CanSat 2020
Preliminary Design Review (PDR)
Version 1.0

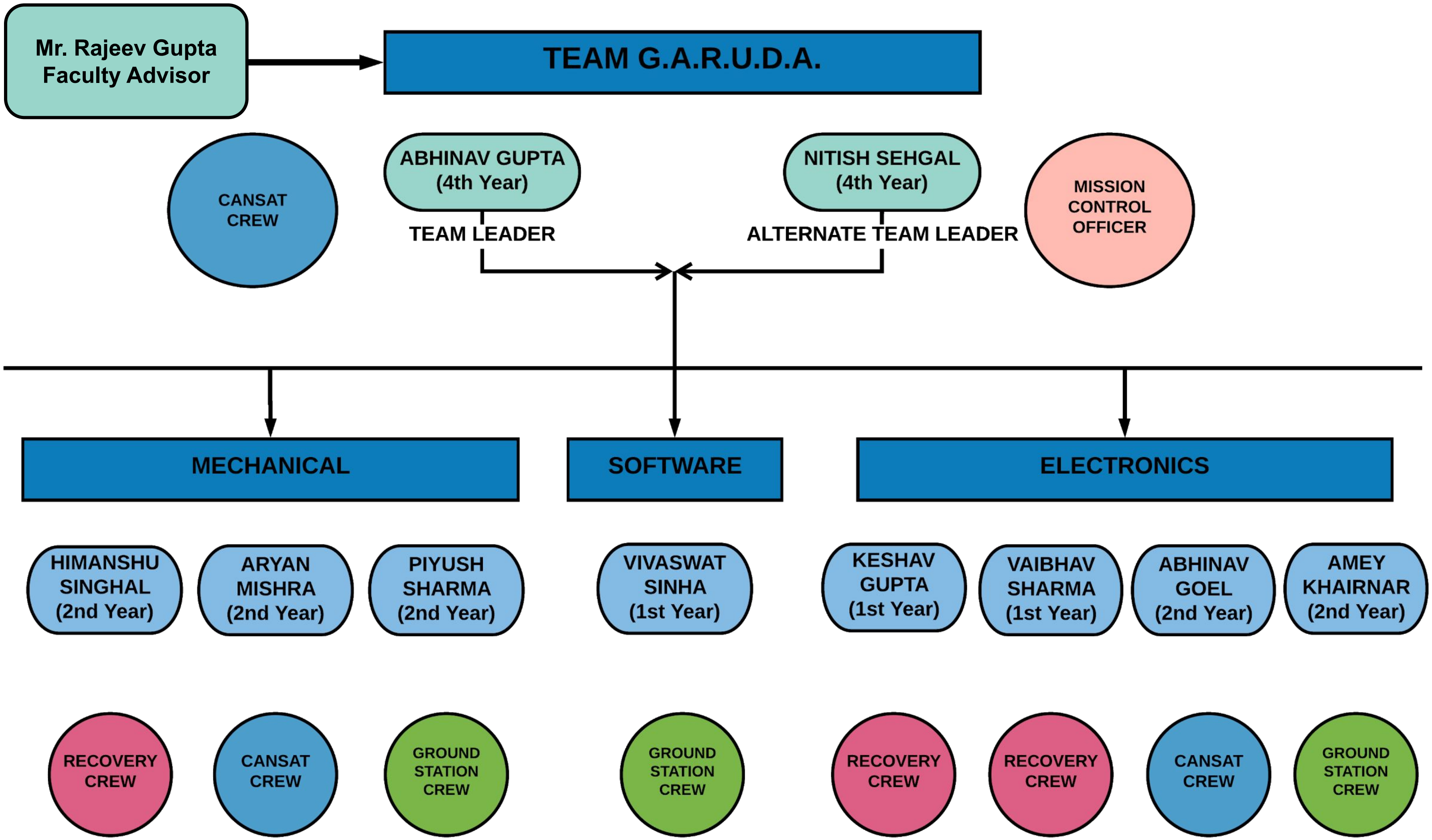
#4800

TEAM G.A.R.U.D.A.

Glide Actuating Robust Unmanned Data Aggregator

Presentation Outline

Team Organization



Acronyms

ADC	Analog to Digital Converter
A	Analysis
BR	Base Requirement
Cg	Center of Gravity
Cp	Center of Pressure
CSV	Comma Separated Value
CDH	Communication and Data Handling
CReq	Competition Requirement
CCDH	Container Communication and Data Handling
CONOPS	Concept Of Operations
D	Demonstration
DS	Data Sheet
DP	Dependency
DCR	Descent Control Requirements
E	Estimated
EEPROM	Electrically Erasable Programmable Read Only Memory
EPS	Electrical Power Subsystem
EPSR	Electrical Power Subsystem Requirements
FSW	Flight Software
FSWR	Flight Software Design Requirements
G	G-Force
GUI	Graphical User Interface
GND	Ground
GCSR	Ground Control System Requirements
GCS	Ground Control System
GPS	Ground Positioning System
I	Inspection
IDE	Integrated Development Environment
I^2C	Inter Integrated Circuit
LDR	Light Dependent Resistor
M	Measured
MSR	Mechanical Subsystem Requirements
MCU	Micro Controller Unit
PANID	Personal Area Network Identification Number
PCDH	Payload Communications and Data Handling
RF	Radio Frequency
SSR	Sensor Subsystem Requirements
SPI	Serial Peripheral Interface
T	Test
UART	Universal Asynchronous Receiver Transmitter
Vm	Verification Method
VSWR	Voltage Standing Wave Ratio

Systems Overview

Piyush Sharma

The terms payload and glider are interchangeably used throughout the presentation.

Mission Summary (1/2)

General Objectives

- To design a CanSat containing a container and a delta wing glider as the science payload.
- The CanSat shall be launched at an altitude of 670 meters to 725 meters.
- After deployment of the CanSat, it shall deploy a parachute which will descend at a velocity of 20m/s.
- As it reaches around 450 meters the container shall release the delta wing glider which will glide in helical path of radius 250 metres and collect and transmit telemetry for one minute.
- The Delta wing glider shall remain 100 metres above the ground while gliding for one minute.
- After gliding for one minute, the glider shall deploy a parachute to restrict its gliding and causing it to descend at 10 m/s.

Mechanical Objectives

- Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.
- 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.
- All descent control device attachment components shall survive 30 Gs of shock.
- All structures shall be built to survive 15 Gs of launch acceleration.

Mission Summary (2/2)

Electronics Objectives

- All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.
- The science payload shall measure altitude using an air pressure sensor and shall provide position using GPS.
- The science payload shall measure particulates in the air as it glides and shall measure outside temperature.
- Telemetry shall be updated once per second.
- The ground station shall generate a csv file of all sensor data as specified in the telemetry section and XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed.

Bonus Objectives

- A video camera shall be integrated into the science payload and point toward the coordinate provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved. Points will be awarded only if the camera can maintain pointing at the provided coordinates for 30 seconds uninterrupted.

External Objectives

- To gain experience from the competition and look forward to organise a similar competition in India.
- To raise funds for the the team for upcoming competitions.

System Requirement Summary (1/6)

ID	Requirement	Rationale	Verification Method			
			A	I	T	D
BR-1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	CReq	✓		✓	
BR-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.	CReq	✓	✓	✓	
BR-3	No sharp edges will be designed in the container so that it doesn't get stuck in the rocket payload section which is made up of cardboard.	CReq		✓	✓	
BR-4	Color of container- Fluorescent color maybe pink, red or orange.	CReq		✓	✓	
BR-5	The container shall be solid and fully enclose the science payload. Small holes to allow access to turn on the science payload is allowed. The end of the container where the payload deploys may be open.	CReq	✓			✓
BR-6	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	CReq	✓			✓
BR-7	The rocket airframe shall not be used as part of the CanSat operations.	CReq	✓			✓
BR-8	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.	CReq	✓	✓	✓	✓
BR-9	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	CReq	✓	✓		
BR-10	The container shall release the payload at 450 meters +/- 10 meters.	CReq	✓	✓	✓	
BR-11	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container	CReq		✓	✓	

System Requirement Summary (2/6)

ID	Requirement	Rationale	Verification Method			
			A	I	T	D
BR-12	The science payload shall be a delta wing glider.	CReq	✓	✓	✓	✓
BR-13	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s	CReq	✓	✓		
BR-14	All descent control device attachment components shall survive 30 Gs of shock.	CReq			✓	
BR-15	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	CReq	✓	✓	✓	
BR-16	All structures shall be built to survive 15 Gs of launch acceleration.	CReq	✓		✓	
BR-17	All structures shall be built to survive 30 Gs of shock.	CReq	✓		✓	
BR-18	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	CReq	✓	✓	✓	
BR-19	All mechanisms shall be capable of maintaining their configuration or states under all forces.	CReq	✓	✓	✓	
BR-20	Mechanisms shall not use pyrotechnics or chemicals	CReq	✓	✓		
BR-21	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	CReq	✓		✓	✓
BR-22	The science payload shall measure altitude using an air pressure sensor.	CReq	✓		✓	✓

System Requirement Summary (3/6)

ID	Requirement	Rationale	Verification Method			
			A	I	T	D
BR-23	The science payload shall provide position using GPS.	CReq	✓		✓	✓
BR-24	The science payload shall measure its battery voltage.	CReq	✓	✓		✓
BR-25	The science payload shall measure outside temperature.	CReq	✓	✓	✓	✓
BR-26	The science payload shall measure particulates in the air as it glides.	CReq	✓		✓	✓
BR-27	The science payload shall measure air speed.	CReq	✓		✓	✓
BR-28	The science payload shall transmit all sensor data in the telemetry.	CReq	✓	✓	✓	✓
BR-29	Telemetry shall be updated once per second.	CReq		✓	✓	✓
BR-30	The Parachutes shall be fluorescent Pink or Orange	CReq	✓			✓
BR-31	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	CReq	✓	✓	✓	
BR-32	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.	CReq	✓	✓	✓	
BR-33	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	CReq	✓		✓	

System Requirement Summary (4/6)

ID	Requirement	Rationale	Verification Method			
			A	I	T	D
BR-34	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission	CReq	✓	✓	✓	
BR-35	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	CReq	✓	✓	✓	✓
BR-36	XBEE radios shall have their NETID/PANID set to their team number.	CReq	✓	✓		✓
BR-37	XBEE radios shall not use broadcast mode	CReq	✓	✓		✓
BR-38	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	CReq		✓		✓
BR-39	Each team shall develop their own ground station.	CReq	✓	✓	✓	✓
BR-40	All telemetry shall be displayed in real time during descent	CReq	✓	✓	✓	
BR-41	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	CReq	✓		✓	✓
BR-42	Teams shall plot each telemetry data field in real time during flight.	CReq	✓	✓	✓	✓
BR-44	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	CReq	✓		✓	
BR-45	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	CReq	✓	✓		

System Requirement Summary (5/6)

ID	Requirement	Rationale	Verification Method			
			A	I	T	D
BR-46	Both the container and probe shall be labeled with team contact information including email address.	CReq	✓	✓	✓	
BR-47	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	CReq	✓	✓	✓	✓
BR-48	No lasers allowed	CReq	✓	✓		
BR-49	The probe must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration.	CReq	✓	✓	✓	
BR-50	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the CanSat and in the stowed state	CReq	✓	✓	✓	✓
BR-51	An audio beacon is required for the probe. It may be powered after landing or operate continuously.	CReq	✓	✓	✓	✓
BR-52	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed	CReq	✓	✓	✓	
BR-53	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.	CReq	✓		✓	✓
BR-54	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.	CReq	✓	✓	✓	
BR-55	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	CReq	✓	✓		

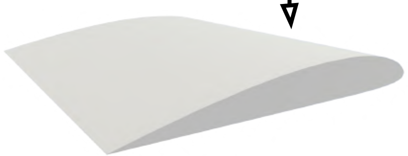
System Requirement Summary (6/6)

ID	Requirement	Rationale	Verification Method			
			A	I	T	D
BR-56	The CanSat must operate during the environmental tests laid out in Section 3.5.	CReq	✓	✓	✓	
BR-57	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	CReq	✓	✓	✓	
Bonus	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved.	Bonus Objectives	✓	✓	✓	✓

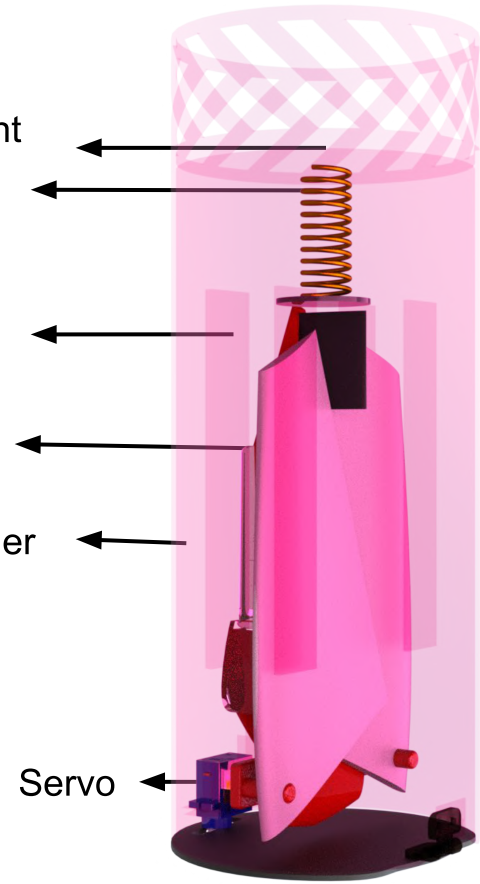
System Level CanSat Configuration Trade & Selection (1/4)

CONFIGURATION 1

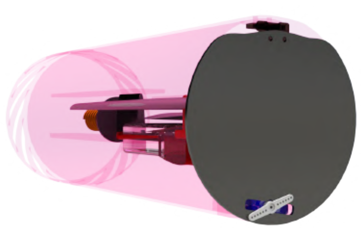
The **glider** is kept in **nose down position** and is **resting on the lid**. The **spring** is **compressed** which in turn causes the **glider** to be **pushed out**, as soon as the **lid opens**.



NACA 6412

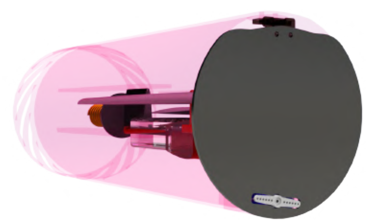


Side View (Glider Position)



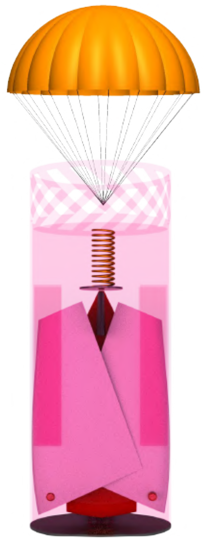
Step 1

In **Step 1** the **lid** is **held in position** due to offset between the servo blade and the cutout. When the **servo rotates** and the **blade matches** with the **cutout** causing the **lid to open** as shown in **Step 2**.



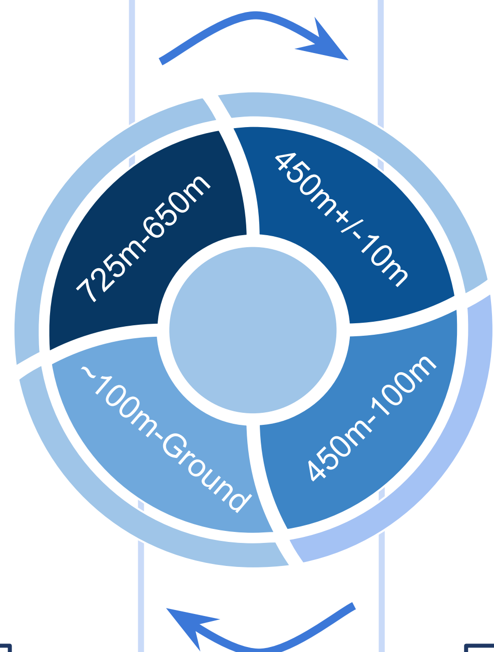
Step 2

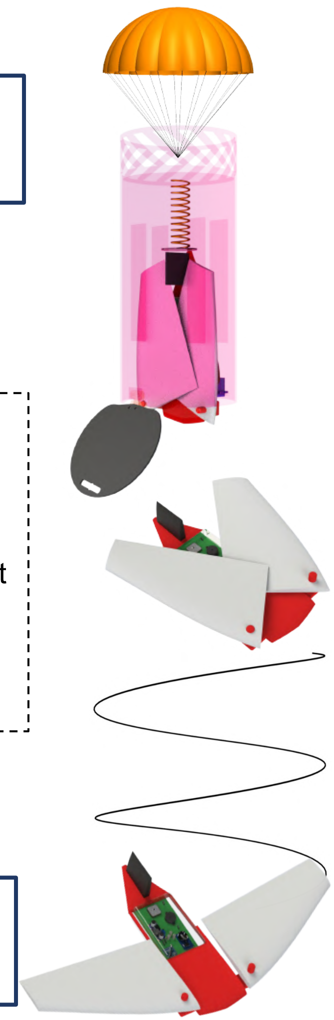
CONFIGURATION 1



CanSat Deployment from rocket

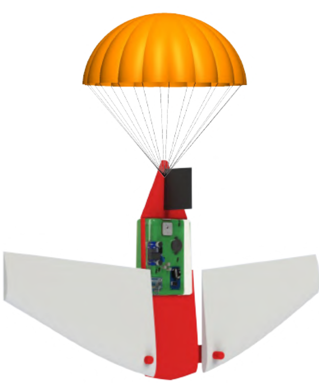
Deployment of Payload





The **glider** is kept in **stowed position** with the help of the **lid** and the **spring** is **constantly pushing** the glider.

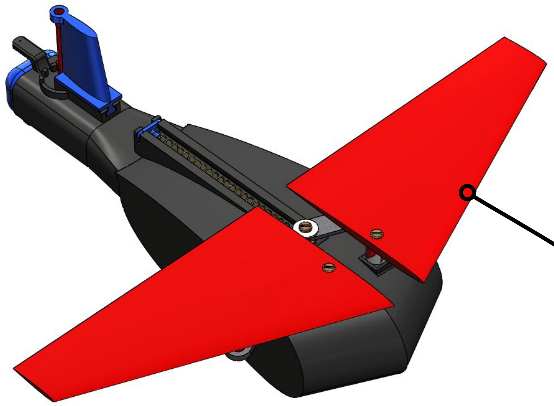
Upon **reaching** the height of **450 m** the **servo is actuated** and the **lid** which was kept closed due to the offset of the servo blade **opens**.

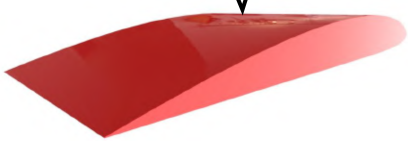


Glider descends using parachute.

Glider descends in helical path

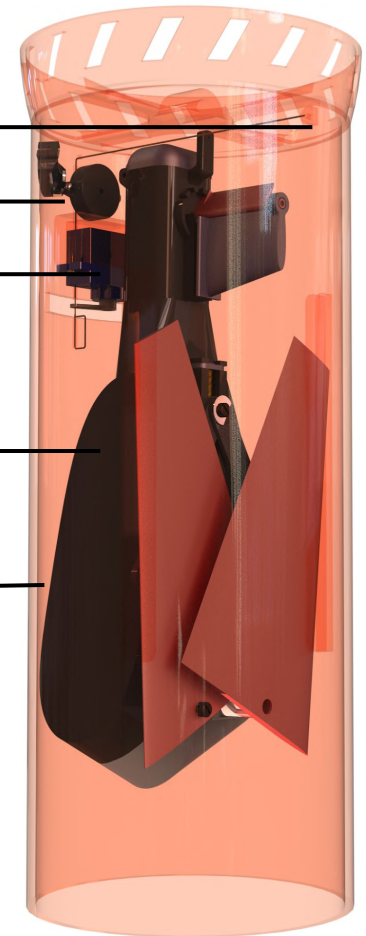
CONFIGURATION 2



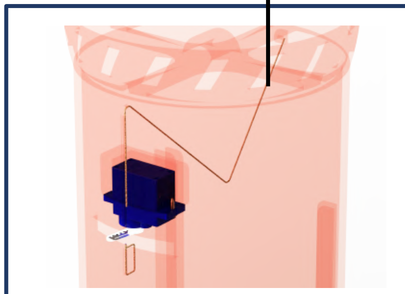


NACA 3411

The **glider** is kept in **nose down position** and is **tied in position** with the help of **Kevlar thread**. When the **thread is cut** due to the motion of **servo**, the **glider** will **slip out** of the container



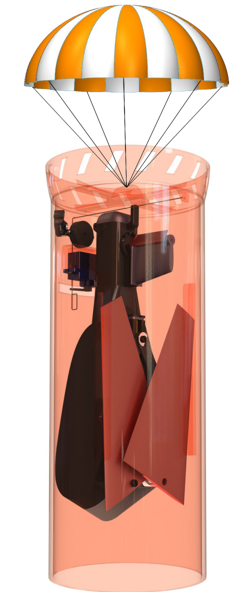
Side View (Glider Position)

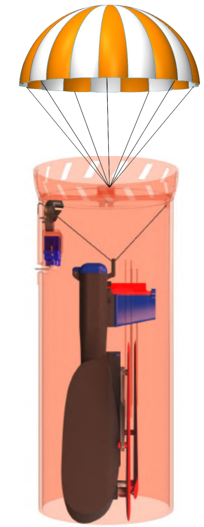


A **metal blade** is attached to the **servo arm** which when actuated **facilitates the cutting** of the kevlar thread. This **releases the glider** from the container.

System Level CanSat Configuration Trade & Selection (4/4)

CONFIGURATION 2

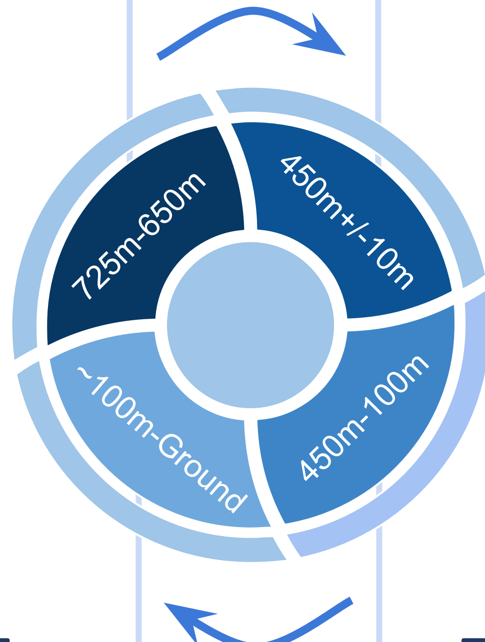




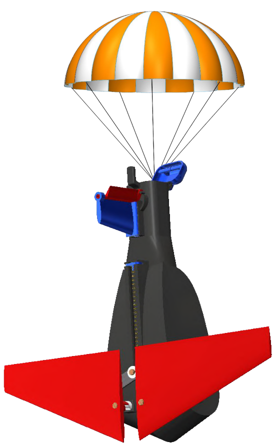
CanSat Deployment from rocket

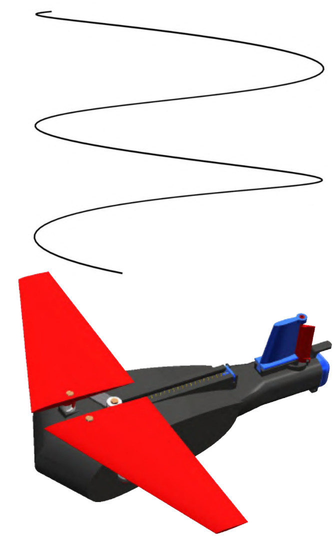
Deployment of Payload

The **glider** is kept in **stowed position** with the help of the **thread** which is **fixed to the container** and passes through the glider's mount as well, **tying** the glider **to the container**.



Upon **reaching** the height of **450 m** the **servo** is **actuated** which in turn **cuts the thread** hence, **releasing the glider.**





Glider descends using parachute.

Glider descends in helical path

System Level Configuration Selection

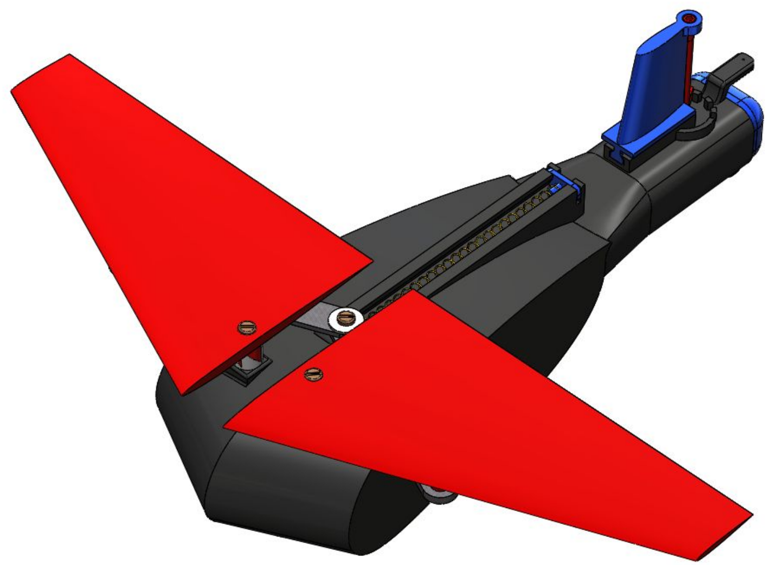
SELECTED CONFIGURATION: CONFIGURATION 2

Rationale

- Thread cutting release mechanism is being selected due its simplicity and reliability.
- Parasol Wing glider is chosen. This helps to attain a fairly complex and sturdy wing opening mechanism over the top of the fuselage body without compromising on the rigidity and strength of the wings.
- Provides ample space for PCB while being the most aerodynamically efficient shape.

