/13]

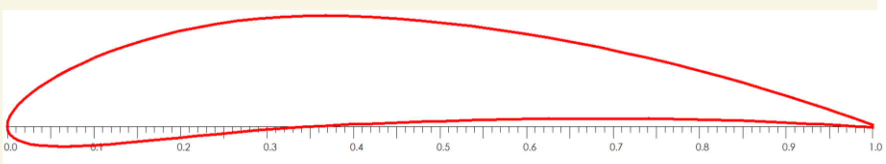
Parachute Specifications

Chute Style:	Hexagonal light weight with shroud lines
Canopy Shape:	Hexagonal
Canopy Diameter(in.):	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(in.):	8.00
Material:	I mil thick polyethylene plastic
Reinforcement Rings:	6.00
Manufacturer:	Apogee components

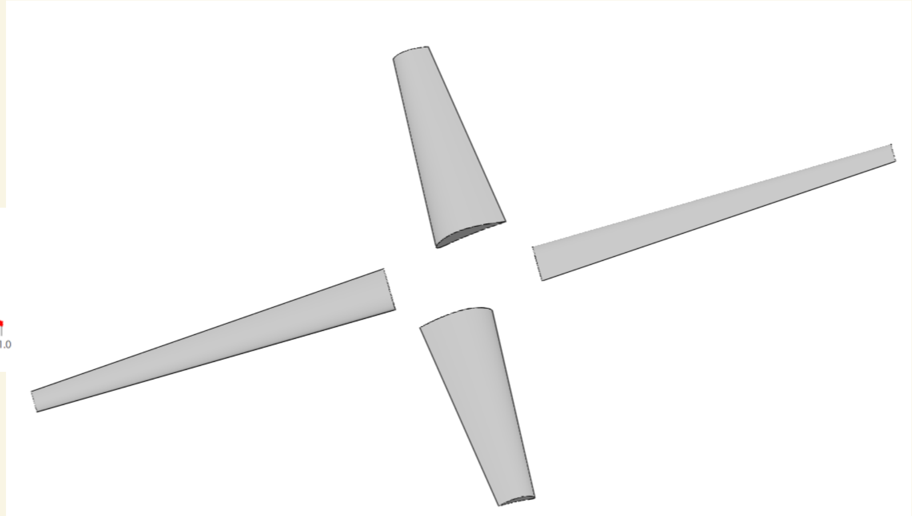
Payload: Autogyro Blade Selection

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

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



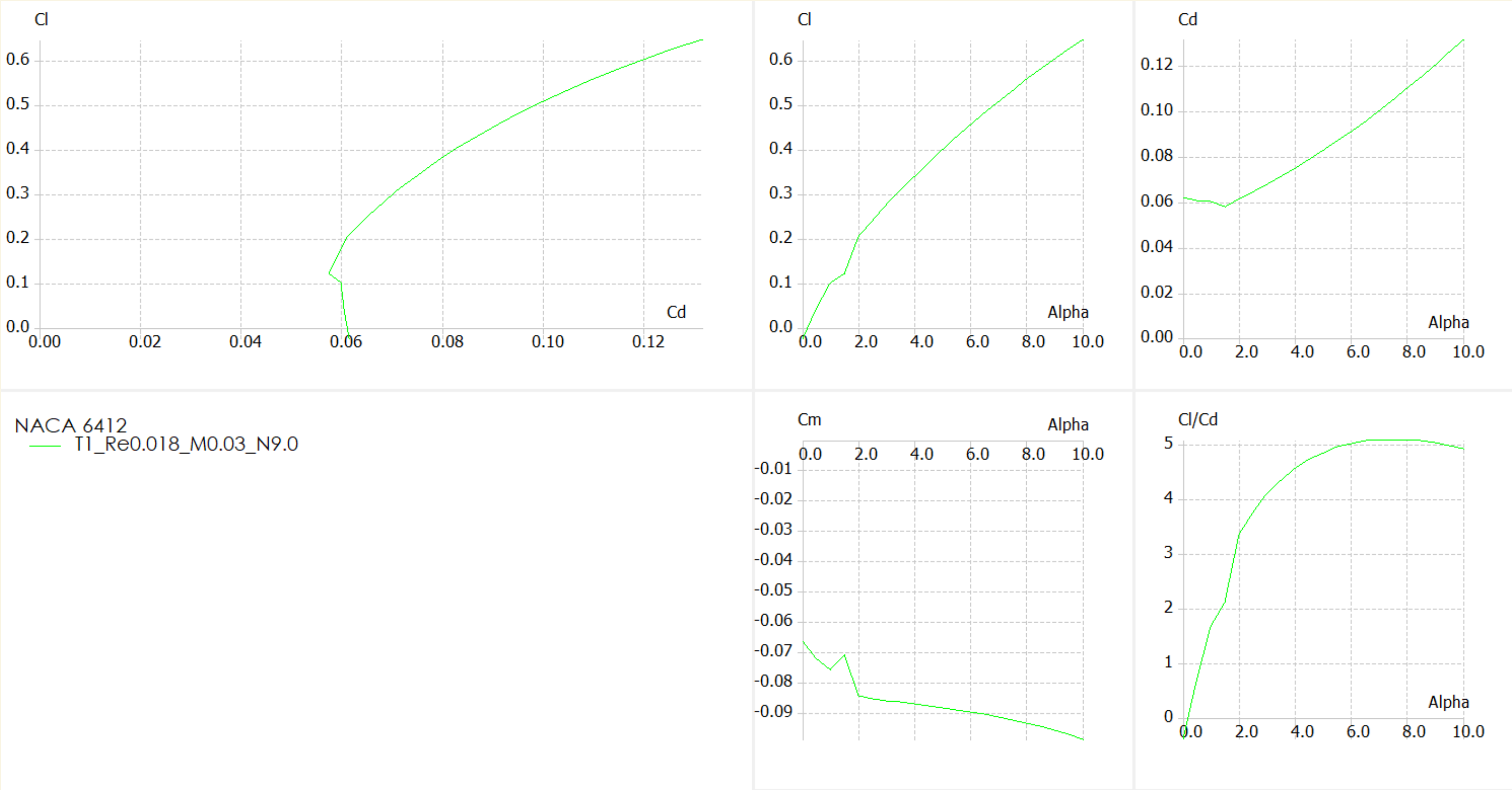
Airfoil geometry



Blade geometry

Payload: Autogyro Blade Selection

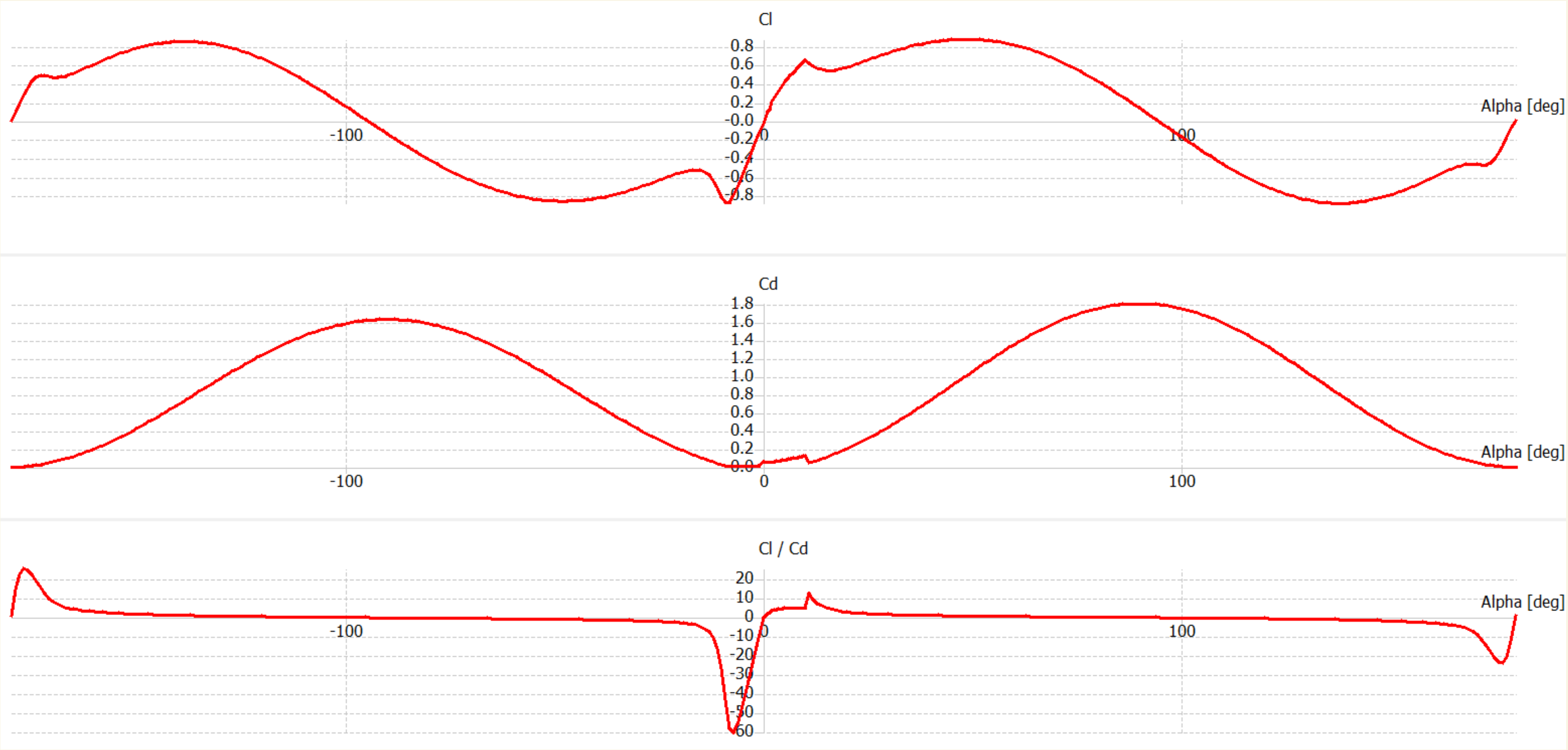
The coefficient of lift and drag graphs with pitch angle are given.



Descent Rate Estimates (Payload) [11/13]

Payload: Autogyro Blade Selection

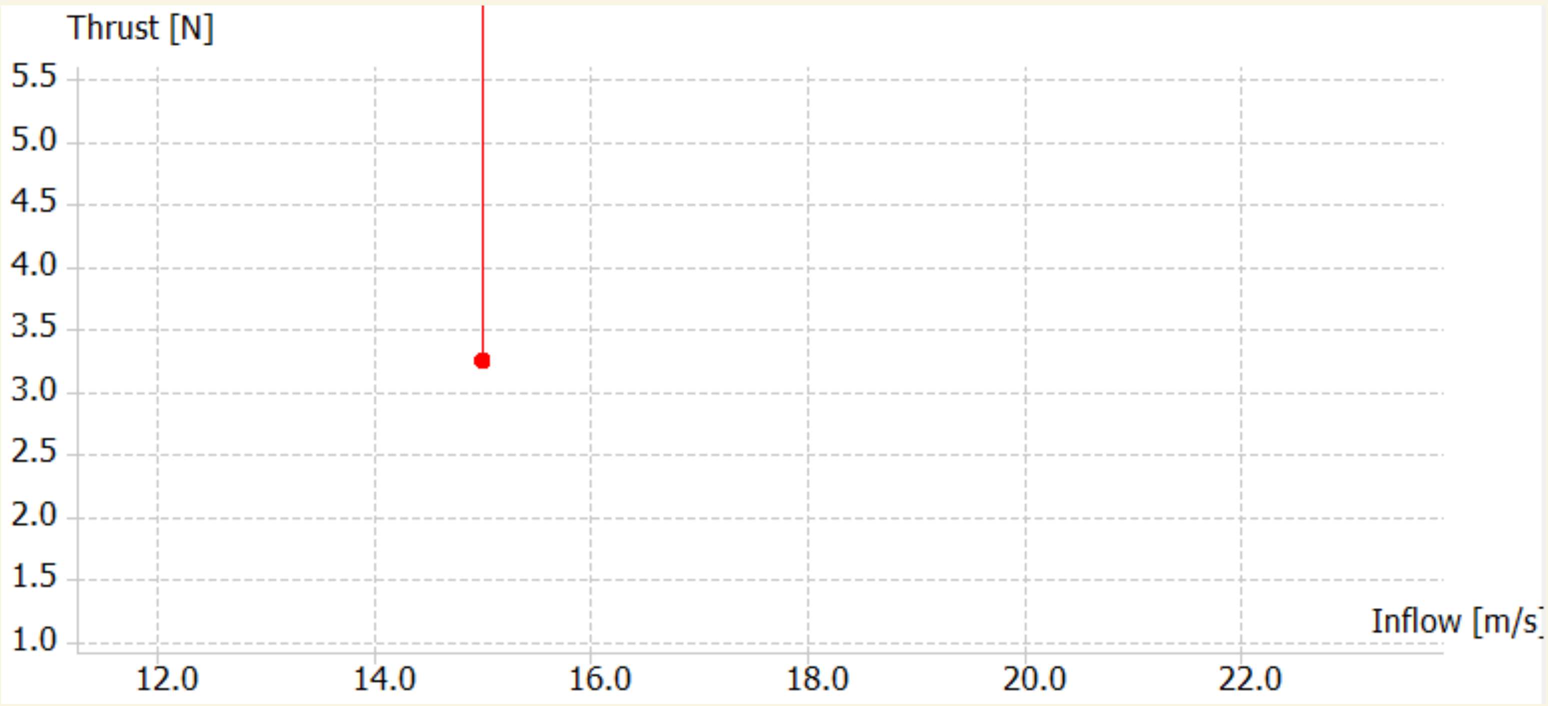
The extrapolated graphs of coefficients of lift and drag are as follows.



Descent Rate Estimates (Payload) [12/13]

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 [13/13]

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

Divyansh Agarwal

Mechanical Subsystem Overview [1/2]

Major Structural Elements

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

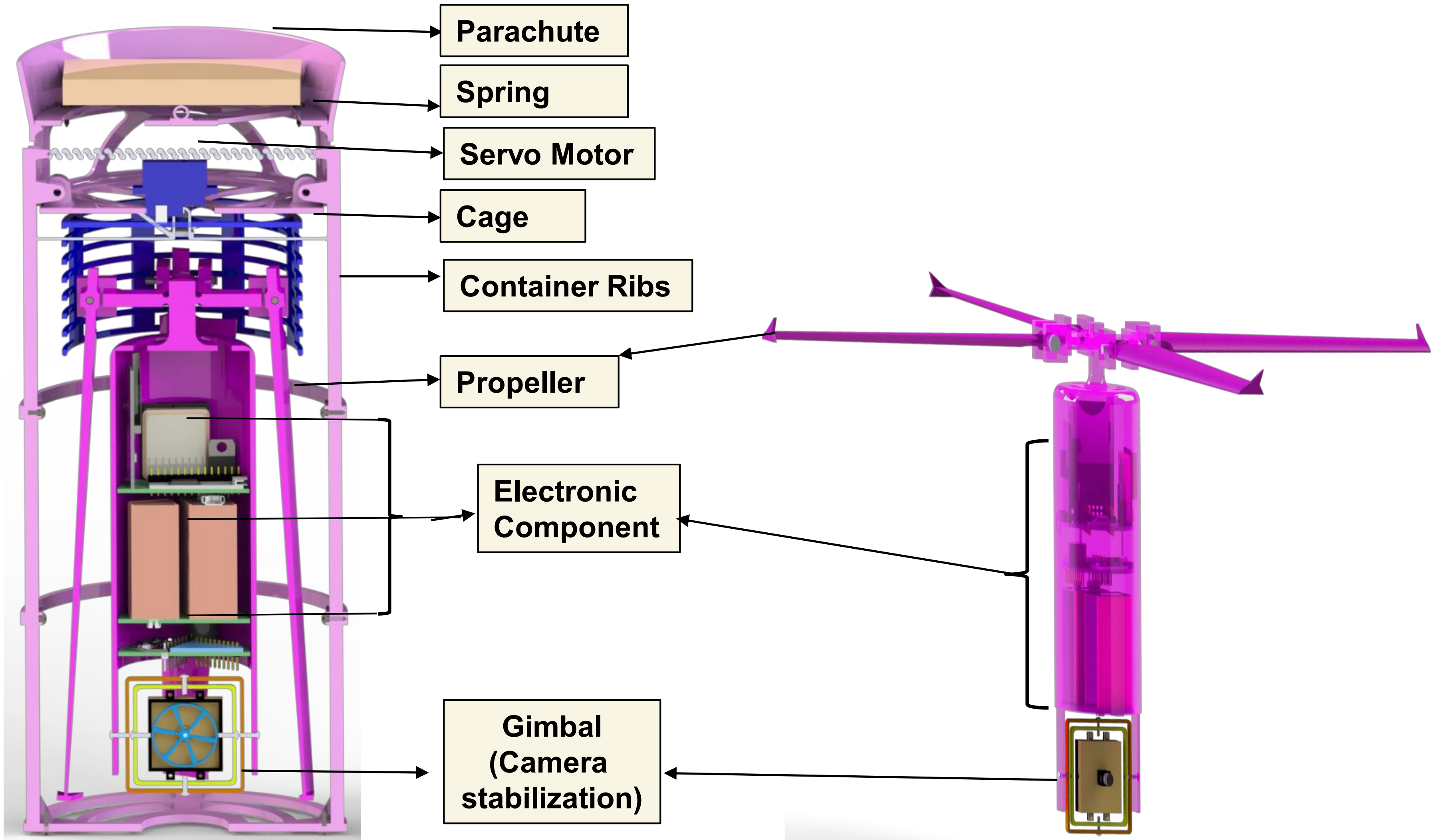
Material Selection

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 Sub-System Requirements [1/2]

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 Requirement			High		✔		

Mechanical Sub-System Requirements [2/2]

ID	Requirement	Rationale	Parent	Children	Priority	Verification Method			
						A	I	T	D
MSR-5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Competition Requirement			High	✓			
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	✓	✓		

CONFIGURATION 1

The rotor hub is mounted on the payload via a ball bearing to which the blades are hinged.

Merits

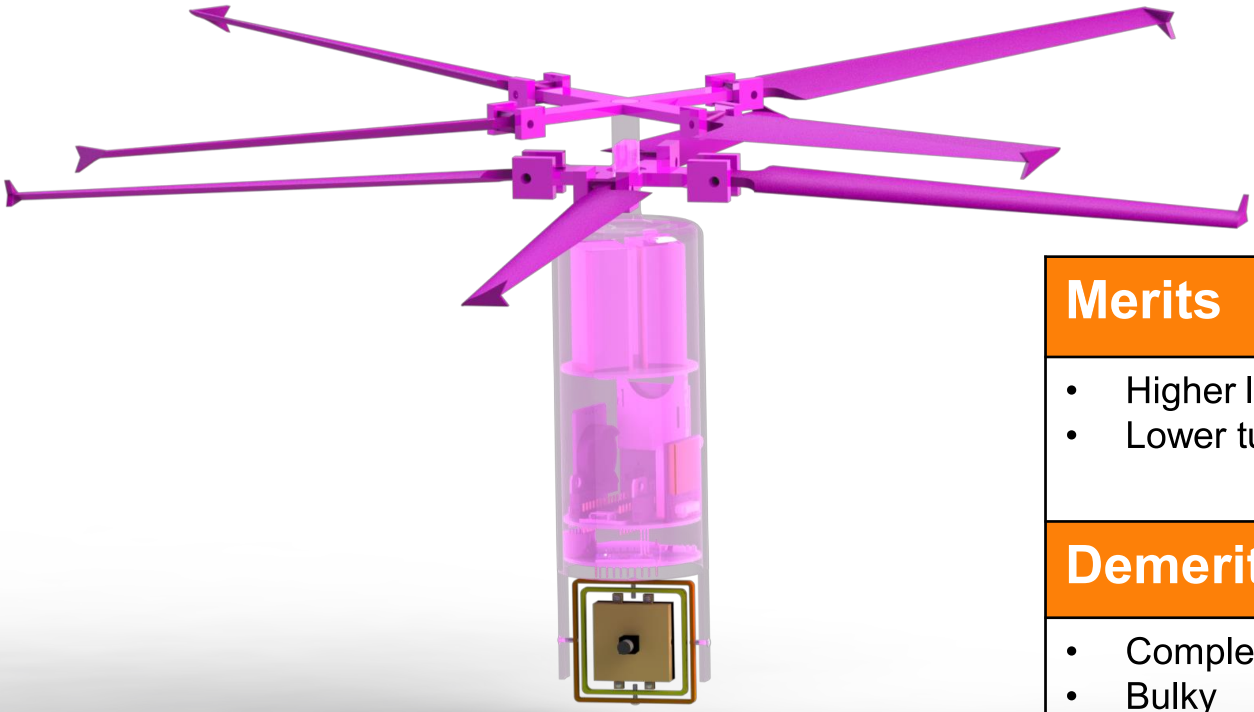
- The payload remain stable even under strong crosswinds.
- Better structural integrity.

Demerits

- Comparatively bulkier due to bearing.

CONFIGURATION 2

Dual rotor hub system is mounted on the payload via a ball bearing to which the blades are hinged.



Merits

- Higher lift is generated
- Lower turbulence

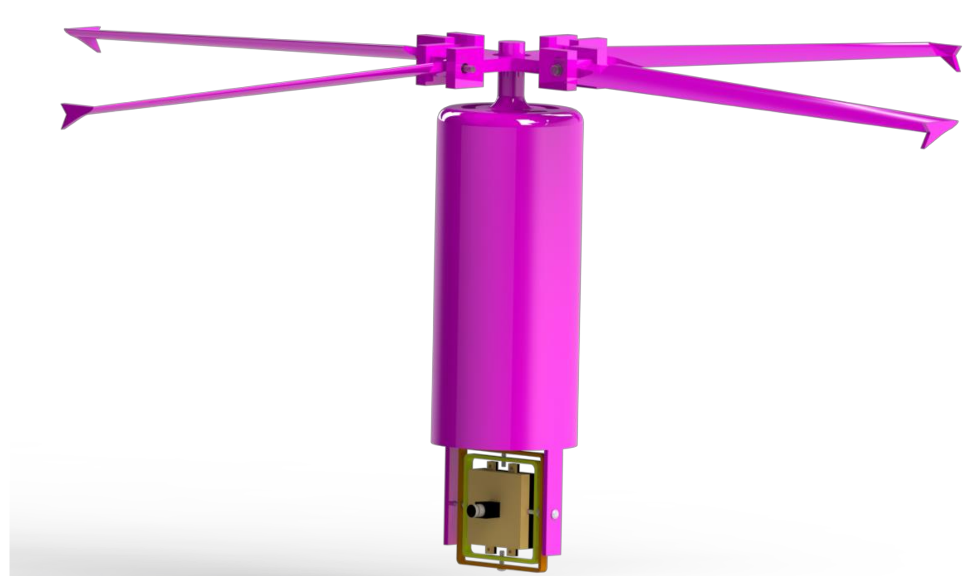
Demerits

- Complex to manufacture
- Bulky
- Takes more space
- High center of gravity

Rationale

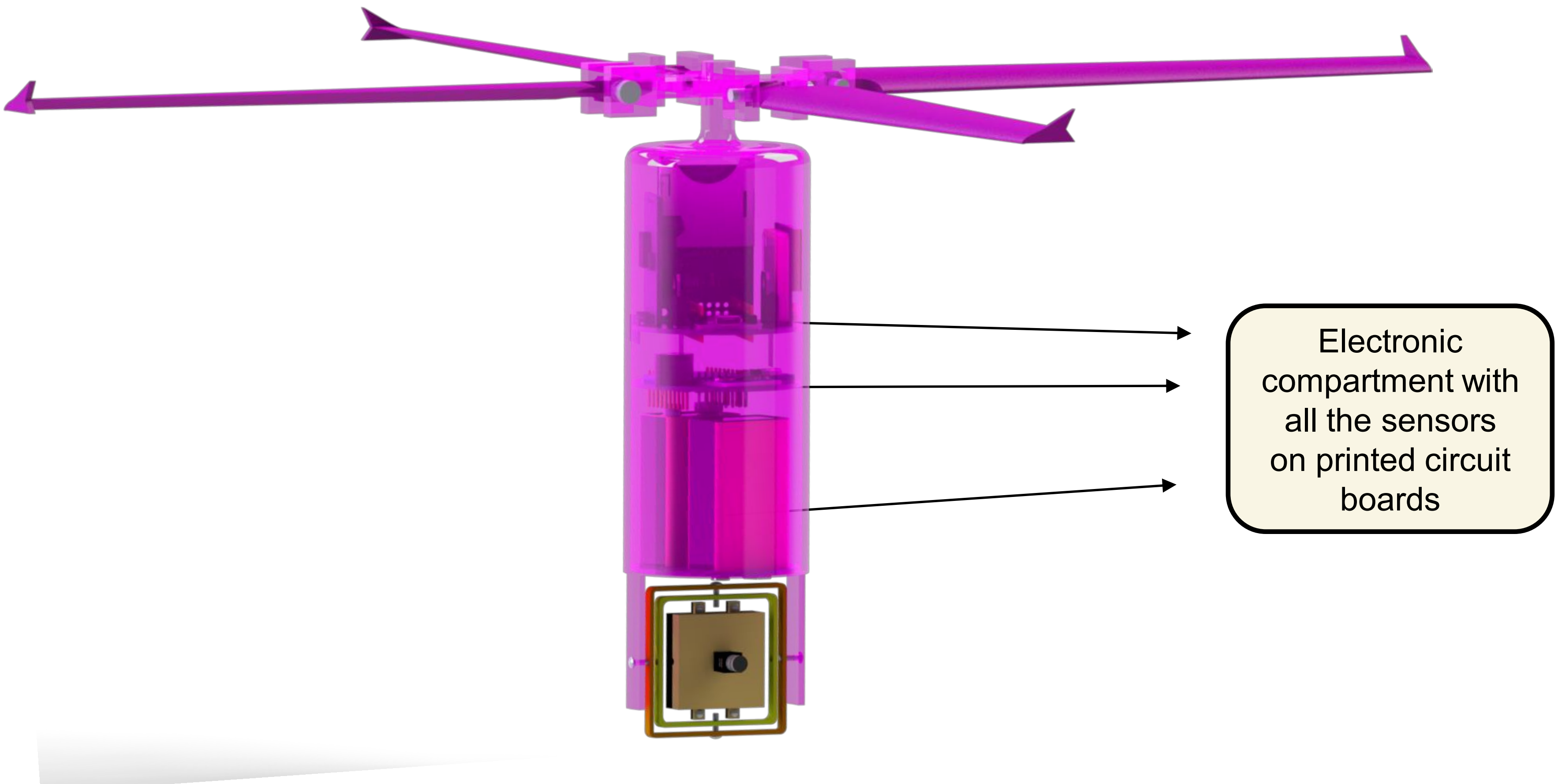
Configuration 1 has lower center of gravity compared to configuration 2 thus, is aerodynamically more stable.