Parasol Wings, though uncommon, are employed when **more space is required** inside the fuselage

CanSat

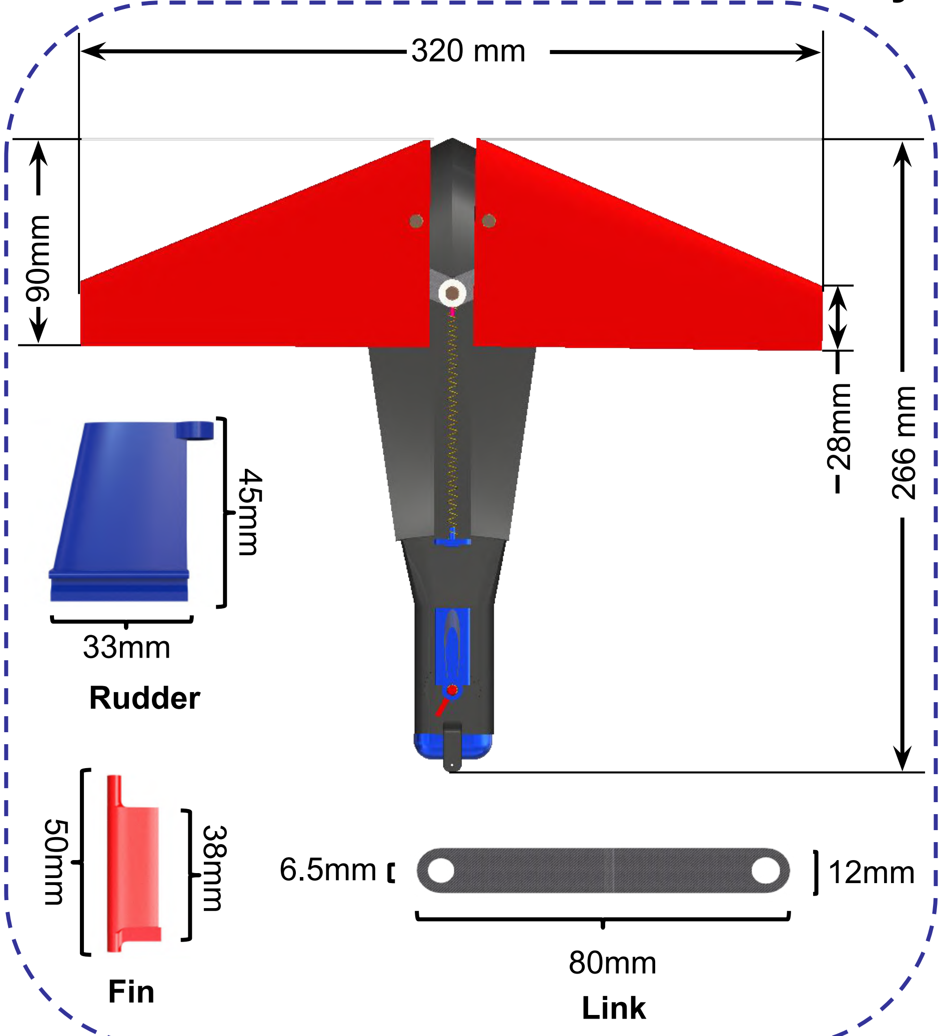


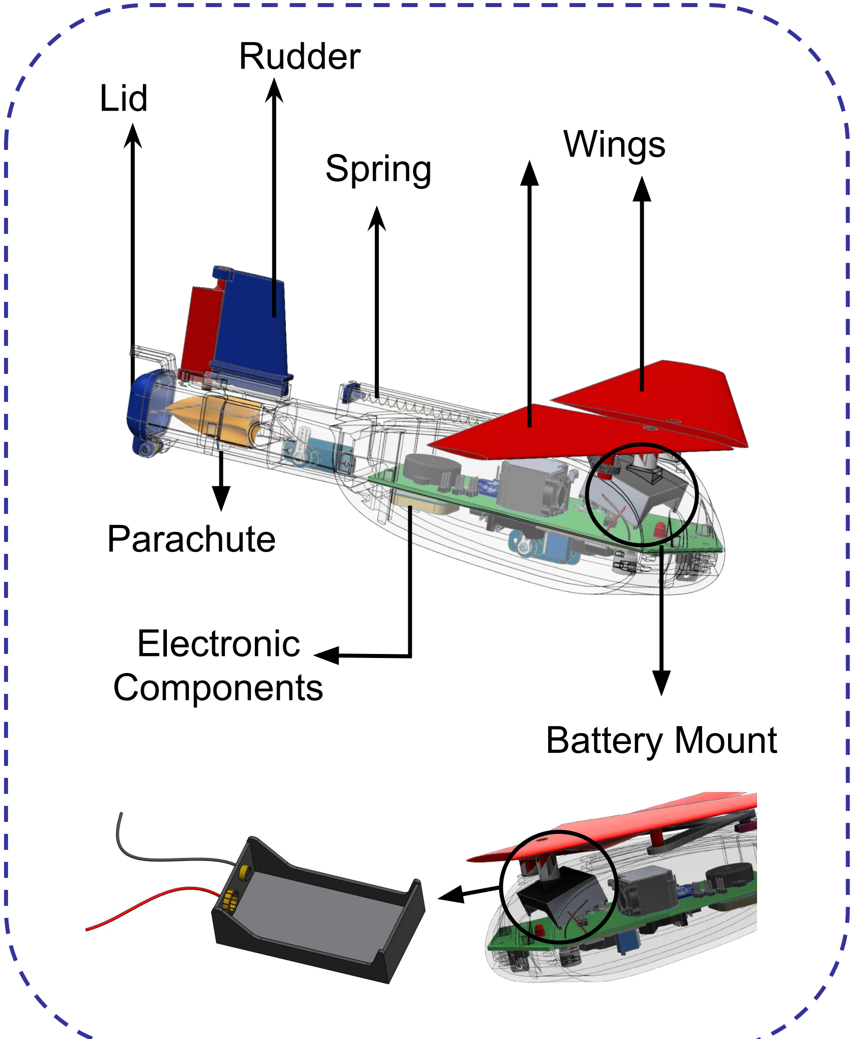
Payload

PBY-5 Catalina

Physical Layout (1/4)

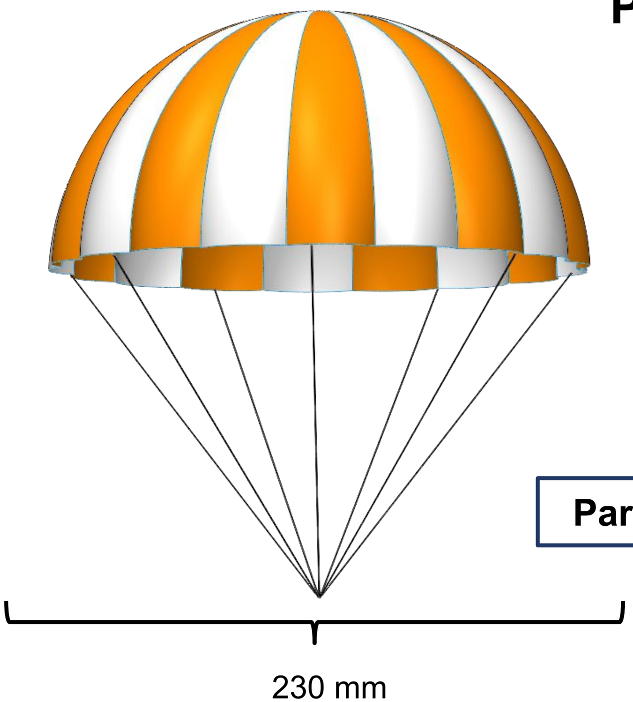
Payload



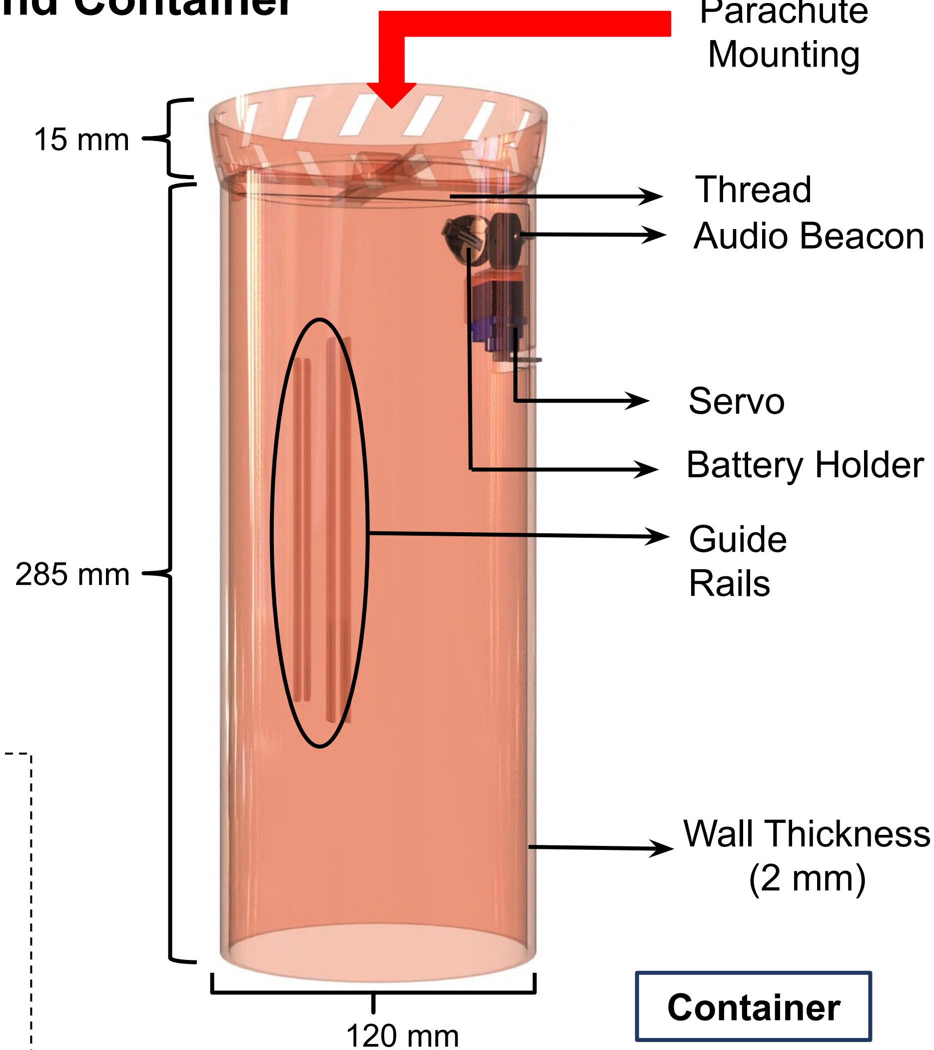


Physical Layout (2/4)

Parachute and Container



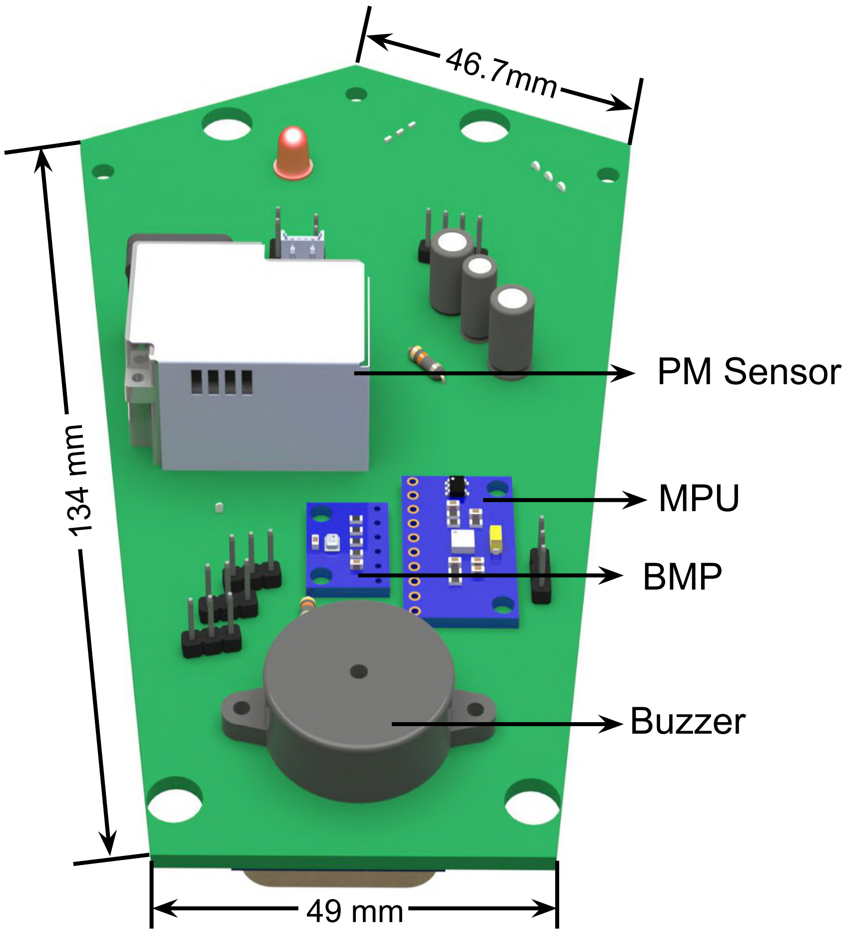
Parachute



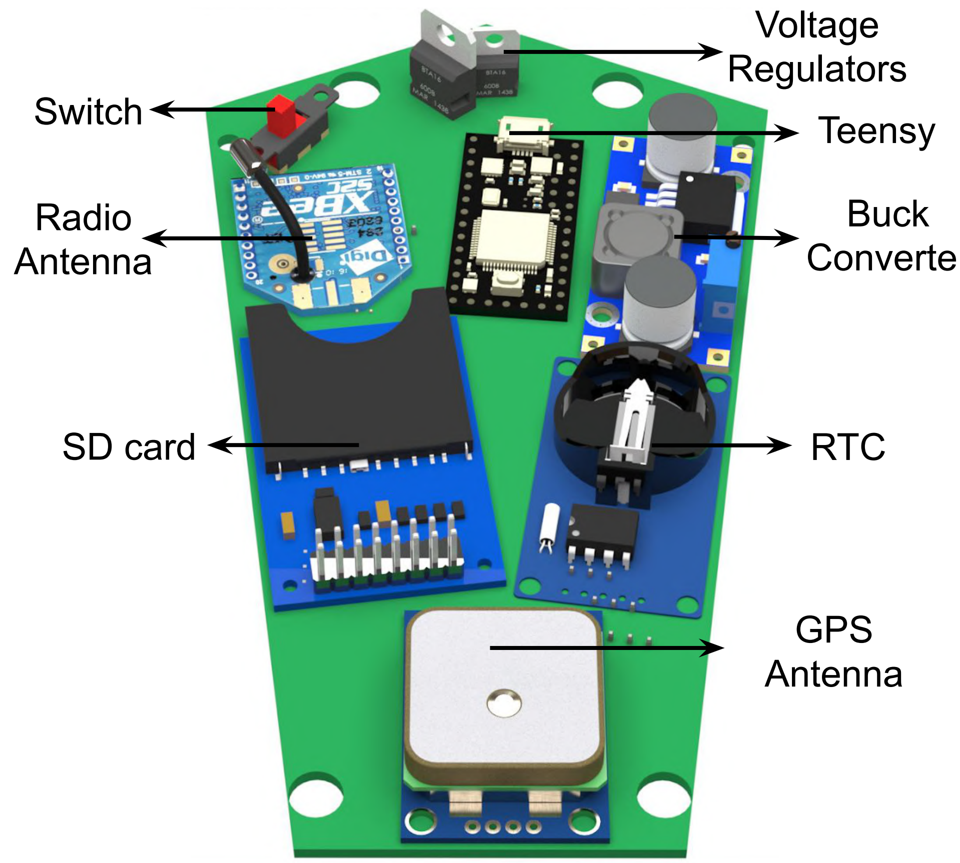
Container

- The container contains minimal amount of electronics. One **audio beacon (Buzzer)**, **button cell**, **servo** for thread cutting.
- The parachute **shroud lines** will be tied to the **container mounting**. The parachute will **open automatically** due to the cuts provided in the container for the flow of air.

Printed Circuit Board (PCB)



Front Side



Back Side

Physical Layout (4/4)

1

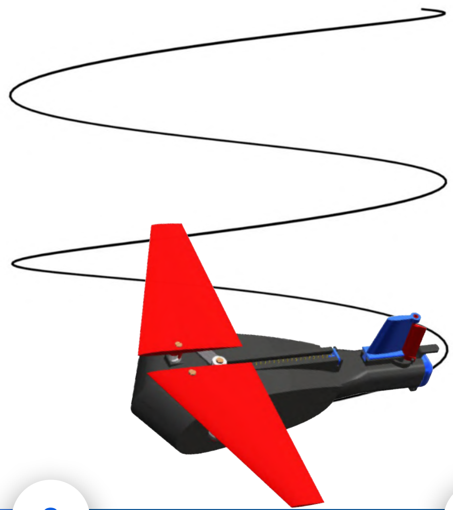
Launch Configuration

For launch configuration the **glider stowed in nose down position** and, is **restricted** using the **guide rails** on the sides.Glider **connected** to the container **via thread.**

2

After getting released from the rocket the **parachute** is **deployed** which is **connected to a circular mount** on the container.

Pre Payload Deployment



3

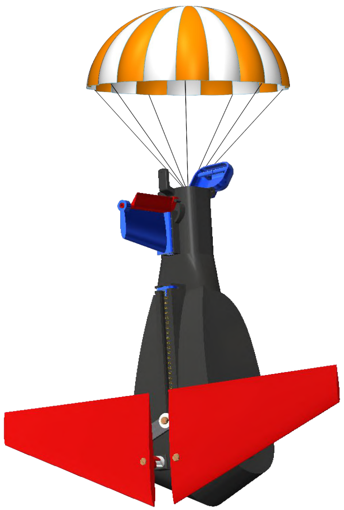
Post Payload Deployment

After **reaching 450m** the container **releases the payload** and the payload **glides in a helical path upto 100m.**

4

After **reaching** the height of **100 m** the **payload parachute is deployed** and the **glider descends** until it **touches the ground**.

Payload Deployed Parachute



System Concept of Operations (1/2)

1 — Pre Launch

- Competition area arrival
- Team briefing
- Last checks for integration
- Setting up Ground Control Station
- Last check of fully integrated CanSat
- Placement of CanSat into the Rocket Payload

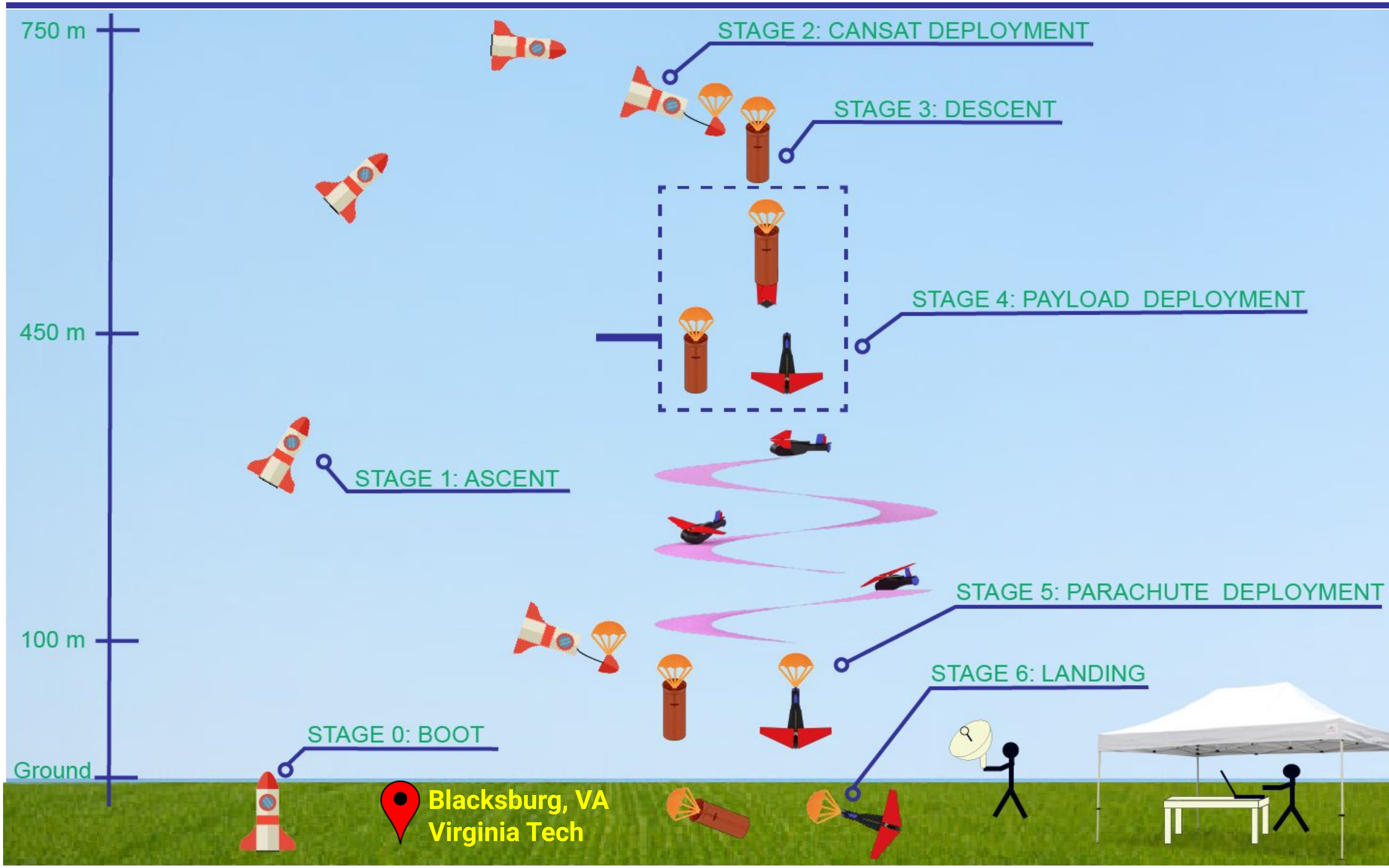
2 — Launch

- Ascent, separation and descent phases (described in the next slide)
- Telemetry data obtaining and .csv file creation via GCS software

3 — Post Launch

- Recovery of Payload and Container
- Damage inspection of container and payload
- Analysis of sampled data
- Preparation of the PFR
- PFR presentation to the jury

System Concept of Operations (2/2)

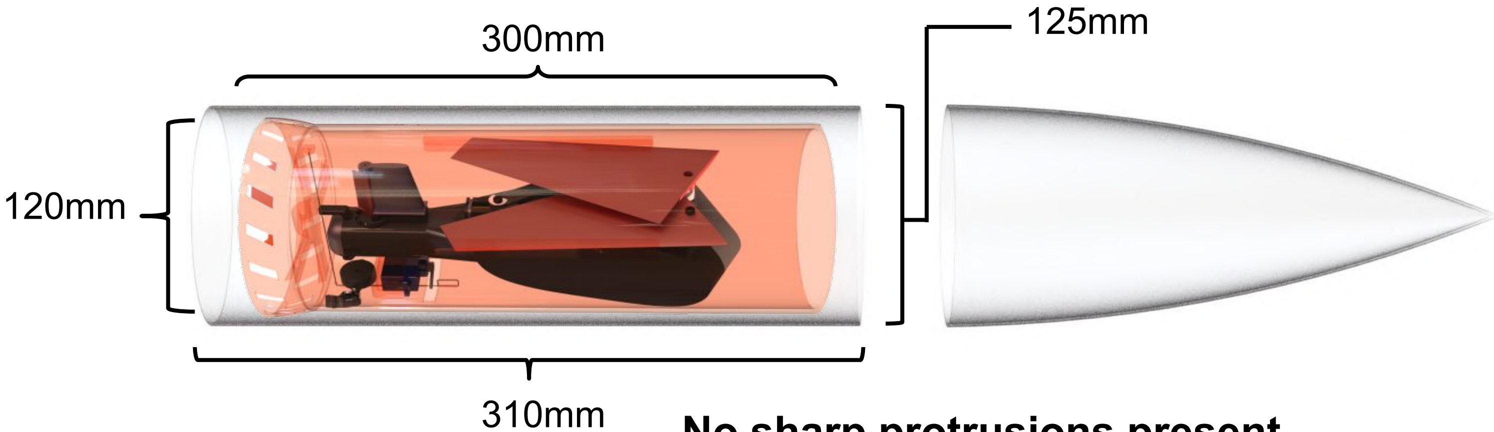


Launch Vehicle Compatibility

- **Rocket payload section dimension according to mission guideline**
  - Height: 310 mm
  - Diameter: 125 mm

- **CanSat dimensions**
  - Height: 300 mm
  - Diameter: 120 mm

- **Clearance**
  - Height: 10 mm
  - Diameter: 5 mm



No sharp protrusions present

Sensor Subsystem Design

Abhinav Goel

Sensor Subsystem Overview

	Sensor Type	Model	Purpose
P	Air Pressure	BMP180	Measurement of altitude by using air pressure
A	Air Temperature	BMP180	Measurement of air temperature
Y	GPS	Adafruit Ultimate GPS	Determination of location
L	Power Voltage	Teensy 3.2's Analog Input Pin	Measurement of payload battery voltage
O	Camera	Pixy2	Recording video during descent
A	PM Sensor	Honeywell HPMA 115S0	Measurement of particles present in air
D	Air Speed Sensor	MS4525DO	Measurement of air speed
	Pitch and Roll Sensor	**MPU 6050**	Measurement of Roll and Pitch for **BONUS CAMERA STABILIZATION**

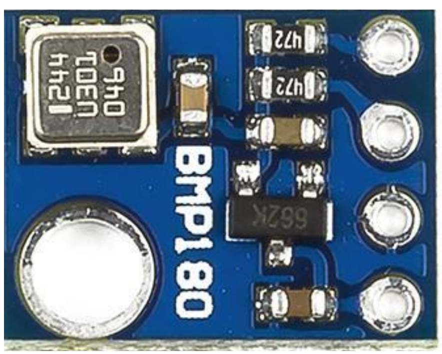
Container electronics does not consist of any sensor module.

Sensor Subsystem Requirements

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
SSR-1	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	CReq	BR-15	The components shielded from the environment	Very High	✓	✓	✓	
SSR-2	The science payload shall measure altitude using an air pressure sensor	CReq	BR-22	Air pressure sensor has been used	Very High	✓		✓	✓
SSR-3	The science payload shall provide position using GPS.	CReq	BR-23	GPS has been used	Very High	✓		✓	✓
SSR-4	The science payload shall measure its battery voltage.	CReq	BR-24	Battery voltage measured	Very High	✓	✓		✓
SSR-5	The science payload shall measure outside temperature.	CReq	BR-25	Temperature sensor has been used	Very High	✓	✓	✓	✓
SSR-6	The science payload shall measure particulates in the air as it glides.	CReq	BR-26	Particulate Sensor has been used	Very High	✓		✓	✓
SSR-7	The science payload shall measure air speed.	CReq	BR-27	Air Speed sensor has been used	Very High	✓		✓	✓
SSR-8	The science payload shall transmit all sensor data in the telemetry.	CReq	BR-28	Data transmitter has been used	Very High	✓	✓	✓	✓
SSR-9	Video shall be in color with a minimum resolution of 640x480 pixels and 30 fps.	Bonus Objectives	-	Camera has been used	High	✓	✓	✓	
SSR-10	After the separation of container and payload at 450 meters, camera of the payload records a video during the descent and store the video to the SD Card.	Bonus Objectives	-	Camera and SD card has been used	High	✓		✓	
SSR-11	The camera shall point at the specified coordinates for 30 seconds uninterrupted.	Bonus Objectives	-	Camera stabilisation implemented	High	✓			

Payload Air Pressure Sensor Trade & Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Power Consumption (mW)	Resolution (Pa)	Cost ($)
BMP180	**3.6 x 3.8 x 0.9**	**1.2**	**I²C**	**0.0165**	**± 2.00**	**3.00**
MPL3115A2	5.0 x 3.0 x 1.1	1.2	I²C	0.0425	± 1.50	14.98
BMP280	2.0 x 2.5 x 0.95	3	I²C/SPI	0.0091	±100.00	3.48



BMP180

SELECTED AIR PRESSURE SENSOR: BMP180

Rationale:

- High Resolution of ±1 Pa
- Relatively lower standard operation power consumption (61.2% lesser than MPL3115A2 and 17.5% lesser than BMP280)
- High data acquisition rate (BMP180 - 7.5 ms MPL3115A2 - 10 ms BMP280 - 11.5ms)
- Adequately low standard operation RMS measurement noise : 0.05 hPa

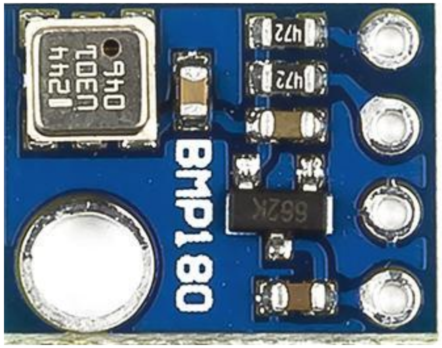
Payload Air Temperature Sensor Trade & Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Power Consumption (mW)	Resolution (^{O} C)	Cost ($)
BMP180	**3.6 x 3.8 x 0.9**	**1.2**	**I²C**	**0.0165**	**± 0.100**	**3.00**
MPL3115A2	5.0 x 3.0 x 1.1	1.2	I²C	0.0425	± 1.500	14.98
MCP9808	3.0 x 3.0 x 0.9	0.9	I²C/SPI	0.0561	±0.125	4.82

SELECTED AIR TEMPERATURE SENSOR: BMP180

Rationale:

- High Resolution of ± 0.1^{O}C
- Relatively lower power consumption during standard operation (61.2% lesser than MPL3115A2 and 99.7% lesser than MCP9808)
- High data acquisition rate : BMP180 - 7.5 ms MPL3115A2 - 10 ms MCP9808 - 30 ms



BMP180

GPS Sensor Trade & Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Power Consumption (mW)	Resolution (m)	Cost ($)
Adafruit Ultimate GPS	**25.0 x 35.0 x 6.5**	**8.5**	**UART**	**82.5**	**±1.8**	**39.95**
LS20031	30.0 x 30.0 x 7.0	7.0	UART	42.9	±3.0	69.95
NEO-7M	16.0 x 12.0 x 3.0	16.0	UART	200.0	±2.5	29.95

Adafruit Ultimate GPS

SELECTED GPS SENSOR: ADAFRUIT ULTIMATE GPS

Rationale:

- Considering the maximum output voltage of the microprocessor being 3.3V, satisfies both 3.3V and 5V supply voltage pins.
- Considering its affordable cost, satisfies high position accuracy as 1.8 meter

Uses NMEA 0183 GGA protocol and meets the mission requirements.

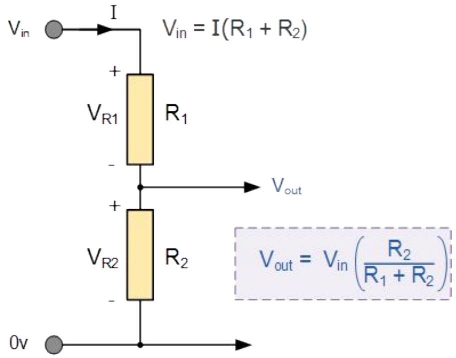
Payload Power Voltage Sensor Trade & Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Power Consumption (mW)	Error Rate	Resolution (mV)	Cost ($)
Teensy 3.2's Analog Input Pin	**152 x 102 x 13**	**12**	**Analog**	**33**	**0.03 %**	**0.00007**	**0.00**
Max 471 B43 module	73 x 63 x 10	10	Analog	4.95	0.10 %	0.00122	7.47
Phidgets Precision Voltage Sensor	165 x 120 x 25	21	Analog	49	0.50 %	0.00488	17.00

SELECTED SENSOR: TEENSY 3.2'S ANALOG INPUT PIN

Rationale:

- Lower error rate than rejected trade (70% lesser than B43 module and 94% lesser than Phidgets Precision sensor)
- Sufficient resolution for a stable measurement.
- Payload supply voltage value(0-3.3V) within device measurement range.
- Onboard CPU placement reduces external occupancy on main PCB.



Teensy Analog Input PIN

Air Speed Sensor Trade & Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Power Consumption (mW)	Pressure Error (Max)	Resolution (Psi)	Price ($)
MS4525DO Air Speed Sensor	**80 x 60 x 20**	**3**	**Analog Input**	**16.5**	**0.25 %**	**150/16383**	**52.99**
MPXV7002DP Air Speed Sensor	80 x 65 x 20	7	Analog Input	52.5	2.50 %	0.6/16383	27.89
MPXV5010DP Air Speed Sensor	80 x 65 x 20	7	Analog Input	25.0	5.00 %	10/16383	21.73

MS4525DO

SELECTED AIR SPEED SENSOR: MS4525DO

Rationale:

- Relatively better start up time of 8.4 ms compared to 20ms for both MPXV5010DP and MPXV7002DP Airspeed sensors.
- On chip 14 bit A/D convertor leading to effective decrease in board area.
- Provides significantly higher accuracy than other rejected trades.
- Lesser pressure error and power consumption as compared to it counterparts.

Particulate/Dust Sensor Trade & Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Power Consumption (mW)	Resolution (µg/m^3)	Cost ($)
Honeywell HPMA 115S0	**44.0 x 36.0 x 12.0**	**35**	**UART**	**400**	**15**	**35.00**
SPS 30	40.6 x 40.6 x 12.2	26	UART,I^2C	300	10	46.71
GP2Y1026AU0F	46.0 x 30.0 x 17.6	10	UART	100	100	11.95

SELECTED PM SENSOR: HONEYWELL HPMA 115S0

Rationale:

- Laser-based light scattering particle sensor with an accuracy of 15% of the calculated concentration.
- Quick response time (<6s)
- Proven Electromagnetic compatibility(EMC) ensures robustness in device accuracy.
- CPU compatibility removes requirement of level shifter for data transmission @3.3V

HONEYWELL HPMA 115S0

Bonus Camera Trade & Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Frame Rate (fps)	Power Consumption (mW)	Resolution (p)	Cost ($)
Pixy2	**42 x 38 x 15**	**10.0**	**UART Serial, SPI, I^2C**	**60**	**700**	**1296 x 976**	**29.90**
OV5642	34 x 24 x 24	8.0	SCCB, MIPI	30	392	1920 x 1080	32.99
Arducam MT9M001	40 x 40 x 15	9.1	SPI	30	325	1280 x 1024	16.79

PIXY2

SELECTED CAMERA: PIXY2

Rationale:

- Much higher Frame Rate (>100% than OV5642 and ArduCam)
- Large variety of Communication interfaces, leading to ease of use.
- Sufficient Resolution
- Integrated Light Source For Quality Video

Container Air Pressure Sensor Trade & Selection

No Container Air Pressure Sensor Used

- The electronics in the container consists of a Servo motor, Lithium ion battery, Boost convertor, a Buzzer connected through a latch and a Kill Switch.
- The buzzer gets activated when the container splits up from the payload (i.e. when servomotor gets the PWM signal from the Payload), the PWM signal triggers the Latch which further turns the buzzer on.

Container Electronic Components

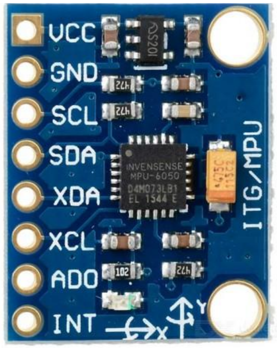
Payload Camera Stabilisation Trade & Selection*

Model	Dimensions (mm x mm x mm)	Weight (mm/s^2)	Accuracy (mG)	Interface	Power Consumption (mW)	Resolution (bit)	Cost ($)
MPU6050	**3.0 x 3.0 x 0.6**	**20.58**	**60**	**I²C, SPI**	**12.87**	**16**	**2.12**
LSM6DS33	3.0 x 3.0 x 0.8	5.88	40	I²C, SPI	7.92	16	8.00
ADXL345	3.0 x 5.0 x 1.0	12.446	40	I²C, SPI	4.95	10	10.00

SELECTED PITCH AND ROLL SENSOR: MPU6050

Rationale:

- High Resolution of 16 bits (60% > than ADXL345)
- High Accuracy of 60 mG (50% > than LSM6DS33 and ADXL345)
- Increased reliability using sensor fusion of both MPU-6050 gyroscope and accelerometer



MPU6050

***Slide represents bonus task trade and selection for in-situ communication device between payload camera subsystem and storage module on board the main PCB**

Descent Control Design

Himanshu Singhal

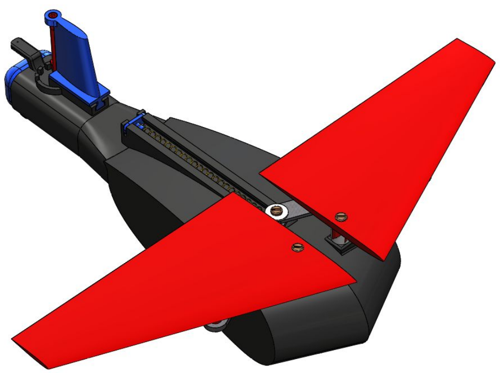
Container

- **Mass of container is 240.55 g** and it has an **outer diameter of 120 mm** and **300 mm height**. It is divided into **segments** for **parachute** and **payload** with opening mechanism.
- **Colour selection:** Orange

Descent

- A **Hexagonal Parachute** of diameter **23 cm** (9 inches) is used for container descent.

Glider



- Foldable **high wing glider** is used with **vertical stabilizers**.
- Glider follows **helical descent path** of **radius 250 m**.
- Glider is designed so that it **glides** for approximately **one minute** and remains **above 100 meters** after being released.

Descent

- After release from the container at **450 m +/- 10 m**, the glider glides and descends helically in a circle radius of 250 m.
- After **gliding for one minute**, at approximately 100 m altitude, a **hexagonal type** parachute of **30 cm** (12 inches) diameter will be deployed.

Descent Control Overview (2/3)

Major Components

Servo Motor

Payload release mechanism and payload parachute deployment.

Torsional Spring

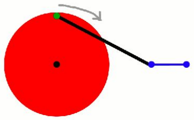
Glider parachute lid opening mechanism.

Kevlar Thread

Used in payload release mechanism in thread cutting.

Hexagonal Parachute

Used for CanSat descent and for a part of payload descent.

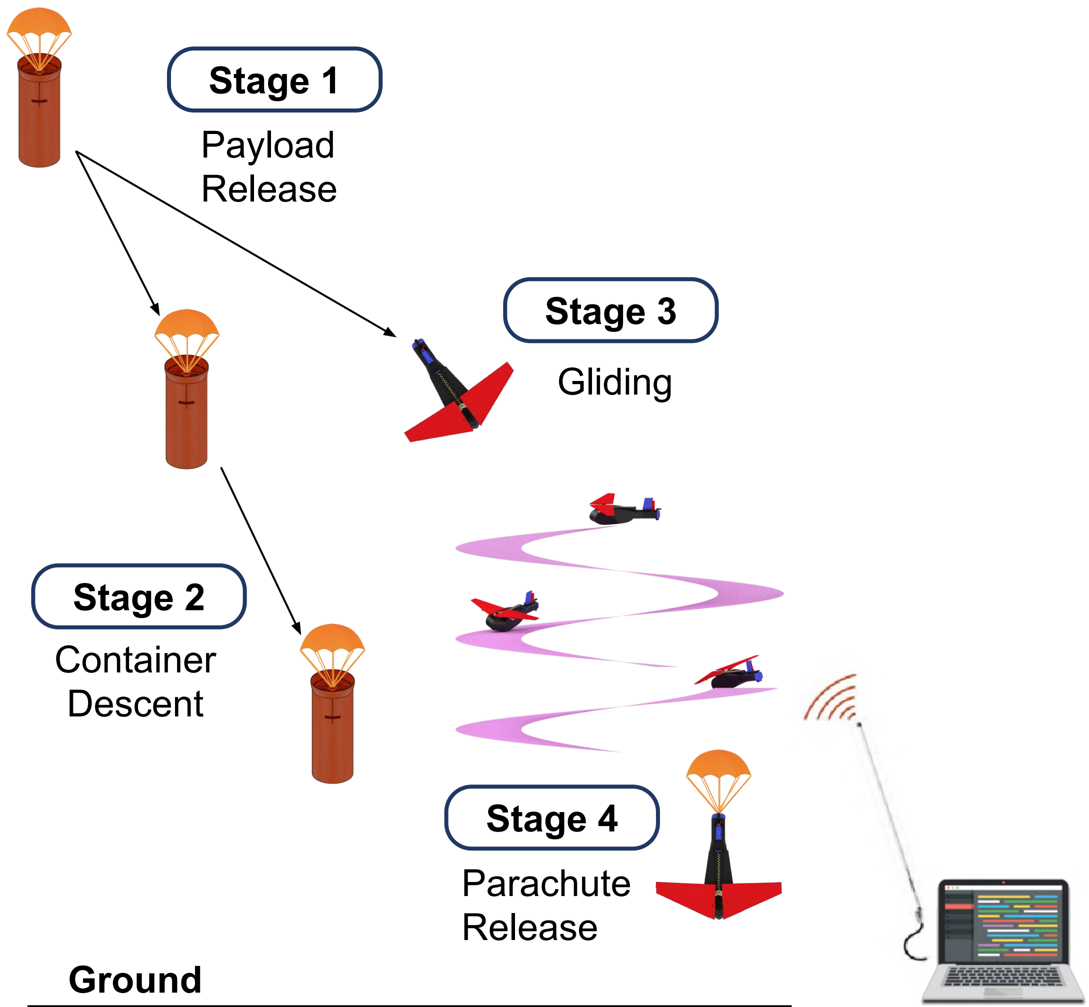


Slider Crank Mechanism

Used for payload deployment mechanism.

Descent Control Overview (3/3)

Descent Rate Overview



STAGES

Stage : 1	Velocity of Container and Payload: **16.09 m/s**
Stage : 2	Velocity of Container: **10.33 m/s**
Stage : 3	Horizontal velocity: **20.16 m/s** Vertical velocity : **3.23 m/s**
Stage : 4	Velocity of Glider: **9.52 m/s**

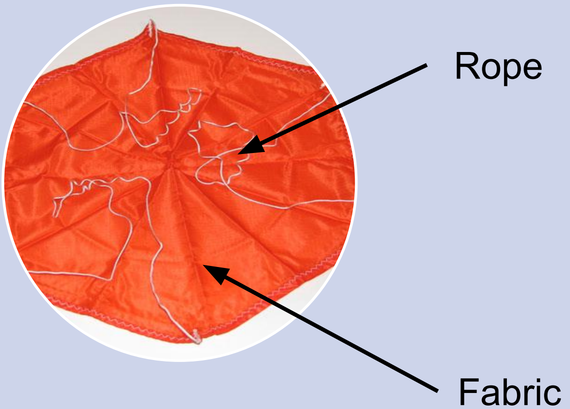
Descent Control Requirements

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
DCR-1	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.	CReq	BR - 1	The mass meets the requirement	Very High	✓		✓	
DCR-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.	CReq	BR - 2	The CanSat fits in the cylindrical envelope	Very High	✓	✓	✓	
DCR-3	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s.	CReq	BR - 9	Descent Rate Meets Requirement	Very High	✓	✓		
DCR-4	The container shall release the payload at 450 meters +/- 10 meters.	CReq	BR - 10	The payload shall be released at the given altitude	Very High	✓	✓	✓	
DCR-5	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.	CReq	BR - 11	The payload will glide as required	Very High		✓	✓	
DCR-6	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s	CReq	BR - 13	The parachute will be deployed as required	Very High	✓	✓		
DCR-7	All descent control device attachment components shall survive 30 Gs of shock.	CReq	BR - 17	Components are capable of surviving the given shock	Very High	✓		✓	
DCR-8	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time.	Bonus Objectives	-	The camera will point for the given time	Very High	✓			

Payload Descent Control Strategy Selection and Trade (1/7)

Pre Payload Deployment

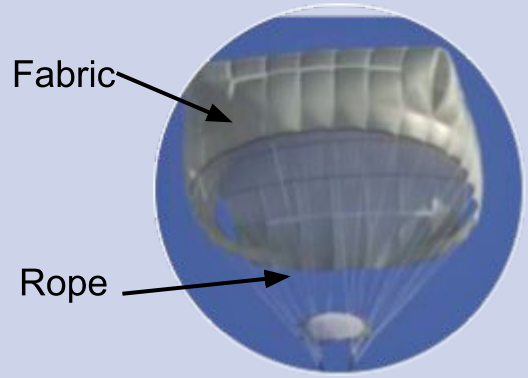
Hexagonal Type Parachute



- Easy to manufacture
- Easy to stack
- High drag coefficient
- Low horizontal displacement

Cruciform Parachute

- Good strength to weight ratio
- Durable
- Voluminous
- More Complex to make



Payload Descent Control Strategy Selection and Trade (2/7)

Pre Payload Deployment

Shape	Diameter (cm)	Drag coefficient	Payload descent rate (m/s)	Price ($)
Hexagonal Parachute	**23**	**0.9**	**16.09**	**6**
Cruciform Parachute	23	0.8	16.55	9

Hexagonal Parachute

SELECTED PARACHUTE: HEXAGONAL TYPE

Rationale:

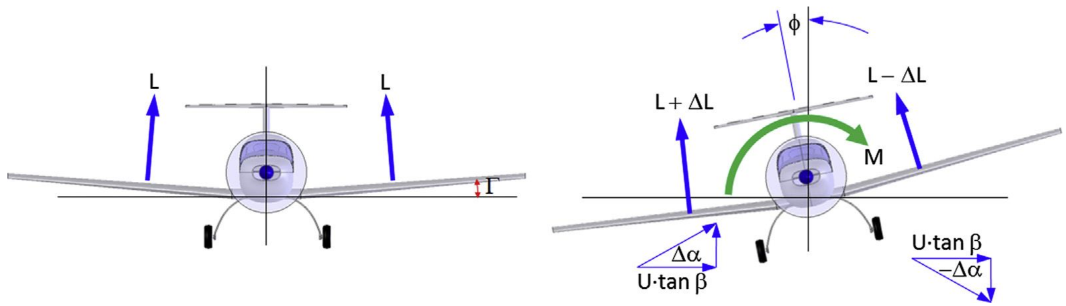
- Higher coefficient of drag
- Less swaying motion
- Compact, thus require less space

Payload Descent Control Strategy Selection and Trade (3/7)

Post Payload Deployment (For 1 minute of gliding)

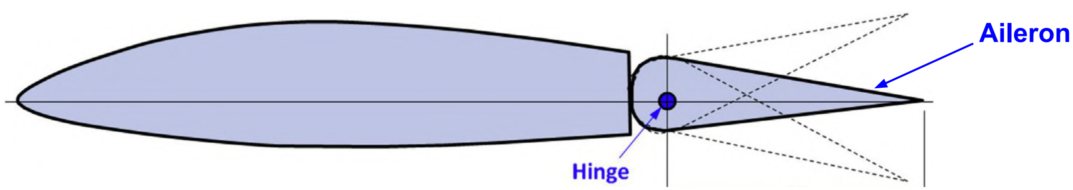
The glider must **maintain roll** during the flight (movement in helix path). For this, we need to have **variable lift** on the wings during the flight. There are mainly two ways to achieve this:

- **Dihedral wings**



Wing Dihedral is the upward angle of an aircraft's wing, from the wing root to the wing tip. The amount of dihedral determines the amount of **inherent stability along the roll axis**. As roll stability is increased, an aircraft will naturally return to its original position if it is subject to a brief or slight roll displacement.

- **Ailerons**



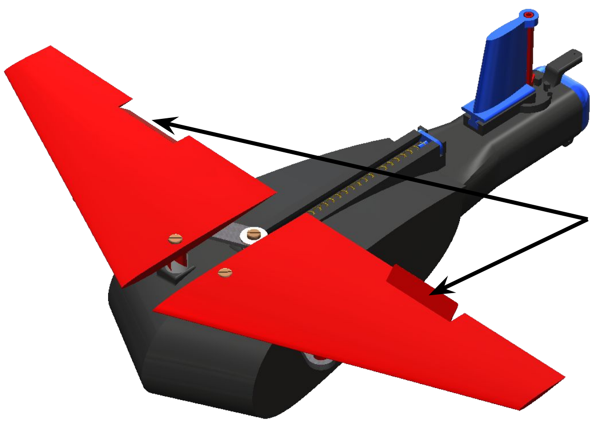
Ailerons are a primary flight control surface which control movement about the longitudinal axis (referred to as "roll") of an aircraft. The ailerons are attached to the outboard trailing edge of each wing and move in opposite directions from each other. The aileron reduces or **eliminates adverse yaw** by forcing the leading edge of the aileron deflected Trailing Edge Up, downward and outside the regular outside mold line.

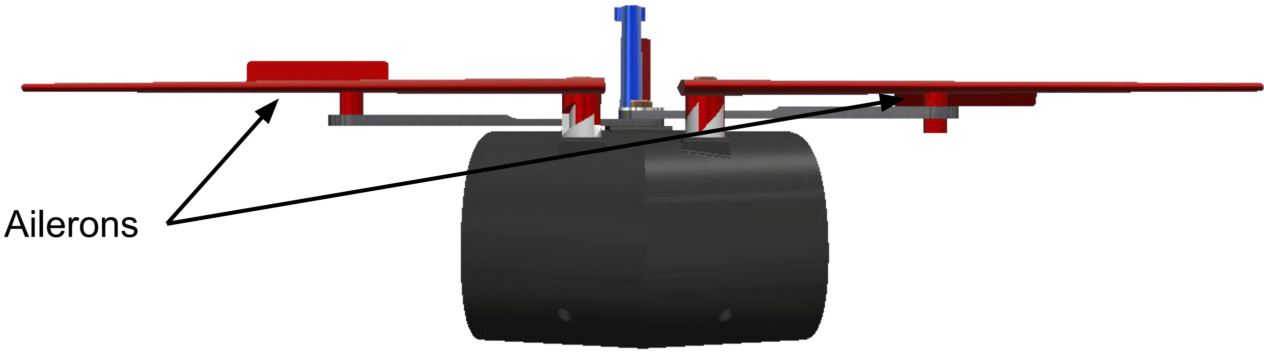
Reference

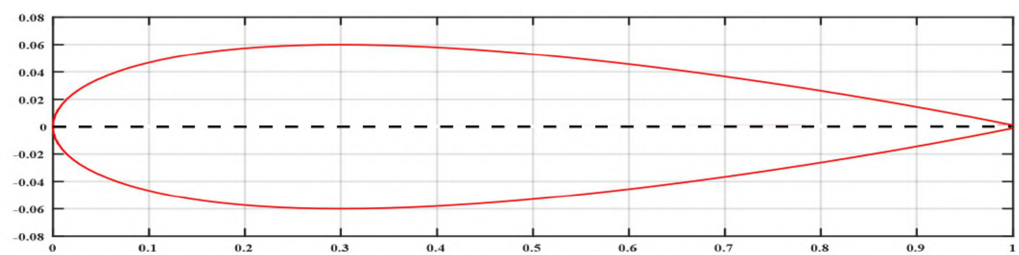
Snorri Gudmundsson, C. R. (2014). General Aviation Aircraft Design: Applied Methods and Procedures. USA: Elsevier Inc.

Payload Descent Control Strategy Selection and Trade (4/7)

Design 1







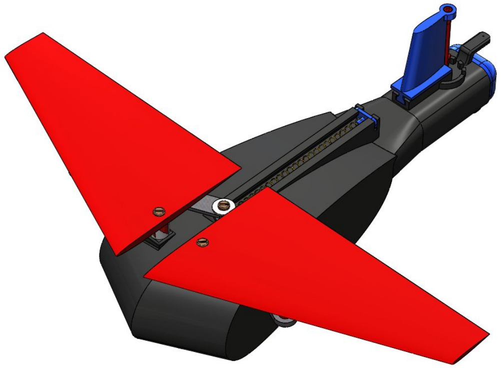
NACA 0012 Airfoil Profile

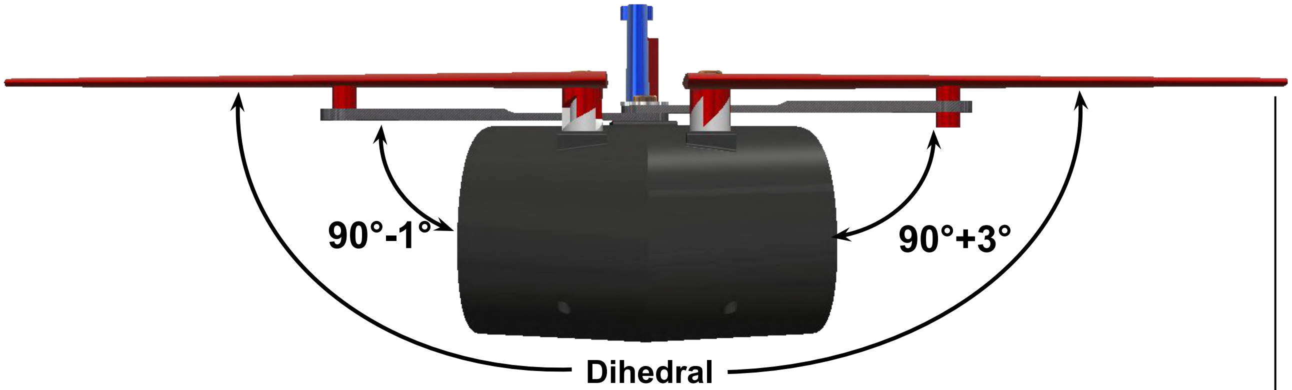
Description
• Helps in stall recovery • Could enhance the lift generated by the wing. • Incorporating ailerons hinders the wing folding mechanism.

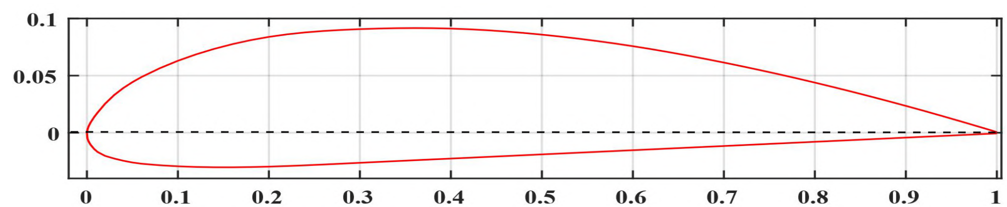
Design Elements		
• Ailerons	• Rudder	• NACA 0012

Payload Descent Control Strategy Selection and Trade (5/7)

Design 2







NACA 3411 Airfoil Profile

Description

- Dihedral wings give rise to increased drag and decreased roll rate, providing overall stability.
- The lift component is incline at some angle thus reduces the effective lift generated by the wings.

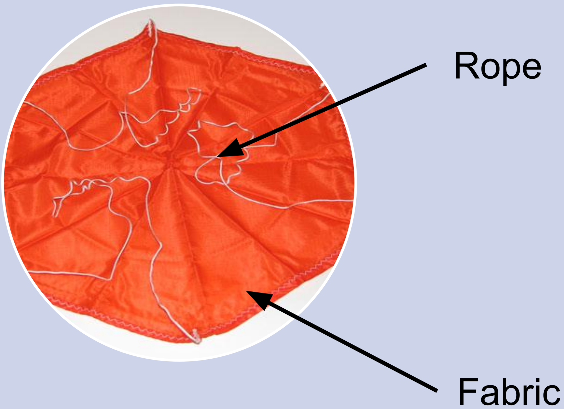
Selected Design

- **Design 2 is chosen due to its simplicity.**
- **Increased stability without increasing the mass.**
- **Facilitates smooth release of payload due to absence of any protrusions on the wings.**

Payload Descent Control Strategy Selection and Trade (6/7)

Payload Descent Control Strategy (after 1 minute of gliding)

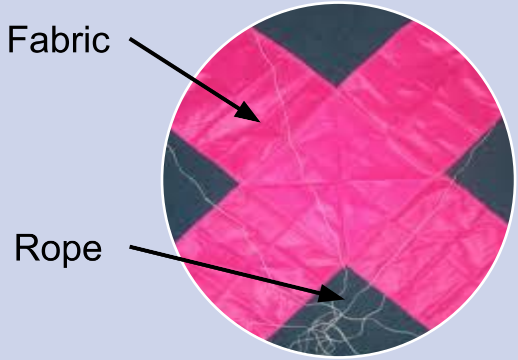
Hexagonal Type Parachute



- Easy to manufacture
- Easy to stack
- High drag coefficient
- Low horizontal displacement

X Type Parachute

- Provides lower descent velocity than required
- Low drag coefficient
- Durable
- Relatively high horizontal displacement



Payload Descent Control Strategy Selection and Trade (7/7)

Payload Descent Control Strategy (after 1 minute of gliding)

Shape	Diameter (cm)	Drag coefficient	Payload descent rate (m/s)	Price ($)
Hexagonal Parachute	**30**	**0.9**	**9.52**	**6**
X type parachute	25	0.75	12.552	8

Hexagonal Parachute

SELECTED PARACHUTE: HEXAGONAL TYPE

Rationale:

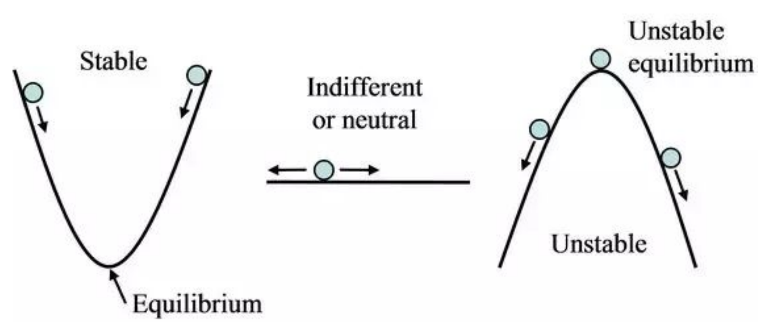
- Higher coefficient of drag
- Less swaying motion
- Compact, thus require less space

Payload Descent Stability Control Strategy Selection and Trade (1/4)

Active Stability vs Passive Stability

The first challenge for the glider is to maintain **pitch stability** during the flight. The two ways considered to achieve this are as follows:

- **Active Stability**
  - Formation of **closed loop system**.
  - Sensors transmits data about the aircraft's current path.
  - High lift devices like slats, flaps, slots etc. are controlled according to the desired path.
  - *Example*: F-22 Raptors, are inherently designed to be roll unstable for better maneuverability and are stabilized using complex control systems.
- **Passive Stability**
  - Used in relatively simple operations.
  - Natural design tendency to return to initial position, i.e. **stable equilibrium** design.
  - No use of external output or heavy use of feedback loops.



Requires Passive Stability

Requires Active Stability

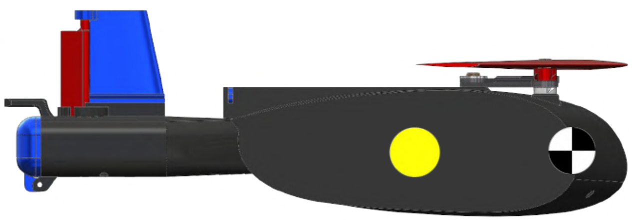
SELECTED: PASSIVE STABILITY

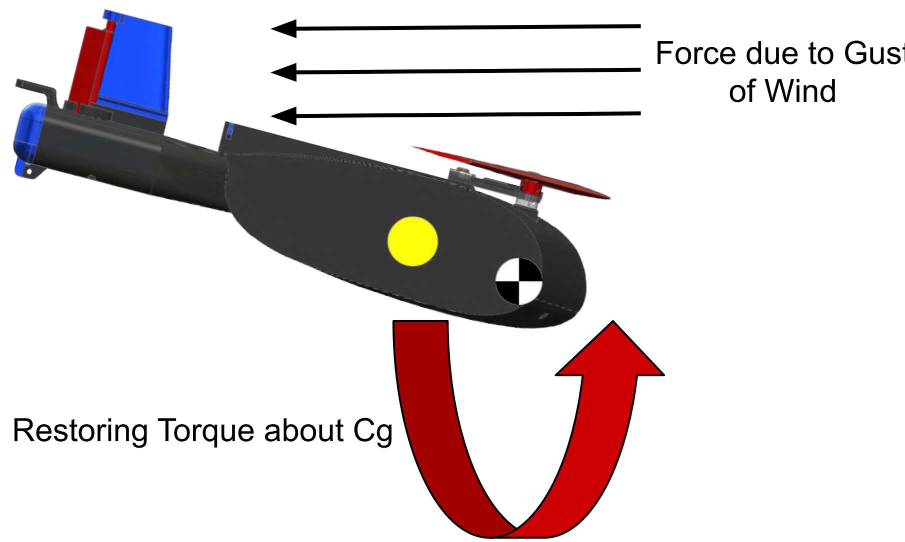
Rationale:
- Reduced cost and complexity.
- Reduction in mass (No need to use servos/actuators)
- Better reliability (Less number of parts translates to lower error rate.)