Having four blades compared to eight, in the configuration 2, reduces the amount of thrust but having eight blades with more thrust is rejected owing to the huge weight it brings along with it.



Payload Mechanical Layout of Components Trade & Selection [4/10]

Location of Electrical Components

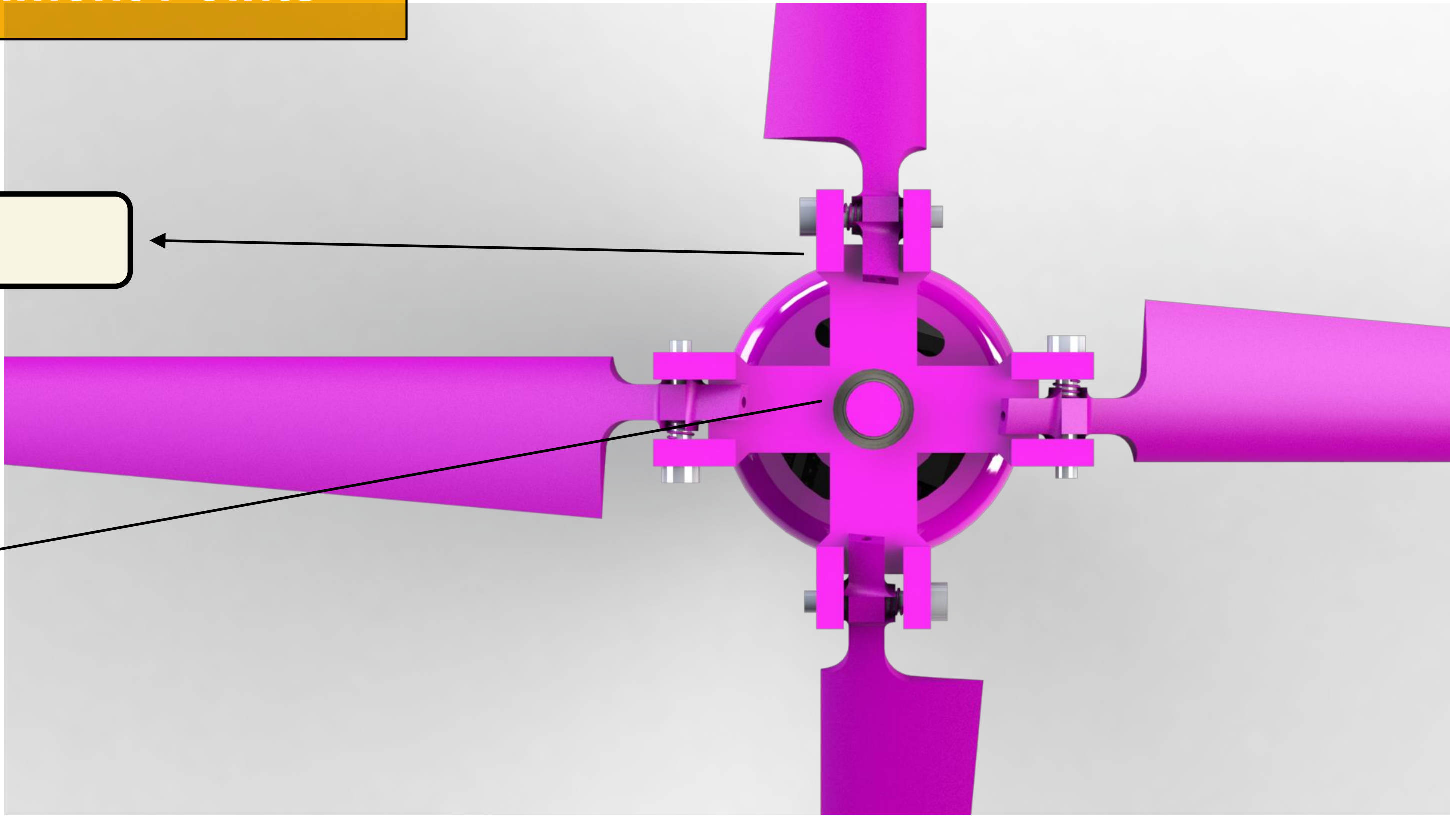


Payload Mechanical Layout of Components Trade & Selection [5/10]

Autogyro Attachment Points

Hinge

Bearing

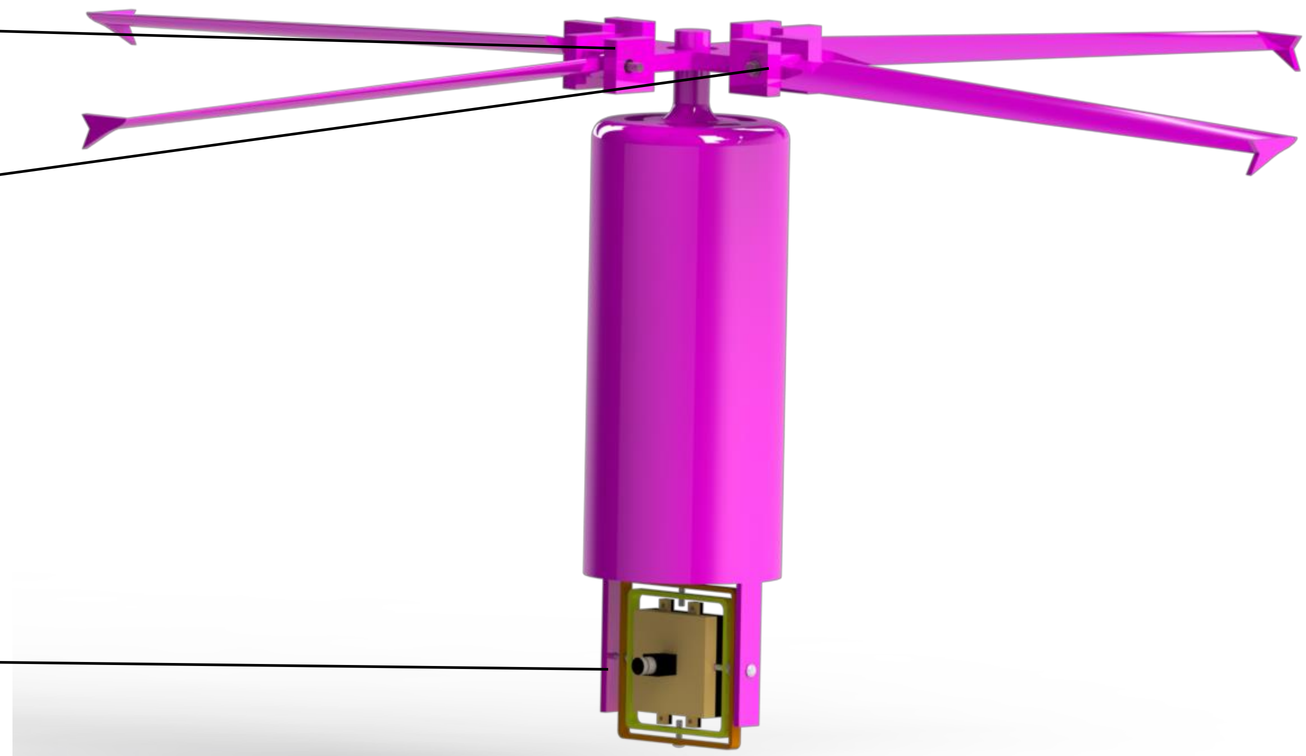


Major Mechanical Parts

Hinge

Torsional spring

Gimbal (Camera Stabilization)



Payload Mechanical Layout of Components Trade & Selection [7/10]

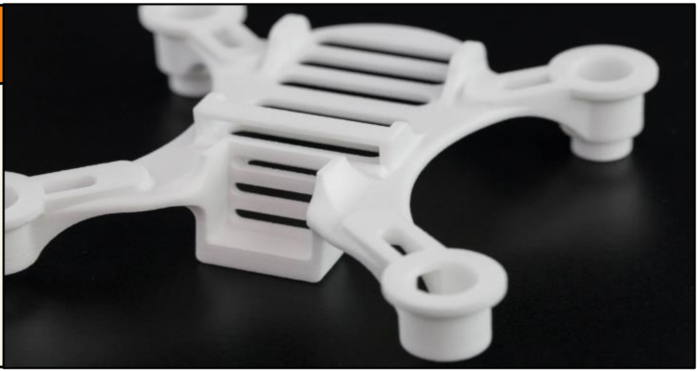
PAYLOAD BODY						
Material	**Density (g/cm^3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
CARBO NFIBRE	1.3	45-48	3D PRINTING (FDM)	$30-80	• Very light and strong	• Radio waves cannot pass through it
HDPE	0.97	32	CNC (machined)	$30	• Strong and durable. • Relatively light weight.	• Stress cracking

SELECTED	PROPERTY REQUIRED FOR SELECTION
HDPE	• **DOES NOT BLOCK RADIO WAVES** • **CAN ABSORB 30G OF SHOCK** • **HIGH IMPACT STRENGHT**

Payload Mechanical Layout of Components Trade & Selection [8/10]

ROTATING HUB						
Material	**Density (g/cm^3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
NYLON PA 2200	0.93	48	3D PRINTING (FDM)	$25-65	• Flexible and strong • UV and chemical resistant	• Constantly meant to keep dry • It can shrink
HDPE	0.97	32	CNC (machined)	$30	• Strong and durable. • Relatively light weight.	• Stress cracking

SELECTED	PROPERTY REQUIRED FOR SELECTION
NYLON PA-2200	• **RELATIVELY LESSER WEIGHT AND FLEXIBLITY** • **HIGH STRENGTH EVEN AT 1mm THICKNESS**

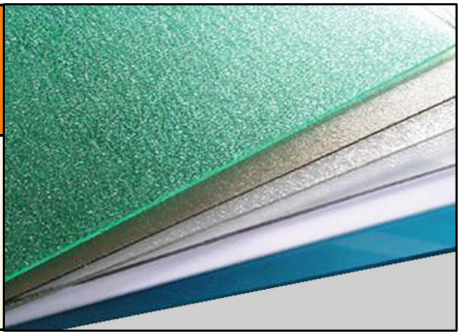


Payload Mechanical Layout of Components Trade & Selection [9/10]

PAYLOAD PROPELLER

Material	Density (g/cm^3)	Tensile strength (MPa)	Manufac-turing Technology	Cost per kg	Advantages	Disadvantages
POLYCARBONATE	1.2	72	3D PRINTING (MJ)	$40-75	• Flexible and Durable • High Tensile Strength	• Needs Warm environment for optimum quality • High price
ABS	1.06-1.08	27-46	3D PRINTING (FDM)	$10-40	• Mechanically strong and long life span	• Toxic and required heated bed • Poor fatigue and UV resistance

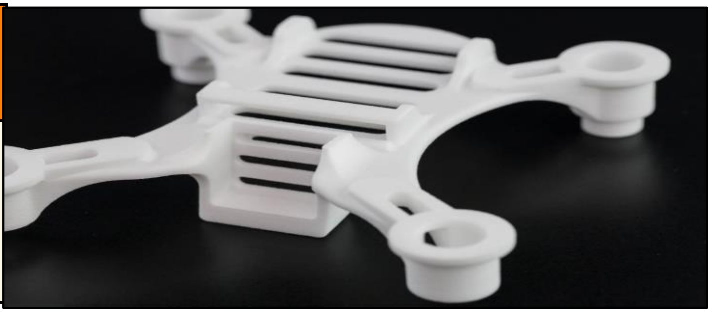
SELECTED	PROPERTY REQUIRED FOR SELECTION
POLY-CARBONATE	• **DURABLE ,LIGHTWEIGHT, SHATTERPROOF AND ENERGY EFFICIENT** • **HIGH STIFFNESS TO WEIGHT RATIO** • **HAVE GLASS LIKE PLANE SURFACES**



Payload Mechanical Layout of Components Trade & Selection [10/10]

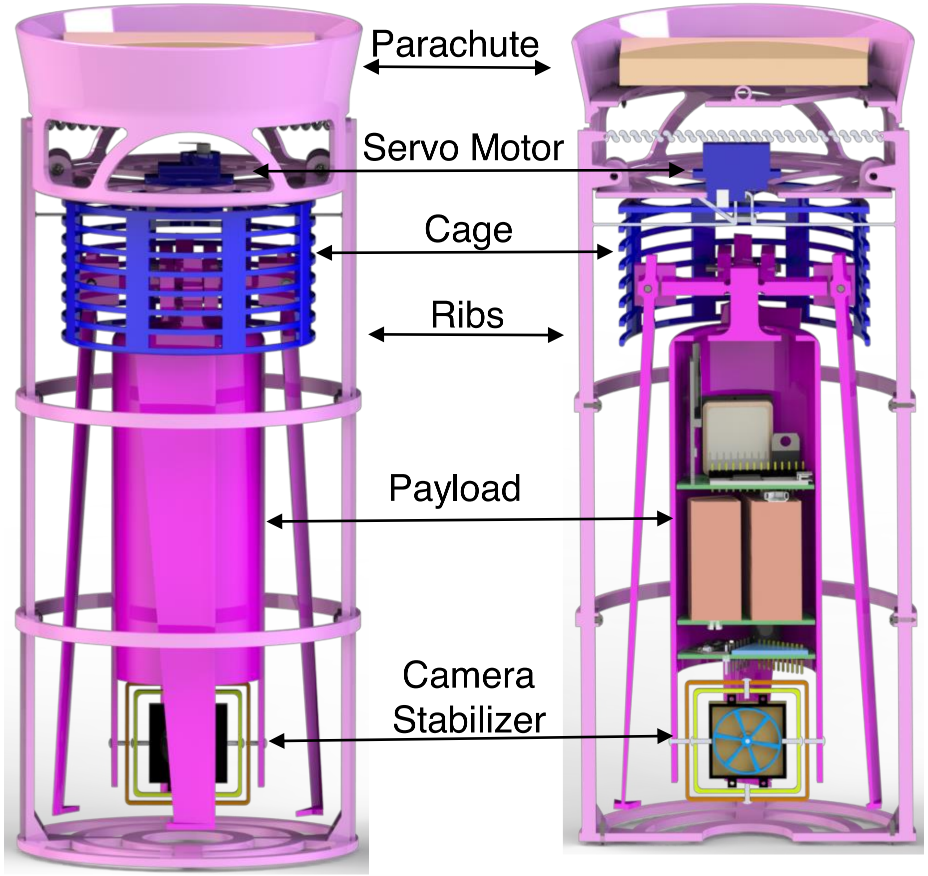
GIMBAL						
Material	**Density (g/cm^3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
NYLON PA 2200	0.93	48	3D PRINTING(FDM)	$25-65	• Flexible and strong • Uv and chemical resistant	• Constantly meant to keep dry • It can shrink
PLA	1.25	37	3D PRINTIND(FDM)	$10-40	• High strength • Low shrinkage and warping • biodegradable	• Relatively heavier • Low flexibility • Low heat distortion temperature

SELECTED	PROPERTY REQUIRED FOR SELECTION
NYLON PA 2200	• **RELATIVELY LESSER WEIGHT AND FLEXIBILITY**



CONFIGURATION 1

The blades are stowed with the help of a cage that is connected to the container.



Merits

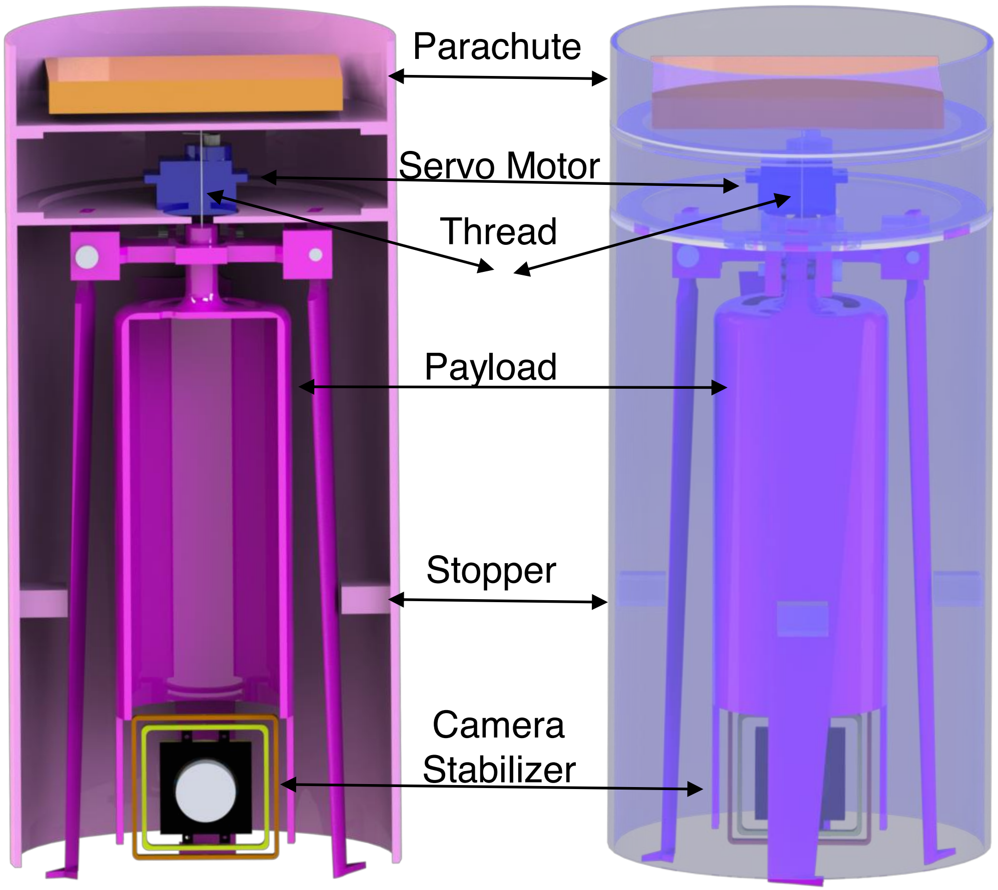
- Less chances of blades getting stuck.

Demerits

- Cage is bulky.
- Cage is difficult to manufacture

CONFIGURATION 2

The blades are stowed with the help of stoppers built in the container.



Merits
• Simple design. • Easy to manufacture

Demerits
• Relatively clumsier approach • Chance of getting blades stuck.

Payload Pre Deployment Configuration Trade & Selection [3/3]

Rationale

- Configuration 2 have payload dangling inside the container and turbulence would make blades to hit the walls of the container repeatedly thus causing structural damage.
- If the payload happens to rotate inside the container which has a high probability in configuration 2 the blades would also hit the stoppers thus may break the hinges.
- In configuration 1 the payload is firmly place and all sort of motion is restricted thus minimizing the chances of unnecessary structural damages.

Hence configuration 1 is selected.

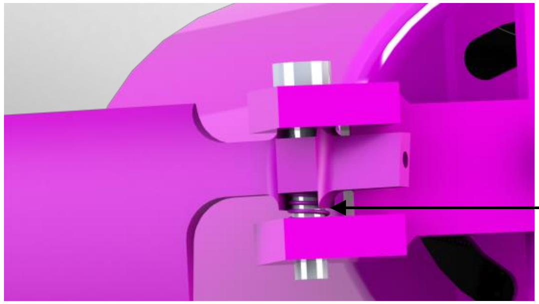
Payload Deployment Configuration Trade and Selection [1/3]

CONFIGURATION 1

- The auto gyro (blades) have torsional spring attached to them. As the Payload is released, the spring relaxes, thus deploying autogyro blades.

Stowed

Deployed



Screw + Spring

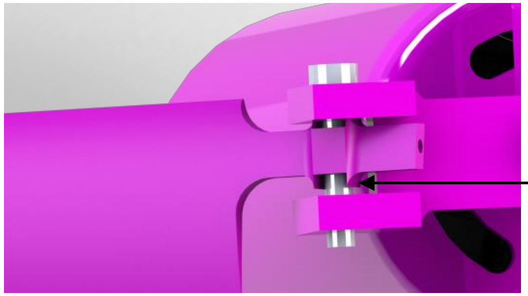
Payload Deployment Configuration Trade and Selection [2/3]

CONFIGURATION 2

- Once the payload is released, the blades open due to air pressure

Stowed

Deployed



Payload Deployment Configuration Trade and Selection [3/3]

RATIONALE

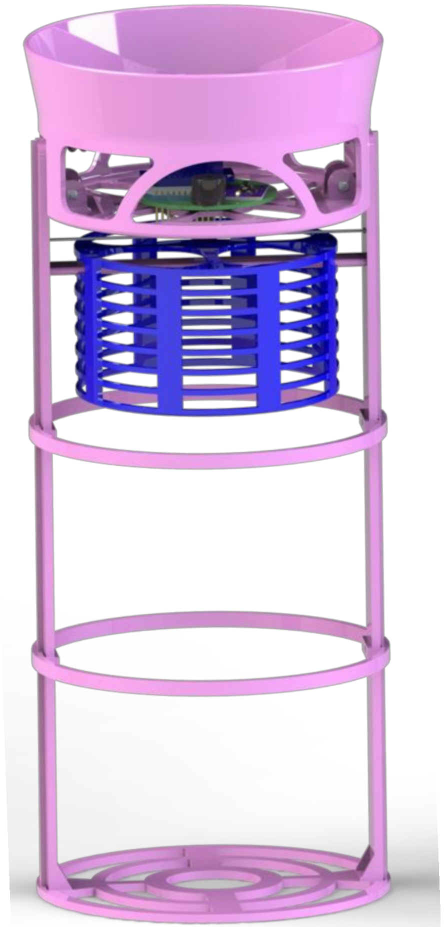
CONFIGURATION 1		CONFIGURATION 2	
Merits	**Demerits**	**Merits**	**Demerits**
• Quick deployment • Since all blades open simultaneously, no instability incurred. • It is very reliable.	• Bulkier	• Simpler design • Lightweight	• Deployment may be asymmetric and time varies greatly, thus may miss the 450 m mark.

Configuration 1 selected over the other due to quick and predictable deploy time.

In configuration 2 since the time required for complete deployment depends on its orientation.

Container Mechanical Layout of Components Trade & Selection [1/11]

CONTAINER CONFIGURATION 1



Configuration 1

Merits

- Light weight
- Last moment changes could be made
- Payload could easily be integrated into the container

Demerits

- Lower structural integrity as the entire weight of the payload is carried by the ribs

CONTAINER CONFIGURATION 2

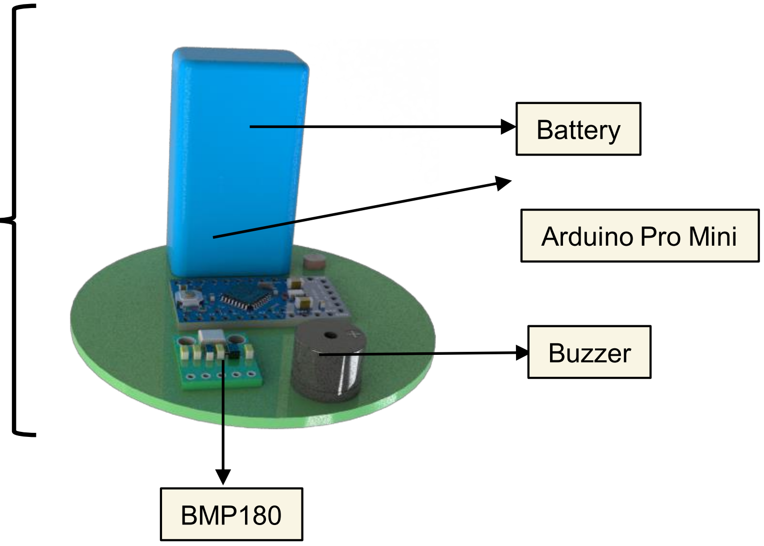
Merits
- The structural forces are more evenly distributed throughout the body
- No moving parts thus minimize the chances of structural failures

Demerits
- Extremely bulky
- Poor mechanical attachment possibilities between payload and container.

Container Mechanical Layout of Components Trade & Selection [3/11]

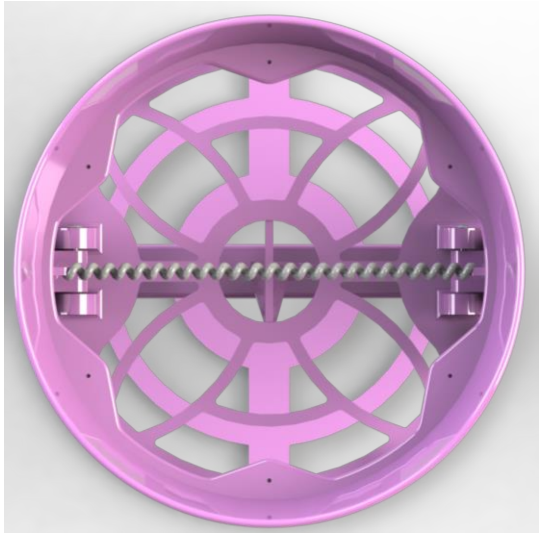
Rationale for selecting configuration 1

- **Configuration 1 being extremely light weight makes it our first choice.**
- **Payload integration is very easy with the added advantages of last moment changes.**
- **Payload is firmly placed in the container rather than just dangling in the air.**

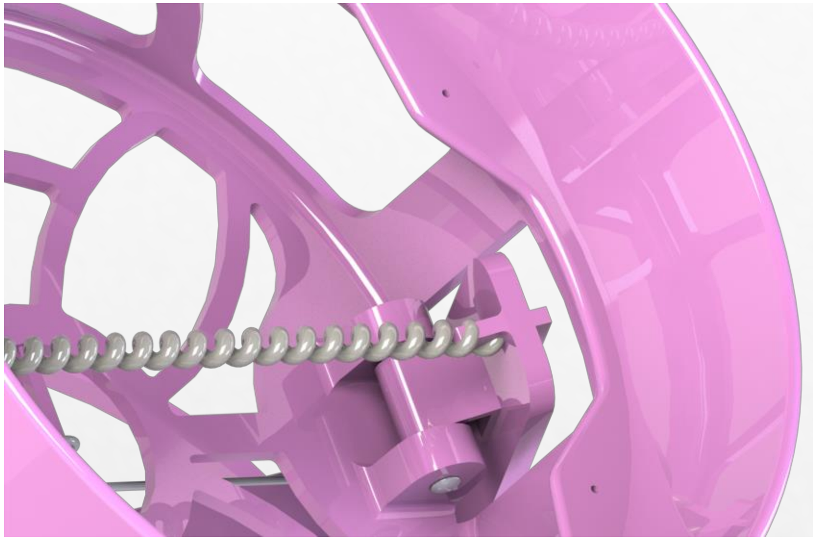


Battery
Arduino Pro Mini
Buzzer
BMP180

Container Mechanical Layout of Components Trade & Selection [5/11]



Spring for container opening



Hinge for container ribs opening

3D printed parachute compartment

Container Mechanical Layout of Components Trade & Selection [6/11]

CONTAINER/PARACHUTE MOUNTING LID						
Material	**Density (g/cm^3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
ABS	1.06-1.08	27-46	3D PRINTING (FDM)	$10-40	• Mechanically strong and long life span	• Toxic and required heated bed
HDPE	0.97	32	CNC (MACHINED)	$30	• Strong and durable. • Relatively light weight.	• Stress cracking • Relatively expensive

SELECTED	PROPERTY REQUIRED FOR SELECTION
HDPE	• HIGH IMPACT STRENGTH • OUTSTANDING RESISTANCE TO FATIGUE

CONTAINER RIB(BODY)						
Material	**Density (g/cm³)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
CARBON FIBRE	1.3	45-48	3D PRINTING (FDM)	$30-80	• Very light and strong	• Radio waves cannot pass through it
HDPE	0.97	32	CNC (machined)	$30	• Strong and durable. • Relatively light weight.	• Stress cracking

SELECTED	PROPERTY REQUIRED FOR SELECTION
HDPE	• HIGH TENSILE AND IMPACT STENGTH • HIGH STRENGTH TO DENSITY RATIO

Container Mechanical Layout of Components Trade & Selection [8/11]

CONTAINER RIBS						
Material	**Density (g/cm^3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
PLA	1.25	37	3D PRINTING (FDM)	$10-40	• High strength • Low shrinkage and warping • biodegradable	• Not very sturdy and deform when exposed to heat
HDPE	0.97	32	CNC (Machined)	$30	• Strong and durable. • Relatively light weight.	• Stress cracking • Relatively expensive

SELECTED	PROPERTY REQUIRED FOR SELECTION
HDPE	• **IT CAN ABSORB 30G OF SHOCK** • **HIGH IMPACT RESISTANCE**

Container Mechanical Layout of Components Trade & Selection [9/11]

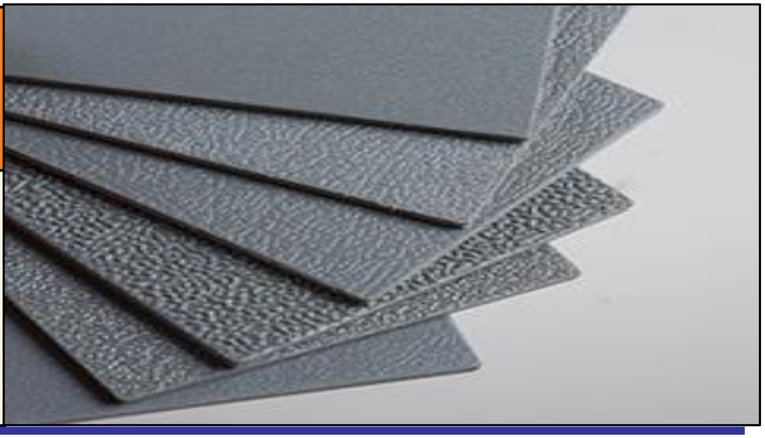
CONTAINER RIBS (BASE)						
Material	**Density (g/cm^3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
POLYPROPYLENE	0.946	40	3D PRINTING (FDM)	$60-120	• Recyclable, stiff and strong	• Impacted by UV • Heavy warping
HDPE	0.97	32	CNC (Machined)	$30	• Strong and durable. • Relatively light weight.	• Stress cracking

SELECTED	PROPERTY REQUIRED FOR SELECTION
HDPE	• **HIGH STRENGTH TO DENSITY RATIO** • **CAN ABSORB 30G OF SHOCK**

Container Mechanical Layout of Components Trade & Selection [10/11]

CONTAINER CAGE						
Material	**Density (g/cm3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
HIPS	1.03-1.04	32	3D Printing FDM	$10-40	• Easy to machine and fabricate. • Strong impact resistance.	• Increase moisture absorption.
ABS	1.04	40	3DPrinting FDM	$24-32	• Mechanically strong and long life span	• Poor fatigue and • UV resistance

SELECTED	PROPERTY REQUIRED FOR SELECTION
ABS	• GOOD IMPACT RESISTANCE WITH TOUGHNESS AND RIGIDITY • RELATIVELY LIGHT WEIGHT



Container Mechanical Layout of Components Trade & Selection [11/11]

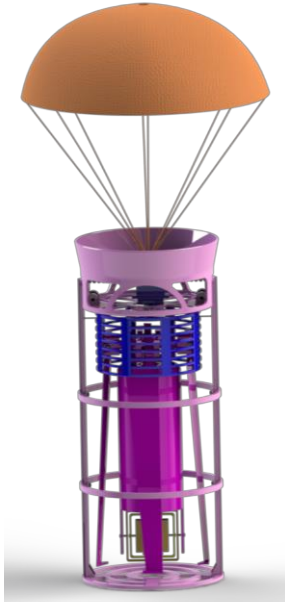
CONTAINER-PARACHUTE SECTION						
Material	**Density (g/cm^3)**	**Tensile strength (MPa)**	**Manufacturing Technology**	**Cost per kg**	**Advantages**	**Disadvantages**
HIPS	1.03	19-26.4	3D PRINTING (FDM)	$24-32	• Easy to machine, • Easy to fabricate. • Strong impact resistance.	• Increase moisture absorption.
HDPE	0.97	32	CNC (MACHINED)	$30	• Strong and durable. • Relatively light weight.	• Stress cracking • Relatively Expensive

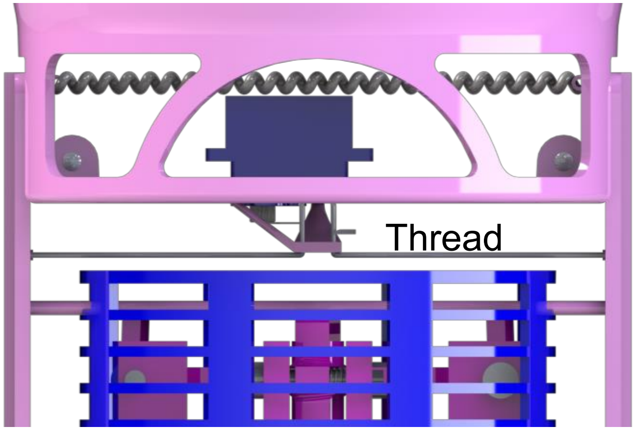
SELECTED MATERIAL	PROPERTY REQUIRED FOR SELECTION
HDPE	• IT CAN ABSORB 30G OF SHOCK • HIGH STRENGTH • RELATIVEY LIGHTWEIGHT

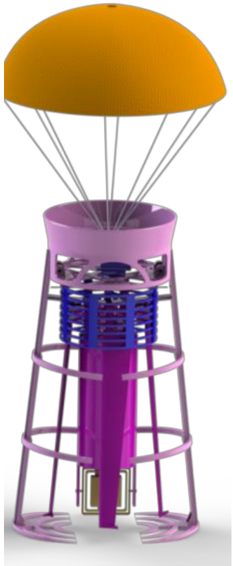
Payload Release Mechanism [1/3]

- Payload is placed inside a cage connected to the container preventing the blades from opening
- The spring, placed inside the container, is in a stressed position when the container is in closed state via a thread. Once the thread is cut by the servo motor, the spring relaxes, pulling and opening the ribs alongside, thus deploying the payload.

Payload Release Mechanism [2/3]



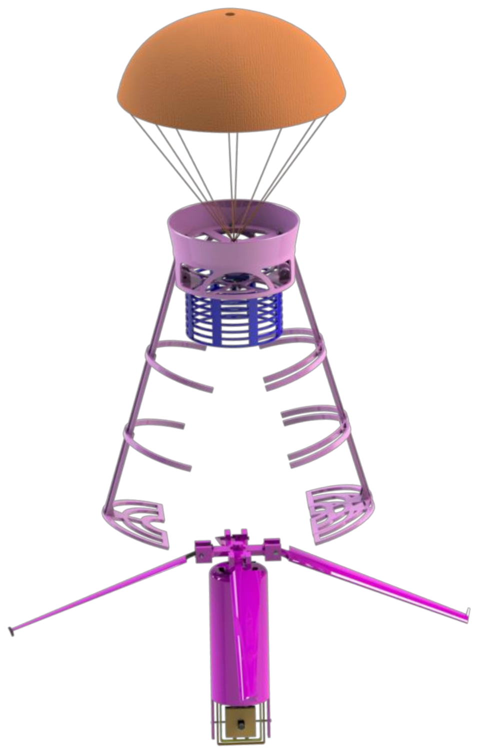




The payload rests on the container base while the CanSat descents.

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

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



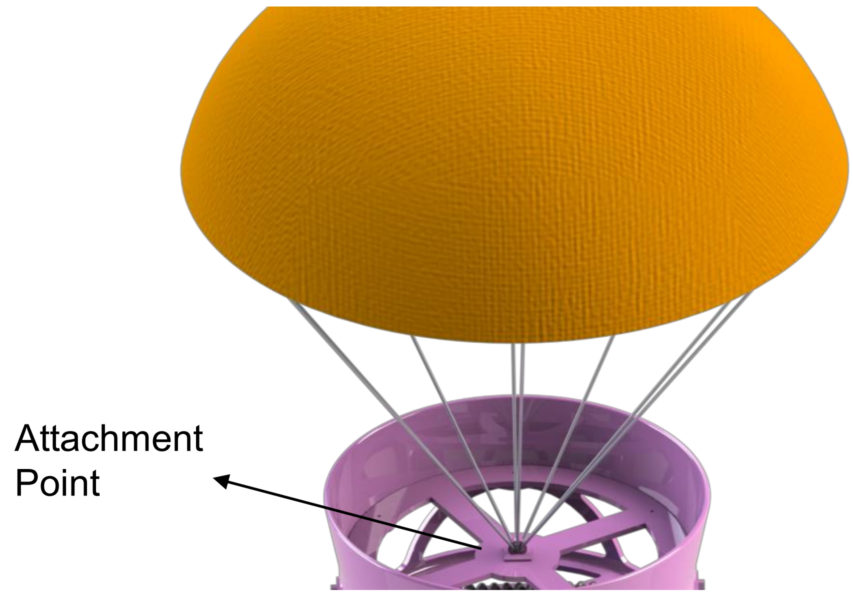
The payload gets free from the cage and container. The autogyro blades start opening.

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

Container Parachute Release Mechanism [1/2]

- Parachute is folded and placed in a compartment having diameter of 110mm and height 24mm.
- The eye bolt, attached at the end of the suspension lines, is fixed on the hook present in the parachute compartment.
- Once the CanSat is released from the rocket, the parachute inflates due to the air pressure thus, deploying itself.

Container Parachute Release Mechanism [2/2]



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.

Electronics Structural Integrity

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)	Uncertainty (Tolerance) & Sources of Uncertainty	Determination (Sources)	Method of Correction
Microcontroller		Teensy 3.2	1	5.2	0.1	Actual	-
Sensors	Air Pressure Temperature	BMP180	1	0.9	0.1	Actual	-
Tilt Sensor		MPU-6050	1	2.1	0.1	Actual	-
Autogyro Blade spin Sensor		AH44E	1	2.9	0.1	Actual	-
GPS Sensor		BN220	1	5.36	0.01	Datasheet	-
Power Voltage Sensor		Voltage Divider Circuit	1	0.8	0.1	Actual	-
XBEE Radio		XBEE Pro S2C	1	4.3	0.1	Actual	-
CanSat Antenna		FXP70 Freedom (Patch Antenna)	1	1.2	0.1	Actual	-
Audio Beacon		MCKPI-G2437	1	1.86	0.01	Datasheet	-
Battery		9V Li-Ion	2	37.00	0.01	Datasheet	-
BLDC Motor		82212/13T	1	50.7	0.1	Actual	-
Camera Stabilization		TurboWing Cyclops DV	1	4.5	0.1	Datasheet	**M1**
		ESC	1	15.0	0.1	Actual	Metallic portion on the wires will be stripped off

Mass Budget [2/8]

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

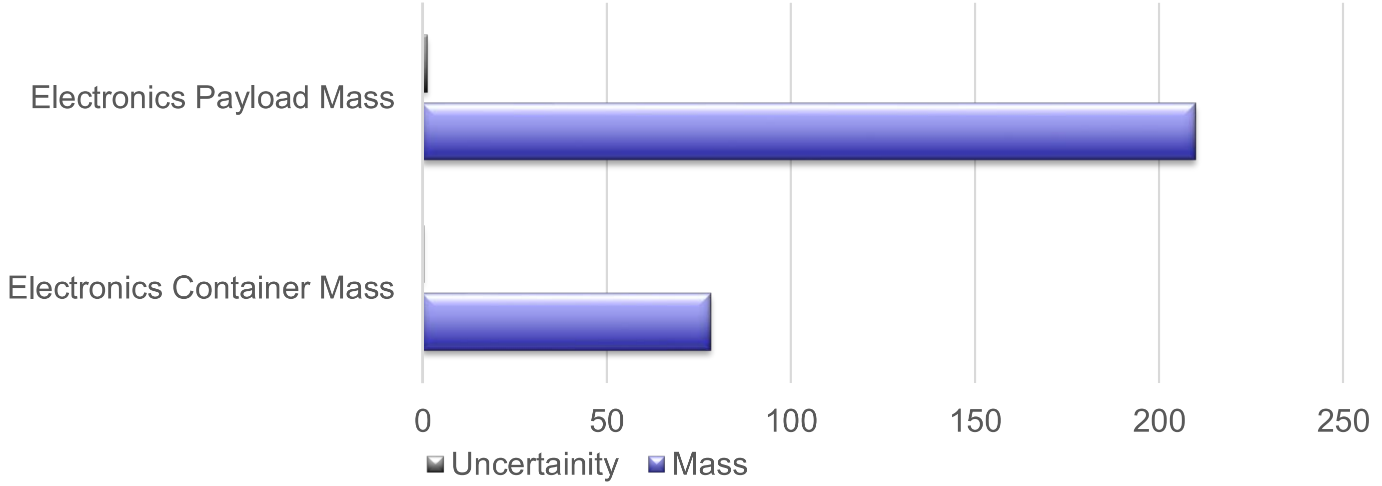
ELECTRONICS – CONTAINER						
Part	**Component Name**	**Quantity**	**Mass (g)**	**Uncertainty (Tolerance) & Sources**	**Determination**	**Method of Correction**
Servo Motor	Micro Servo (9g)	1	14.7	0.1	Actual	
Air Pressure Sensor	BMP180	1	0.9	0.1	Actual	-
Voltage Regulator	LM1117(3.3V)	1	0.98	0.01	Datasheet	-
Voltage Regulator	LM 7805(5V)	1	1.84	0.01	Datasheet	-
Audio Beacon	MCKPI-G2437	1	1.86	0.01	Datasheet	-
Battery	9V Li-Ion	1	40.00	0.01	Datasheet	
Microcontroller	Arduino Pro Mini	1	4.00	0.01	Datasheet	
External Switch	SPDT Switch	1	1	-	Estimated	M2
PCB		1	7	-	Estimated	M1
Misc.	Jumpers, LEDs	-	6	-	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

Mass Budget [4/8]

TOTAL ELECTRONICS MASS BUDGET

Electronics Payload Total Mass	210.03 ± 1.26g
Electronics Container Total Mass	78.28 ± 0.25g
TOTAL	**288.31 ± 1.51g**



Mass Budget [5/8]

MECHANICAL – PAYLOAD							
	Part	**Material**	**Quantity**	**Mass (g)**	**Uncertainty (Tolerance) & Sources**	**Determination**	**Method of Correction**
Structural Elements	**Payload Body**	3D printed HDPE	1	38.26	0.1	Actual	-
	Rotating Hub	3D printed nylon PA-2200	1	18.02	0.01	Simulated	**M5**
	Propeller	Vacuum formed polycarbonate	4	26.37	0.01	Simulated	-
	Gimbal (Camera Stabilization)	3D printed nylon PA-2200	1	20		Estimated	-
Misc.Components	**Misc.**	Adhesives, nuts, bolts, screws etc.	-	10		Estimated	**M6**
	TOTAL			**112.65**	**0.12**		

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.

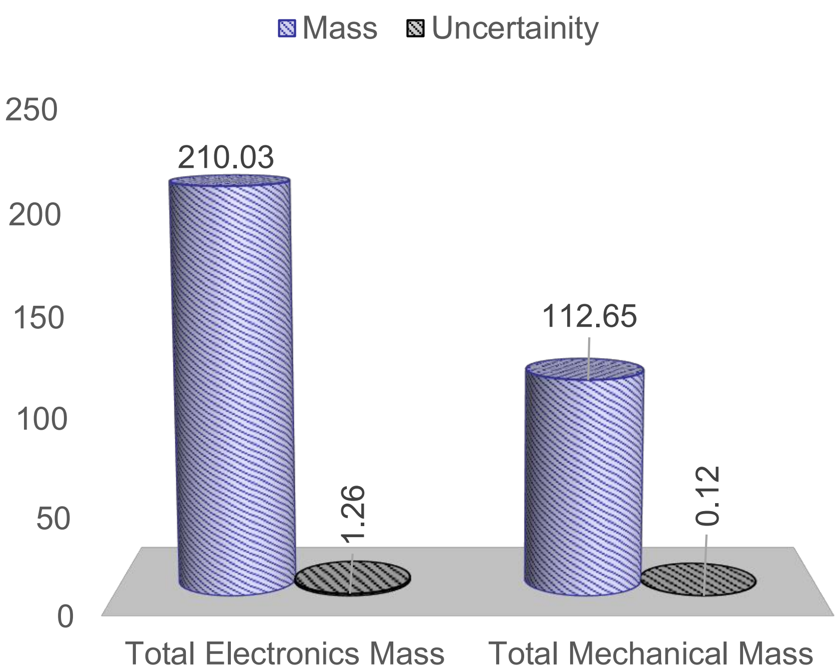
Mass Budget [6/8]

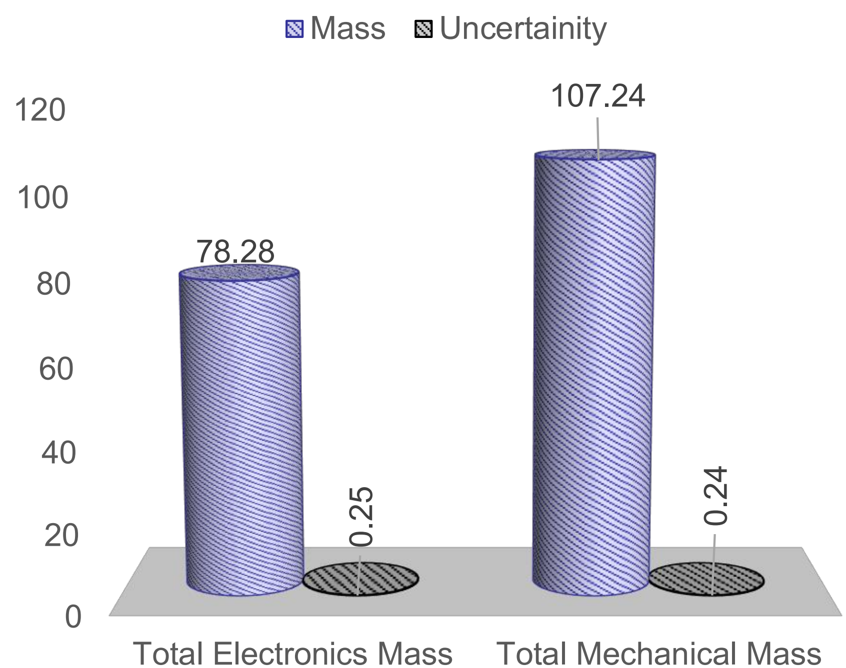
MECHANICAL – CONTAINER								
	Part		Material	Quantity	Mass (g)	Uncertainty (Tolerance) & Sources	Determination	Method of Correction
Structural Elements	Parachute Section		CNC machined HDPE	1	42.26	0.01	Simulation	
	Ribs	Main Body	CNC machined HDPE	2	32.82	0.01	Simulation	
		Supporting Body	CNC machined HDPE	4	10.52	0.01	Simulation	
		Base	CNC machined HDPE	2	11.54	0.01	Simulation	
	Cage		3D printed ABS	1	13.2	0.1	Actual	
Components	Parachute		TFR Thin Mill Chutes	1	18.8	0.1	Datasheet	
Misc.Components	Misc.		Adhesives, nuts, bolts, Kevlar thread, screws, torsional spring etc.		10		Estimated	**M6**(Ensuring that Adhesives are used in limited quantity.)
TOTAL					107.24	0.24		

Mass Budget [7/8]

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	508.20 ± 1.87g

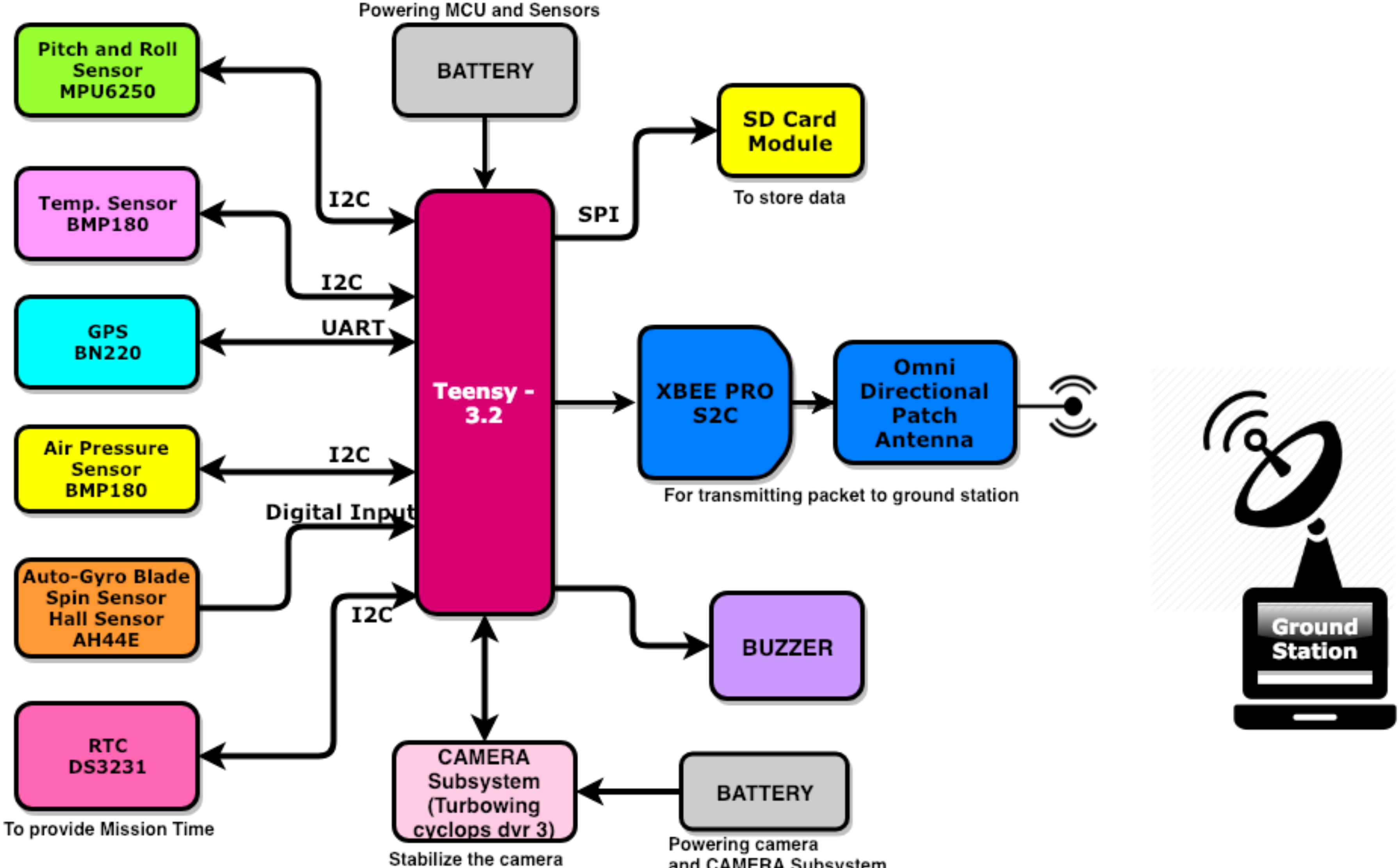
MARGIN	
510.07g – 500g = 10.07g	10.07g
506.33g – 500g= 6.33g	6.33 g

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

Archiev Kumar

Payload CDH Overview



Payload CDH Requirements[1/2]

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	✔	✔	✔	

Payload CDH Requirements[2/2]

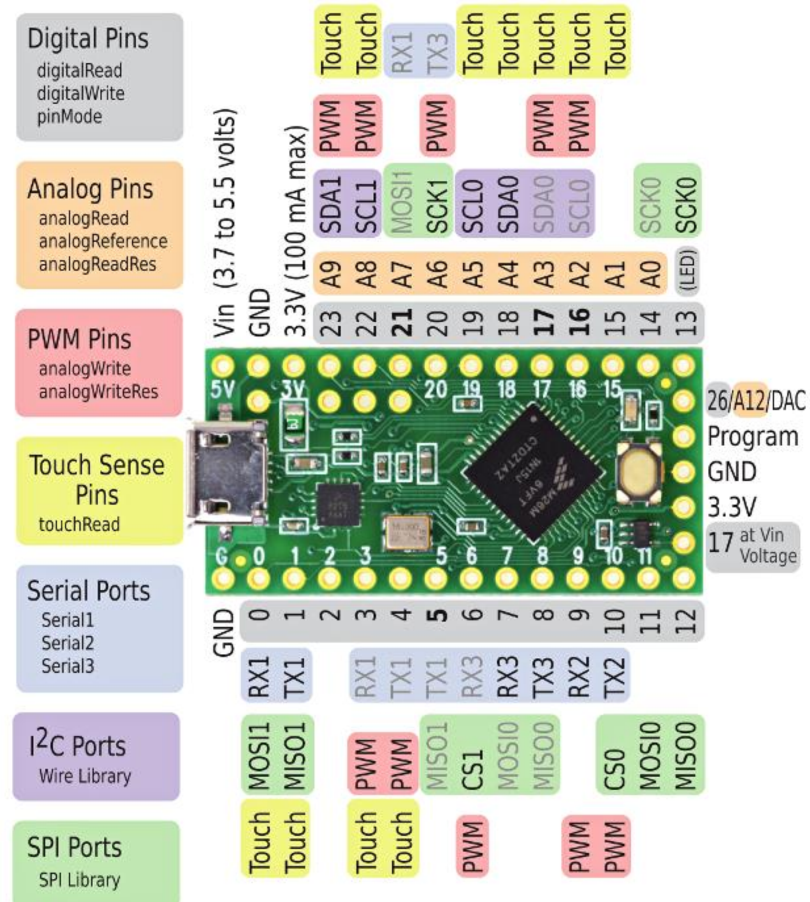
ID	Requirement	Rationale	Parent	Priority	Verification Method			
					A	I	T	D
PCDH-05	The NETID/PANID of XBee radios should be same as the team number.	Competition Requirement	BR- 32	High	✔	✔	✔	
PCDH-06	Telemetry data of all sensors shall be displayed in real time in a csv file.	Competition Requirement	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		✔		

Payload Processor & Memory Trade & Selection[1/4]

Processor	Input Voltage (V)	Processor/ CPU Speed	Boot Time (seconds)	Data Interfaces (Pins)	Flash Memory (kB)	SRAM (kB)	EEPROM (kB)	Weight (g)
Arduino Nano	7-12	ATmega328P Speed = 16MHz	2-3	Digital I/O - 22 Analog Input – 8 Hardware UART-1 SPI – 1 I2C - 1	32	2	1	7
Arduino Pro Mini	3.3-12	ATmega328 Speed = 8MHz	8	Digital I/O – 14 Analog Input – 6 Hardware UART-1 SPI – 1 I2C - 1	32	2	1	4
Teensy 3.2	3.3-12	MK20DX256V LH7 Cortex-M4 Speed = 72MHz	1	Digital I/O – 34 Analog Input – 22 Analog Output – 1 UART – 3 SPI – 1 I2C - 2	256	64	2	5

Payload Processor & Memory Trade & Selection[2/4]

SELECTED	REASONS
TEENSY 3.2	• Lightweight and economical • Easier to integrate on PCB • Efficient Programming (Arduino IDE Compatible) • High RAM – 64 kb • Very less boot time ~ 1s • Large number of communication interfaces.