Payload Descent Stability Control Strategy Selection and Trade (2/4)

Tumbling Prevention & NADIR Direction

- The **design of glider** is such so that **after mounting** of all the electronics inside the fuselage, the **Cg lies close to the nose area**.
- If **Cg is placed ahead of Cp in an aircraft**, then even if the **nose is displaced** from the **NADIR Direction** (say, due to a gust of wind), a **Restoring Torque** will be **generated** about the Cg ,thereby **correcting the path** again.





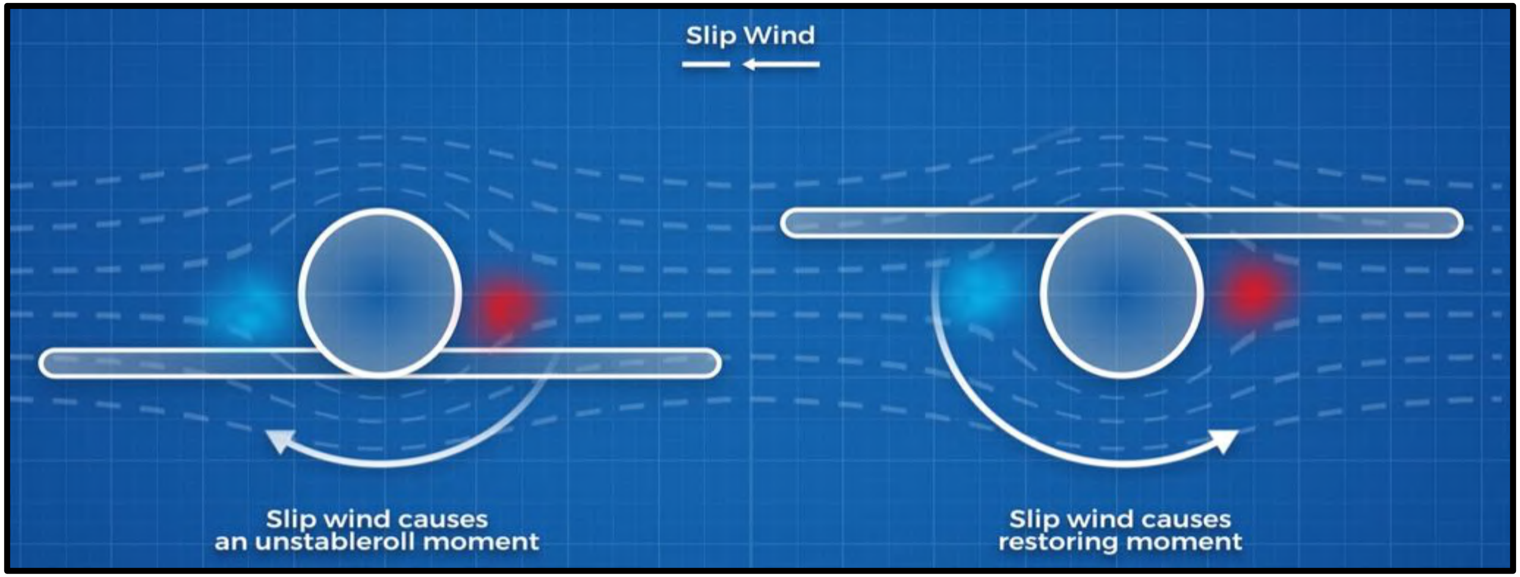
	Cg
	Cp

Payload Descent Stability Control Strategy Selection and Trade (3/4)

Wing Configurations

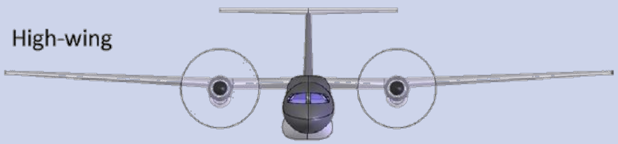
- **High Wing**
- **Mid Wing**
- **Low Wing**

We only compared **High Wing** and **Low Wing** for our glider. **Mid Wing** poses **space constraints** for a suitable wing opening mechanism for the glider and providing **structural stability** to the whole wing assembly also **becomes difficult**.



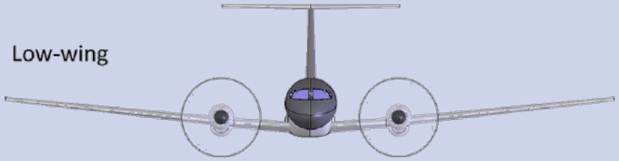
Payload Descent Stability Control Strategy Selection and Trade (4/4)

High Wing Configuration

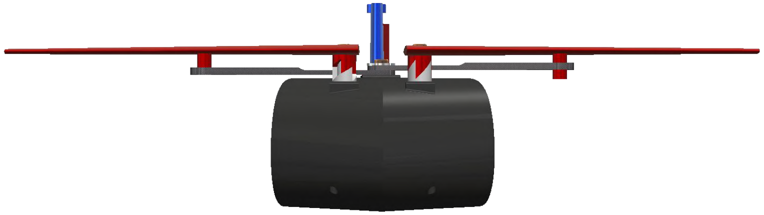


- **Fuselage** is present **below the wings**.
- This configuration tends to be **more stable** than low wing.
- In case of cross winds, **exhibits roll stability**.

- **Fuselage** is present **above the wings.**
- A **little bit less stable**, hence **often implemented with dihedral**.
- Exhibits **less roll stability** in comparison to High Wing,



Low Wing Configuration



High Wing Configuration

SELECTED DESIGN: HIGH WING GLIDER

Rationale:

- Higher roll stability
- Promotes lower lift-induced drag
- Aerodynamically clean design

Descent Rate Estimates (1/7)

CanSat (Container & Payload) (750m To 450m +/-10m)

Description:

- The CanSat ejects from the rocket and container parachute deploys, assuming at a height of 750 m.
- The required descent rate is 20 m/s +/- 5 m/s.

Mass of CanSat (m) = 594.72 g
Drag Coefficient (C_D) = 0.9
Diameter of container parachute (D) = 23 cm
Density of Air (p) = 1.205 kg/m^3

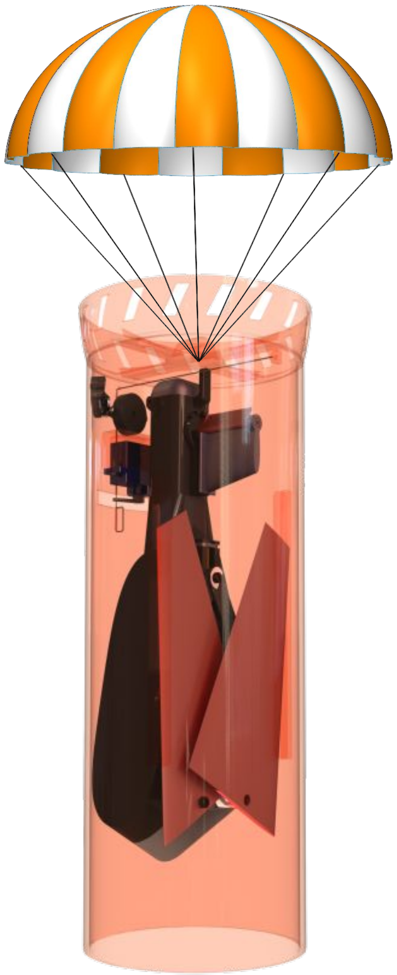
Descent Velocity (*v*) of CanSat is calculated using:

$$v = \sqrt{\frac{8mg}{\rho \pi C_D D^2}}$$

$$v = 16.09\ m/s$$

Assumptions:

- Density of air is assumed to be constant.
- Drag coefficient is assumed to be constant.
- Acceleration due to gravity is assumed to be constant (g=9.81 m/s^2).



CanSat
(Parachute Deployed)

Container Only
(450m +/- 10m to Ground)

Description:

- The container after successfully releasing the glider, will continue descending with the help of the parachute.
- The required descent rate is 20 m/s +/- 5 m/s.

Mass of Container without payload = 240.55 g
Drag Coefficient = 0.9
Diameter of container parachute = 23 cm
Density of Air = 1.205 kg/m^3

Descent Velocity (*v*) of Container is calculated using:

$$v = \sqrt{\frac{8mg}{\rho \pi C_D D^2}}$$

$$v = 10.33\ m/s$$

Assumptions:

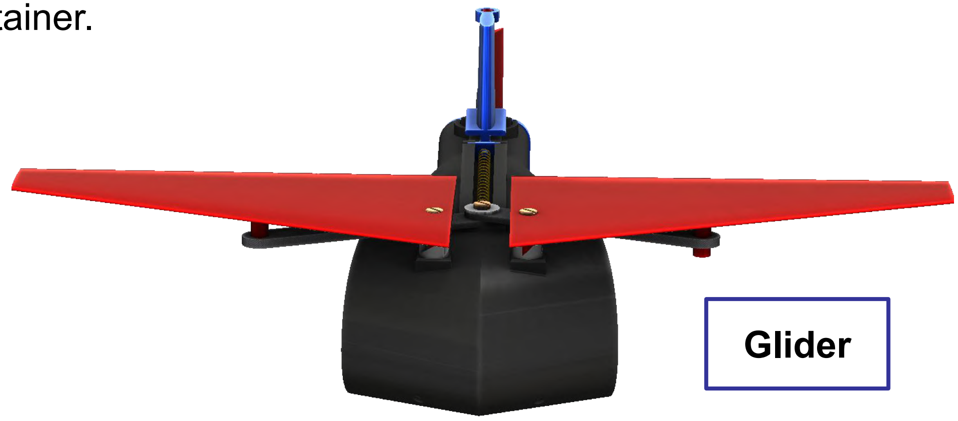
- Density of air is assumed to be constant.
- Drag coefficient is assumed to be constant.
- Acceleration due to gravity is assumed to be constant (g=9.81 m/s^2).

Container (Parachute Deployed)

Glider (1/3)
(450m +/- 10m: 1 minute of gliding)

Description:

- The glider after getting successfully released from the container, begins its descent.
- The glider is required to glide in a circular pattern with a 250 m radius for one minute and stay above 100 m after release from the container.

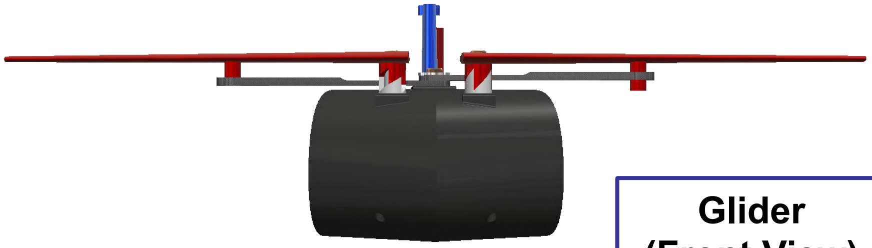


Glider

Vertical Velocity Estimate

Airfoil Used: NACA 3411
Weight of glider = 354.17 g
Lift coefficient of airfoil = 0.816
Drag Coefficient of airfoil = 0.019
Density of air = 1.205 kg/m^3
Descent rate is given by formula:

$$v = \frac{C_D}{C_L^{3/2}}\sqrt{\frac{2w}{\rho S C_L}} = 3.23\ m/s$$



Glider (Front View)

Where,
w = Weight of glider C_D = Drag coefficient
C_L = Lift coefficient ρ = Density
Assumptions:
Density of air is assumed to be constant.

Glider (2/3)
(450m +/- 10m: 1 minute of gliding)

Horizontal Velocity Estimate:

$$v = \sqrt{\frac{2w}{\rho S C_L}}$$

$$\boldsymbol{v = 3.23\ m/s}$$

Glide Angle:

$$\tan\theta = \frac{C_D}{C_L}$$

$C_L = 0.816 \quad C_D = 0.019$

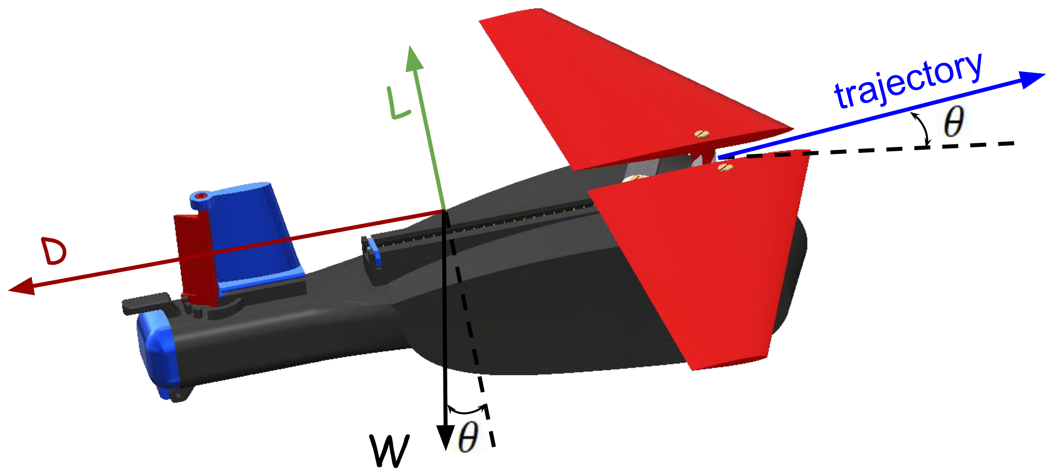
$$\boldsymbol{\theta = 1.33^o}$$

Glider Banking angle:

$$\tan\alpha = \frac{v^2}{Rg}$$

$v = 20.16$ m/s $\quad R = 250$ m

$$\boldsymbol{\alpha = 9.826^o}$$



w = Payload Mass

θ = Glide Angle

C_L = Lift Coefficient

C_D = Drag Coefficient

S = Wing Area

α = Banking Angle

v = Horizontal Velocity

R = Radius of Spiral

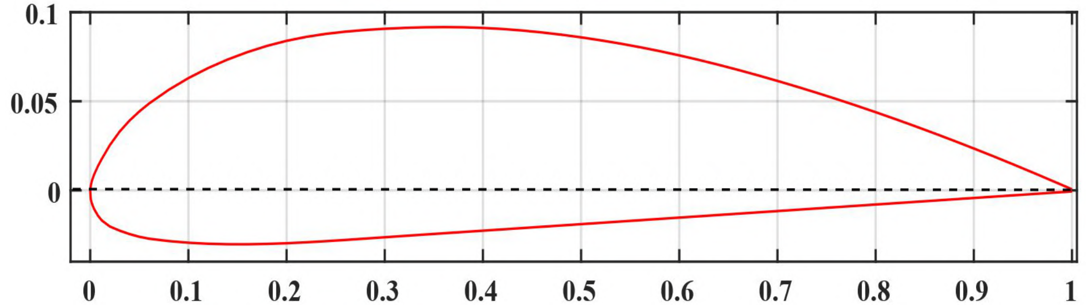
Reference:

http://www.phys.uconn.edu/~rozman/Courses/P2200_14F/downloads/glider/glider-2014-11-05.pdf

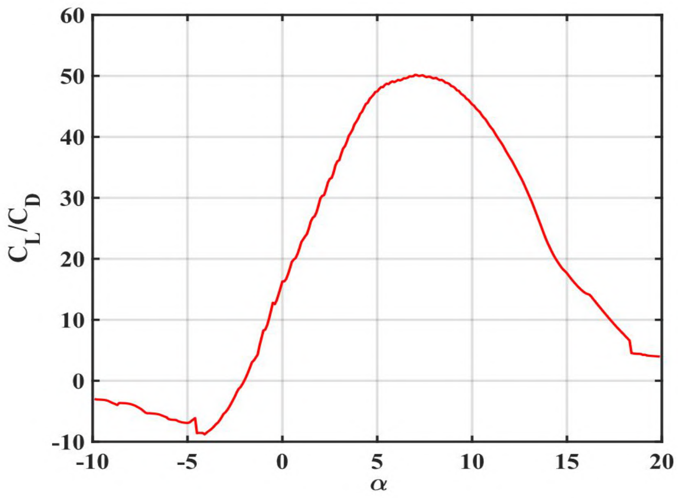
Glider (3/3)
(450m +/- 10m: 1 minute of gliding)

AIRFOIL DESIGN

Airfoil used: NACA 3411
Reynold's Number (Re): 90,000
Critical Angle: 14 degrees (max)
Air Density: 1.205 kg/m^3



NACA 3411 Airfoil Profile



Description:

- **NACA 3411** is an aerofoil widely used in **aircraft wing design**. It provides a **smooth stall entry**.
- It has **lower aspect ratios**, hence it provides **maximum lift coefficient** and **maximum resultant force**.

$$C_L = 0.816$$
$$C_D = 0.019$$

$$\frac{C_L}{C_D} = 42.95$$

Descent Rate Estimates (6/7)

Glider With Parachute (After 1 minute of Gliding)

Description:

- After one minute of gliding, the glider is required to release a parachute.
- The required descent rate is 10 m/s +/- 5 m/s.

Mass of Glider = 354.17 g
Diameter of Parachute = 30 cm
Density of air = 1.205 kg/m^3
Drag coefficient = 0.9

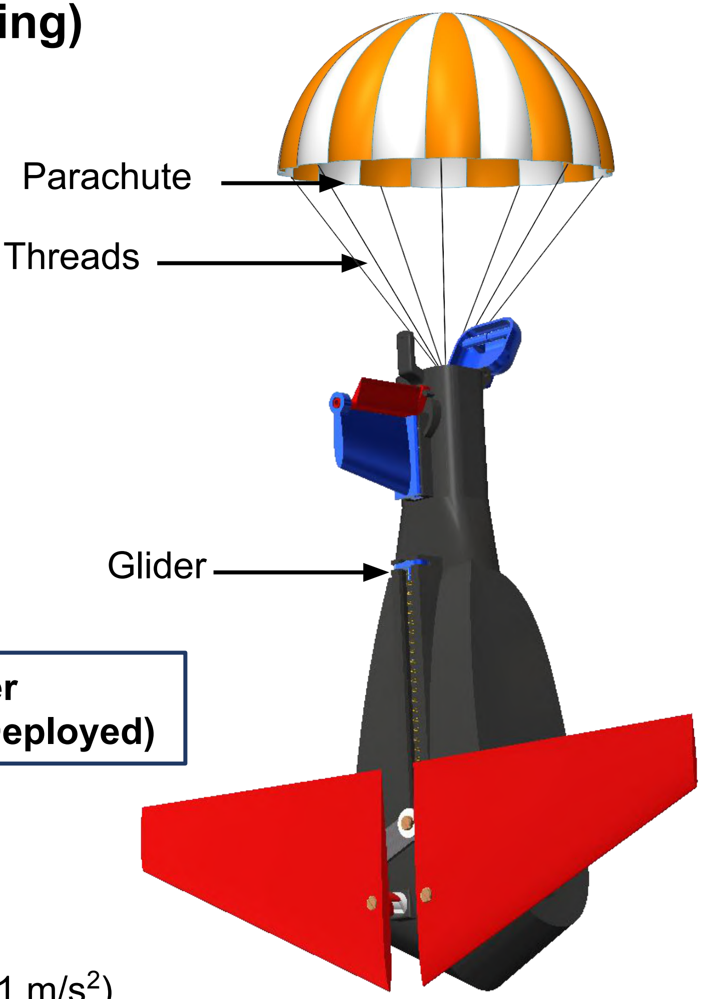
Descent Velocity using formula:

$$v = \sqrt{\frac{8mg}{\rho \pi C_D D^2}}$$

$$v = 9.52 m/s$$

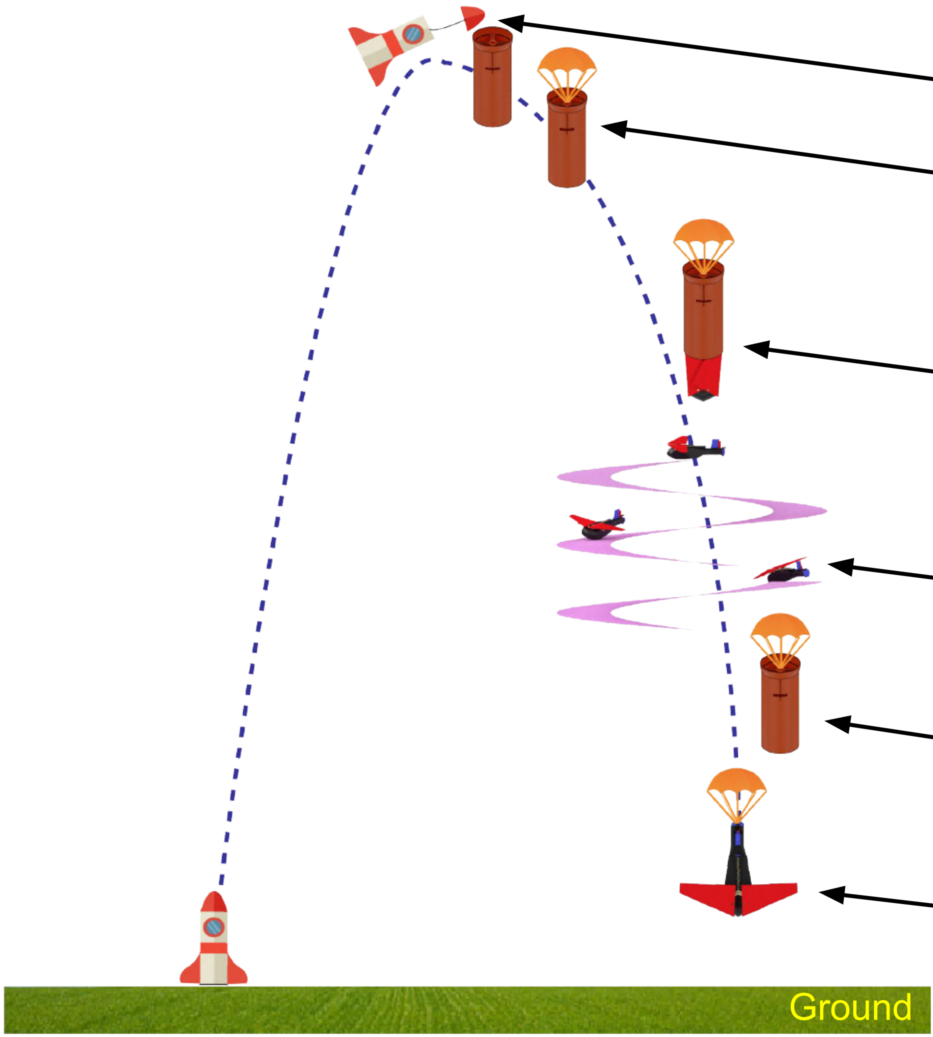
Assumptions:

- Density of air is assumed to be constant.
- Drag coefficient is assumed to be constant.
- Acceleration due to gravity is assumed to be constant (g=9.81 m/s^2).



Glider (Parachute Deployed)

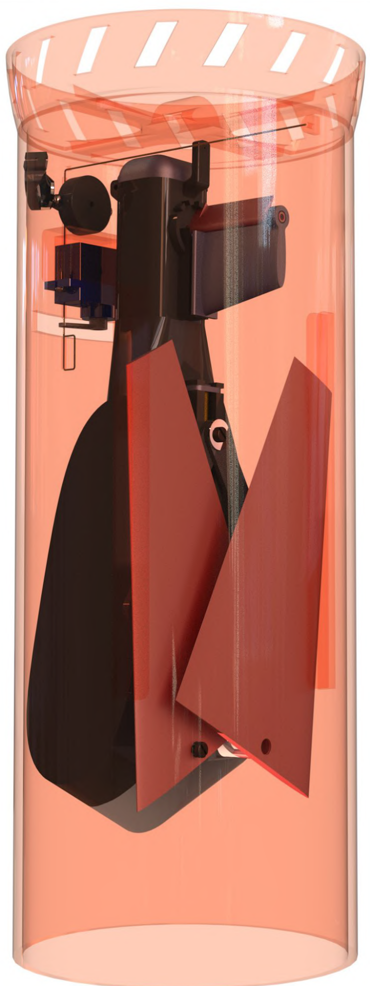
Descent Rate Estimates Summary



Mechanical Subsystem Design

Aryan Mishra

Mechanical Subsystem Overview (1/2)



Glider in Container

Container

Major Structural Elements

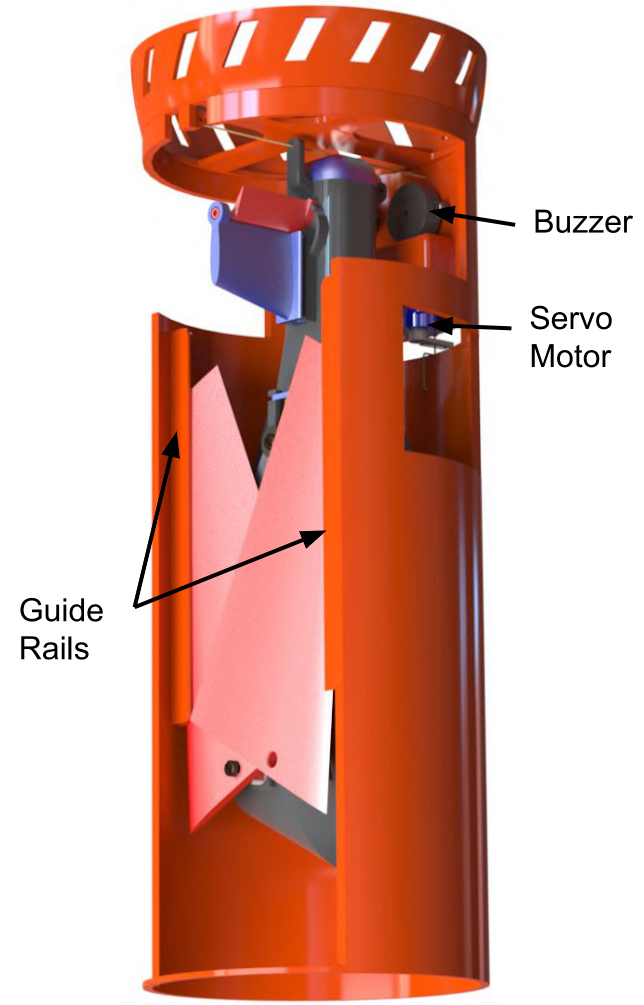
- **Main cylindrical body**
- **Guide Rails** - to support glider wings.
- **Parachute mount and chamber**
- **Payload Deployment Mechanism**
- **Parachute Deployment Mechanism**
- **Audio beacon -** for recovery
- **Hook** - to tie thread
- **Servo motor** - for thread cutting

Material Chosen

- **Polycarbonate for container**

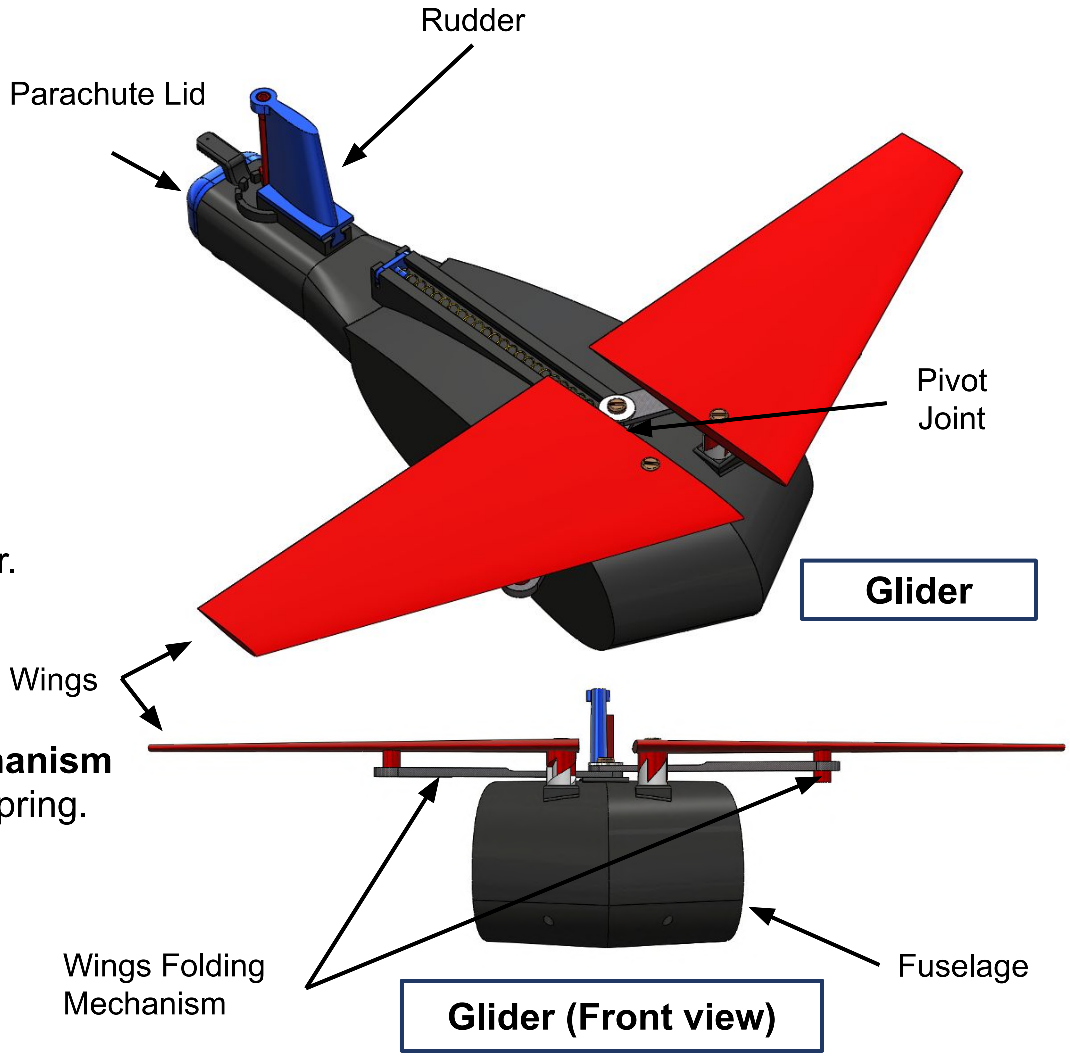
Interface Definitions

- **Mountings** for **servo motor** and **audio beacon** are provided.
- **Parachute chamber** is provided on the **top** of the container.