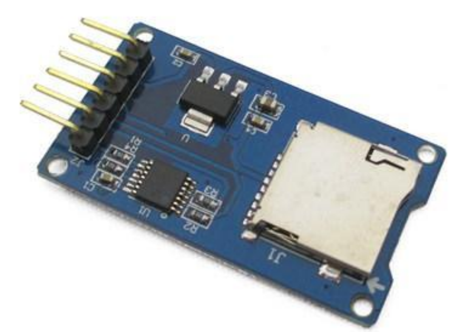


Digital I/O – 34
Analog Input – 22
Analog Output – 1
UART – 3
SPI – 1
I2C - 2

Payload Processor & Memory Trade & Selection[3/4]

Model	Weight (g)	Interface	Memory Space (GB)	Price ($)
Micro Module Slot socket Reader	6	I2C	16 (expandable)	3.09
Arduino SD Card Module	6	SPI	16(expandable)	1.81
MagiDeal Data Logger SD storage Board	9	SPI	16 (expandable)	1.61

SELECTED	REASONS
Arduino SD Card Module	✓ Communications interface is a standard SPI interface ✓ Smaller and economical ✓ Arduino IDE Compatible ✓ Micro SD card connector: self bomb deck, easy card insertion. ✓ Support Micro SD Card, Micro SDHC card (high speed card)



Payload Processor & Memory Trade & Selection[4/4]

SD CARD SELECTION

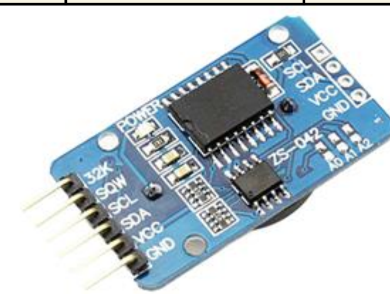
Model	Features	Memory Space (GB)	Cost
SanDisk 16 GB	25 MB/sec data transfer rate SD - protocol compatible Supports SPI Mode Read speed : 96 MB/s	16	$3.5
HP 16 GB	Read speed up to 80MB/s, write minumum 30MB/s	16	$3.9

SELECTED	REASONS
SanDisk 16 GB	✓ 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)

Payload Real-Time Clock

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**
TEENSY RTC	HARDWARE (INTERNAL)	-	After reset condition external crystal and coin cell for RTC will help to keep the mission time by running RTC.	-	Coin Cell Battery	5-20 ppm (determined by crystal selected)	-
DS1307	HARDWARE	2.3 g	After reset condition external clock still keeps the mission time	$ 1.5	2V and 3.5 V (Coin Cell Battery)	~23 ppm 2 sec/day	I2C

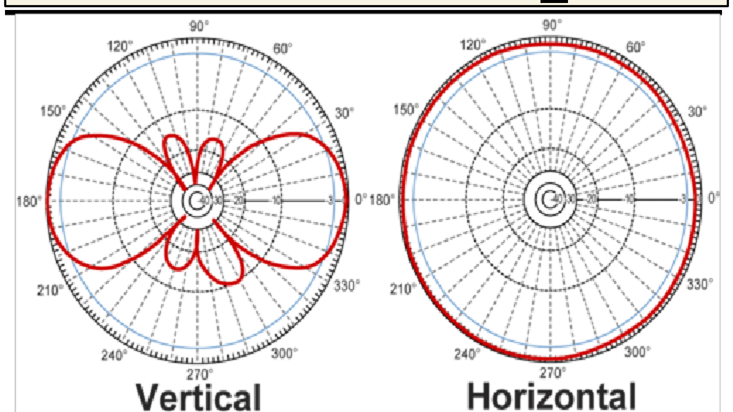
SELECTED	REASONS
DS3231	✓ Low Power Operation Extends Battery-Backup Run Time ✓ Fast (400kHz) I2C Interface ✓ To use internal RTC on Teensy, a has to be soldered. Crystal soldered to Teensy 3.2 is possible fail-point in flight conditions (could snap off).



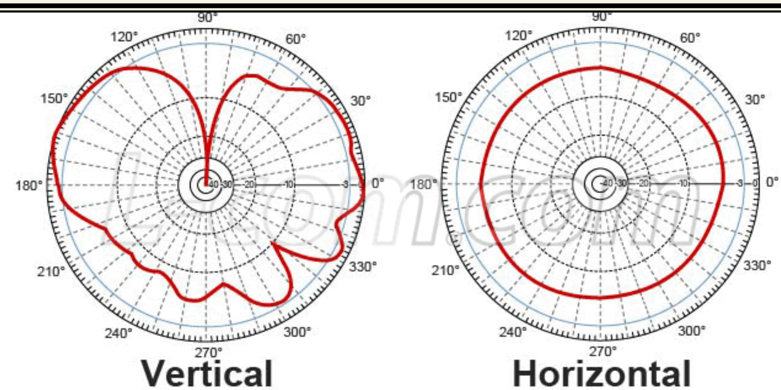
Payload Antenna Trade & Selection[1/2]

Model	Peak Gain	Dimensions	Directivity	Weight	Connector	Range (Frequency range)	VSWR
DS_ RE04U	4dBi	238mm(length) 19mm(diameter)	Omni	421g	N-Male	2.4 GHz – 2.5 GHz	<1.5-1
DS_ HG2402R D-RSF	2.2dBi	105mm(length) 10mm(diameter)	Omni	15g	RPSMA	2.4 GHz – 2.5 GHz	<2.0
FXP70 Freedom	5dBi	27mm*25mm* 0.08 mm	Omni	1.2g	MHFI (U.FL Compatible)	2.4GHz	<1.5-1

Radiation Pattern of DS_RE04U

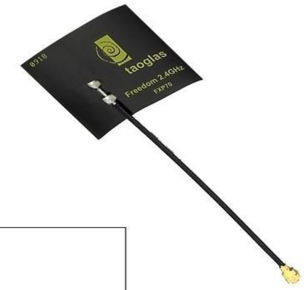


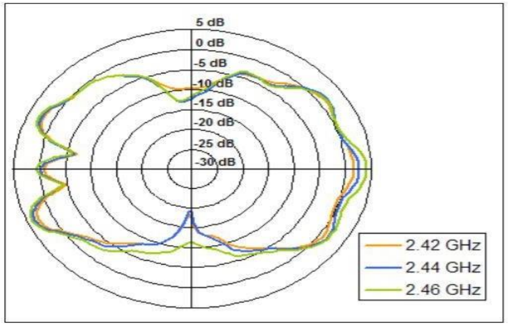
Radiation Pattern of DS_HG2402RD-RSF



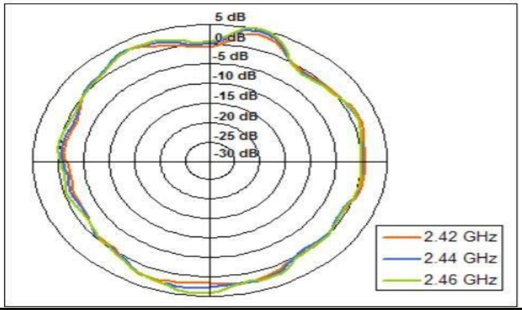
Payload Antenna Trade & Selection[2/2]

SELECTED	REASONS
FXP70 Freedom Patch Antenna	✓ Lesser Weight ✓ Better Gain and Omni Directional ✓ Can Easily Fit in our CanSat ✓ Previous experience with other hardware projects.

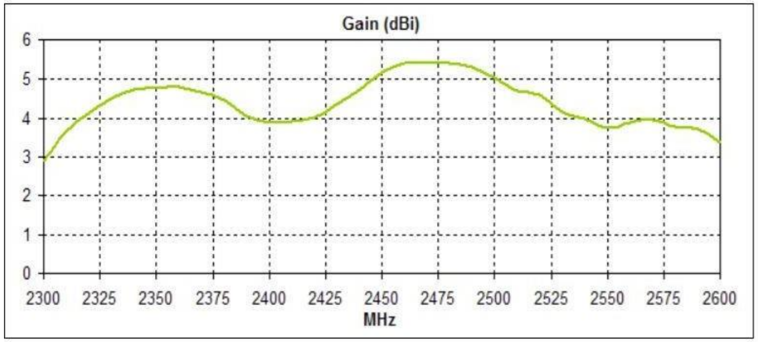




Radiation pattern YZ Plane



Radiation Pattern of FXP70 Freedom



GAIN of FXP70 Freedom Patch Antenna.

Payload Radio Configuration

Model	Line of Sight Range	Transmit Power output	Receiver Sensitivity (dBm)	Supply Voltage (V)	Weight (g)	Operating Frequency	Power down Current
XBee	Up to 400ft.	2mW (+3dBm)	-96	2.1-3.6		ISM 2.4GHz	<1μA
XBee-PRO(S2B)	Up to 2 miles.	63mW (+18dBm)	-102	2.7-3.6		ISM 2.4GHz	3.5μA typical
XBee-PRO(S2C)	Up to 2 miles.	63mW (+18dBm)	-101	2.1-3.6		ISM 2.4GHz	<1μA

SELECTED	REASONS
XBee-PRO(S2C) **Landing is detected using data from sensors like BMP 180, MPU. At less than 5 m, telemetry will be stopped.**	• Low Operating Current and Range is within our Requirements with very good Margins. • **XBee Radio Module** is interfaced to the Arduino Pro Mini 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

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 .

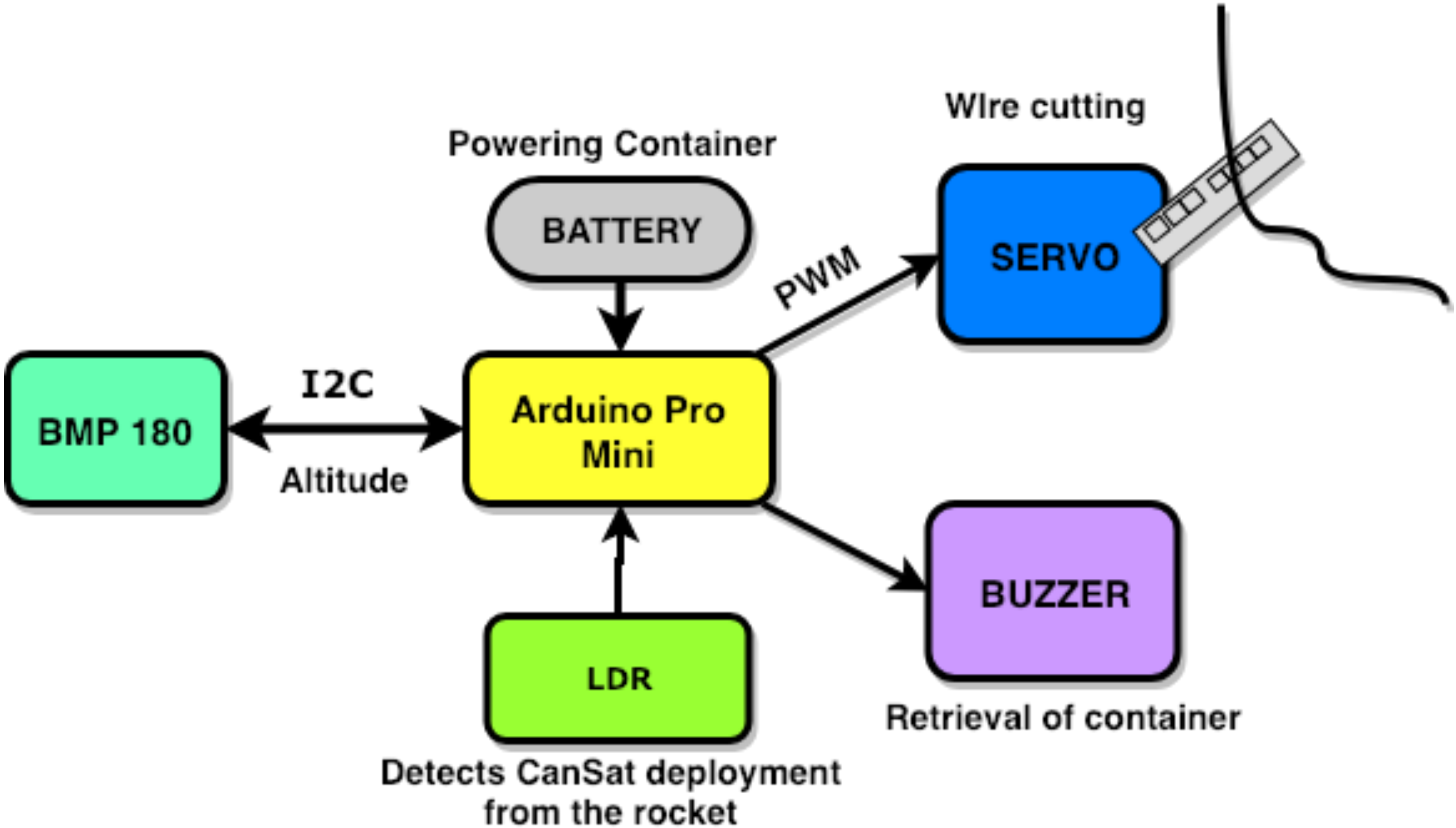
Telemetry Format :

<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, 0,0,36,2,1.2

Container CDH Overview



Container CDH Requirements

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		✔		

Container Processor & Memory Trade & Selection[1/2]

Processor	Input Voltage (V)	Processor/ CPU Speed	Boot Time (seconds)	Data Interfaces (Pins)	Flash Memory (kB)	SRAM (kB)	EEPROM (kB)	Weight (g)
Arduino Nano	7-12	ATmega328P Speed = 16MHz	2-3	Digital I/O - 22 Analog Input – 8 Hardware UART-1 SPI – 1 I2C - 1	32	2	1	7
Arduino Pro Mini	3.3-12	ATmega328 Speed = 8MHz	8	Digital I/O – 14 Analog Input – 6 Hardware UART-1 SPI – 1 I2C - 1	32	2	1	4

Memory Selection

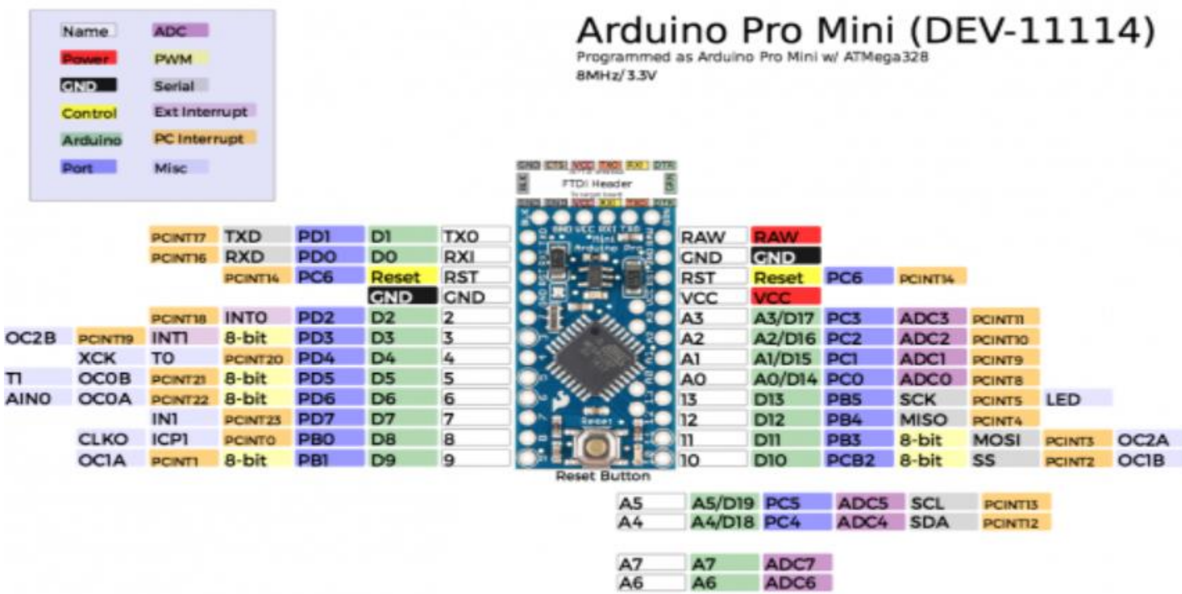
SELECTED	REASONS
Arduino Pro Mini	• Lighter than Nano and economical • Easier to integrate on PCB • Efficient Programming (Arduino IDE Compatible)

EEPROM will be used as memory storage unit.
Data will be stored in EEPROM at rate of 1 Hz.

Container Processor & Memory Trade & Selection[2/2]

Advantages of Using EEPROM

- ✓ The method of erasure is electrical and immediate.
- ✓ It is possible to erase entire contents of EEPROM as well as particular byte as per selection.
- ✓ It is very easy to program and erase the contents of EEPROM without removing it from board or test. The designers incorporate circuitry to program/erase the EEPROM in the board itself.
- ✓ To change the contents, additional equipments are not required.
- ✓ Electrical interfaces of different types viz. serial bus and parallel bus are available.
- ✓ It is possible to re-program EEPROM infinite number of times.



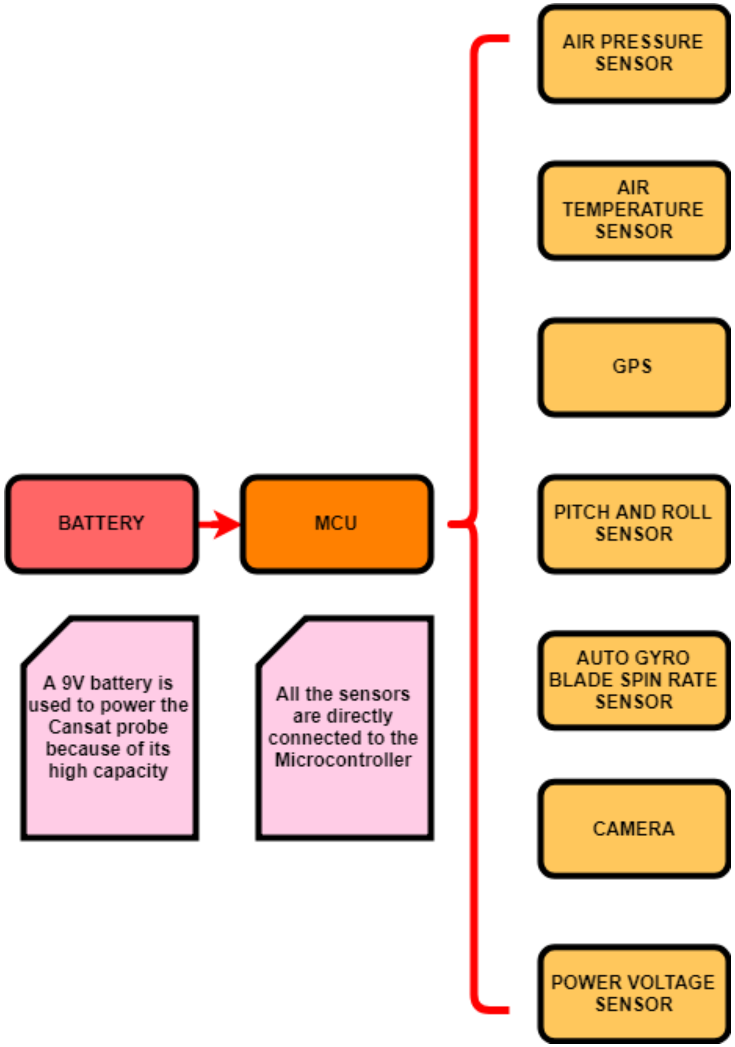
Arduino Pro Mini I/O Pins

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

Electrical Power Subsystem (EPS) Design

Anmol Gulati

EPS Overview



Major EPS components used are:

1. Switch : Switches On/Off the payload as and when required
2. Voltage Regulators (9-5V and 5-3.3V) : This setup allows to incorporate both 5V and 3.3V components in the design . All selected sensors work at 3.3 V whereas the camera , camera stabilisation mechanism and the audio beacon work at 5V .
3. Li-ion Coin Cell : It is used to power the external RTC. It has high energy density and also less weight .
4. Voltage Divider : A simple voltage divider circuit was used to bring the battery voltage down to acceptable levels for our ADC . The values of the resistors chosen were reasonably high so as limit their power consumption but not high enough to hinder measurement due to very little current .
5. Container subsystem : A 9-3.3V LDO was used to power the MCU which in turn powers a servo to deploy the payload.