Multiple Sectioned container to show details

Glider



Major Structural Elements

- Fuselage
- Wing assembly
- Slider crank and connectors
- Rudder assembly

Material Chosen

- PETG for Wings.
- Nylon PA 2200 for Fuselage and Rudder.

Interface definitions

- A **four link slider crank inspired mechanism** for wing deployment with compressed spring.
- Parachute Lid is hinged with the help of **torsional spring**.
- **PCB is screwed** to fuselage.

Mechanical Sub-System Requirements (1/2)

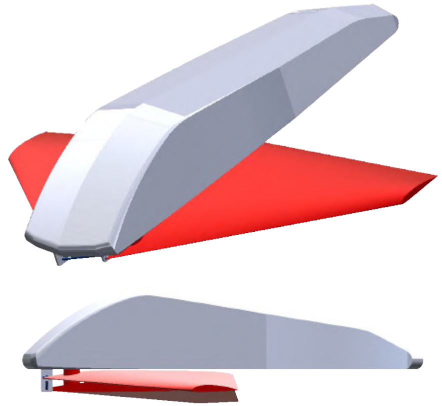
ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
MSR-1	Total mass of the CanSat (Glider and Container) shall be 600 grams +/- 10 grams	CReq	BR-1	The mass meets the requirements	Very High	✓		✓	
MSR-2	CanSat shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length. Tolerances are to be included to facilitate container deployment from the rocket fairing.	CReq	BR-2	The CanSat fits in the cylindrical envelope	Very 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.	CReq	BR-3	The container does not have any sharp edges	Very High		✓	✓	
MSR-4	The container shall be a fluorescent color; pink, red or orange.	CReq	BR-4	The container is orange orange in colour	Very High		✓	✓	
MSR-5	The container shall release the payload at 450 meters +/- 10 meters.	CReq	BR-10	The payload is released at the given time	Very High	✓	✓	✓	
MSR-6	The science payload shall be a delta wing glider.	CReq	BR-12	The payload is a delta wing glider	Very High	✓	✓	✓	✓
MSR-7	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 m/s +/- 5 m/s.	CReq	BR-13	The parachute is deployed after the given time	Very High	✓	✓		
MSR-8	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	CReq	BR-18	All electronics are hard mount	Very High	✓	✓	✓	

Mechanical Sub-System Requirements (2/2)

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
MSR-9	All mechanisms shall be capable of maintaining their configuration or states under all forces.	CReq	BR-19	All mechanisms are capable of maintaining their states	Very High	✓	✓	✓	
MSR-10	Mechanisms shall not use pyrotechnics or chemicals.	CReq	BR-20	No chemicals or pyrotechnics used	Very High	✓		✓	✓
MSR-11	All descent control device attachment components shall survive 30 Gs of shock.	CReq	BR-14	All components will be able to survive the shock	Very High			✓	
MSR-12	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	CReq	BR-6	No deployable parts will be restrained	Very High	✓			✓
MSR-14	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.	CReq	BR-55	Spring contacts not used	Very High	✓	✓		
MSR-15	CanSat design must be ergonomically correct to facilitate a successful launch.	CReq	-	Design is ergonomically correct	Very High	✓			
MSR-16	Modular alignment of CanSat for easy fabrication and modelling.	CReq	-	Alignment is modular	Very High	✓	✓		

Configuration 1 - Frustum Fuselage

PIPER PA 28



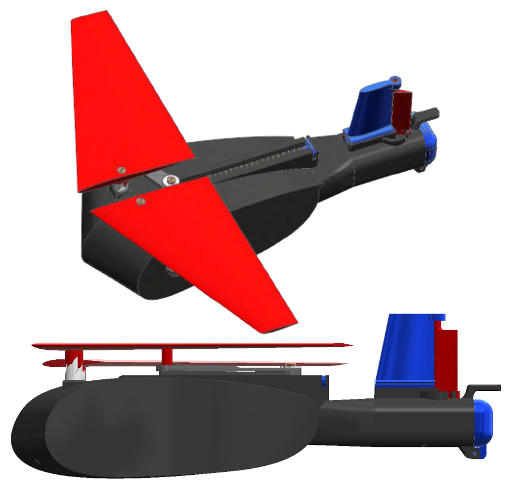
The design for this configuration is derived from the famous lightweight plane **Piper PA 28:**

- The **empennage** is shaped like a **frustum**.
- This shape is preferred when **ample space is required** (in our case we require it for electronics).
- The wings folding **mechanism** can be **incorporated easily** on the flat underside of the fuselage.

Configuration 2 - Tadpole Fuselage

The design for this configuration is derived from **modern sailplanes:**

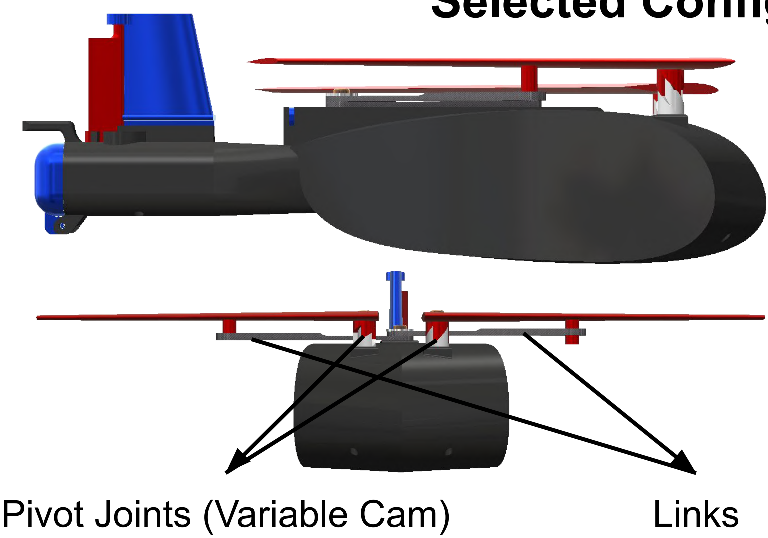
- The **empennage** resembles the shape of a **tadpole**.
- This shape is preferred for modern sailplanes as its the **most aerodynamically efficient shape**.
- It generates **lower drag** than frustum shape as it can **sustain laminar boundary layer**.



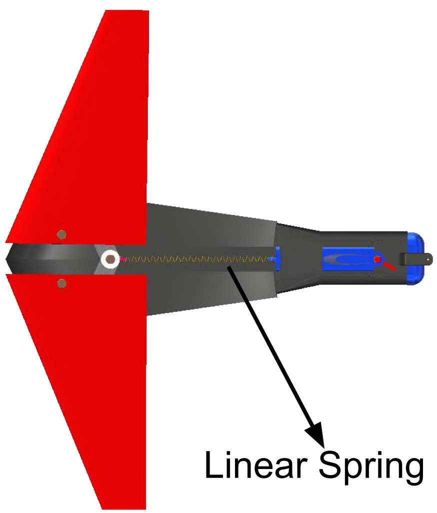
SAILPLANE

Payload Mechanical Layout of Components Trade & Selection (2/7)

Selected Configuration: Tadpole Fuselage



- This mechanism is actuated using links and a **Linear Compression Spring.**
- The links move along the slot providing the wings a rotational motion about the pivot joints.
- The pivot points consist of **Variable Cam** profiles.
- Wings after opening reside in the same plane.

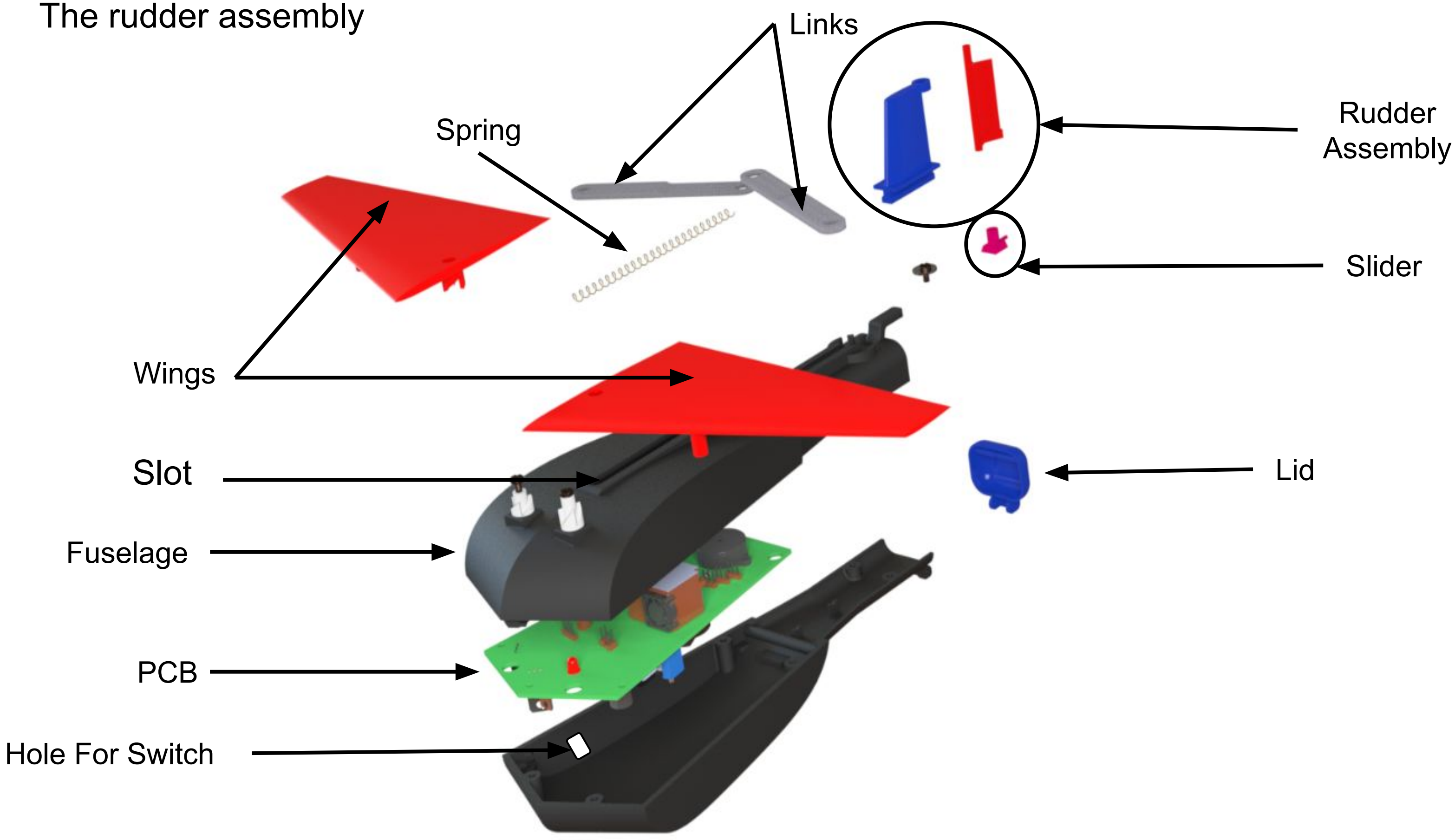


SELECTED CONFIGURATION: TADPOLE FUSELAGE
Rationale: • Suffers from less drag • Less wetted area on the empennage • Enough space to incorporate the electronics and glider parachute deployment mechanism

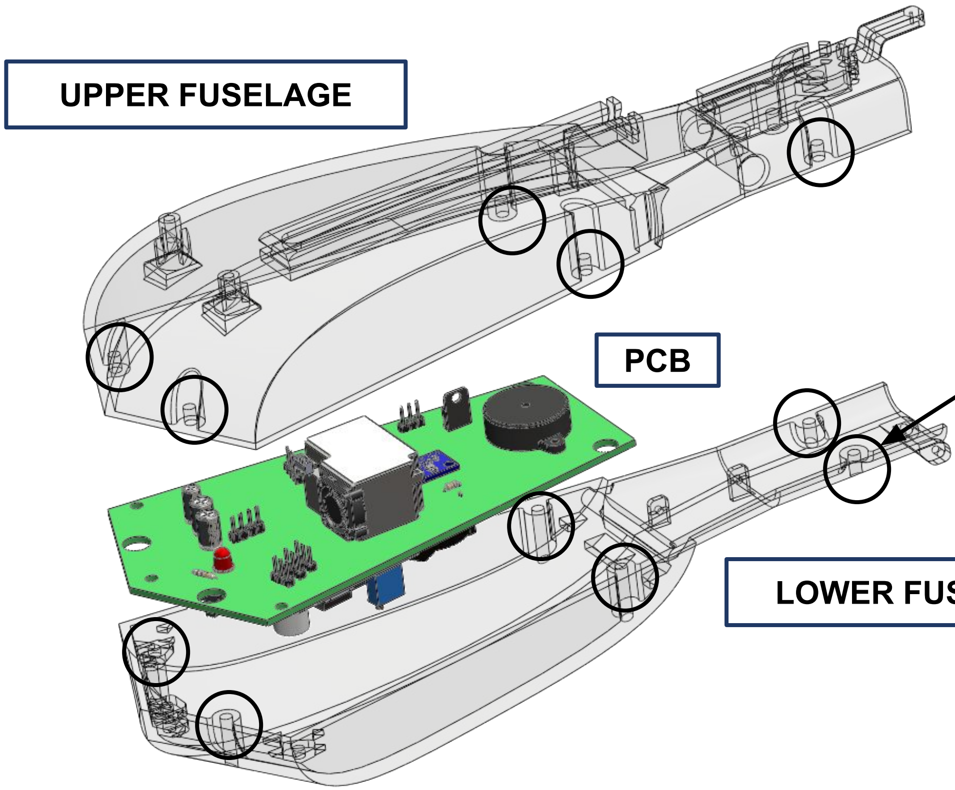
Payload Mechanical Layout of Components Trade & Selection (3/7)

The glider (payload) consists of 3 major sub-assemblies:

- The fuselage (containing the PCB and parachute)
- The wing folding mechanism
- The rudder assembly



Payload Mechanical Layout of Components Trade & Selection (4/7)



M3 Self Tapping Screw

The fuselage is divided into two parts:

- Upper Fuselage
- Lower Fuselage

○ Shows all the locations for the screws to complete the assembly.

Both parts are held together using **M3 screws** and PCB is placed firmly between the two parts with the help of screws, preventing any rattling or shaking of the PCB.

Payload Mechanical Layout of Components Trade & Selection (5/7)

Part(s)	Materials	Density (g/cm3)	Tensile Strength (MPa)	Pros	Cons
Fuselage + Rudder Assembly + Lid	**PA 2200**	**0.95**	**40**	**Easier to print with excellent surface finish**	**Begin to droop and deform, particularly if under load, as it approaches 60°C**
	ABS	1.00	27	Superior mechanical properties over PLA	While printing it's more prone to warping

PA 2200

SELECTED FABRICATION MATERIAL: PA 2200

Rationale:

- It has better self-bonding characteristics, translating a great filament for making parts that can be drilled, tapped, or screwed. Both parts of fuselage will be held together with the screws hence this property is very useful.
- As PA 2200 is less prone to warping, close to perfect fits can be achieved for the components.
- Low density hence provides reduction in mass.

Payload Mechanical Layout of Components Trade & Selection (6/7)

Part(s)	Materials	Density (g/cm3)	Tensile Strength (MPa)	Pros	Cons
Links + Slider	**Carbon Fiber**	**1.30**	**45**	**Light and strong at the same time**	**Does not allow passage of radio waves through it**
	HDPE	0.97	32	Comparatively Light, Strong and durable	Will have to be obtained by CNC

SELECTED FABRICATION MATERIAL: CARBON FIBER

Rationale:

- These are relatively small parts hence won't interfere too much with radio waves.
- We require appreciable strength for links as they are very thin.
- High impact strength is required for the crank and slider because of the sudden opening of the wing mechanism.

CARBON FIBER

Payload Mechanical Layout of Components Trade & Selection (7/7)

Part(s)	Materials	Density (g/cm3)	Tensile Strength (MPa)	Pros	Cons
Wings	**PETG**	**1.27**	**51**	**Extremely durable parts can be printed using this**	**Generally more expensive than PLA**
	PLA	1.24	26	Easier to print and provides sufficient strength	More brittle as compared to PETG

PETG

SELECTED FABRICATION MATERIAL: PETG

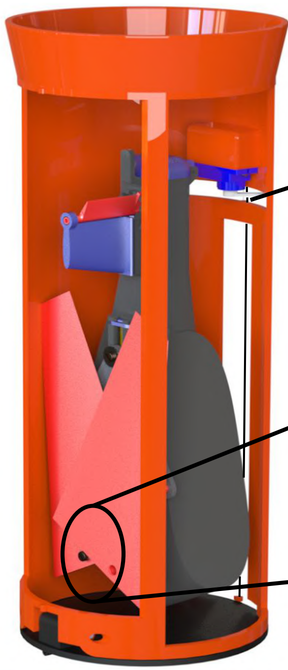
Rationale:

- Since the wings and the joint at root chord bear the weight of payload, thereby making **durability** and **flexibility** an essential requirement.
- Low shrinkage coefficient, almost no warping. Helps obtain the exact aerofoil shape of the wing.

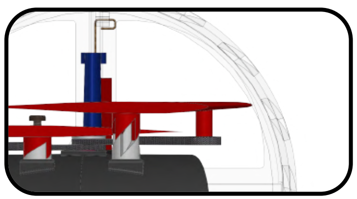
Payload Pre Deployment Configuration Trade & Selection

Design 1

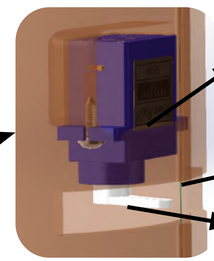
- Payload is held in position with the help of **lid.**
- Payload held in position due to **friction**.



Multiple sectioned view



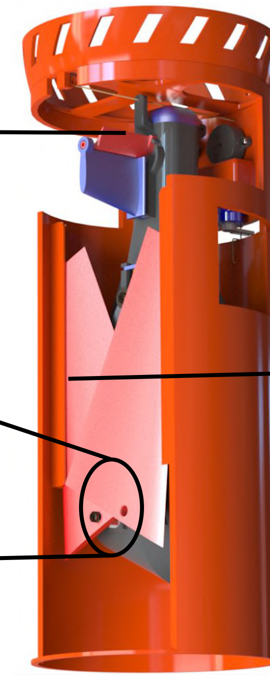
Cutting Mechanism



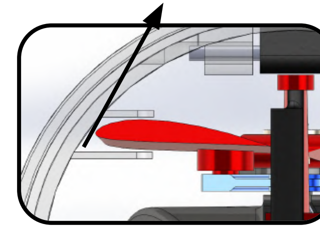
Wing Folding Mechanism

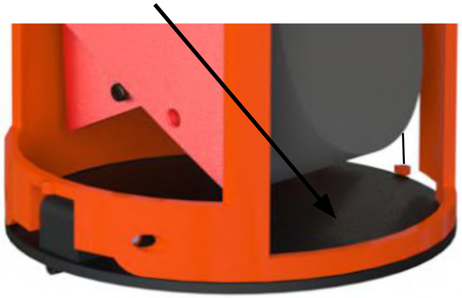
Design 2

- Payload rotation is restricted with help of **guide rails.**.
- Payload is tied and hanged to the container **mount** with thread.



Multiple sectioned view





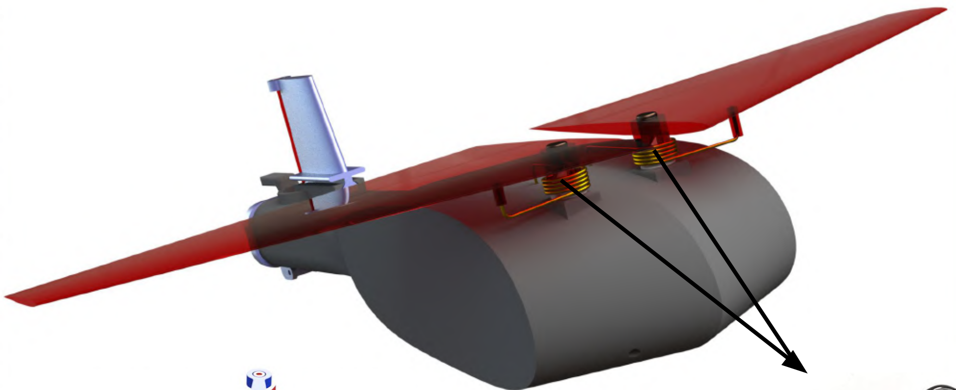
SELECTED CONFIGURATION: DESIGN 2

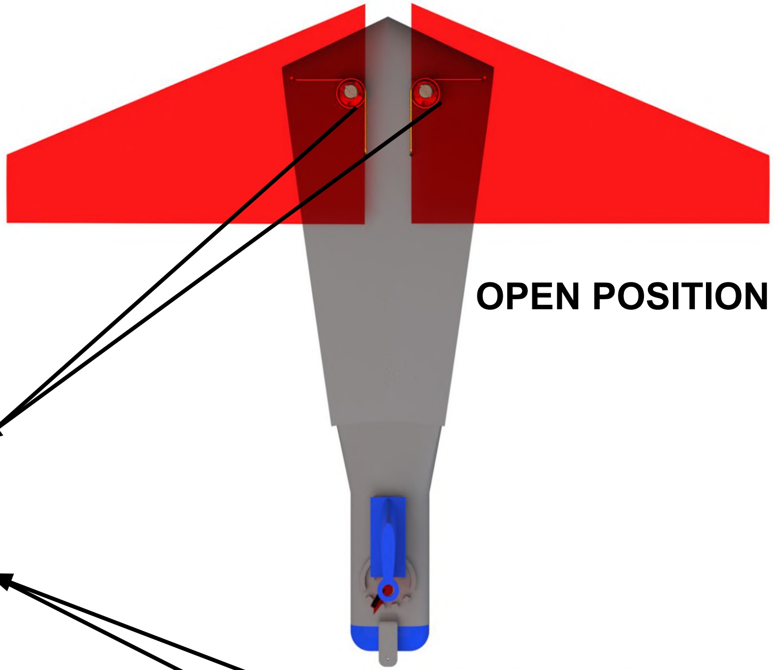
Rationale

- Lid not required.
- Guide Rails prevent internal rotation of the glider.
- Guide Rails provide extra support to the wings.

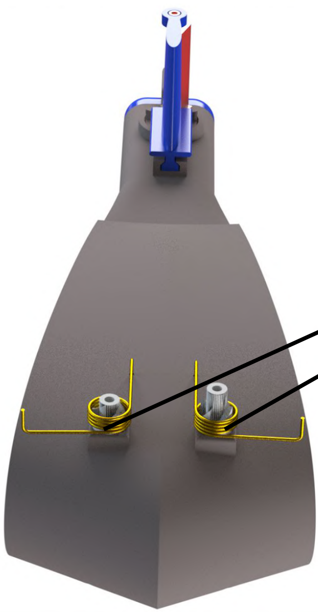
Payload Deployment Configuration Trade & Selection (1/5)

CONFIGURATION 1

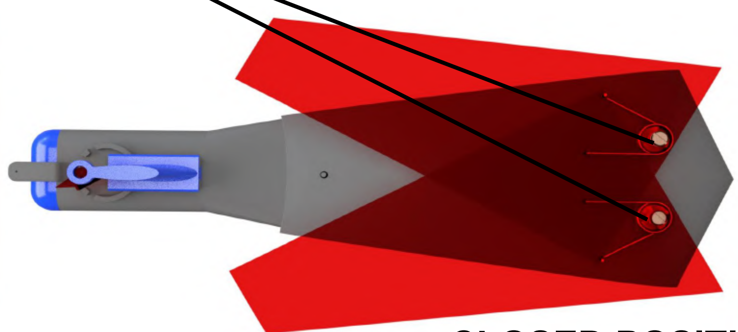




OPEN POSITION



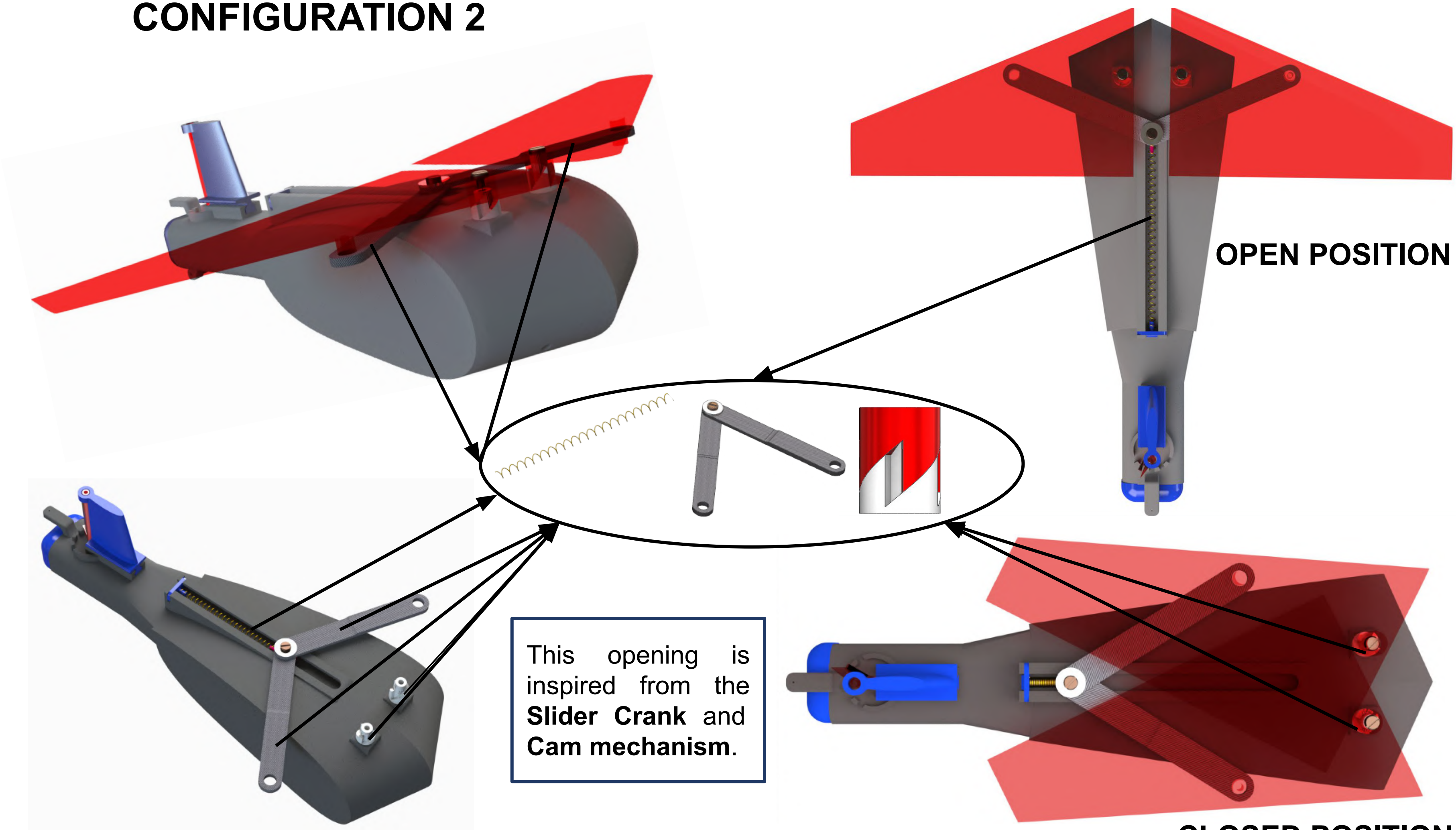
The **Torsional Spring** being used **provides the torque** necessary to open the wings for deployment.
The required torsion springs will be **concentrically attached to pivots** around the hinge.