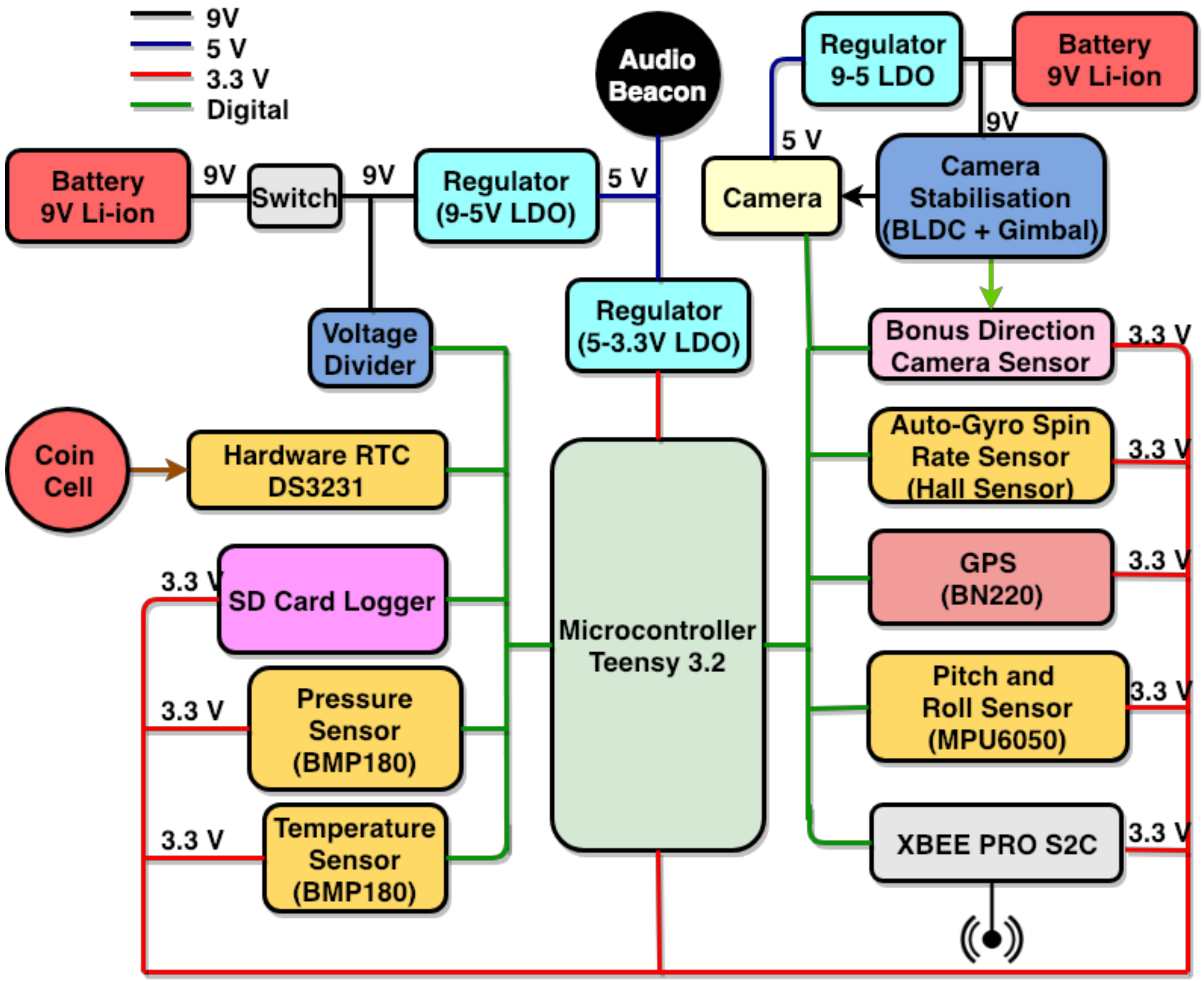
EPS Requirements(1/2)

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(2/2)

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



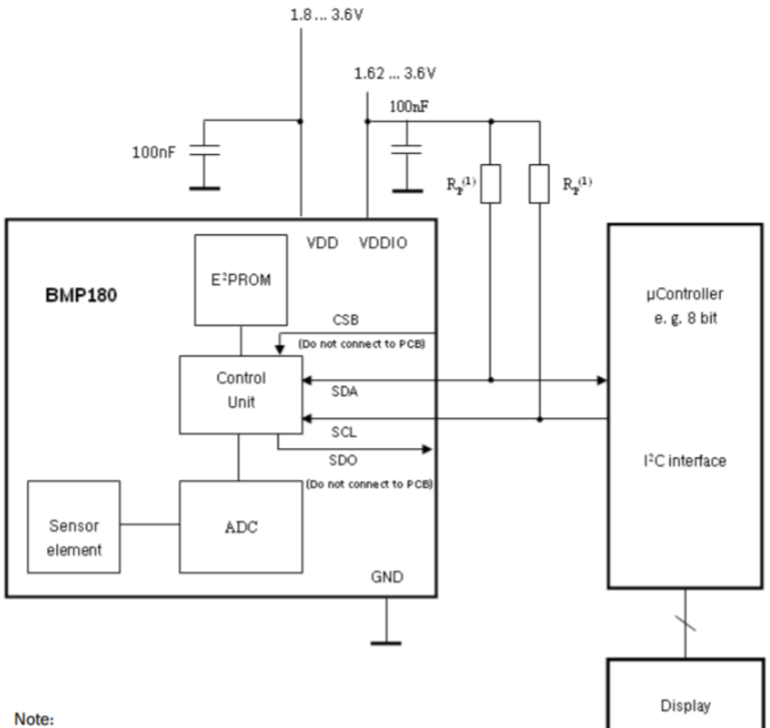
Payload Power Trade & Selection

Model	Weight	Type	Voltage	Capacity	Cost
EBL Li-ion battery	37g	Li-ion	9V	600mAh	$10.18
Energizer 9V	45.6g	Alkaline	9V	550mAh	$8.35
Beston NI-MH 9V	52g	Li-ion	9V	300mAh	$6.83

SELECTED	REASONS
EBL Li-ion battery	• High capacity, optimum for operating payload for 2 hours. • Voltage requirement of all sensors and MCU is fulfilled. • **Battery Configuration: A single battery config. One for the electronics in non-camera section and other one for the camera section.**

Payload Power Budget[1/15]

BMP - 180

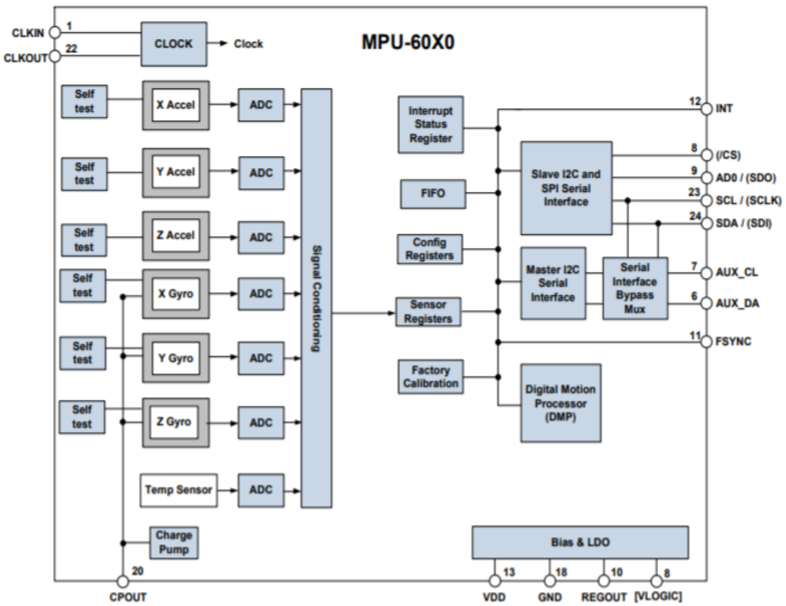


Note:
(1) Pull-up resistors for I^2C bus, R_p = 2.2kΩ ... 10kΩ, typ. 4.7kΩ

Parameter	Symbol	Condition	Min	Typ	Max	Units
Operating temperature	T_A	operational	-40		+85	°C
		full accuracy	0		+65	
Supply voltage	V_{DD}	ripple max. 50mVpp	1.8	2.5	3.6	V
			1.62	2.5	3.6	
Supply current @ 1 sample / sec. 25°C	I_{DDLOW}	ultra low power mode		3		µA
	I_{DDSTD}	standard mode		5		µA
	I_{DDHR}	high resolution mode		7		µA
	I_{DDUHR}	Ultra high res. mode		12		µA
	I_{DDAR}	Advanced res. mode		32		µA
Peak current	I_{peak}	during conversion		650	1000	µA
Standby current	I_{DDSBM}	@ 25°C		0.1	4[1]	µA
Relative accuracy pressure V_{DD} = 3.3V		950 . . . 1050 hPa @ 25 °C		±0.12		hPa
				±1.0		m
		700 ... 900hPa 25 . . . 40 °C		±0.12		hPa
				±1.0		m
Absolute accuracy pressure V_{DD} = 3.3V		300 . . . 1100 hPa 0 . . . +65 °C	-4.0	-1.0*	+2.0	hPa
		300 . . . 1100 hPa -20 . . . 0 °C	-6.0	-1.0*	+4.5	hPa
Resolution of output data		pressure		0.01		hPa
		temperature		0.1		°C
Noise in pressure		see table on page 12-13				
Absolute accuracy temperature V_{DD} = 3.3V		@ 25 °C	-1.5	±0.5	+1.5	°C
		0 . . . +65 °C	-2.0	±1.0	+2.0	°C

Payload Power Budget[2/15]

MPU - 6050

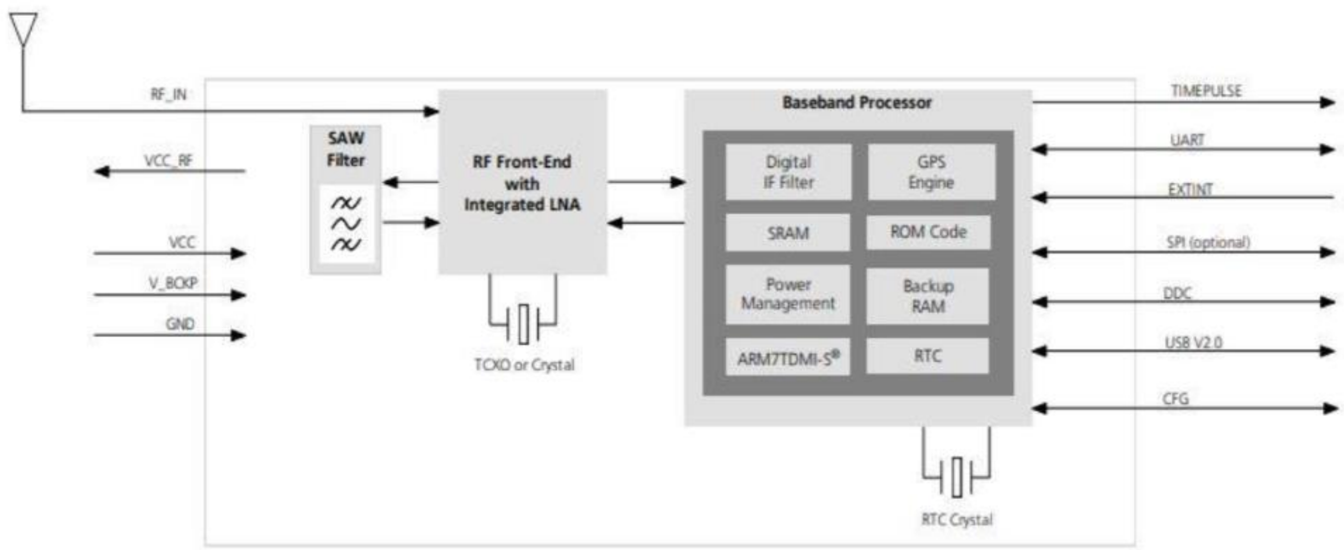


PARAMETER	CONDITIONS	MIN	TYP	MAX	Units	Notes
TEMPERATURE SENSOR						
Range			-40 to +85		°C	
Sensitivity	Untrimmed		340		LSB/°C	
Temperature Offset	35°C		-521		LSB	
Linearity	Best fit straight line (-40°C to +85°C)		±1		°C	
VDD POWER SUPPLY						
Operating Voltages		2.375		3.46	V	
Normal Operating Current	Gyroscope + Accelerometer + DMP		3.9		mA	
	Gyroscope + Accelerometer (DMP disabled)		3.8		mA	
	Gyroscope + DMP (Accelerometer disabled)		3.7		mA	
	Gyroscope only (DMP & Accelerometer disabled)		3.6		mA	
	Accelerometer only (DMP & Gyroscope disabled)		500		µA	
Accelerometer Low Power Mode Current	1.25 Hz update rate		10		µA	
	5 Hz update rate		20		µA	
	20 Hz update rate		70		µA	
	40 Hz update rate		140		µA	
Full-Chip Idle Mode Supply Current			5		µA	
Power Supply Ramp Rate	Monotonic ramp. Ramp rate is 10% to 90% of the final value			100	ms	
VLOGIC REFERENCE VOLTAGE	MPU-6050 only					
Voltage Range	VLOGIC must be ≤VDD at all times	1.71		VDD	V	
Power Supply Ramp Rate	Monotonic ramp. Ramp rate is 10% to 90% of the final value			3	ms	
Normal Operating Current			100		µA	
TEMPERATURE RANGE						
Specified Temperature Range	Performance parameters are not applicable beyond Specified Temperature Range	-40		+85	°C	

Payload Power Budget[3/15]

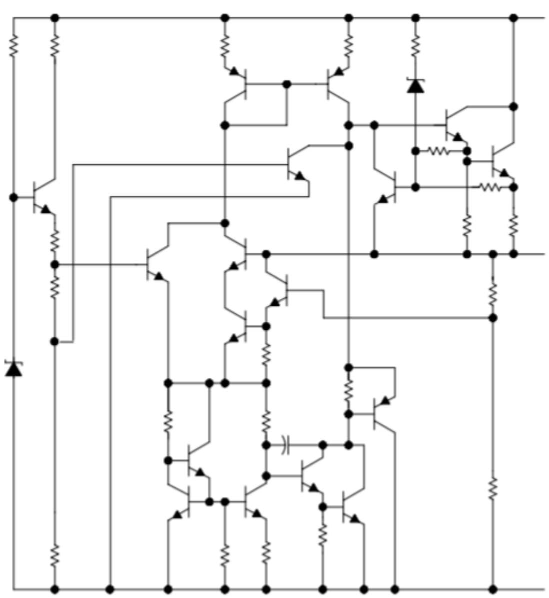
GPS

Power consumption	VCC	DC Voltage 3.0V-5.5V,Typical: 5.0V
	Current	Capture 50mA@5.0V
Mechanical Specifications	Dimension	22mm*20mm*6mm
	Weight	5.3g
	Connector	1.00mm spacing between the 4pins patch seat
Environment	Operating temp	-40 °C ~ +85°C
	Storage Temp	-40°C ~ +105°C



Payload Power Budget[4/15]

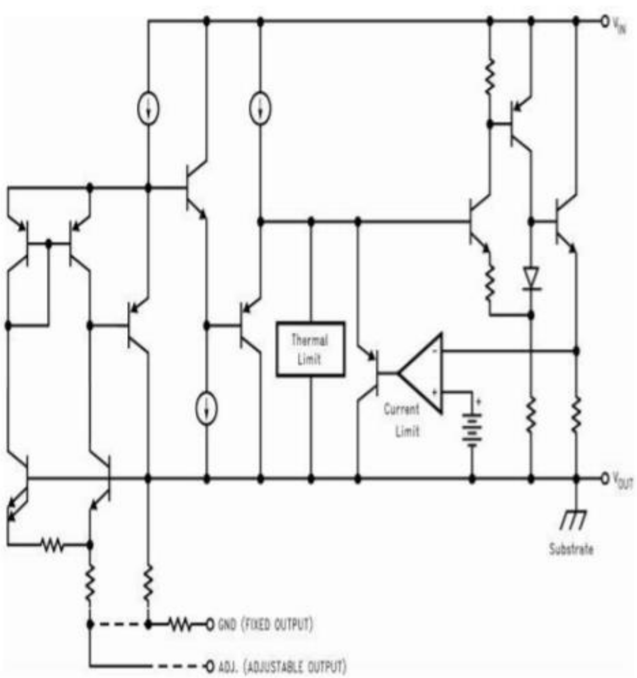
LM7805(5V) SPECIFICATIONS



PARAMETER	TEST CONDITIONS	T_J†	µA7805C MIN	µA7805C TYP	µA7805C MAX	UNIT
Output voltage	I_O = 5 mA to 1 A, V_I = 7 V to 20 V, $P_D \le 15$ W	25°C	4.8	5	5.2	V
		0°C to 125°C	4.75		5.25	
Input voltage regulation	V_I = 7 V to 25 V	25°C		3	100	mV
	V_I = 8 V to 12 V			1	50	
Ripple rejection	V_I = 8 V to 18 V, f = 120 Hz	0°C to 125°C	62	78		dB
Output voltage regulation	I_O = 5 mA to 1.5 A	25°C		15	100	mV
	I_O = 250 mA to 750 mA			5	50	
Output resistance	f = 1 kHz	0°C to 125°C		0.017		Ω
Temperature coefficient of output voltage	I_O = 5 mA	0°C to 125°C		–1.1		mV/°C
Output noise voltage	f = 10 Hz to 100 kHz	25°C		40		µV
Dropout voltage	I_O = 1 A	25°C		2		V
Bias current		25°C		4.2	8	mA
Bias current change	V_I = 7 V to 25 V	0°C to 125°C			1.3	mA
	I_O = 5 mA to 1 A				0.5	
Short-circuit output current		25°C		750		mA
Peak output current		25°C		2.2		A

Payload Power Budget[5/15]

LM1117(3.3V) SPECIFICATIONS

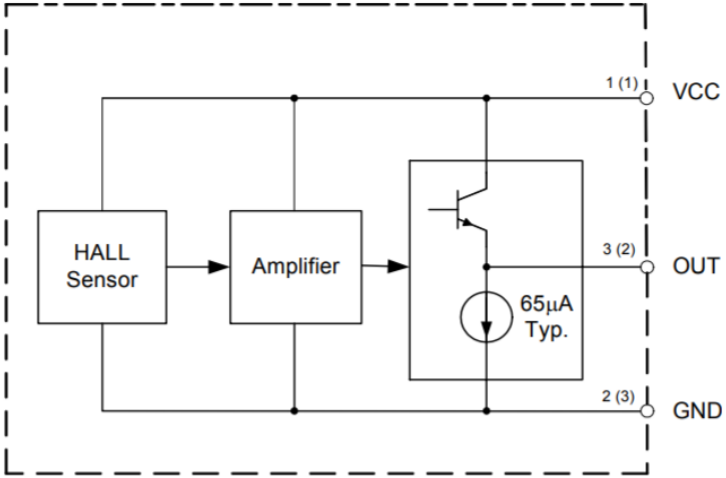


PARAMETER		TEST CONDITIONS		MIN[1]	TYP[2]	MAX[1]	UNIT
V_{REF}	Reference Voltage	LM1117-ADJ I_{OUT} = 10 mA, $V_{IN} - V_{OUT}$ = 2 V, T_J = 25°C		1.238	1.25	1.262	V
		LM1117-ADJ 10 mA ≤ I_{OUT} ≤ 800 mA, 1.4 V ≤ $V_{IN} - V_{OUT}$ ≤ 10 V	T_J = 25°C		1.25		
			over the junction temperature range 0°C to 125°C	1.225		1.27	
V_{OUT}	Output Voltage	LM1117-1.8 I_{OUT} = 10 mA, V_{IN} = 3.8 V, T_J = 25°C		1.782	1.8	1.818	V
		LM1117-1.8 0 ≤ I_{OUT} ≤ 800 mA, 3.2 V ≤ V_{IN} ≤ 10 V	T_J = 25°C		1.8		
			over the junction temperature range 0°C to 125°C	1.746		1.854	
		LM1117-2.5 I_{OUT} = 10 mA, V_{IN} = 4.5 V, T_J = 25°C		2.475	2.5	2.525	V
		LM1117-2.5 0 ≤ I_{OUT} ≤ 800 mA, 3.9 V ≤ V_{IN} ≤ 10 V	T_J = 25°C		2.5		
			over the junction temperature range 0°C to 125°C	2.45		2.55	
		LM1117-3.3 I_{OUT} = 10 mA, V_{IN} = 5 V T_J = 25°C		3.267	3.3	3.333	V
		LM1117-3.3 0 ≤ I_{OUT} ≤ 800 mA, 4.75 V ≤ V_{IN} ≤ 10 V	T_J = 25°C		3.3		
			over the junction temperature range 0°C to 125°C	3.235		3.365	
		LM1117-5.0 I_{OUT} = 10 mA, V_{IN} = 7 V, T_J = 25°C		4.95	5	5.05	V
		LM1117-5.0 0 ≤ I_{OUT} ≤ 800 mA, 6.5 V ≤ V_{IN} ≤ 12 V	T_J = 25°C		5		
			over the junction temperature range 0°C to 125°C	4.9		5.1	
ΔV_{OUT}	Line Regulation[3]	LM1117-ADJ I_{OUT} = 10mA, 1.5V ≤ V_{IN}-V_{OUT} ≤ 13.75V	T_J = 25°C		0.035%		
			over the junction temperature range 0°C to 125°C			0.2%	
		LM1117-1.8 I_{OUT} = 0 mA, 3.2 V ≤ V_{IN} ≤ 10 V	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			6	
		LM1117-2.5 I_{OUT} = 0 mA, 3.9 V ≤ V_{IN} ≤ 10 V	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			6	
		LM1117-3.3 I_{OUT} = 0 mA, 4.75 V ≤ V_{IN} ≤ 15 V	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			6	
		LM1117-5.0 I_{OUT} = 0 mA, 6.5 V ≤ V_{IN} ≤ 15 V	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			10	
ΔV_{OUT}	Load Regulation[3]	LM1117-ADJ $V_{IN} - V_{OUT}$ = 3 V, 10 ≤ I_{OUT} ≤ 800 mA	T_J = 25°C		0.2%		
			over the junction temperature range 0°C to 125°C			0.4%	
		LM1117-1.8 V_{IN} = 3.2 V, 0 ≤ I_{OUT} ≤ 800 mA	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			10	
		LM1117-2.5 V_{IN} = 3.9 V, 0 ≤ I_{OUT} ≤ 800 mA	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			10	
		LM1117-3.3 V_{IN} = 4.75 V, 0 ≤ I_{OUT} ≤ 800 mA	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			10	
		LM1117-5.0 V_{IN} = 6.5 V, 0 ≤ I_{OUT} ≤ 800 mA	T_J = 25°C		1		mV
			over the junction temperature range 0°C to 125°C			15	

Payload Power Budget[6/15]

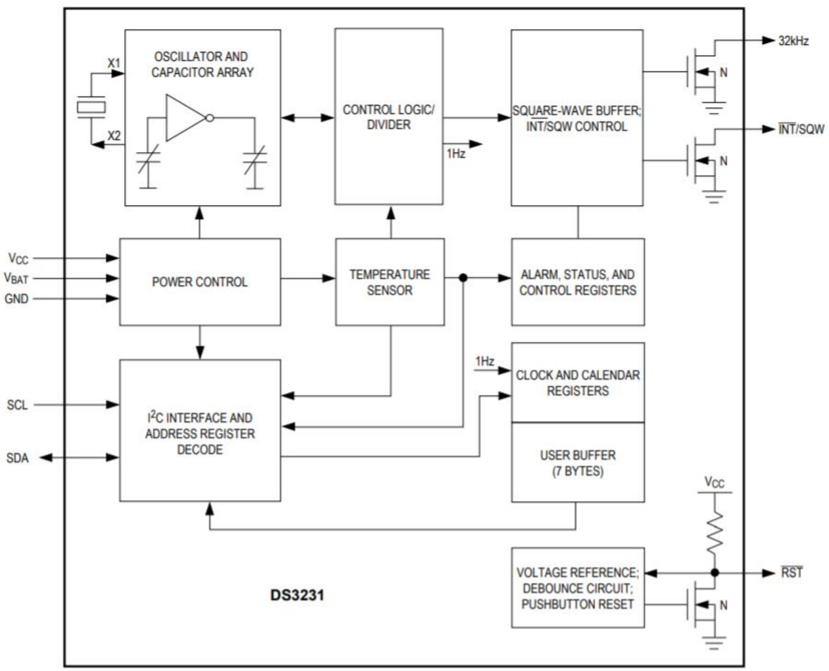
AUTO GYRO SPIN RATE SENSOR AH49E

Parameter	Symbol	Value	Unit
Supply Voltage	V_{CC}	8	V
Output Current	I_O	10	mA
Operating Temperature	T_A	-40 to 100	^{0}C
Storage Temperature Range	T_{STG}	-50 to 150	^{0}C
ESD (Human Body Model)		3000	V



Payload Power Budget[7/15]

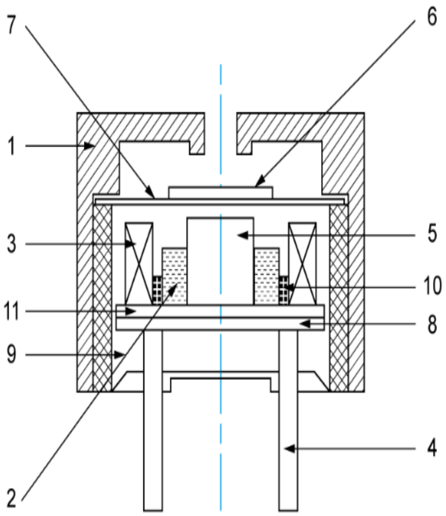
RTC



PARAMETER	SYMBOL	CONDITIONS		MIN	TYP	MAX	UNITS
Supply Voltage	V_{CC}			2.3	3.3	5.5	V
	V_{BAT}			2.3	3.0	5.5	V
Logic 1 Input SDA, SCL	V_{IH}			0.7 x V_{CC}		V_{CC} + 0.3	V
Logic 0 Input SDA, SCL	V_{IL}			-0.3		0.3 x V_{CC}	V
Active Supply Current	I_{CCA}	(Notes 4, 5)	V_{CC} = 3.63V			200	µA
			V_{CC} = 5.5V			300	
Standby Supply Current	I_{CCS}	I²C bus inactive, 32kHz output on, SQW output off (Note 5)	V_{CC} = 3.63V			110	µA
			V_{CC} = 5.5V			170	
Temperature Conversion Current	$I_{CCSCONV}$	I²C bus inactive, 32kHz output on, SQW output off	V_{CC} = 3.63V			575	µA
			V_{CC} = 5.5V			650	
Power-Fail Voltage	V_{PF}			2.45	2.575	2.70	V
Logic 0 Output, 32kHz, $\overline{INT}$/SQW, SDA	V_{OL}	I_{OL} = 3mA				0.4	V
Logic 0 Output, $\overline{RST}$	V_{OL}	I_{OL} = 1mA				0.4	V
Output Leakage Current 32kHz, $\overline{INT}$/SQW, SDA	I_{LO}	Output high impedance		-1	0	+1	µA
Input Leakage SCL	I_{LI}			-1		+1	µA
$\overline{RST}$ Pin I/O Leakage	I_{OL}	$\overline{RST}$ high impedance (Note 6)		-200		+10	µA
V_{BAT} Leakage Current (V_{CC} Active)	I_{BATLKG}				25	100	nA

Payload Power Budget[8/15]

Buzzer(Multicomp MCKPI-G2437-3671)



No.	Name
1	Housing
2	Winding Coil
3	Magnet
4	Pin
5	Pin Armiture
6	Weight Diaphragm
7	Plate Diaphragm
8	P. C. Board
9	Epoxy
10	Silicon Rubber
11	Plate Armiture