CLOSED POSITION

Payload Deployment Configuration Trade & Selection (2/5)

CONFIGURATION 2



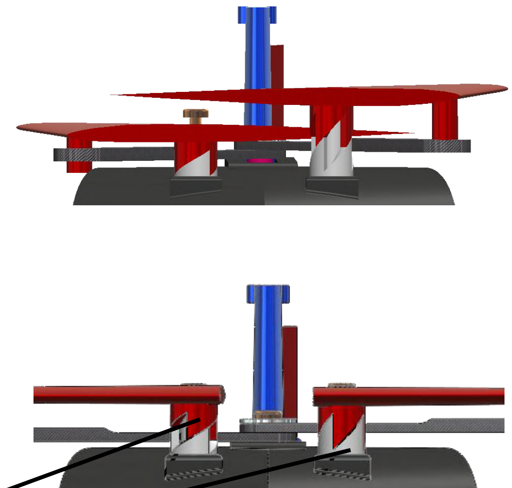
This opening is inspired from the **Slider Crank** and **Cam mechanism**.

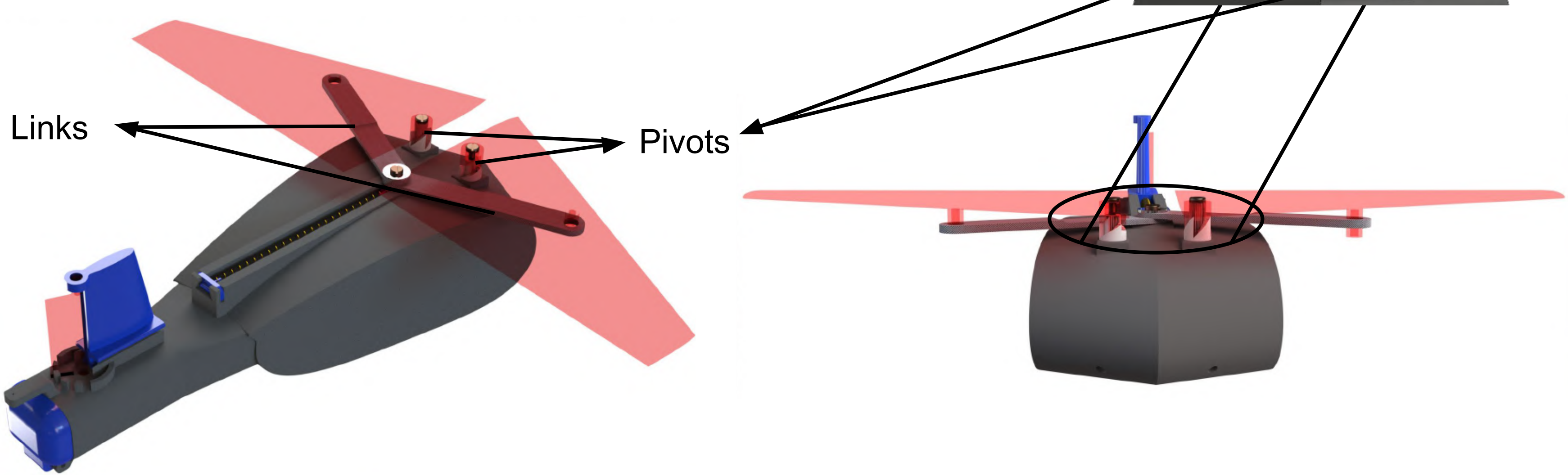
Payload Deployment Configuration Trade & Selection (3/5)

SELECTED CONFIGURATION: SLIDER CRANK AND VARIABLE CAM

Rationale:

- Kinematic chain formed by the links provides overall rigidity to the opening mechanism.
- The 30G of shock will be shared equally among the links and wings hence redistributing the force.
- A single linear spring is sufficient to keep the assembly in open position leading to better reliability.

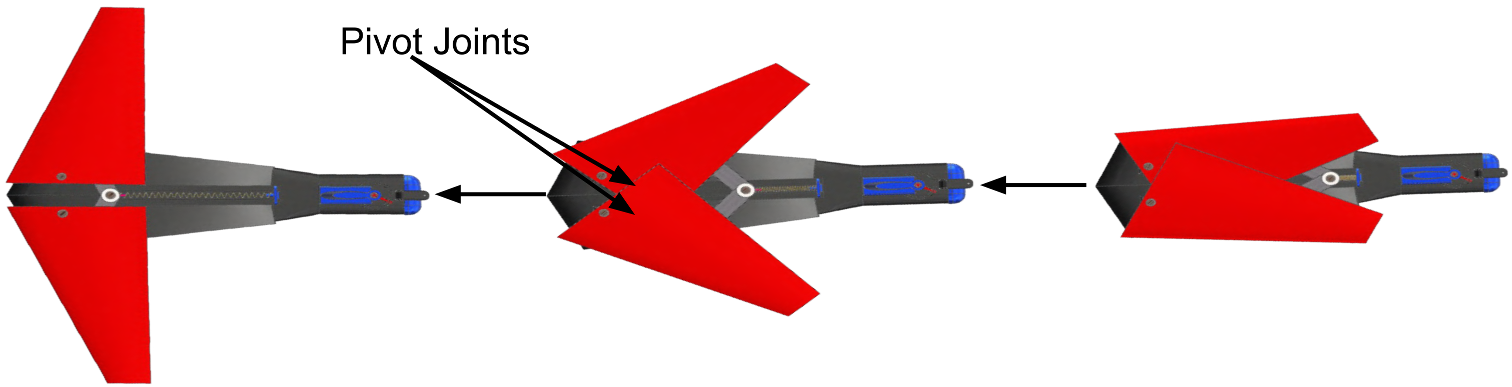




Payload Deployment Configuration Trade & Selection (4/5)

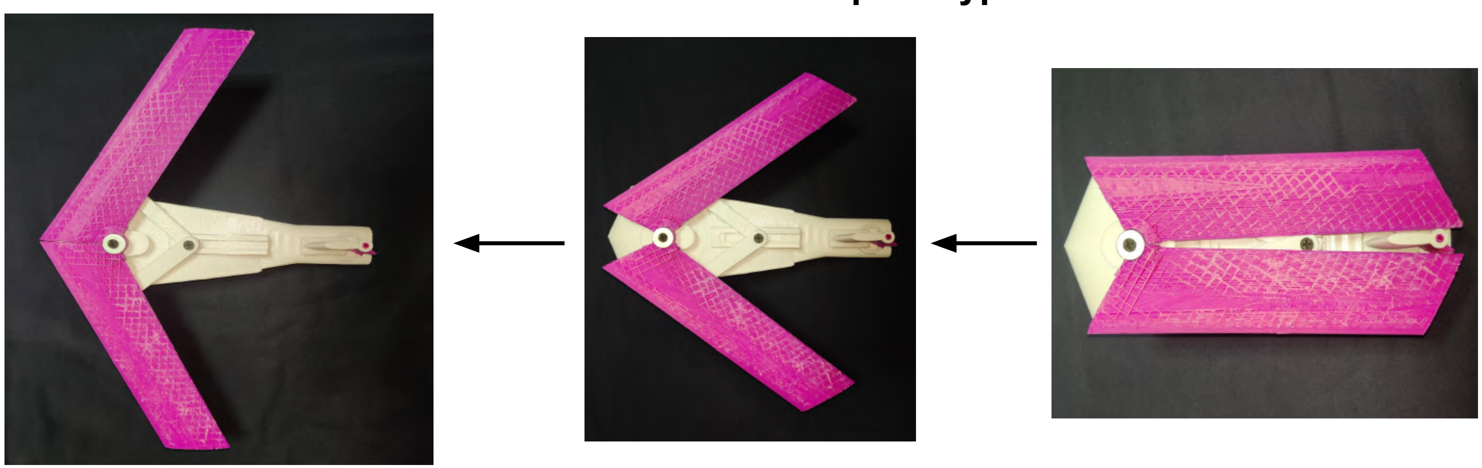
Glider Opening Mechanism Demonstration

CAD Model



The above illustration shows the **intermediate steps** which the **glider** will go through **after release**. The following **photos** and the **video** contained in the **Hyperlink** illustrate the **flawless working** of the **slider crank mechanism** in the **initial prototype**.

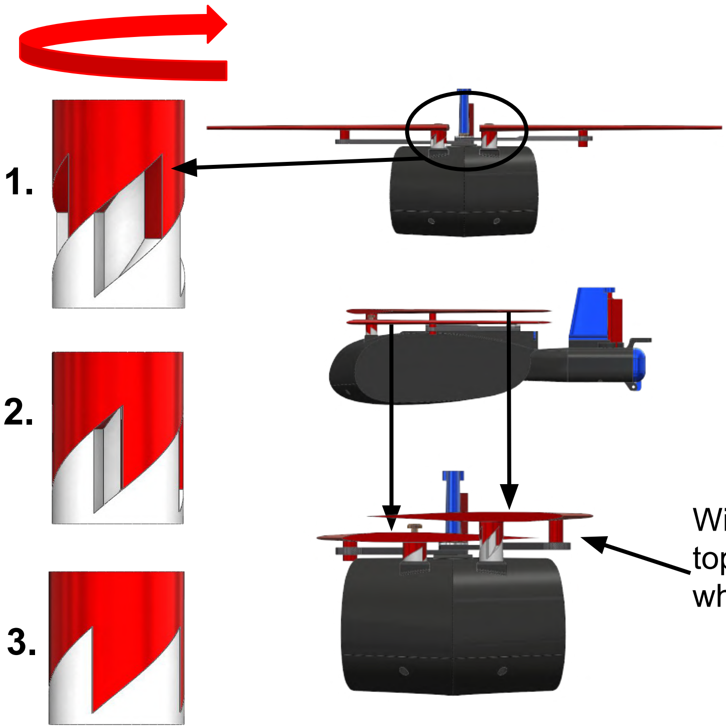
Prototype



Our prototype testing: https://youtu.be/MSHwx3qeH8g

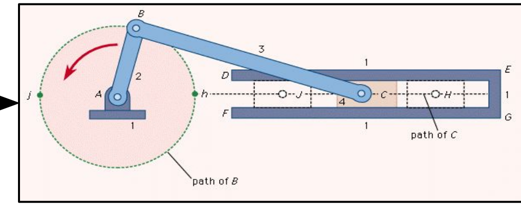
Payload Deployment Configuration Trade & Selection (5/5)

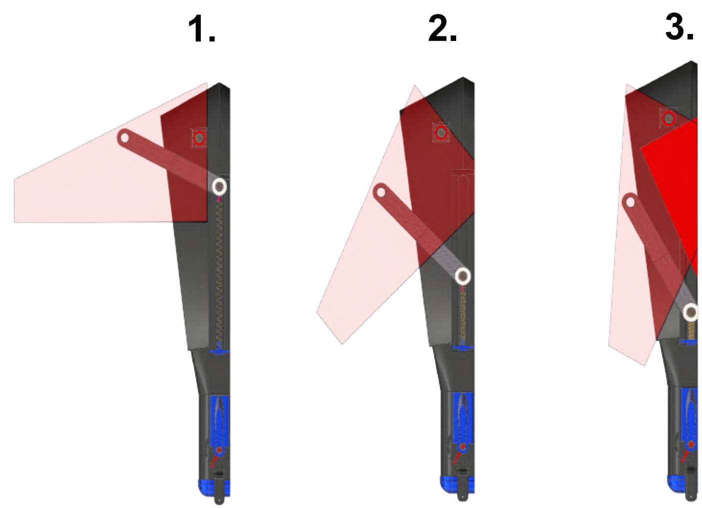
Stages of Cam & Follower Mechanism



Wings stacked on top of each other when stowed.

Slider Crank Mechanism Working





Movement of Slider Crank Slider

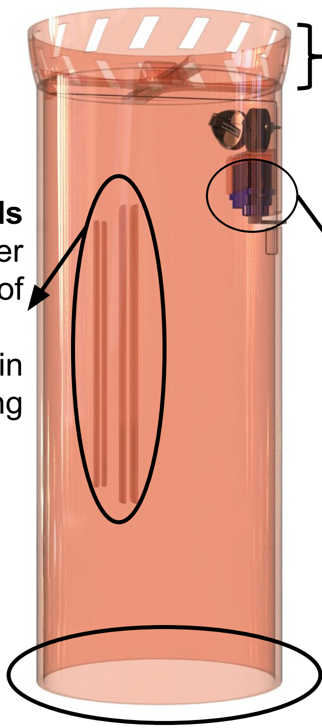
- **Cam Profile** when rotated provides a **linear motion** as well.
- **Wings** are **stacked on top of each other** when stowed, and **return to same plane** after deployment.

- **Slider Crank Mechanism** used to convert linear to rotational motion.
- Here we are using it to **obtain rotational motion** about the **pivot point** where **both the wings** are **attached**.

The **combination** of the above two mechanisms helps us to achieve a **compact** and **rigid wing structure**. In **stowed position**, the wings are **stacked on top** of each other and after **opening**, the wings **resemble** the structure similar to that of a **Parasol Wing aircraft**.

Container Mechanical Layout of Components Trade & Selection (1/3)

Design 1



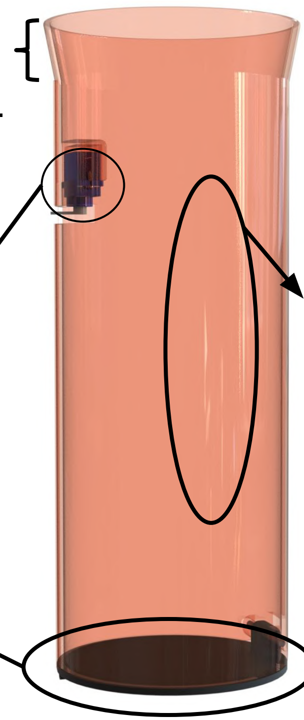
Dedicated Air openings to support inflation of Parachute.

Guide Rails made in inner boundary of container to hold payload in position during flight.

Thread cutting mechanism to **release the glider hanging from the kevlar thread.**

No Lid, Hence no extra weight & complexities.

Design 2



No Dedicated Air openings to support inflation of Parachute.

Thread cutting mechanism to **release the glider by opening the lid tied with thread.**

Smooth Boundaries which provide easy release.

Lid adds extra weight & complexities.

Parameters	Design 1	Design 2
Durability	High	Low
Weight	Medium	High
Cost	Low	Medium
Strength	High	Medium
Stability	Medium	Low
Aerodynamics	High	Low

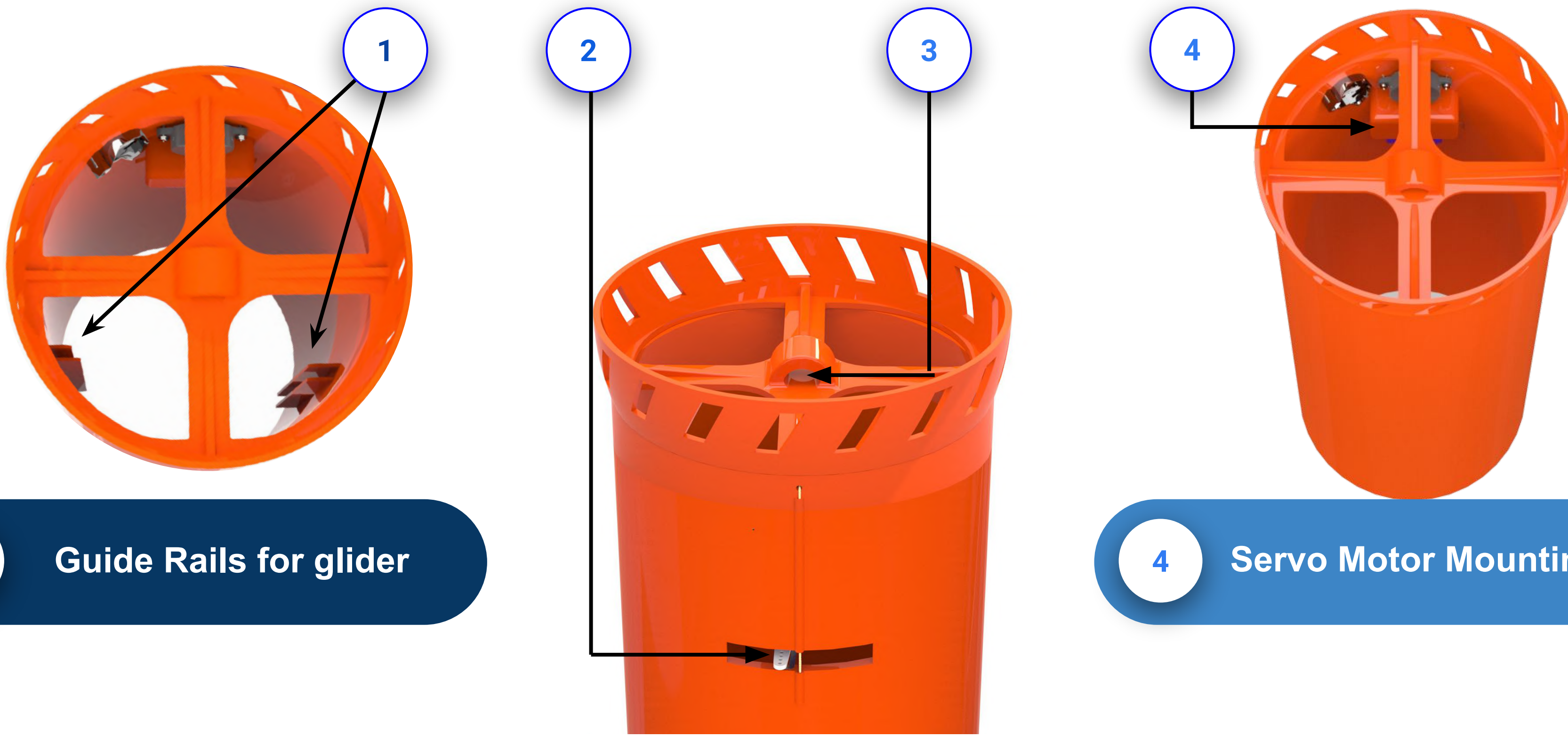
SELECTED DESIGN: DESIGN 1

Rationale:

- Less weight
- Better durability
- Less cost
- Easy to make

Container Mechanical Layout of Components Trade & Selection (2/3)

Assembly Of Container & Parachute Mounting



1 Guide Rails for glider

4 Servo Motor Mounting

2 Opening for Thread Cutting

3 Parachute Mount

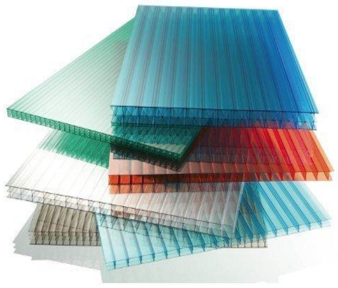
Container Mechanical Layout of Components Trade & Selection (3/3)

Part(s)	Materials	Density (g/cm3)	Tensile Strength (MPa)	Pros	Cons
Container	**Polycarbonate**	**1.22**	**63**	**High impact strength and can maintain toughness from 140^{O}C to -20^{O}C**	**Generally requires heated bed hence expensive as compared to PETG**
	PETG	1.27	51	Does not require heated bed as warping is not so prominent	Has lower glass transition temperature than Polycarbonate at about 80^{O}C

SELECTED FABRICATION MATERIAL: POLYCARBONATE

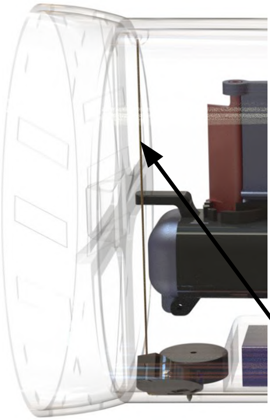
Rationale:

- The container has to be shatterproof so that it can handle 30Gs of shock.
- It is able to maintain its mechanical properties over a wide range of temperature.
- Container walls are quite thin hence the price difference between this and PETG won't be significant.



Polycarbonate

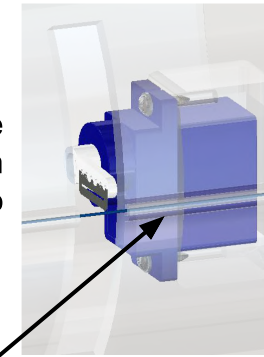
Payload Release Mechanism



A **thread** is passed through the slot provided for the thread outside the container and is tied to the mounting on the container body.

Thread

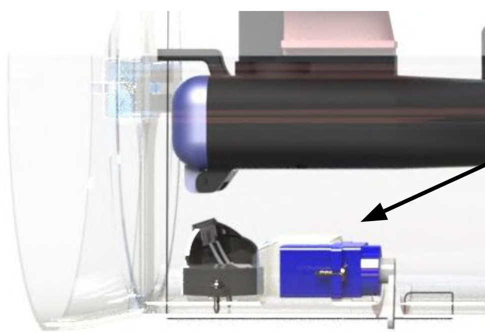
A **sharp blade** is attached to the servo blade. When rotated, the servo cuts the thread.



Thread slot on the outer body of the container.

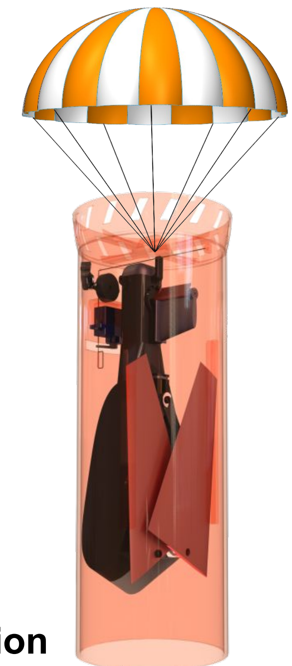
After the thread cutting since the container is open from the bottom, the glider starts to slide down the container due to its weight.

The same thread passes through a **mount** present on the **body of glider**, essentially tying the glider to the container.



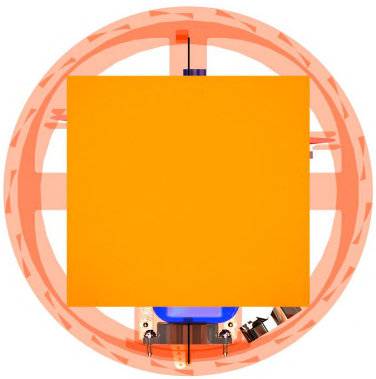
Servo mounted on the container wall.

Container Parachute Attachment Mechanism



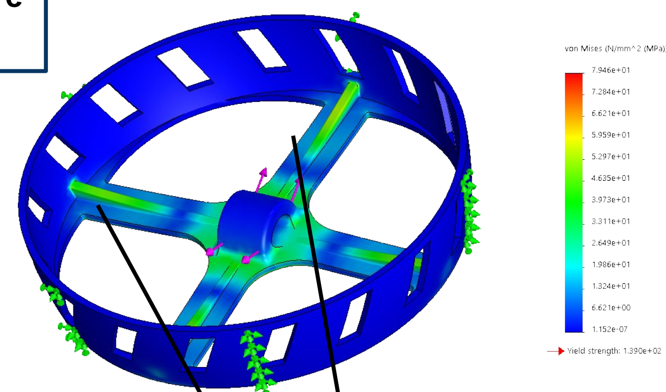
Parachute Deployed

Once **the CanSat is released** from the rocket, the **parachute inflates** due to the **air pressure** thus, **deploying** itself.



Parachute in Stowed Position

Stress Simulation of Parachute Mounting



Mounting of parachute

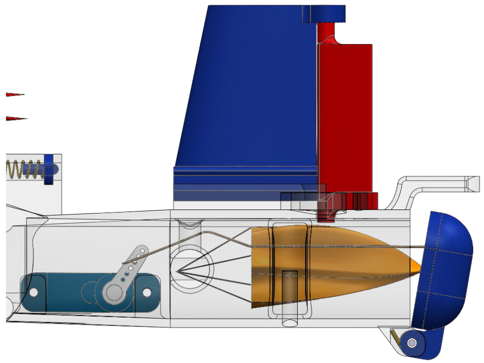
Ribs are provided which **improve the structural integrity** of the **mount** significantly. Can be commonly seen on elevated road corridors.

RESULTS

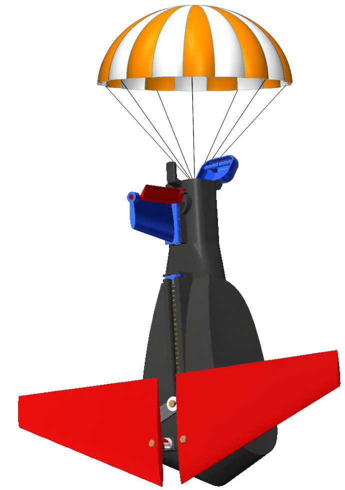
- A **force of 200N** was applied during simulation which produces a **deformation** of only about **1 mm** and the **stresses** are **well below yield point**.
- The **mounting** is **simple and easy to manufacture**.
- It weighs around **40 grams**, hence is **lightweight**.

Payload Parachute Attachment & Deployment Mechanism*

Initially **lid** is held with the **help of thread** and thread is **looped over the servo blade.**



When **servo arm moves** at an angle of **90º**, the lid **opens** by the **restoring force** of torsional spring.

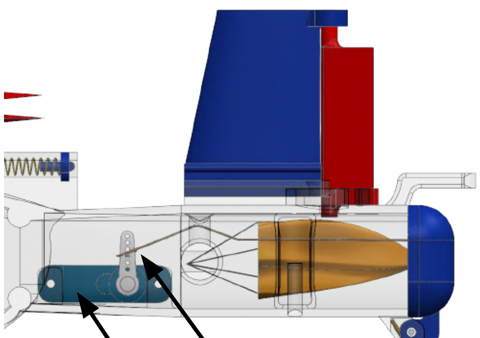


Step 1

Step 2

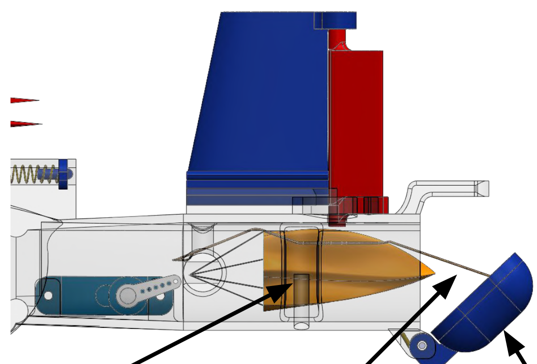
Step 3

Step 4



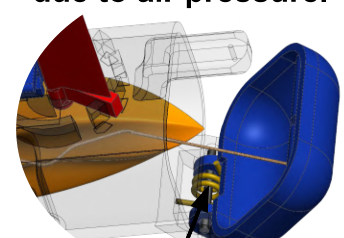
Servo Motor **Servo Arm**

When **servo arm** moves **clockwise** the **loop starts slipping** out of the servo arm.



Parachute **Thread** **Lid**

The **parachute comes out** from the open lid, **due to air pressure.**



Torsional Spring

***This slide is added to explain the payload parachute attachment and deployment mechanism.**

Electronics Structural Integrity

Securing Connections

- Depending on the connection components, **proper methods** for securing will be used.
- **Electrical connections** have been done through **Soldering.**
- Specific adhesives for electronics: Electric tape.