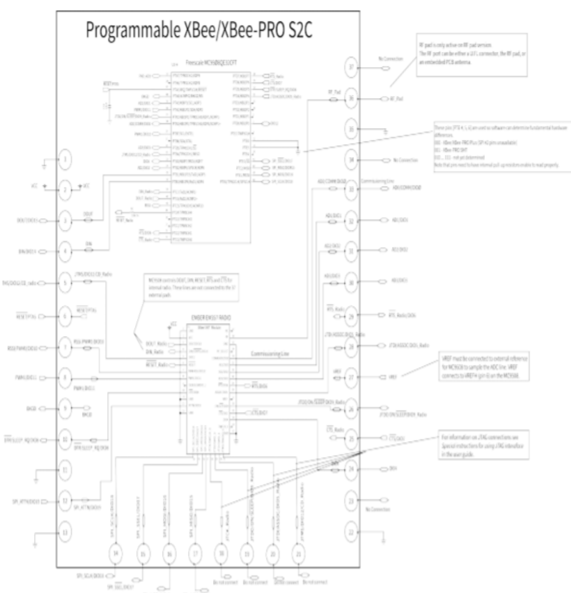
Specification

1. Rated Voltage: 12VDC
2. Operating Voltage: 8 ~ 15VDC
3. Max. Rated Current: 20mA at 12VDC
4. Min. Sound Pressure Level: 100dB at 12VDC/10cm
5. Resonant Frequency: 3.7±0.5KHz
6. Tone Nature: Continuous
7. Case Material: PBT/Black
8. Operating Temperature: -20~+80°C
9. Store Temperature: -30~+100°C

Payload Power Budget[9/15]

XBEE PRO S2C

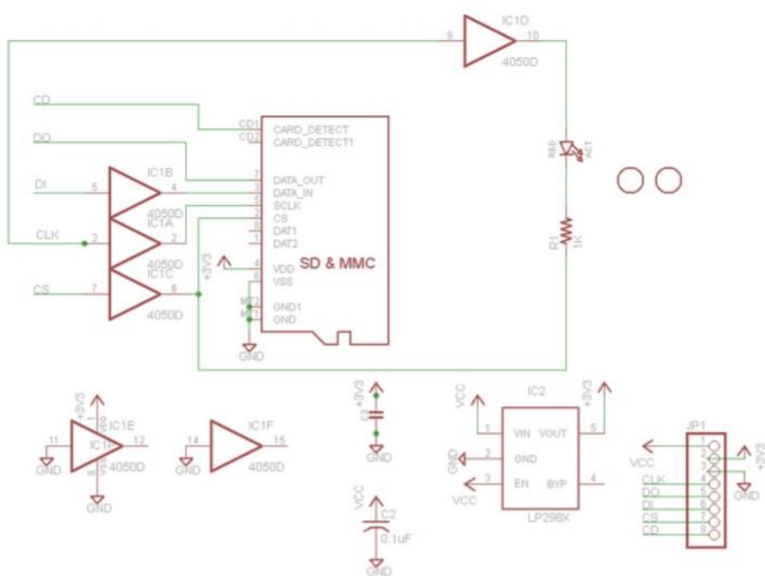
Specification	XBee S2C	XBee-PRO S2C	XBee S2D
Adjustable power	Yes		
Transmit current (typical, VCC = 3.3 V)	45 mA (8 dBm, Boost mode) 33 mA (5 dBm, Normal mode)	120 mA (18 dBm)	2.1 - 3.6 V
Idle / receive current (typical, VCC = 3.3 V)	31 mA (Boost mode) 28 mA (Normal mode)	31 mA	45 mA
Power-down current	<1 uA @ 25C	<1 uA @ 25C	31 mA



GPIO electrical specification	Value
Voltage - supply	2.1 - 3.6 V
Low Schmitt switching threshold	0.42 - 0.5 x VCC
High Schmitt switching threshold	0.62 - 0.8 x VCC
Input current for logic 0	-0.5 μA
Input current for logic 1	0.5 μA
Input pull-up resistor value	29 kΩ
Input pull-down resistor value	29 kΩ

Payload Power Budget[10/15]

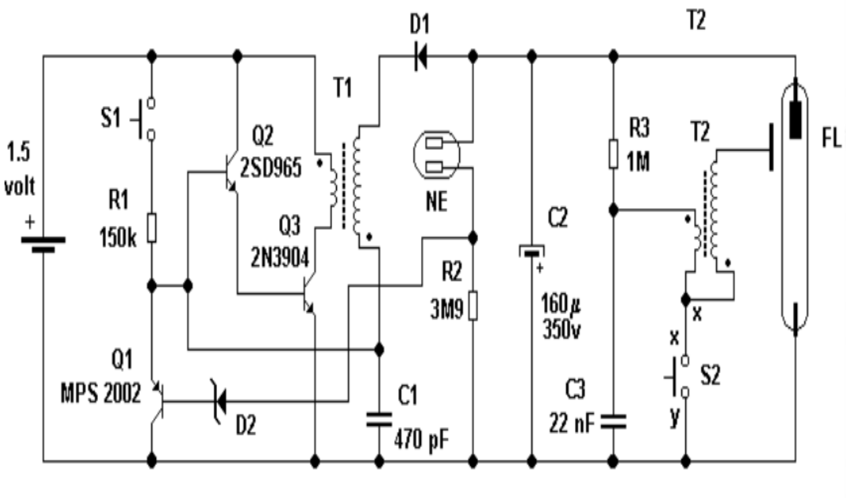
SD CARD READER MODULE



Items	Min	Typical	Max	Unit
Power Voltage VCC	4.5	5	5.5	V
Current	0.2	80	200	mA
Interface Electrical Potential	3.3 or 5			V
Support Card Type	Micro SD Card(<=2G)， Mirco SDHC Card(<=32G)			—
Size	42X24X12			mm
Weight	5			g

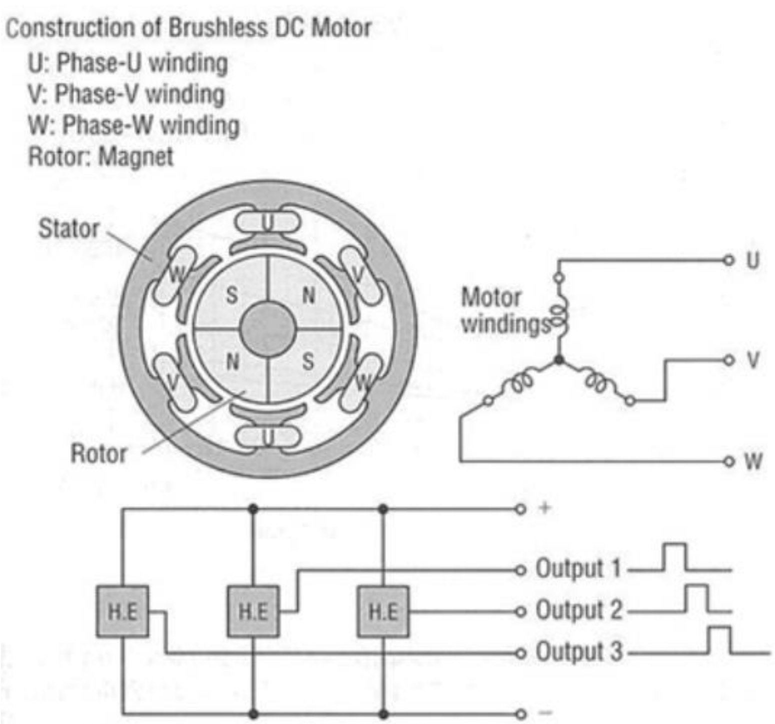
Payload Power Budget[11/15]

CAMERA



Output power	0/25mw/200mw switchable (25mW: 14dBm 200mW: 23dBm)
Supply voltage	5-26V
Current consumption	0 mW: 90mA@12V 25mW: 130mA@12V 200mW: 250mA@12V
antenna	5dbm
Frequency band	5362~5945MHz
Channel customer	48
Channel SEL	Touch Switch
Channel Indicate	CH1-CH8 Channel indication with 4LEDS and frequency group indicate with 3LEDS
Input format	NTSC
Power memory function	Power settings comes with memory function , Can automatically save the last power setting.

BLDC MOTOR(ON GIMABL FOR BONUS CAMERA STABILIZATION)



No. of Cells:	2 - 3 Li-Poly 6 - 10 NiCd/NiMH
Kv:	1000 RPM/V
Max Efficiency:	80%
Max Efficiency Current:	4 - 10A (>75%)
No Load Current:	0.5A @10V
Resistance:	0.090 ohms
Max Current:	13A for 60S
Max Watts:	150W
Weight:	52.7 g / 1.86 oz
Size:	28 mm dia x 28 mm bell length

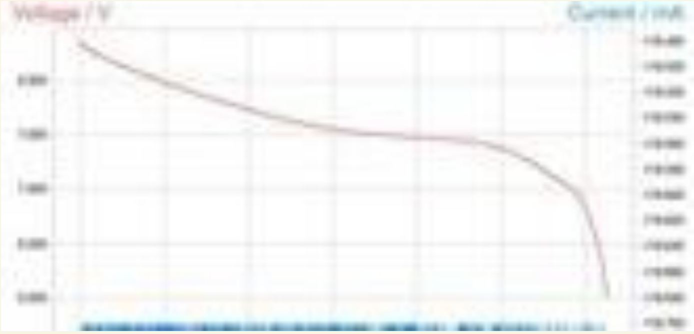
Payload Power Budget[13/15]

S.No	Component	Current(mA)	Voltage (V)	Operation time	Power (Wh)	Duty Cycle	Source/ Uncertainty
1.	**BMP 180**	0.65	3.3	2 hours	0.00429	100%	Datasheet
2.	**TEENSY 3.2**	45	3.3	2 hours	0.297	100%	Datasheet
3.	**UBLOX NEO 6M**	10	3.3	2 hours	0.066	100%	Datasheet
4.	**RTC-DS3231**	0.08	3.3	2 hours	0.00052	100%	Datasheet
5.	**MPU 6050**	1.74	3.3	2 hours	0.01148	100%	Datasheet
6.	AUTO GYRO SPIN RATE SENSOR **AH49E**	3.5	3.3	2 hours	0.0231	75%	Datasheet
7.	MICRO-**SD CARD MODULE**	25	3.3	2 hours	0.165	5%	Datasheet
8.	BUZZER**(MULTICOMP MCKPI-G2437-3671)**	8.3	5	2 hours	0.083	5%	Estimated
9.	XBEE **PRO S2C**	60	3.3	2 hours	0.396	100%	Datasheet
10.	CAMERA	130	5	2 minutes	0.0216	75%	Datasheet
11.	BLDC MOTOR(ON GIMABL FOR BONUS CAMERA STABILIZATION) **A2212/13T**	136	9	2 minutes	0.0408	75%	Datasheet
12.	BLDC CONTROLLER H-BRIDGE **– L298**						

Payload Power Budget[14/15]

TOTAL ENERGY REQUIRED (Except Camera)	TOTAL ENERGY AVAILABLE
1.046402Wh	5.4Wh

- 9V EBL Li-ion Battery (600mAh capacity) is rated for a continuous current 550mA
- Our current requirements without the camera stabilization system is 154.27mA, so we can have this current for 229 minutes.
- Our Total Duration for the mission = 2 Hour Wait + Mission Time (2 minutes)
- Therefore , Total Duration for the mission = 122mins. We only require 154.27mA current for 122 minutes which our Battery can easily provide with a good margin.
- Total Power Available = 5.4Wh
  Total Margin = 5.4Wh-1.046402Wh = 4.35Wh

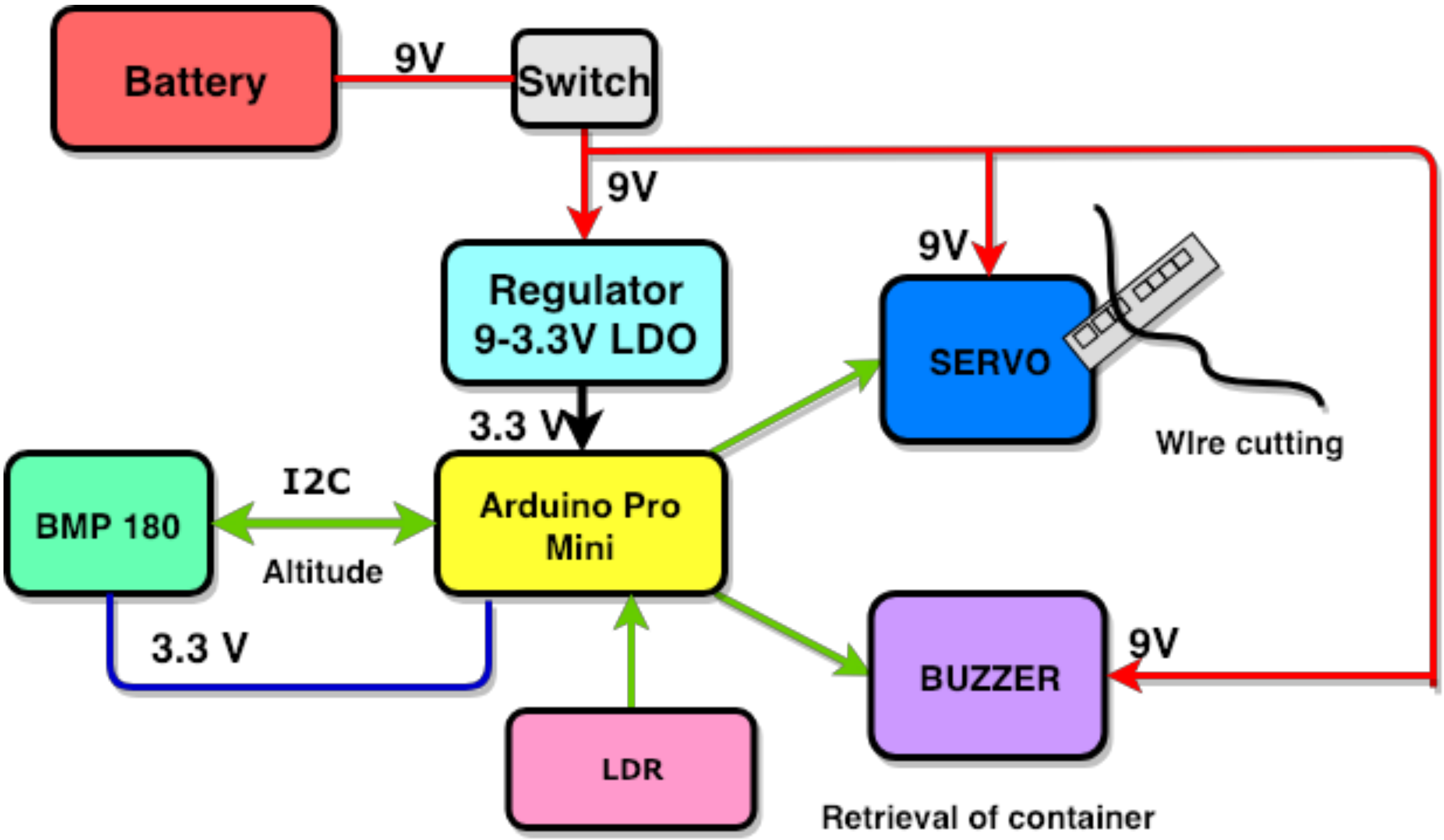


Payload Power Budget[15/15]

TOTAL ENERGY REQUIRED FOR BONUS CAMERA STABILIZATION	TOTAL ENERGY AVAILABLE
0.0624Wh	5.4Wh

- 9V EBL Li-ion Battery (600mAh capacity) is rated for a continuous current 550mAh
- Our current requirement for the camera stabilization system is 266mA, so we can have this current for 159.2 minutes.
- 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 which our battery can easily provide with a good margin.
- Total Power Available = 5.4Wh
- Total Margin = 5.4Wh - 0.0624Wh =5.33Wh
- **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 .**

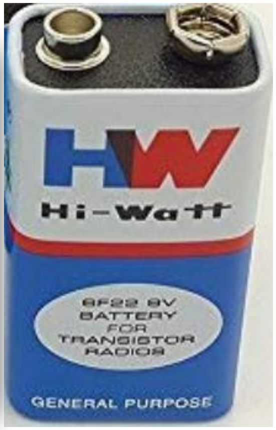
Container Electrical Block Diagram



Container Power Trade & Selection

Model	Type	Voltage	Capacity	Size	Mass
Energizer 522	Alkaline	9V	450mAh	48.4mm X 26.5mm	45g
Ryme B10 BT-905 BT-800	Nickel-Cadmium	3.6V	600mAh	50mm X 34mm X 8mm	50g
APT-HW9V10	Li-ion	9V	500mAh	48.5mm X 26.5mm	40g

SELECTED	RATIONALE
APT-HW9V10	• High capacity, optimum for operating for 2 hours. • Voltage requirement of all sensors and MCU is fulfilled. • Performs equally well in low and as well as high rate of discharge. • **Battery Configuration: A single battery config.**



Container Power Budget[1/2]

S.No	Component	Current(mA)	Voltage(V)	Operating time	Power (Wh)	Duty Cycle	Source/ Uncertainty
1.	BMP 180	0.5	3.3	2 hours	0.0033	100%	Datasheet
2.	Arduino Pro Mini	0.2	3.3	2 hours	0.00132	100%	Datasheet
3.	Audio Beacon	0.2	5	30 minutes	0.0005	5%	Datasheet
4.	Servo Motor	120	5	2 minutes	0.020	5%	Datasheet

Power Available	4.5Wh
Total Power consumed(for 2 hours)	0.02512Wh
Margin	4.47Wh

Container Power Budget[2/2]

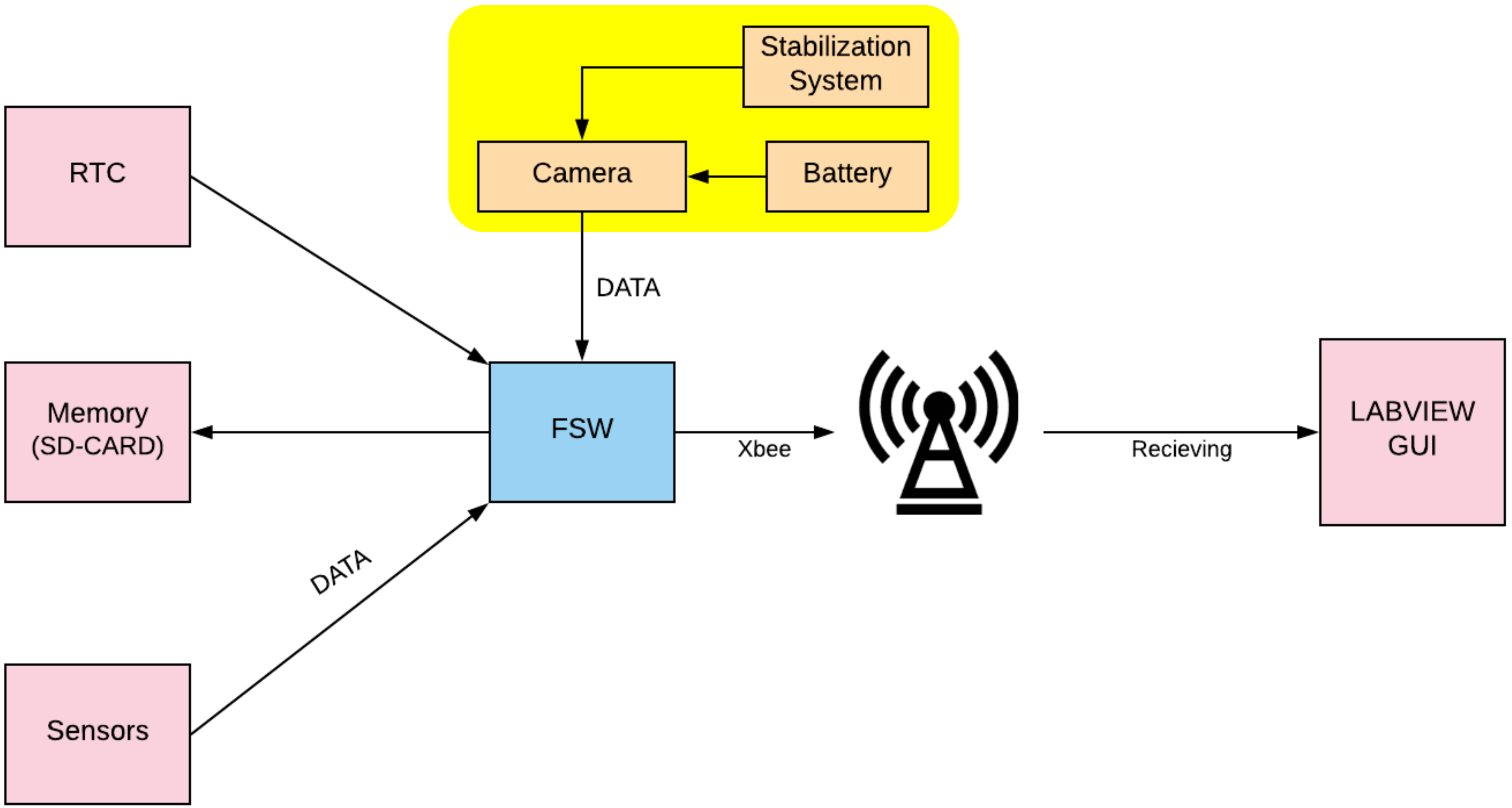
TOTAL ENERGY REQUIRED FOR BONUS CAMERA STABILIZATION	TOTAL ENERGY AVAILABLE
0.02512Wh	**4.5Wh**

- 9V EBL Li-ion Battery (500mAh capacity) is rated for a continuous current 450mAh
- Our current requirement for the container is 121mA, so we can have this current for 247.8 minutes.
- We Only require 121mA current for 120 minutes which our battery can easily provide with a good margin.
- Total Power Available = 4.5Wh
- Total Margin = 4.5Wh - 0.02512Wh =4.47Wh

Flight Software (FSW) Design

Rishabh Yadav

FSW Overview[1/2]



FSW Overview[2/2]

Programming Language

- Python

Development Environment

Arduino IDE – Easy to use with clear programming environment with Open source and extensible software which should provide all the functionality that is Needed.

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 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 in engineering units (meters, meters/ sec, Celsius, etc.)	Mission Requirement	High	SR-34	✔		✔	
GCS-4	Teams shall plot each telemetry data field in real time during flight.	Mission Requirement	High	SRS- 13			✔	

FSW Requirements[2/2]

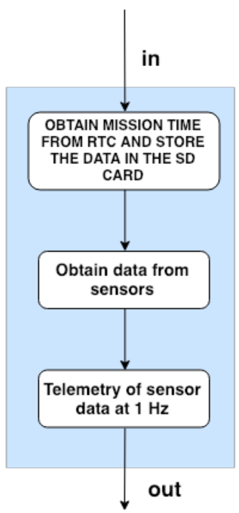
ID	Requirement	Rationale	Priority	Parent	Varification Method			
					A	D	I	T
GCS-5	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand held antenna.	Mission Requirement	High	SRS- 21			✔	
GCS-6	The ground station must be portable 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.	Mission Requirement	High	SRS- 22	✔		✔	

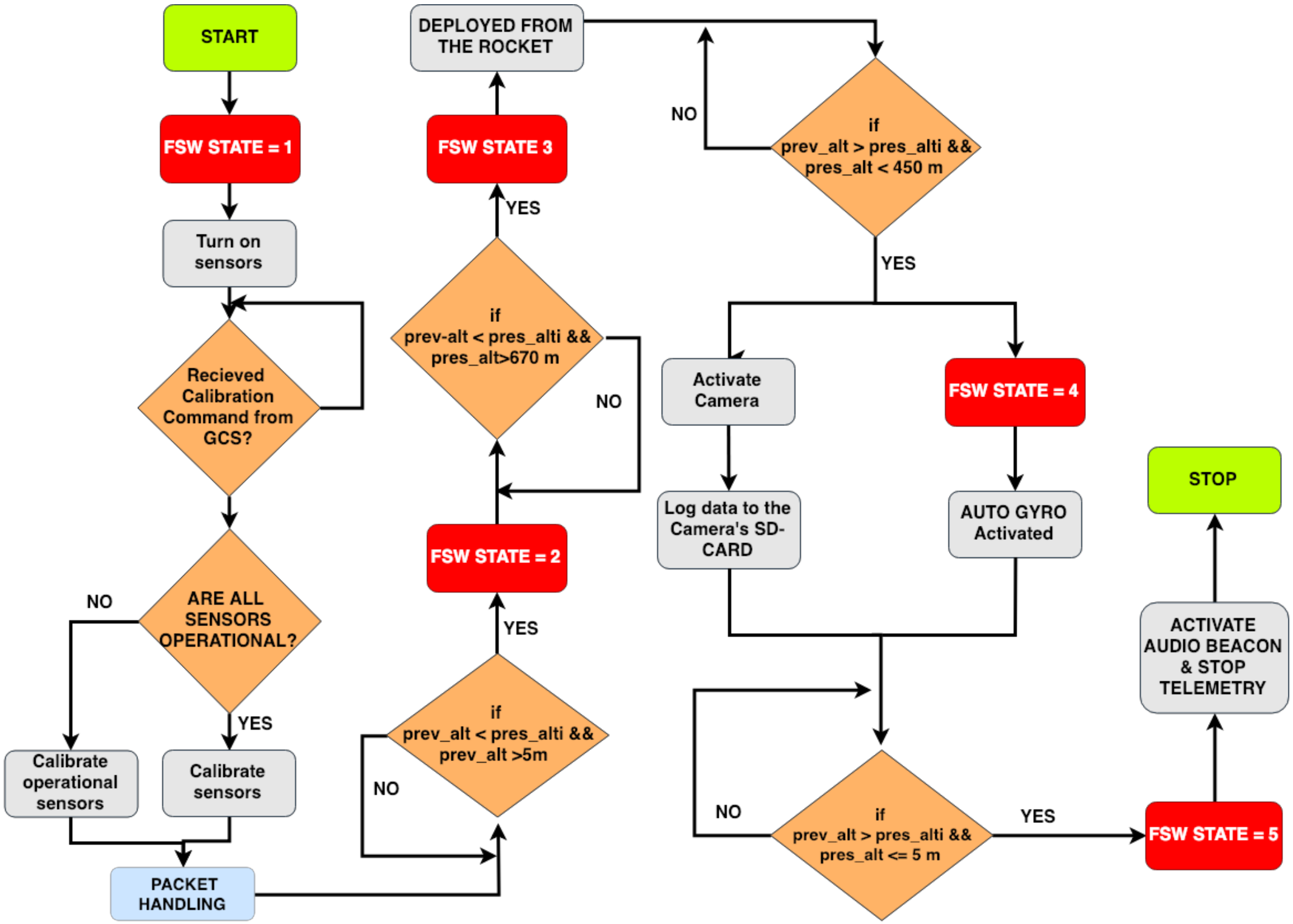
Payload FSW State Diagram[1/3]

INFO :

FSW STATE:

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





Payload FSW State Diagram[2/3]

Processor Reset Control :

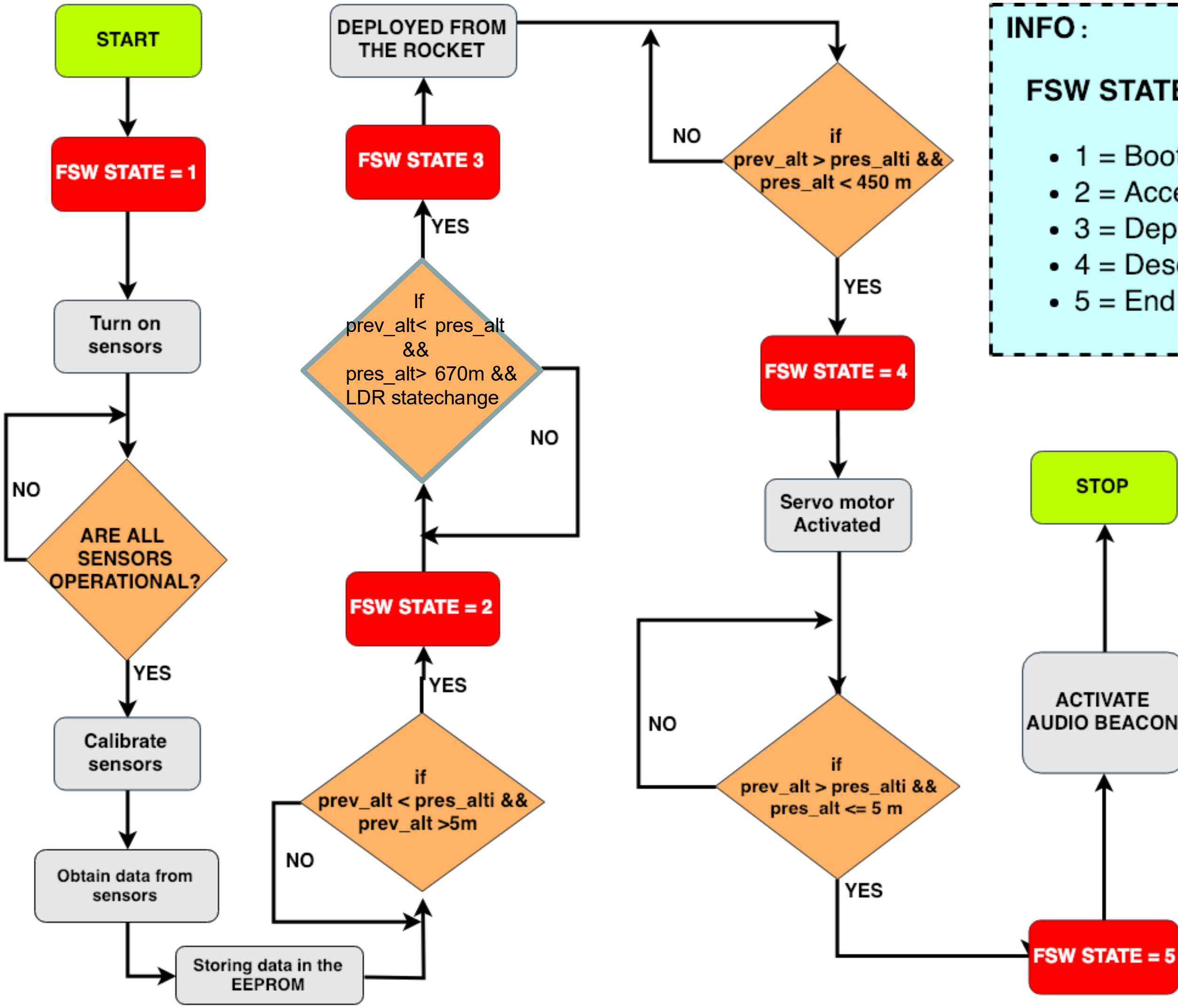
- In the unlikely event of temporary power failure because of the battery, some measures have to be taken.
- These measures help to control the irregular pattern of the telemetry count.

- 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.

Payload FSW State Diagram[3/3]

- 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.

Container FSW State Diagram



INFO :

FSW STATE:

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

Processor Reset Control:

- 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

Software Development Plan[1/3]

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[2/3]

✓ Software subsystem development sequence:

- Waterfall Software Development Life Cycle Model with a well-defined Risk Management System
- Defining FSW functions, states, interactions and requirements
- 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

Software Development Plan[3/3]

✓ Test Methodology:

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

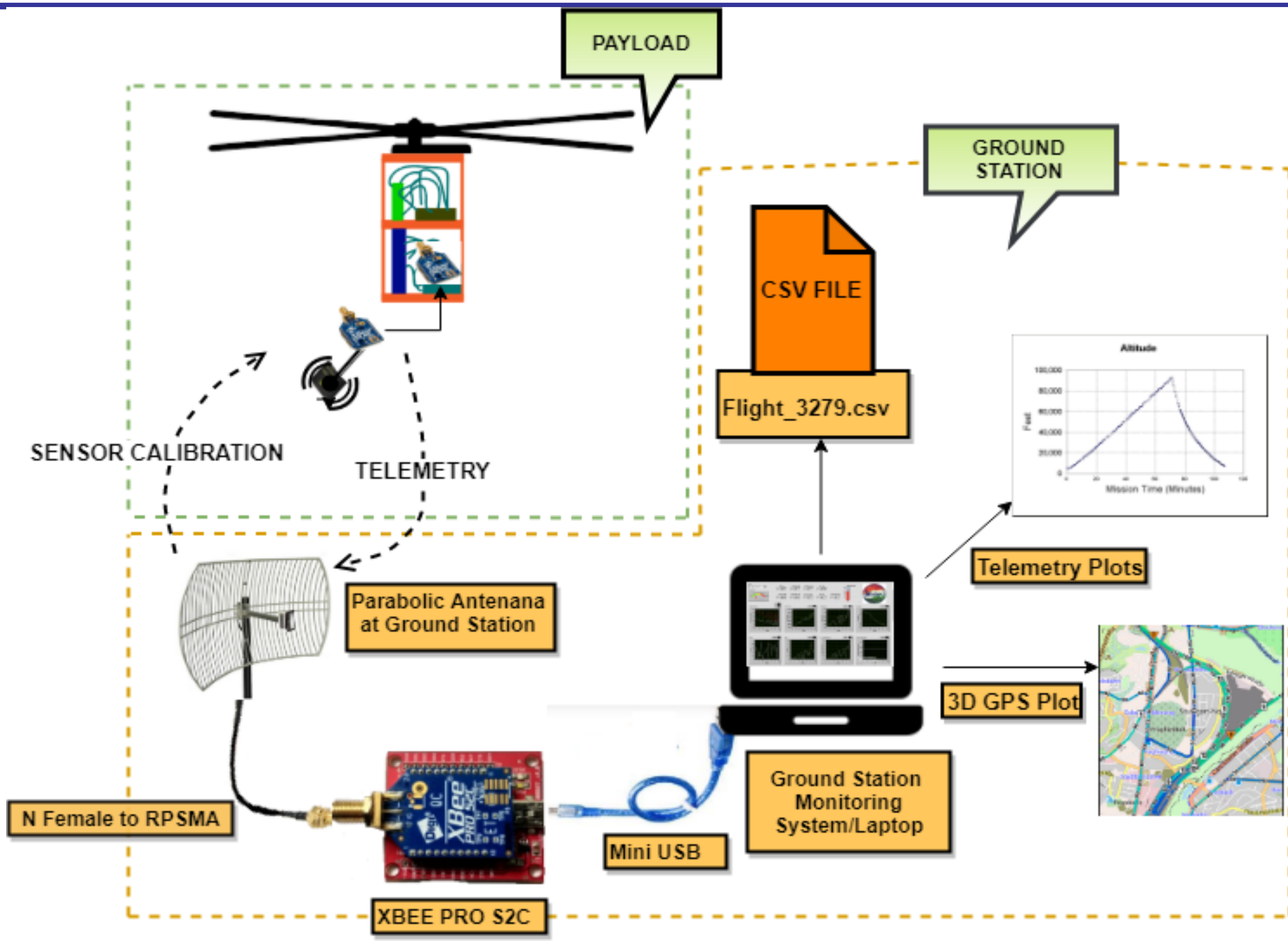
✓ Development Team:

Sanuj Kulshrestha, Anmol Gulati, Vineet Khurana, Rishabh Yadav

Ground Control System (GCS) Design

Vineet Khurana

GCS Overview



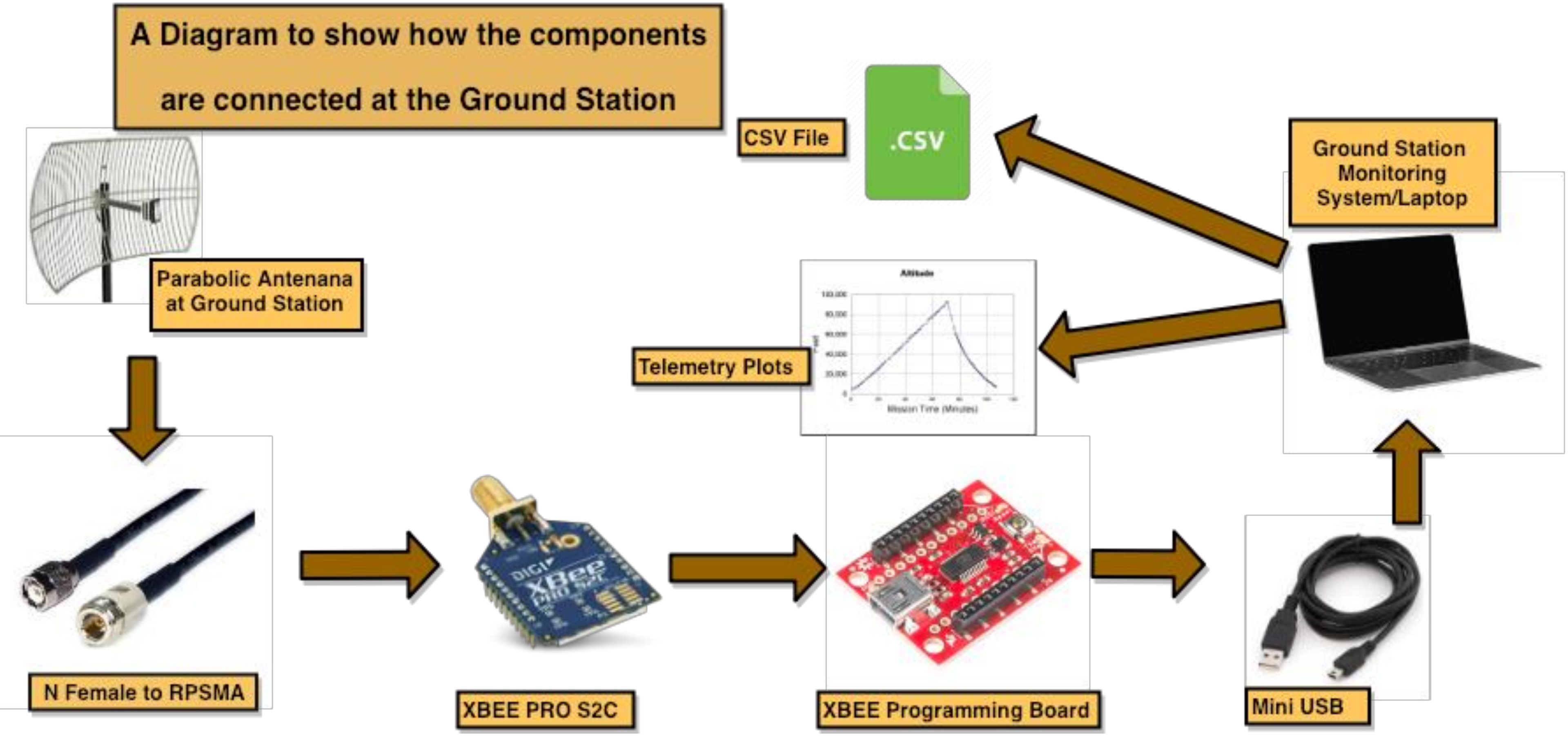
GCS Requirements[1/2]

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
RPSMA	<17GHz	WiFi, Commercial Grade Wireless General High Frequency RF.	$ 2.8
N- Female	<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]

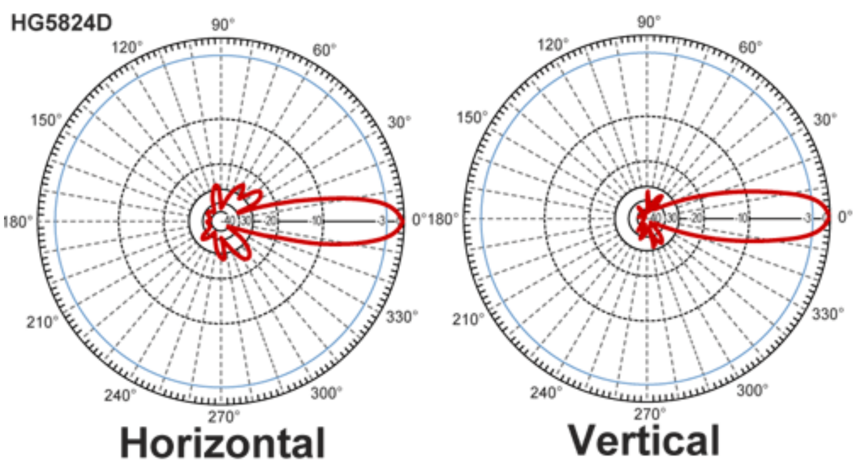
Specifications

- ✓ GCS must 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.
- ✓ We'll be doing telemetry on Mac OS X and it won't create auto update problems. In case of Windows we'll make sure that it is updated to latest versions and auto-updates are turned off.

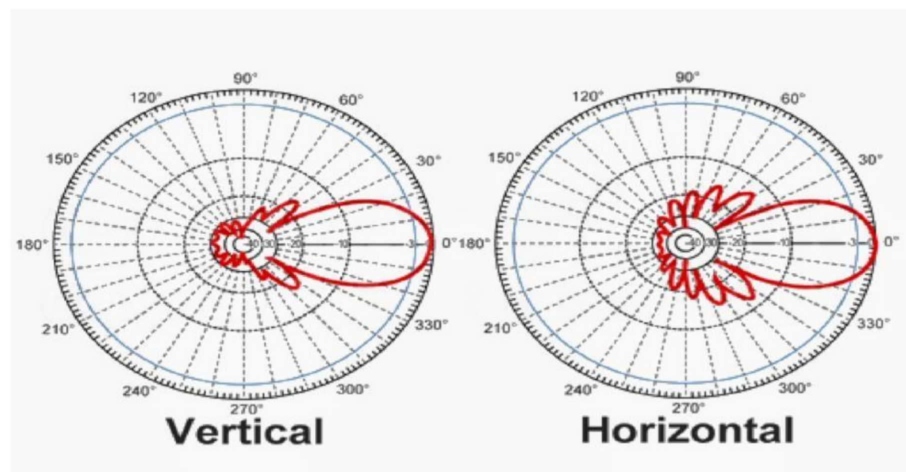
GCS Antenna Trade & Selection[1/2]

Model	Frequency	Gain	Directivity	VSWR	Range	Weight	Mounting
TP-Link Grid Parabolic	**2.4GHz-2.5GHz**	**24dBi**	**Directional**	**1.5:1 (MAX)**	**Approximate Range at 1 Mbps is 56km**	**4.8Kg**	**Table Top and adjusted Manually**
Yagi	2.4GHz-2.5GHz	9dBi	Directional	<1.5:1avg.	4.8 km	0.21kg	Hand Held

Parabolic Antenna Radiation Pattern



Yagi Antenna Radiation Pattern



GCS Antenna Trade & Selection[2/2]

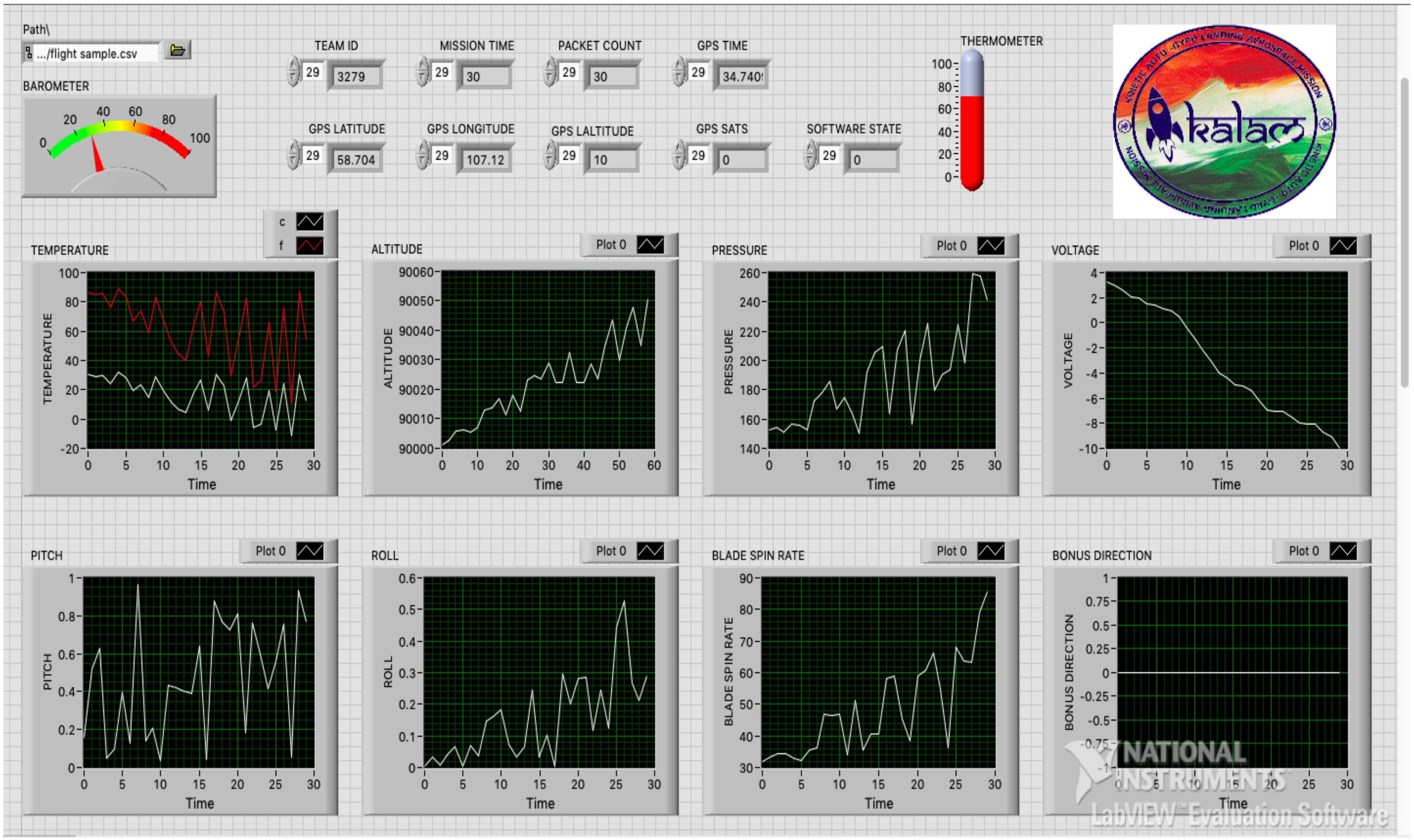
Mounting Parabolic Antenna

Mounting Yagi Antenna

SELECTED	REASONS
TP-Link Grid Parabolic Table top(Adjusted Manually)	• 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.

GCS Software[1/4]

LABVIEW GUI



GCS Software[2/4]

Flight_3279.csv FILE

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	19.74328222429657	-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	0.5268199185916453	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	85.74661979710399	BOOT	0

GCS Software[3/4]

✓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)
2. Anaconda Python Package

GCS Software[4/4]

- ✓ **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.

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.

Subsystem Level Testing Plan [1/9]

Sensor sub system integration and testing

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 , $H(n)= \mathrm{sinc}(\pi(n-5)/25)/25$

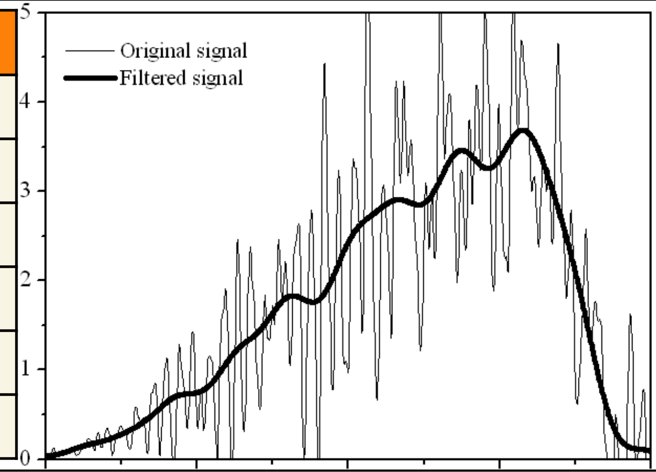
We chose causal Blackman window , which in our case evaluated to be ,
$W(n)= 0.42 -0.5\cos(\pi n/5)+0.08\cos(2\pi n/5)$

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

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]

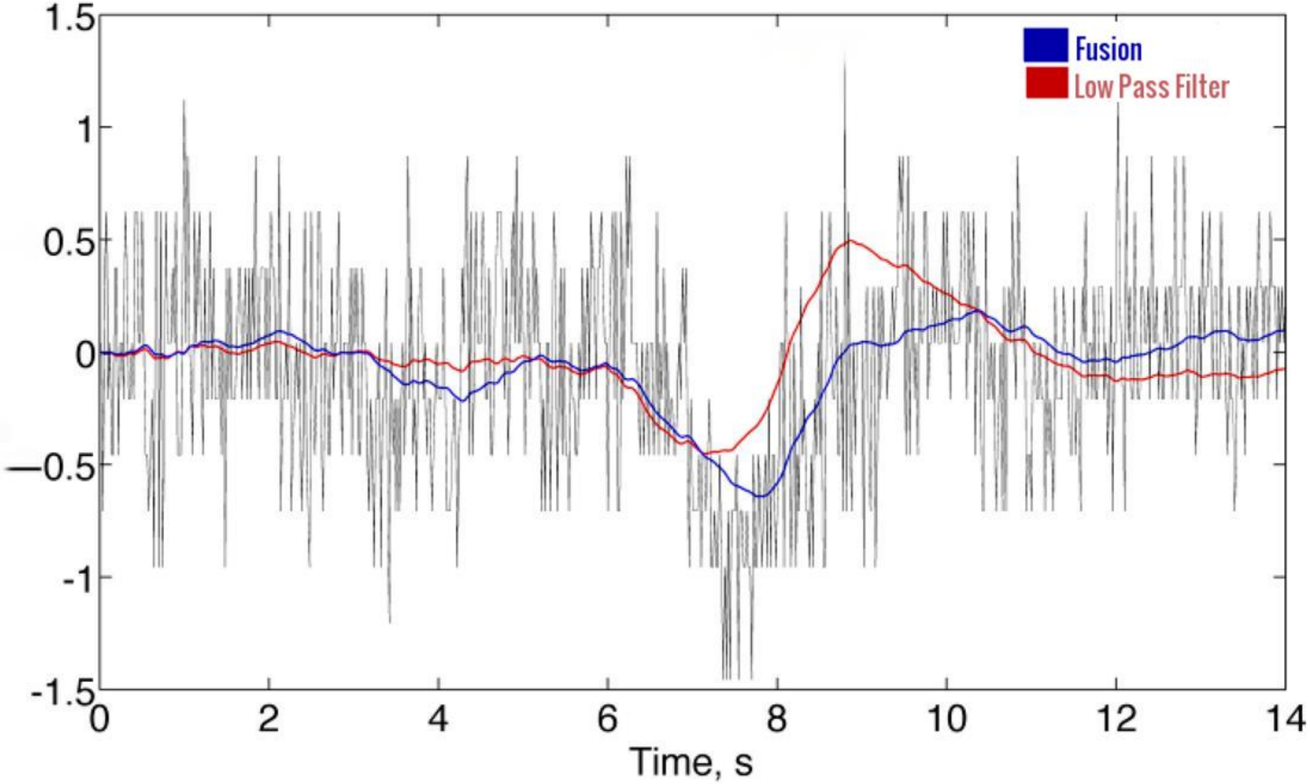
Sensor sub system integration and testing

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).