Descent Control Attachments

- **Parachute connections** will be secured by **knots** on the **top layer** of container.
- **Glider wings** are connected to the fuselage **using links to the slider crank mechanism**.

Mounting Methods

- **PCB** is screwed to **mainframe** using **Phillips screws**.
- All **PCB Components** are **soldered on the PCB**.

Enclosures

- **PLA based enclosures** are made for housing **externally placed components** like the wire cutting servo, buzzer etc.
- **Servo motor** used for **parachute opening** will be **clamped on the curved surface**.

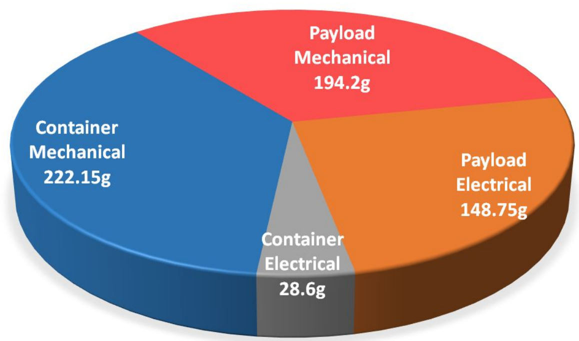
Mass Budget

Container	Mass (g)	Data Type
Structure	203.35±10.50	E
Battery Holder	3.00 ± 0.15	E
Parachute & Ropes	8.80 ± 0.01	M
Servo Motor	4.80 ± 0.00	DS
Buzzer	2.90 ± 0.01	M
Battery x3	17.70 ± 0.00	DS

Mass of Structural Elements = 391.08 ± 19.16 g

Mass of other components = 203.64 ± 00.26 g

Payload	Mass (g)	Data Type
Structure	105.8 ± 5.3	E
Wing x2	69.04 ± 3	E
Wing mounting x2	4.76 ± 0.2	E
Spring x2	5.13 ± 0.01	M
Parachute & Rope	7.00 ± 0.01	M
Electronic Sensors	49.80 ± 0.00	DS
RTC + Battery	11.10 ± 0.00	DS
SD Card	4.54 ± 0.00	DS
NRF	2.00 ± 0.00	DS
Bonus Camera	10.00 ± 0.00	DS
PCB	28.20 + 0.01	M
Antenna	1.20 ± 0.01	M
XBEE	4.80 ± 0.00	DS
Teensy	12.00 ± 0.00	DS
Battery	22.50 ± 0.01	M
Servo Motor x2	9.60 ± 0.00	DS
Buzzer	2.90 ± 0.01	M
Miscellaneous	3.80 ± 0.20	E



Sources Of Uncertainties

- Least count of the weighing scale used is 0.01 g, an error of ± 0.001 g is introduced in all components whose weight is measured.
- Error from modelling software (solidworks) is taken as 5%.

Method of Correction

- If mass of CanSat < 610 g, the wall thickness of container will be increased to increase mass.
- If mass of CanSat > 610 g, topology optimization of container will be done to reduce mass.

Total Mass of Container = 240.55±10.67

+

Total Mass of Payload = 354.17 ± 8.75

Total mass of CanSat (g)

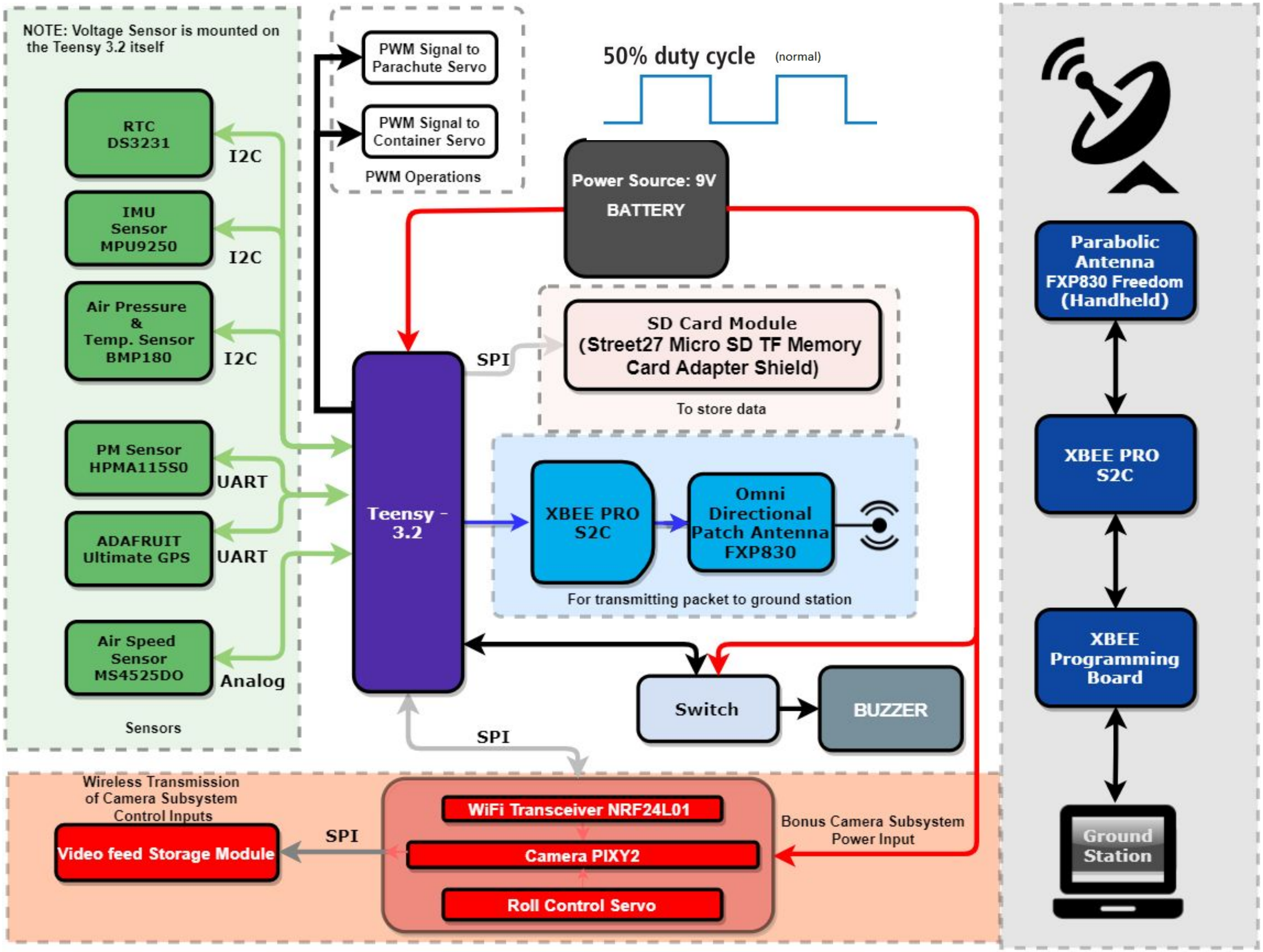
594.72 (g) ± 19.42

Total Mass Margin of CanSat
⇒ (600 - 594.72) = 5.28 g

Communication and Data Handling (CDH) Subsystem Design

Abhinav Gupta

Payload CDH Overview (1/2)



Payload CDH Overview (2/2)

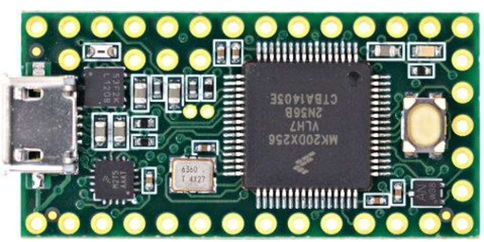
CPU - Teensy 3.2	• **Receiving data** and **executing commands** coming via **UART interface** from **XBEE radio module** • **Sending data packets** via **UART interface** to **XBEE radio module** • **Writing data packets** via **SPI interface** to external **SD card**
Telemetry - XBEE S2C PRO	• **Receiving data packets** from **CPU** using **UART interface**. • **Forwarding data packets** from **CPU** to **Ground Station** using **XBEE**. • **Receiving data and commands** from **Ground Station** using **XBEE**. • **Forwarding data and commands** from **Ground Station** to **CPU** using **UART interface**.
Data Storage - Street27 Micro SD TF	• **Storing Telemetry Data**. • **Receiving and saving data** coming from **CPU** using **SPI interface**.
Sensors	• **Forwarding data** to **CPU** using **UART, I2C or Analog Information**.
Other	• **NRF Module** sends **Camera Information** to **CPU** using **NRF protocol**.

Payload CDH Requirements

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
PCDH-1	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.	CReq	BR - 33	RTC is used to maintain mission times.	Very High	✓		✓	
PCDH-2	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	CReq	BR - 34	XBEE S2C PRO is provided.	High	✓	✓	✓	
PCDH-3	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.	CReq	BR - 35	XBEE S2C PRO has been used which provides 2.4GHz frequency.	Very High	✓	✓	✓	✓
PCDH-4	XBEE radios shall have their NETID/PANID set to their team number.	CReq	BR - 36	NETID and PANID has been set.	Very High	✓	✓		✓
PCDH-5	XBEE radios shall not use broadcast mode.	CReq	BR - 37	XBEE radio are configured accordingly.	Very High	✓	✓		✓
PCDH-6	All telemetry shall be displayed in engineering units (meters, meters/sec,Celsius, etc).	CReq	BR - 41	All calculations are done at standard units.	High	✓		✓	✓
PCDH-7	Teams shall plot each telemetry data field in real time during flight.	CReq	BR - 42	Telemetry data is plotted.	Very High	✓	✓	✓	✓

Payload Processor & Memory Trade & Selection (1/3)

Model	Boot Time (µs)	Dimension (mm x mm x mm)	Processor Speed (MHz)	Data Interface	Pin Configuration	Memory Storage Requirement (KB)	Cost ($)
Teensy 3.2	**300**	**35.5 x 17.7 x 4.0**	**72**	**I2C: 4 UART: 4 SPI: 3**	**Digital I/O: 34 PWM: 12 Analog In: 21**	**EEPROM: 2KB Flash: 256KB RAM: 64KB**	**24.95**
Arduino Nano	150	43.1 x 18.5 x 6.1	16	I2C: 2 UART: 4 SPI: 3	Digital I/O: 22 PWM: 6 Analog In: 8	EEPROM: 1KB Flash: 32KB RAM: 2KB	20.00
Arduino Mega	200	102.0 x 54.0 x 6.1	16	I2C: 2 UART: 2 SPI: 6	Digital I/O: 54 PWM: 15 Analog In: 16	EEPROM: 4KB Flash: 256KB RAM: 8KB	30.00



TEENSY 3.2

SELECTED PROCESSOR: TEENSY 3.2

Rationale:

- Light Weight.
- Fastest Clock Speed (72 MHz).
- Lowest Boot Time (3s).
- Max number if I/O pins (34 digital and 14 analog).

TEENSY 3.2 GPIO PINS

I2C PINS: 16-19
UART PINS: 0-1, 7-8
SPI PINS: 10-12

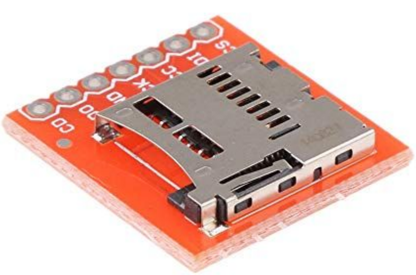
Payload Processor & Memory Trade & Selection (2/3)

Model	Connection Type	Dimensions (mm x mm x mm)	Weight (g)	Supply Voltage (V)	Supply Current (mA)	Power Consumption (mW)	Cost ($)
Street27 Micro SD TF Memory Card Adapter Shield	**SPI**	**2.5 x 2.4 x 2.0**	**4.54**	**3.0 to 5.0**	**80**	**240 to 400**	**3.48**
CENTIoT Micro SD mini Storage Board TF Card Reader Memory Shield Module	SPI	4.1 x 2.4 x 2.0	10.00	4.5 to 5.5	80	360 to 440	7.06

Selected Memory: Street27 Micro SD TF Memory Card Adapter Shield

Rationale:

- Smaller Footprint (upto 39% smaller area than the other counterpart).
- Increased efficiency without redundant LDO and level shifter.
- Relatively Lesser Weight (54.6% lesser than the rejected trade).



Street27 MicroSD TF Memory Card Board Adapter Shield

Payload Processor & Memory Trade & Selection (3/3)

Model	Speed (Mb / s)	Dimensions (mm x mm x mm)	Capacity (GB)	Operating Temperature (°C)	Cost ($)
Sandisk 8GB Class 4	**40**	**15.0 x 11.0 x 0.1**	**8**	**-25 to 85**	**5.77**
Strontium 8 GB MicroSDHC Class 6	10	15.0 x 11.0 x 0.1	8	-25 to 80	1.48

Sandisk 8GB Class 4

SELECTED MEMORY CARD: SANDISK 8GB CLASS 4

Rationale:

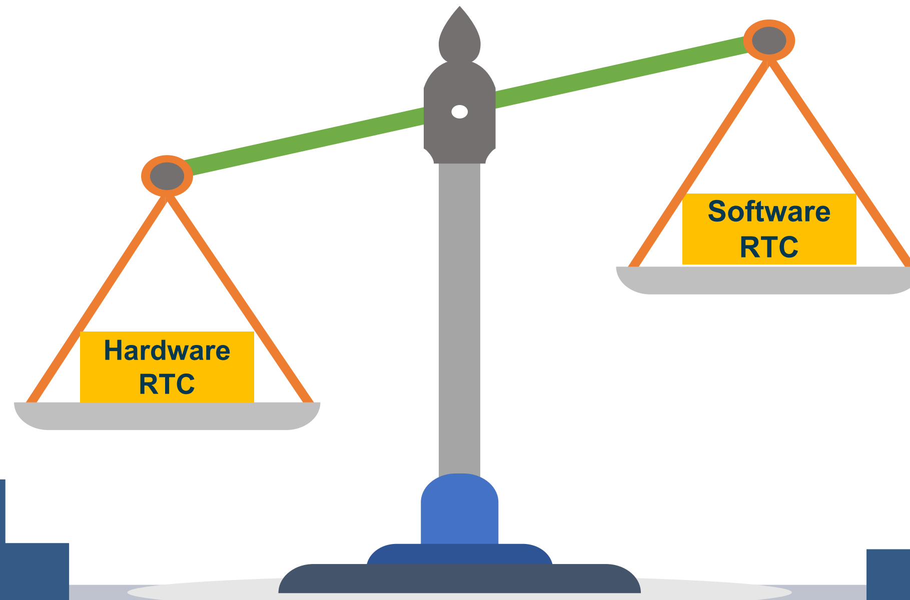
- Higher data transfer rates (400% greater than Strontium MicroSDHC).
- Higher operating temperature range (>6.33% than Strontium MicroSDHC).
- Supports All Data Formats.

Payload Real-Time Clock (1/2)

Reset Tolerance

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

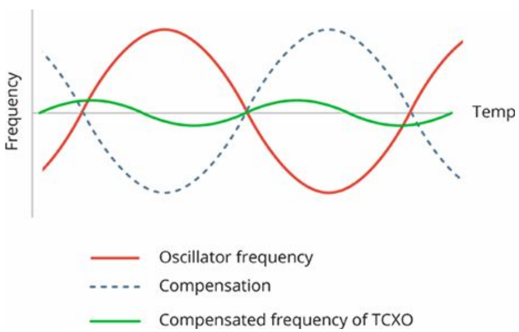
Selected: Hardware RTC due to increased accuracy



Hardware RTC	Software RTC
• Implemented using externally located oscillatory crystal • Battery backup and power failure detection system allows for timekeeping in case of system failure or device reset • SD Card timestamp storage acts as additional backup	• Implemented with a timer/ counter based interrupt generation system. • No power failure backup provision • Larger processor calculation cycles cause system performance bottlenecking.

Payload Real-Time Clock (2/2)

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Power Consumption (mW)	Resolution (ppm)	Cost ($)
DS3231	**37 x 25 x 15**	**8.0**	**I^{2}C**	**0.66mW**	**±2**	**4.0**
DS1307	25 x 23 x 5	2.3	I^{2}C	7.5mW	±23	1.8



DS3231

SELECTED REAL TIME CLOCK : DS3231

Rationale:

- On-board battery provides reset tolerance in face of power supply interruptions.
- Provided 32KHz temperature compensated crystal oscillator (TCXO) provides device robustness and maintains the RTC at ±2 per minute.
- Easy MCU integration.
- Additional 32 bytes 24C32 EEPROM chip from Atmel having unlimited read-write cycles for data storage.

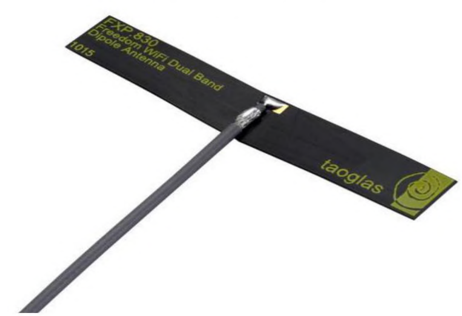
Payload Antenna Trade & Selection (1/2)

Model	Dimensions (mm x mm x mm)	Weight (g)	Radiation Pattern	Polarization	Gain (dBi)	VSWR	Range (m)	Input Power (W)	Cost ($)
FXP830 Freedom	**42 x 7 x 1**	**1.2**	**Omni-Directional**	**Linear**	**2.6**	**<2**	**1710**	**2**	**7.88**
Duck Antenna	210 x 19 x 1.5	25.0	Omni-Directional	Linear Vertical	5.5	<2	3329	50	2.09
WRL-11320	41 x 30 x 1	3.3	Omni-Directional	Vertical, Horizontal	2.0	<3	1500	3	5.06

Selected Antenna Trade: FXP830 Freedom

Rationale:

- Omnidirectional radiation pattern.
- Low connector impedance causes low signal loss.
- Its lightweight and negligible size helps in the accommodation of other components.

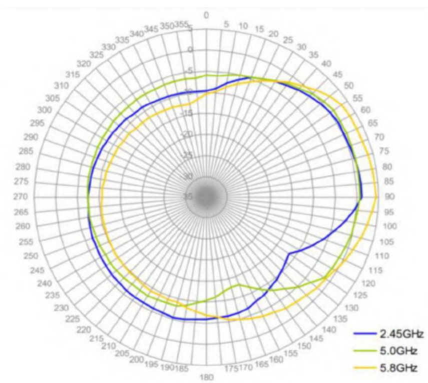


FXP830 Freedom

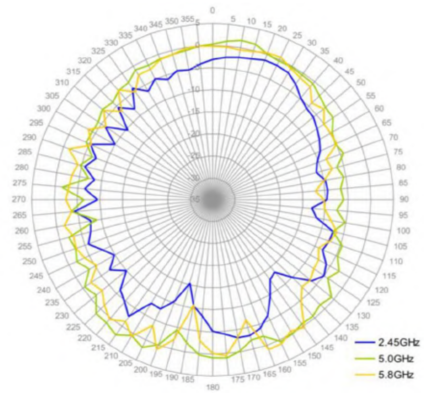
Payload Antenna Trade & Selection (2/2)

Other Parameters And Radiation Pattern Of FXP830

Parameter	Value
Antenna Gain (dB)	2.6
Transmission Power (dBm)	33.103
Operation Frequency (MHz)	2400
Cable Loss (dB)	4
Receiver Sensitivity (dBm)	-73
Free Space Path Loss (dB)	111.703
Calculated Range (m)	1710

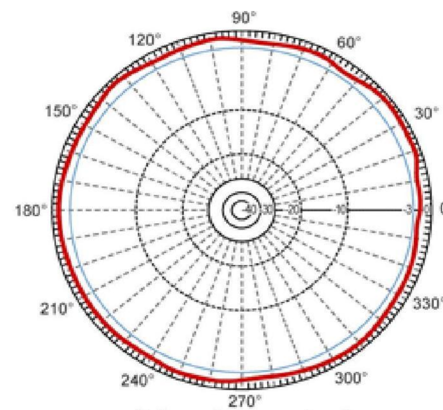


Horizontal Plane

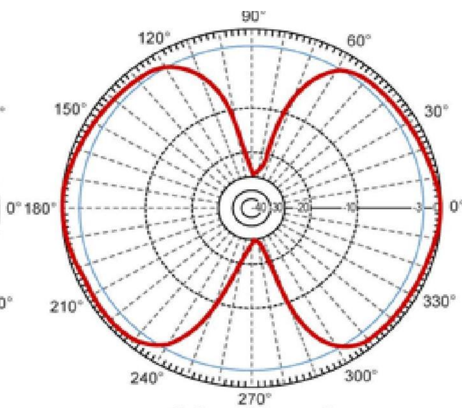


Vertical Plane

Radiation Pattern of Duck Antenna



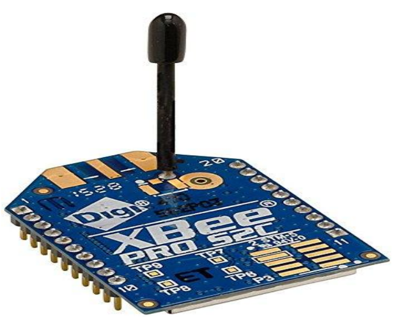
Horizontal



Vertical

Payload Radio Configuration (1/2)

Model	Operating Frequency (GHz)	Sensitivity (dBm)	Transmitted Power mW (dBm)	Data Rate (kbps)	Supply Voltage (V)	Input Power (mW)	Cost ($)
XBEE Pro S2C	**2.4-2.5**	**-101**	**63 (+18)**	**250**	**2.7-3.6**	**396**	**14.09**
XBEE S3B PRO 900 HP	0.90	-101	250	200	2.1-3.6	957	49.00
XBEE S2C	2.4-2.5	-102 (Boost) -101 (Normal)	6.3 (+8) (Boost) 3.1 (+5) (Normal)	250	2.1-3.6	135.3(Boost) 108.9(Normal)	14.04



XBEE Pro S2C

Selected Radio Configuration:XBEE Pro S2C

Rationale:

- Higher data rate (>25% than XBEE S3B Pro).
- Less input power (<50% than XBEE S3B Pro).
- Suitable sensitivity and optimum range for operation and p.

Payload Radio Configuration (2/2)

Configuration

- **Ground station radio**: **Coordinator**
- **Payload radio**: **Endpoint**
- **Destination address**: **Coordinator address**

Data Rate

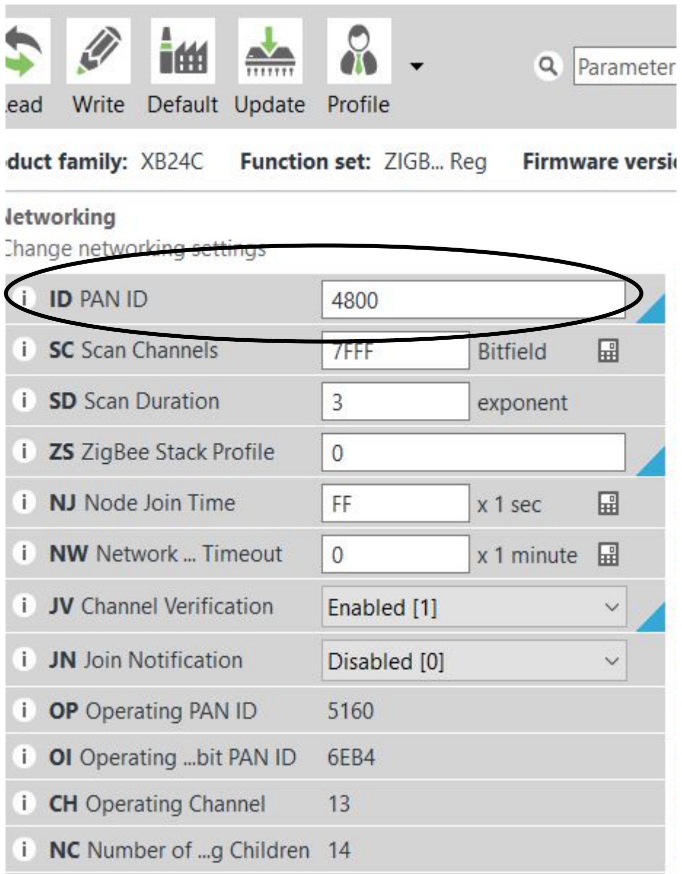
- The **XBEE** will **transmit the data** to the **Ground Station** at a rate of **1 Sample/second (1Hz).**

Transmission Control

- **Calibration command** (At launch pad): **Ground station →Payload**
- **Telemetry** transmission: Endpoint telemetry data→ Coordinator **(@1 sample/s)**
- After **landing**, FSW **stops transmitting** sensor data to Endpoint. As a result, telemetry transmission to Coordinator will be stopped.

Other

- **NETID/PANID : 4800**
- **CAST MODE : UNICAST**



Radio prototyping and testing has been completed.

Payload Telemetry Format (1/2)

Component	Description	Resolution
TEAM ID	Assigned team identification number - 4800	-
MISSION TIME	Total elapsed time in seconds from mission start	1 second
PACKET COUNT	The count of transmitted packets, which is to be maintained through processor reset	-
ALTITUDE	Altitude in metres with relative to the ground	0.1 metre
PRESSURE	Atmospheric Pressure measured in Pascals	1 Pa
TEMPERATURE	Temperature readings in degree Celsius; Resolution	0.1 °C
VOLTAGE	Voltage of CanSat Power bus; Resolution	0.01 V
GPS TIME	Time generates by GPS receiver; Resolution	1 second
GPS LATITUDE	Latitude generated by the GPS receiver in decimal degrees	0.0001 degrees
GPS LONGITUDE	Longitude generated by the GPS receiver in decimal degrees	0.0001 degrees
GPS ALTITUDE	Altitude generated by the GPS receiver in meters above mean sea level	0.1 metre
GPS SATS	Number of GPS satellites being tracked by the GPS receiver	-
AIR SPEED	The air speed relative to the payload in meters/second	0.84 Pa
SOFTWARE STATE	The operating state of the software. (Boot, Idle, Launch Detect, Deploy, etc.)	-
PARTICLE COUNT	A decimal value representing the measured particle count in mg/m^3.	-
BONUS	**<IMU ROLL> ,<IMU PITCH> ,<IMU YAW>, <CAMERA PAN ANGLE>**	-

Payload Telemetry Format (2/2)

Bonus Telemetry Format	● **IMU ROLL** - Rotation about **X - Axis** ● **IMU PITCH** - Rotation about **Y - Axis** ● **IMU YAW** - Rotation about **Z - Axis** ● **CAMERA PAN ANGLE** - Indicates **Servo Rotation angle** as camera rotates with Servo
Data Rate of Packets	● The data is **transmitted with 1 Hz** to the **ground station**. ● **Burst transmission** is used to transmit **telemetry packets**.
Payload Transmission Format	<TEAM ID>, <MISSION TIME>, <PACKET COUNT>, <ALTITUDE>, <PRESSURE>, <TEMP>, <VOLTAGE>, <GPS TIME>, <GPS LATITUDE>, <GPS LONGITUDE>, <GPS ALTITUDE>, <GPS SATS>, <AIR SPEED>, <SOFTWARE STATE>, <PARTICLE COUNT>, ***<IMU ROLL>, *<IMU PITCH>, *<IMU YAW>, *<CAMERA PAN ANGLE>**
Example	4800, 50, 121, 410, 101325, 22.05, 8.7, 02:00, 20.5905, 78.9623, 408, 4, 15, 3, 226, ***0.56, *-4.53, *17.21, *45**
File Name	The telemetry data file shall be named as follows: Flight_<4800>.csv

Payload Communication Module Trade & Selection* (Bonus Task)

Model	Dimensions (mm x mm x mm)	Weight (g)	Interface	Wireless Protocol	Power Consumption (mW)	Cost ($)
NRF24L01	**28 x 15 x 12**	**2**	**SPI**	**2.4 GHz GFSK Modulation**	**39.6**	**1.39**
ESP8266	28 x 15 x 2	2	UART	WiFi	56.1	5.66
HC05	27 x 13 x 3	4	UART	Bluetooth Spec v2.0	165.0	4.91

Selected Communication Module Trade: NRF24L01

Rationale:

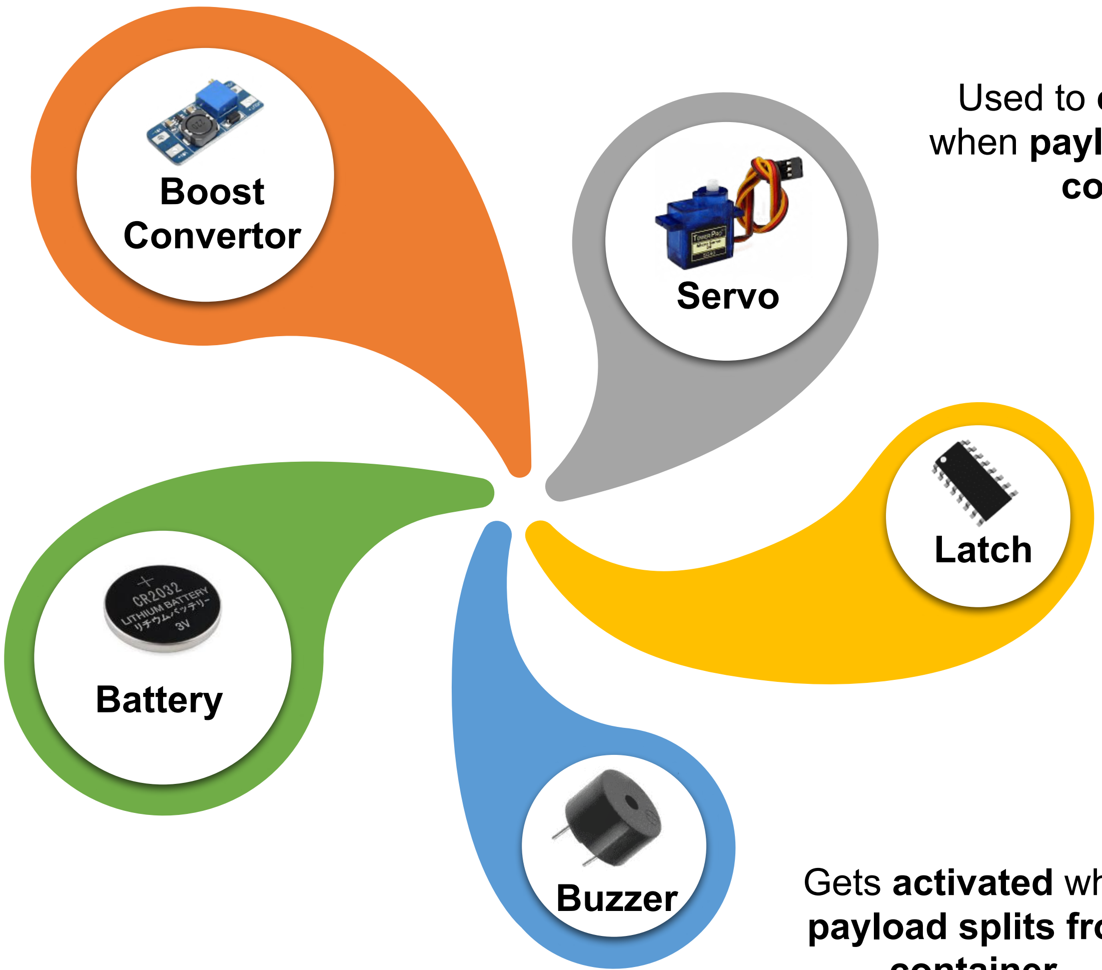
- Lowest power consumption (<41.66% than ESP8266 and <316.67% than HC05).
- Favorable SPI interfacing.
- Sufficiently high max data transmission rate of 10mbps.