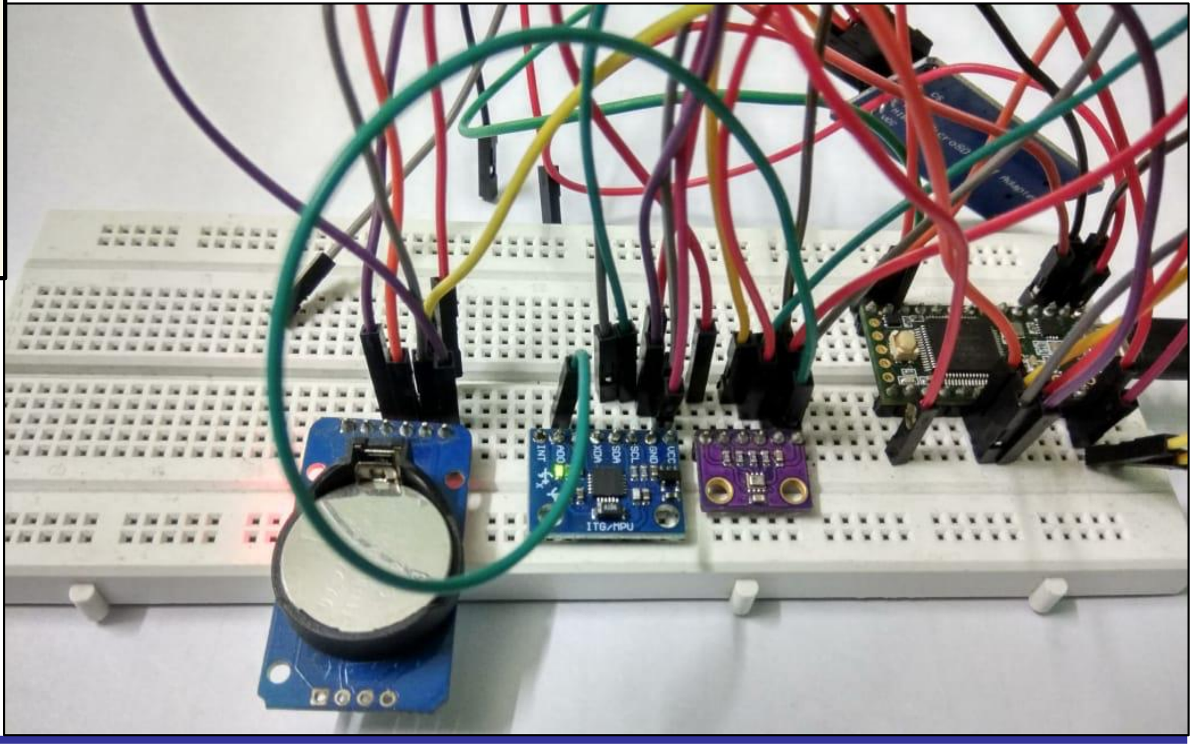
Sensor sub system integration and testing



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.

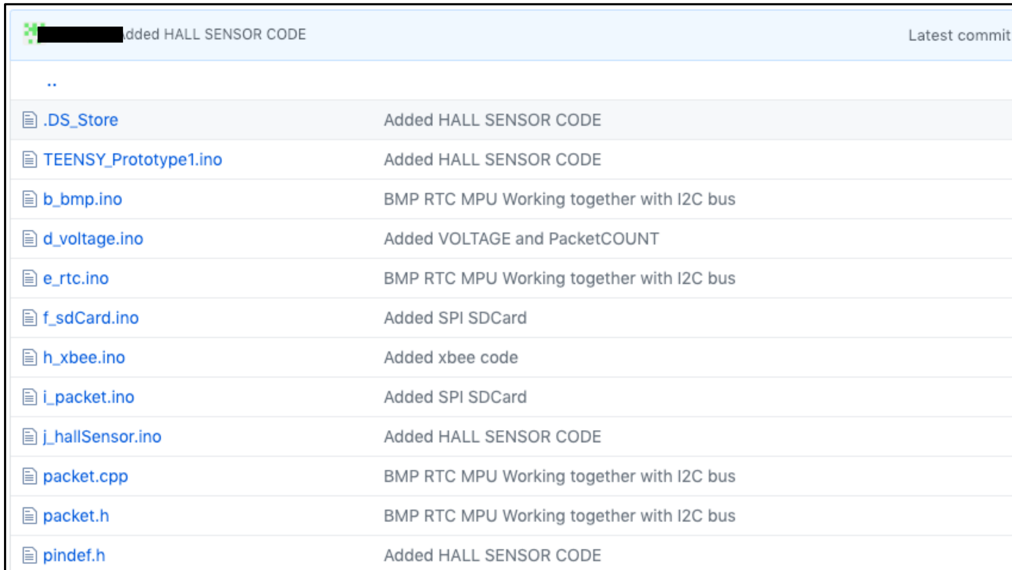
Electrical Power System

- The power required by each component was calculated.
- The Battery and required regulators were chosen accordingly to match the power requirements.

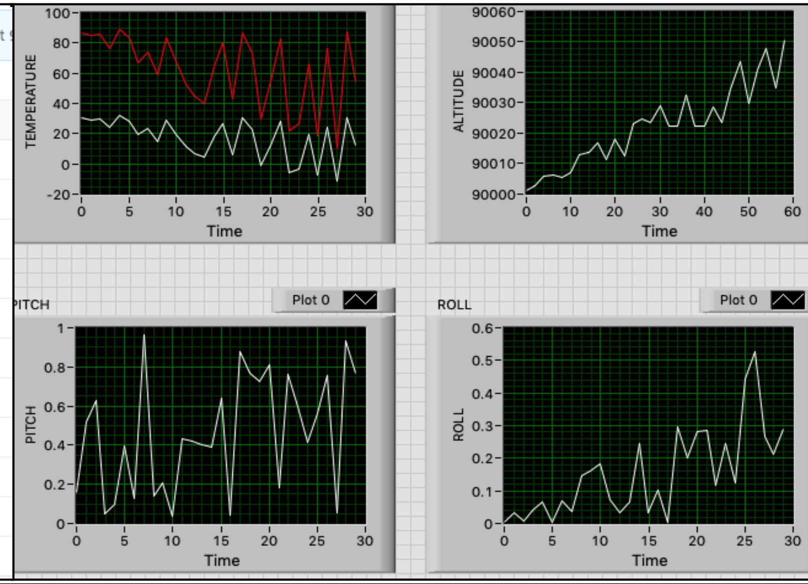


Sensors

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


[redacted] added HALL SENSOR CODE — Latest commit

..	
.DS_Store	Added HALL SENSOR CODE
TEENSY_Prototype1.ino	Added HALL SENSOR CODE
b_bmp.ino	BMP RTC MPU Working together with I2C bus
d_voltage.ino	Added VOLTAGE and PacketCOUNT
e_rtc.ino	BMP RTC MPU Working together with I2C bus
f_sdCard.ino	Added SPI SDCard
h_xbee.ino	Added xbee code
i_packet.ino	Added SPI SDCard
j_hallSensor.ino	Added HALL SENSOR CODE
packet.cpp	BMP RTC MPU Working together with I2C bus
packet.h	BMP RTC MPU Working together with I2C bus
pindef.h	Added HALL SENSOR CODE



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.

Subsystem Level Testing Plan[7/9]

Radio Communications

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

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

Subsystem Level Testing Plan[8/9]

Mechanical
• The mass of the CanSat was checked such that it lies in the mentioned range. • The stress-strain curves were plotted for the container and payload. Shock tests were performed on the container and payload. • Simulations for the auto-gyro mechanism was done on ANSYS

Subsystem Level Testing Plan[9/9]

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

Integrated Level Functional Test Plan[1/4]

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]

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.

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.

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.

Environmental Test Plan[1/4]

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

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.

Environmental Test Plan[3/4]

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.

Fit Check

The following methodology is used.

- A 125mm hole is CNC machined in an aluminium sheet.

- Proceed to pass the fully integrated CanSat through the hole and confirming it is clearance fit.

Mission Operations & Analysis

Gaurav Verma

Overview of Mission Sequence of Events[1/3]

ARRIVAL

- 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.

GROUND STATION CREW

PRE-LAUNCH CHECKS

- 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.

GROUND STATION & CANSAT CREW

ASSEMBLY AND INTEGRATION

- 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.

CANSAT CREW

Overview of Mission Sequence of Events[2/3]

LAUNCH SEQUENCE	RECOVERY	ANALYSIS AND PFR
• 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 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**	• 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**

ROLES & RESPONSIBILITIES

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

Mission Operations Manual Development Plan

- **Pre-Launch Checklist**

Electronics Testing	Structural Components Testing
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

CanSat Location and Recovery

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

Requirements Compliance

Gaurav Verma

Requirements Compliance Overview

All departments (Electronics, Mechanics and Software) have designed and partially developed the CanSat which at present fulfills all the basic requirements. Various factors such as price, safety were considered . It will also be ensured that the resultant prototype is absolutely safe and no dangerous material is incorporated into the design .

Electronics

Breadboard integration of all the sensors has been completed. Team successfully calibrated and fetched air pressure, temperature, pitch and roll, GPS, Battery Voltage, Auto Gyro blade spin rate data and transmitted it via XBEE and tested telemetry at frequency of 1 Hz.

Software

Software team has successfully plotted the received XBEE data using LABVIEW software.

Mechanical

Designs are completed based on the calculations done to comply all basic requirements. Handmade crafted were prepared for testing

BONUS DIRECTION

BLDC was successfully tested to provide camera stabilization about yaw.
Gimbal designs are completed to provide stabilization in other two axis.

In future

- Soon all 3 departments will integrate whole CanSat and perform thermal, vibration, fit, etc. tests for further improvements.
- Electronics and Software team will now try to make the sensor data free from noises.
- BLDC motor and gimbal will be integrated and tested and improvised for camera stabilization.

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	117 - 119	
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	36	
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	100	
4	The container shall be a fluorescent color; pink, red or orange.	Comply	100	
5	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	Comply	34, 35	
6	The rocket airframe shall not be used as part of the CanSat operations.	Comply	34, 35	
7	The CanSat shall deploy from the rocket payload section and immediately deploy the container parachute.	Comply	94	
8	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	Comply	66	
9	The container shall release the payload at 450 meters +/- 10 meters.	Comply	77	
10	The science payload shall descend using an auto-gyro/ passive helicopter recovery descent control system.	Comply	77	
11	The descent rate of the science payload after being released from the container shall be 10 to 15 meters/second.	Comply	70	
12	All descent control device attachment components shall survive 30 Gs of shock.	Comply	115	

Requirements Compliance[2/5]

13	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	22,81	
14	All structures shall be built to survive 15 Gs of launch acceleration.	Comply	115	
15	All structures shall be built to survive 30 Gs of shock.	Comply	115	
16	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	81, 103	
17	All mechanisms shall be capable of maintaining their configuration or states under all forces	Comply	115	
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	41	
21	The science payload shall provide position using GPS.	Comply	44	
22	The science payload shall measure its battery voltage.	Comply	45	
23	The science payload shall measure outside temperature.	Comply	42	
24	The science payload shall measure the spin rate of the auto-gyro blades relative to the science vehicle.	Comply	46	
25	The science payload shall measure pitch and roll.	Comply	43	
26	The payload shall transmit all sensor data in the telemetry	Comply	136,137,188,189	
27	The Parachute shall be fluorescent Pink or Orange	Comply	55,56,57	

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	191	
29	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	Comply	189	
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	173	
31	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	136	
32	XBEE radios shall have their NETID/PANID set to their team number.	Comply	136	
33	XBEE radios shall not use broadcast mode.	Comply	136	
34	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	225 - 231	
35	Each team shall develop their own ground station.	Comply	180,183	
36	All telemetry shall be displayed in real time during descent	Comply	188	
37	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	188	
38	Teams shall plot each telemetry data field in real time during flight.	Comply	188	
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	180, 183	

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	**180, 183**	
41	Both the container and payload shall be labeled with team contact information including email address.	Comply	216	
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	17	
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	146	
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	145	
46	An audio beacon is required for the payload. It may be powered after landing or operate continuously.	Comply	146	
47	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.	Comply	145	
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	147,164	
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	145	

Requirements Compliance[5/5]

50	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	Comply	196	
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	43	
53	The CanSat must operate during the environmental tests laid out in Section 3.5.	Comply	206-210	
54	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	Comply	161, 162, 166	
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	46	

Management

Vineet Khurana

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 dv	1	$15.4	Actual
GPS Sensor		BN220	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	DS 3231	1	$5.97	Actual
Voltage Regulator	LM 7805(5V)	1	$2.5	Actual
	LM7111(3.3V)	1	$2.5	Actual
Communication Module	XBEE Pro 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	Estimated
Rotor	3D printed nylon PA-2200	1	$15	Estimated
Blades	Vacuum formed p olycarbonate	4	$115	Estimated
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]

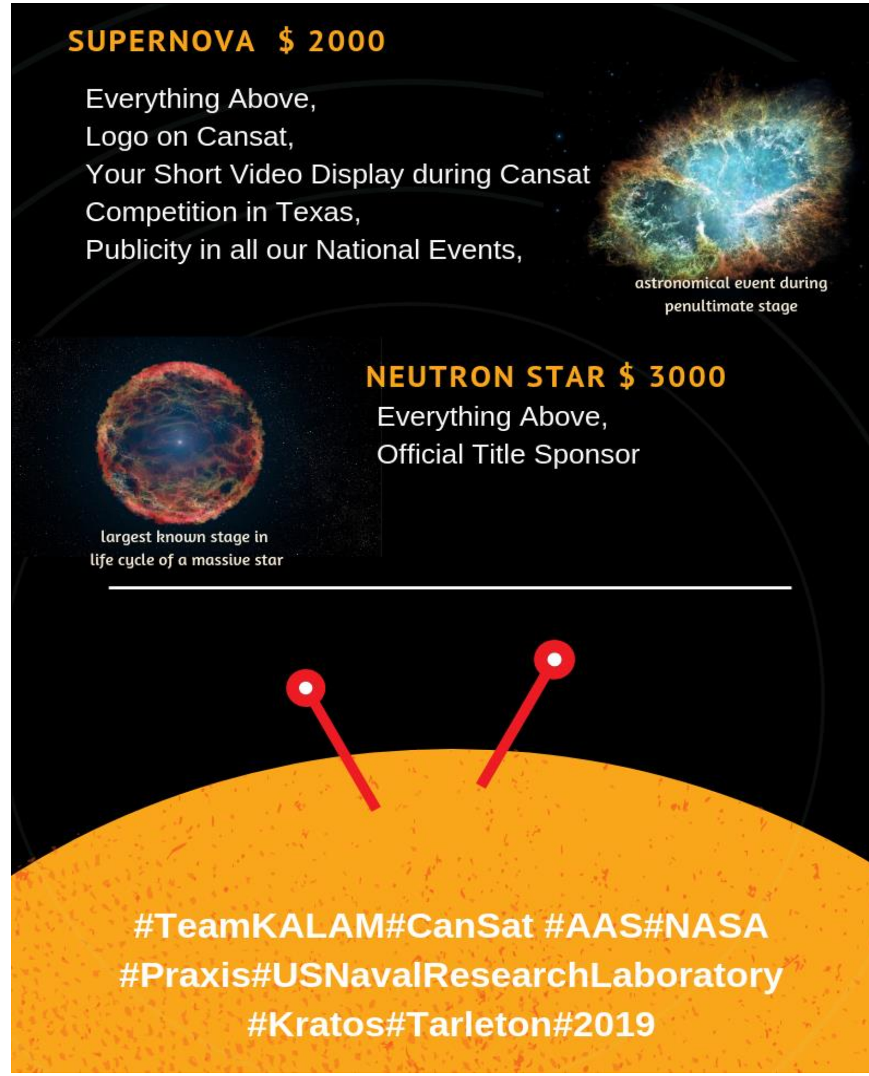
Part	Model	Quantity	Total Cost ($)	Determination
Ground Station Antenna	Parabolic Antenna	1	$46.04	Actual
Communication Module	XBEE Pro S2C	1	$41.61	Actual
Base Circuit Boards	PCB	1	$10	Actual
Laptop	Apple MacBook Air	1	$999	Actual
Others			$20	Estimate
Total			$1096.65	

CanSat Budget – Other Costs [2/4]

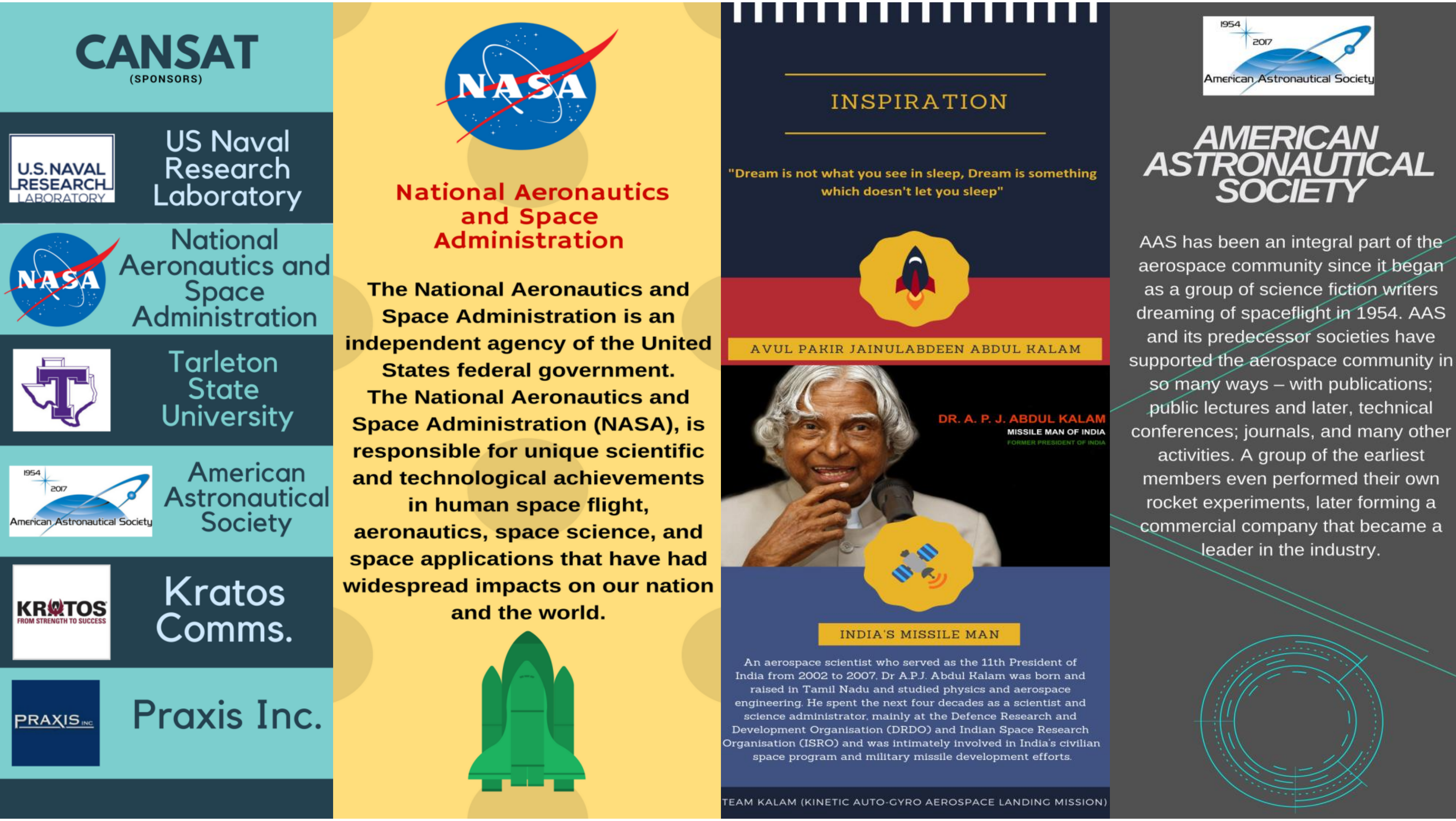
Part	Quantity	Total Cost ($)	Determination
CanSat Fee	1	$100	Actual
Food	12	$900	Estimated
Transport	10	$1500	Estimated
Flight Tickets	10	$15000	Estimated
Accommodation	2	$700	Estimated
Prototyping	-	$3000	Estimated
	Total	**$21200**	**Estimated**

Budget	
College	$500
Amount from Sponsors needed	$3000

CanSat Budget – Other Costs [3/4]

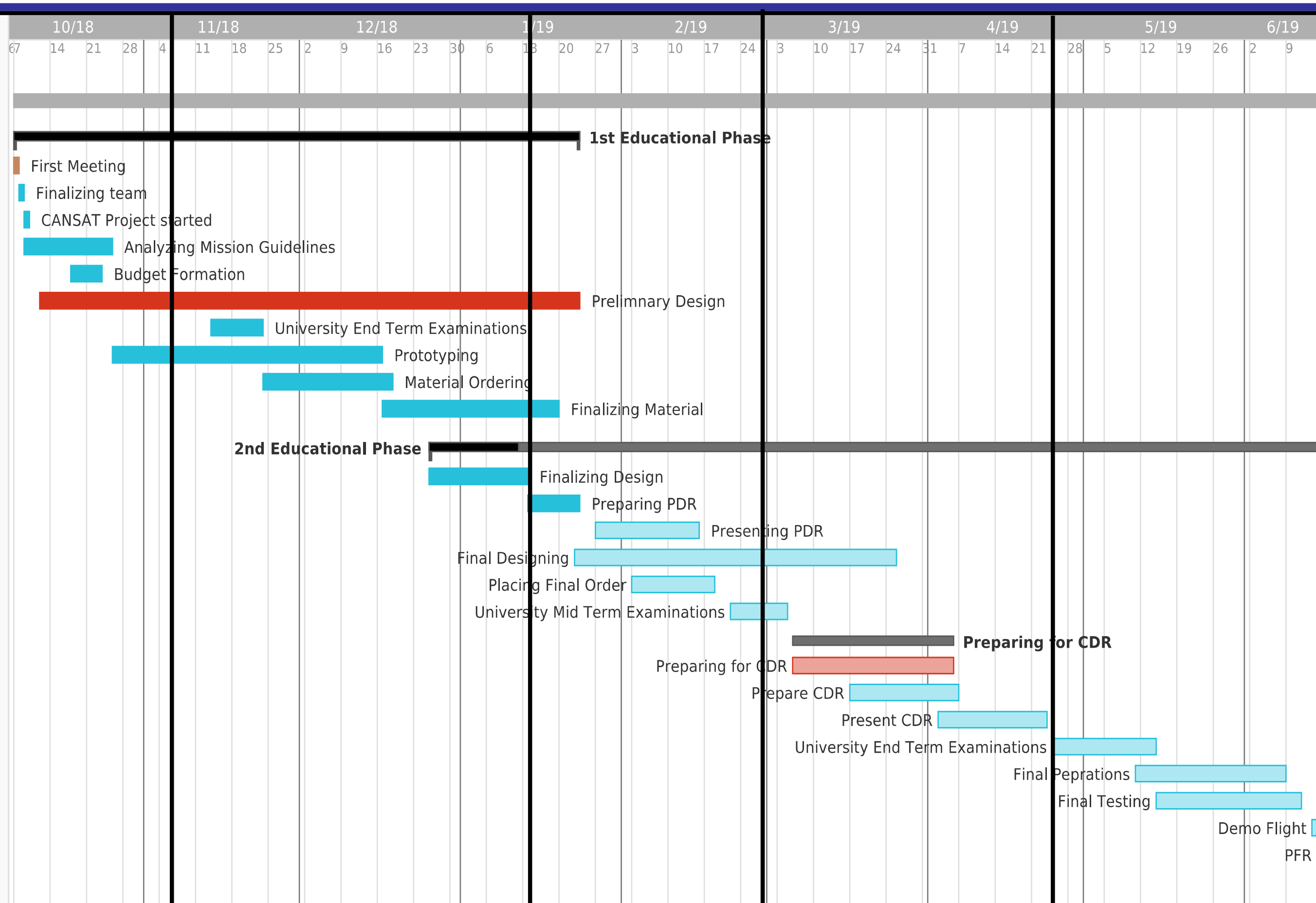


CanSat Budget- Other Costs [4/4]



Detailed Program Schedule[1 of 5]

Task	% Complete
CANSAT	**52%**
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	**10%**
Finalizing Design	100%
Preparing PDR	100%
Presenting PDR	0%
Final Designing	0%
Placing Final Order	0%
University Mid Term Examinations	0%
Preparing for CDR	**0%**
Preparing for CDR	0%
Prepare CDR	0%
Present CDR	0%
University End Term Examinations	0%
Final Peprations	0%
Final Testing	0%
Demo Flight	0%
PFR	0%



Task Assignment	Archiev, Divyansh, Vineet	Sanuj, Anmol, Vineet, Arham, Aayush, Rishabh	Full TEAM	Archiev, Divyansh Sanuj, Anmol, Arham, Gaurav, Bhavuk	Full TEAM

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 : 2nd 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 configuration shall be performed
7 Feb 2019	16 Feb 2019	The fabrication for the CanSat shall begin.

Detailed Program Schedule[4 of 5]

Start Date	End Date	Major Milestones/Activities
3 Feb 2019	18 Feb 2019	Proceeding with the final ordering of the components.
17 Feb 2019	1 Mar 2019	We shall begin with drop tests.
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) shall be done. Solutions to any failures encountered will be quickly assimilated into our design. Full scale fabrication of the CanSat shall be completed.
17 Mar 2019	6 April 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

Conclusions[1 of 4]

Presentation summary

- Through our preliminary design review and presentation, we have identified the major problem statements of the competition and formulated multiple solutions, choosing the best design that fits all our constraints and requirements.
- In electronics, we have finalized all the components, having bought sensors like pressure and temperature sensor, communications modules, GPS sensor etc. Testing for the sensors as well as the XBEE modules has been done, testing for the rest will be done shortly when the components arrive.
- In mechanical structure, we have finalized our design, material, structure, configuration and payload layout after comparing several designs.
- In electrical subsystem, we have calculated the power required for the entire payload components and hence chosen and tested our power source accordingly.

Conclusions[2 of 4]

Major accomplishments:

- 3D models of container, CanSat structure and deployment mechanisms have been obtained in SolidWorks software.
- Multiple designs of payload created and tested through software structures.
- We have already designed the PCB for the electronic components and tested it.
- Communication system has already been tested extensively.

Conclusions[3 of 4]

Major unfinished work:

- Not all electronic components have arrived .
- Environmental tests have to be conducted.
- We feel we have ticked the right boxes and analyzed the problem in a practical and research oriented manner.
- We have had countless discussions about the design and calculation aspects of the competition, keeping each requirement in mind.
- Further testing is planned using a rocket which will launch our CanSat to the same height as the actual launch.

"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 .