NRF24L01

*Slide represents bonus task trade and selection for in-situ communication device between payload camera subsystem and storage module on board the main PCB

Container CDH Overview

No Container Electronics Hence No Container CDH



Used to **step up voltage** upto **15V** for operating the buzzer.

Used to **cut the thread** when **payload splits from container**.

Triggered by the **PWM signal** to turn the buzzer on.

Powers all the components.

Gets **activated** when **payload splits from container**.

Container CDH Requirements

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
CCDH-1	Container electronics is responsible for the payload separation mechanism at 450m.	CReq	BR - 10	The payload will be released at the given altitude.	Very High	✓	✓	✓	
CCDH-2	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.	-	The payload will be separated from the container at the given altitude.	Very High	✓			
CCDH-3	Container shall comprise of a servo motor for lid opening, buzzer and external power source.	By altitude calculation using pressure sensor, the container servo is moved at 450m for lid opening.	-	The container consists of the specified components.	Very High	✓		✓	✓
CCDH-4	The software state shall change when altitude of CanSat is 450m.	In order for the Servo motor to cut the cotton thread.	-	The software state will change at the given altitude.	Very High	✓	✓	✓	

Container Processor and Memory Trade & Selection

No Container Processor and Memory Used

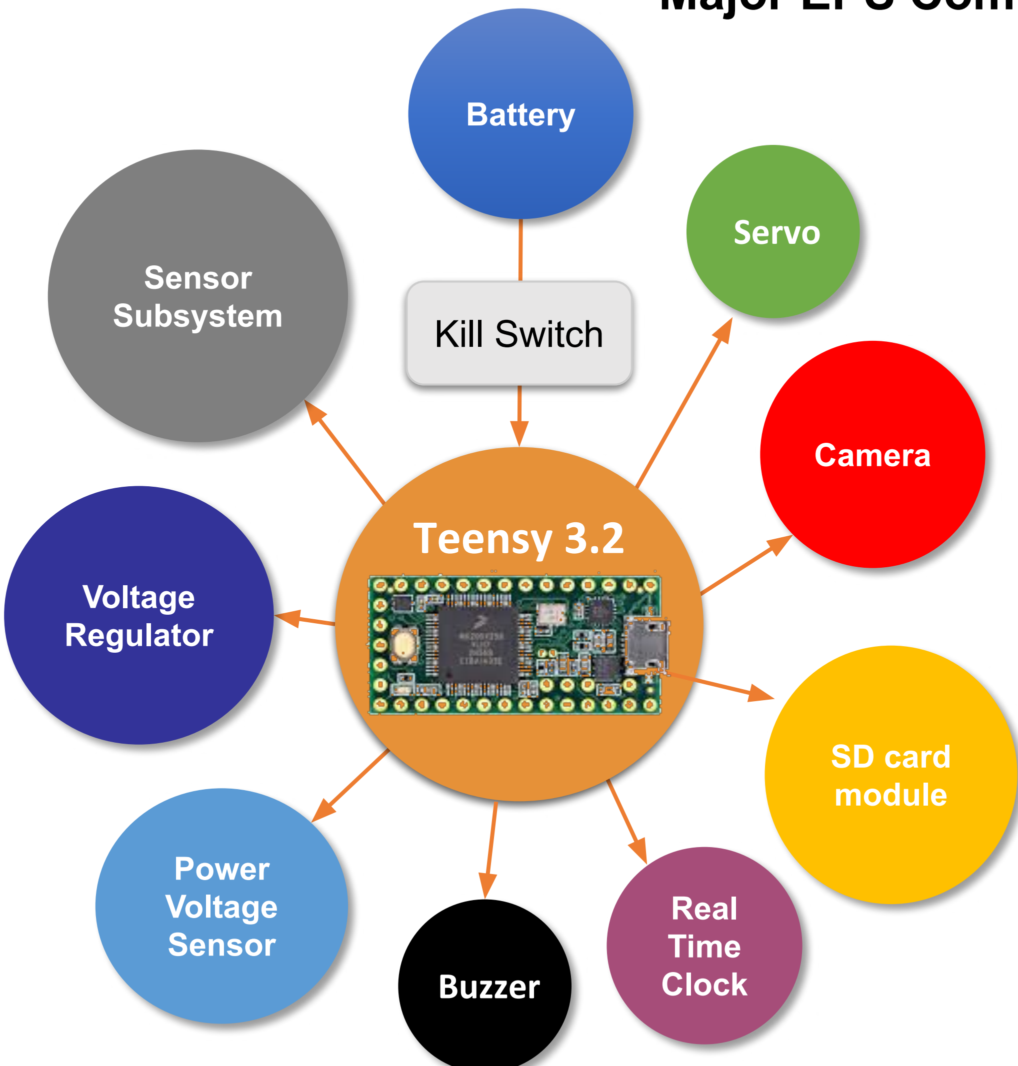
- The electronics in the container consists of a **Servo motor**, **Lithium ion battery**, **Boost convertor** and a **Buzzer** connected through a **latch**.
- The **buzzer** gets **activated** when the container **splits up** from the payload (i.e. when **servo motor** gets the **PWM signal** from the **Payload**), the PWM signal **triggers the Latch** which further **turns the buzzer on.**

Container Electronic Components

Electrical Power Subsystem (EPS) Design

Amey Khairnar

Major EPS Components



- **Kill Switch**: Switch the payload ON/OFF as and when required. It cancels out the power supply to the payload.
- **Li ion coin cell**: It is used to power the external RTC. It has a high energy density and is lightweight.
- **Voltage regulators (9-5V and 9-3.3V)**: This setup allows the incorporation of both 5V and 3.3V components in the design. All selected sensors work at 3.3V whereas the camera and camera stabilisation mechanism work at 5V..
- **Voltage Divider**: Our microcontroller Teensy 3.2 is used as a voltage divider to bring the battery voltage down to acceptable levels of our ADC and then measures the battery voltage.
- **Container Subsystem**: A 9 ⟶15V boost convertor is used to power the container buzzer connected through a latch.
- A **9V battery** is used to power the CanSat probe because of its high capacity.

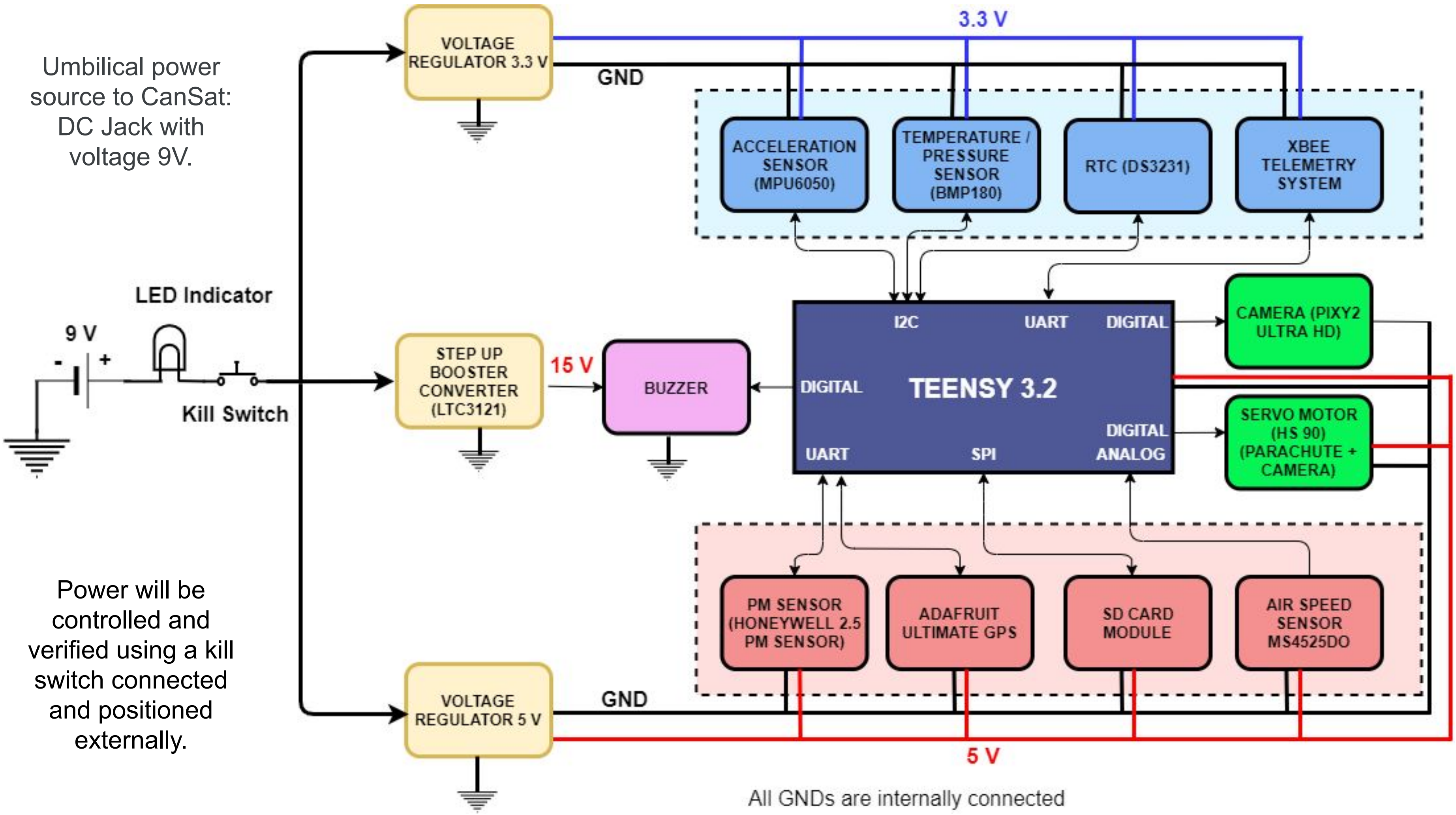
All the sensors are directly connected to the microcontroller

EPS Requirements

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
EPSR-1	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	CReq	BR - 15	The components are enclosed and shielded	Very High	✓	✓	✓	
EPSR-2	The probe must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration.	CReq	BR - 49	The probe contains the switch	Very High	✓	✓	✓	
EPSR-3	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the CanSat and in the stowed state.	CReq	BR - 50	The probe contains a power indicator	Very High	✓	✓	✓	✓
EPSR-4	An audio beacon is required for the payload. It may be powered after landing or operate continuously.	CReq	BR - 51	The audio beacon is included	Very High	✓	✓	✓	✓
EPSR-5	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.	CReq	BR - 53	Ni-Mh battery is used	Very High	✓		✓	✓
EPSR-6	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.	CReq	BR - 54	Battery compartment was included	High	✓	✓	✓	
EPSR-7	Payload/Container shall operate for a minimum of two hours when integrated into rocket.	CReq	BR - 57	Payload capable of operating for 2 hours	High	✓	✓	✓	

Payload Electrical Block Diagram

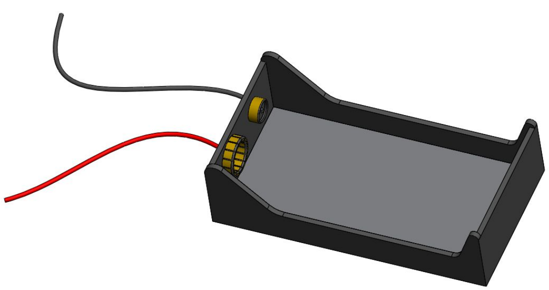
Umbilical power source to CanSat: DC Jack with voltage 9V.



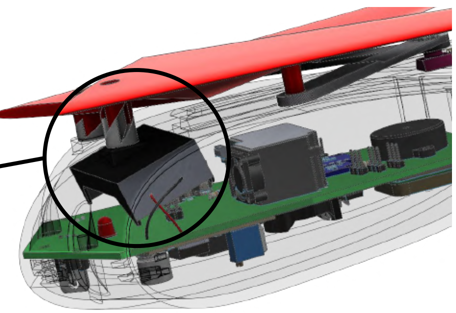
Power will be controlled and verified using a kill switch connected and positioned externally.

Payload Power Trade And Selection

Model	Dimensions (mm x mm x mm)	Weight (g)	Type	Capacity (mAh)	Voltage (V)	Price ($)
EBL 6F22 Battery	**56.0 x 52.0 x 3.8**	**22.5**	**Ni-Mh**	**600**	**9.0**	**8.80**
Samsung 1865025R	18.3 x 64.8 x 4.0	45.0	Li-ion	2500	3.7	8.33
Beston Rechargeable Battery	14.5 x 49.5 x 4.0	35.0	Li-ion	600	9.0	9.00



Battery mounting will **hold the battery** and an **OV17134 connector** is attached to the **top of mounting**.



Battery mounting is provided at the **nose area of the glider**.

SELECTED BATTERY: A SINGLE 9V ENVIE RECHARGEABLE BATTERY

Rationale:

- Caters to the need of the power subsystem.
- High capacity, optimum for operating payload for 2 hours.

Battery Configuration - NONE (Single Cell)

Payload Power Budget (1/3)

Category	Component	Current (mA)		Voltage (V)	Duty Cycle (%)			Average Power Consumed (mW)			Average Energy Consumpt-ion (Wh)	Calculation Source
		Standard	Standby		Pre-Flight	In-Flight	Post-Flight	Pre-Flight	In-Flight	Post-Flight		
SENSORS	BMP180	0.65	0.001	3.3	0	100	100	0.003	2.145	2.145	0.002219	E
	MS4525DO	5.00	0.001	3.3	0	100	0	0.003	16.5	0.003	0.00055	E/DS
	Honeywell HPMA 115S0	80.00	20	5.0	0	100	0	100	400	100	0.213	E/DS
	MPU-6050	3.90	0.5	3.3	0	100	100	1.65	12.85	12.85	0.0149	E/DS
	Buzzer	20.00	0	15.0	0	0	100	0	0	300	0.240	E/DS
	Pixy 2	140.00	0.003	5.0	0	50	0	0.015	700	0.015	0.02336	E/DS
	Street 27 SD card	3.61	0.25	3.3	4.5	4.5	4.5	11.92	11.92	11.92	0.02423	DS
SERVO	Nano Servo x2	60.00	8	5.0	0	2	0	40	300	40	0.090 x 2	E/DS
μC	Teensy 3.2	84.00	0.5	5.0	100	100	100	2.5	420	120	0.1365	E

Payload Power Budget (2/3)

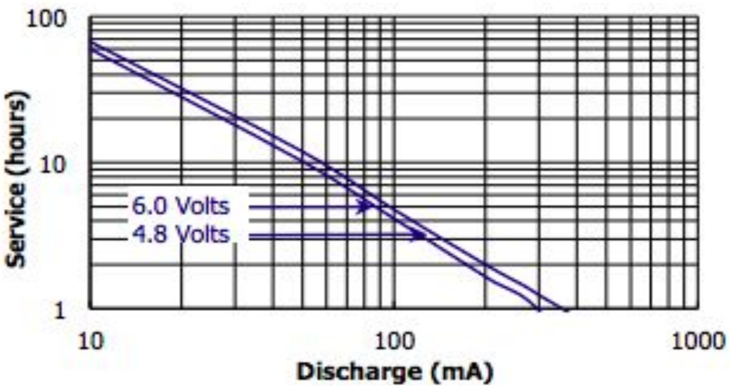
Category	Component	Current (mA)		Voltage (V)	Duty Cycle (%)			Average Power Consumed (mW)			Average Energy Consumpt-ion (Wh)	Calculation Source
		Standard	Standby		Pre-Flight	In-Flight	Post-Flight	Pre-Flight	In-Flight	Post-Flight		
Tx	XBEE Pro S2C	120	31.000	3.3	0	100	100	102.3	396.0	396.0	0.511	E
	NRF24L01	12	0.026	3.3	0	100	100	0.085	39.6	39.6	0.041	E/DS
Boost Convertor	LTC3121	0.5	0.001	3.7	0	0	100	1.850	1.8	74.0	0.076	E/DS
TOTAL								**260.363**	**2300.815**	**1036.53**	**1.373586 Wh**	

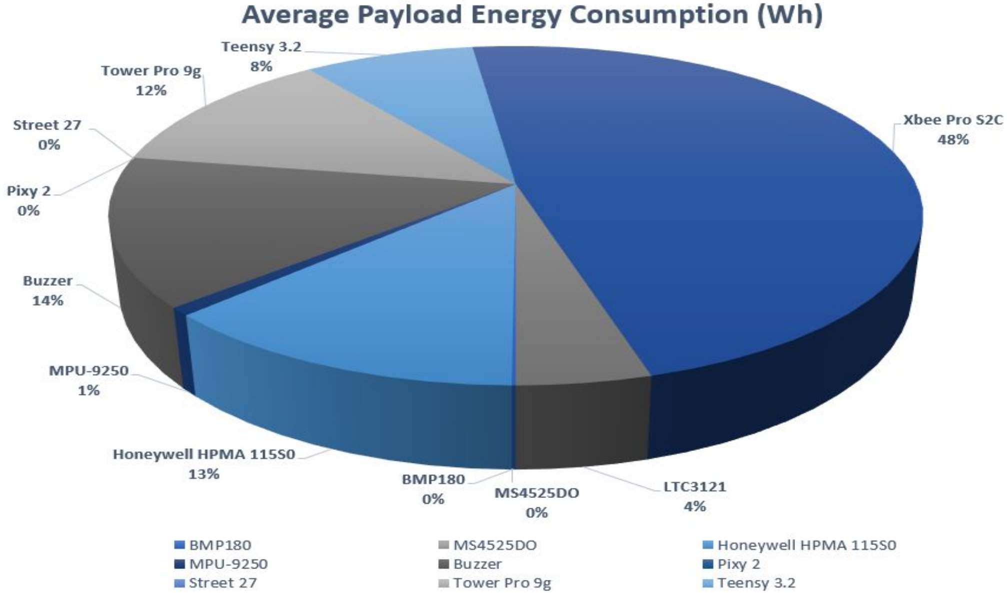
State	Assumed Time For State (hr)
Pre - Flight	1
In - Flight	1/30 = 0.0333 (Approximated)
Post - Flight	1

Total Energy Consumed
Pre-Flight Power(W) x 1 + In-Flight Power (W) x 0.0333 + Post-Flight Power (W) x 1
= 260.63 x 1 + 2300.815 x 0.0333 + 1036.53 x1 = **1.373 Wh**

Available Payload Battery Energy	Total Average Payload Energy Consumption	Payload Energy Margin
5.4 Wh	**1.75489 Wh**	**3.6451 Wh**

Payload Power Budget (3/3)



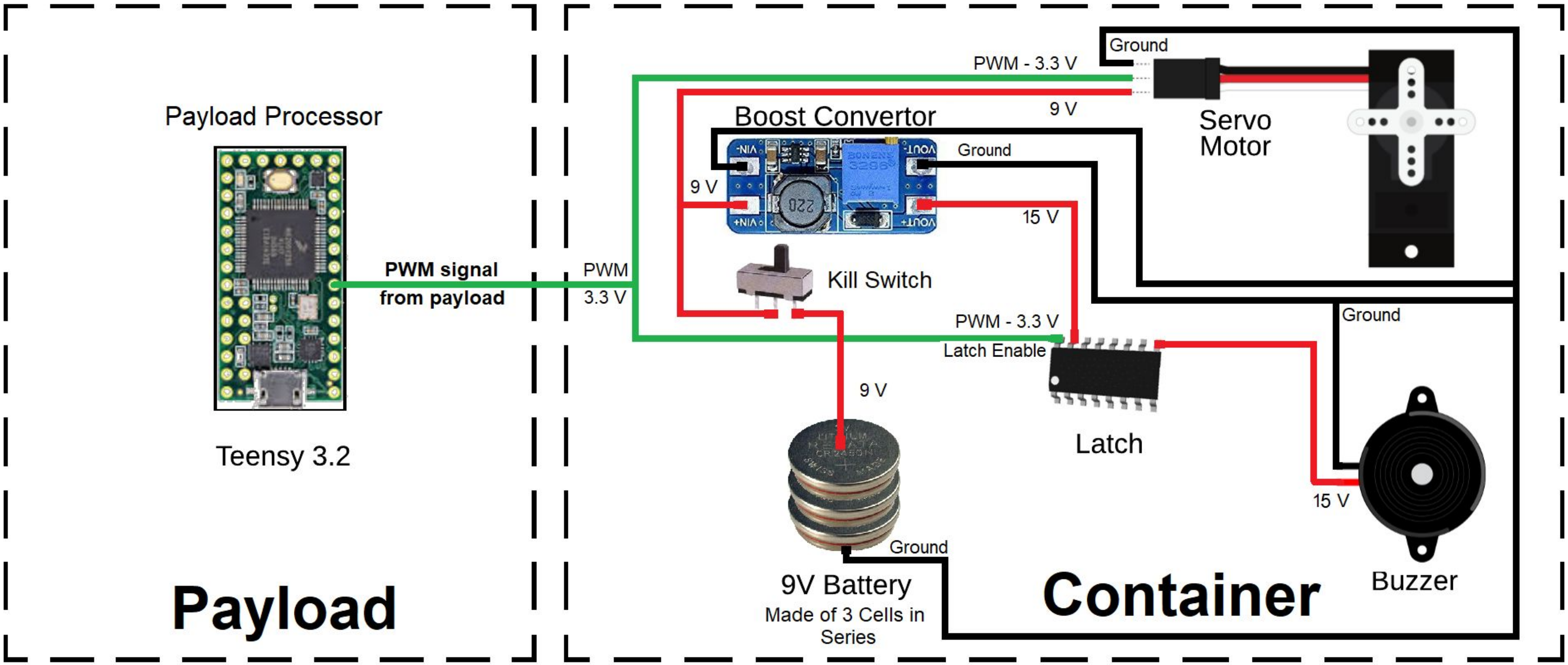


State	Pre-Flight	In-Flight	Post-Flight
Current Consumed (mA)	155.142	376.913	277.216
AVERAGE		**210.944 mA**	

Total Current Consumed By Payload for 2 hrs	Total Current Capacity of battery
444.9205 mAh	**600mAh**
Margin for Current Consumption	**No. of Hours Battery will last**
155.07948 mAh	**2.84 hrs**
% of Battery Power Used	
1.754/5.4 X 100 = 32.48 %	

Since Battery will last for 2.2 hrs, henceforth our battery trade is correct and power requirements are met.

Container Electrical Block Diagram



At **450 meters**, **payload CPU** sends the **PWM signal** to **servo & latch.**

By **thread cutting method** (using servo) science payload is released and **latch** after receiving **PWM signal**, sets **buzzer ON**,which later help recovery crew to recover the container.

Container Power Trade & Selection

Model	Dimensions (mm x mm)	Weight (g)	Type	Capacity (mAh)	Voltage (V)	Discharge Current (mA)	Number of cells used	Price ($)
Renata CR2450N	**24.5 x 5.0**	**5.9**	**Li-ion**	**580**	**3.00**	**0.30**	**3**	**2.10**
Panasonic CR2032	20.0 x 3.2	3.1	Li-ion	225	3.0	0.19	3	0.71
Duracell LR44 A76	11.6 x 5.4	2.0	Alkaline	125	1.5	0.18	6	2.11

Renata CR2450N

Selected Power Trade: Renata CR2450N

Rationale :

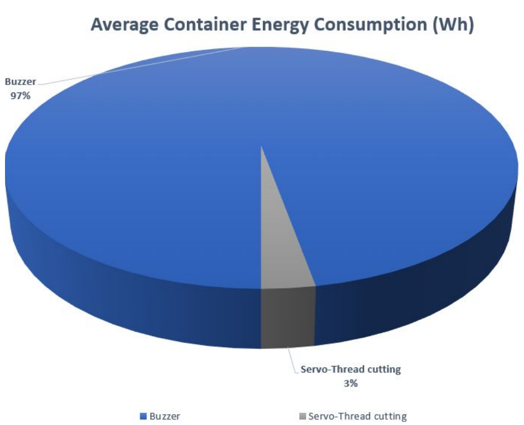
- Higher discharge current than other trades.
- Sufficient energy capacity for servo and buzzer supply.
- Satisfies weight constraints.
- Performs in extreme temperatures (-40ºC to 85ºC).
- Has the highest capacity per unit weight of 98.3mAh/g.

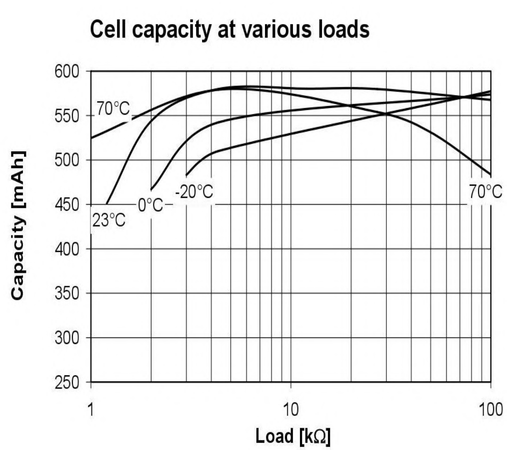
Battery Configuration : Series Connection of 3 cells

Container Power Budget

Component	Current (mA)		Voltage (V)	Duty Cycle (%)			Average Power Consumed (mW)			Average Energy Consumpt-ion (Wh)	Calculation Source
	Standard	Standby		Pre-Flight	In-Flight	Post-Flight	Pre-Flight	In-Flight	Post-Flight		
Buzzer	20	0	12	0	0	100	0	0	24	0.240	E/DS
Servo - Thread cutting	**50**	**20**	**5**	0	2	0	0	25	10	0.007	E/DS
TOTAL							**0**	**25**	**34**	**0.247 Wh**	

State	Pre-Flight	In-Flight	Post-Flight
Time For State (hr)	1	1/30	1





Total Average Container Power Consumption	Total Average Container Energy Consumption
0.590 W	**0.247 Wh**
Available Container Battery Energy	**Container Energy Margin**
1.740 Wh	**1.493 Wh**
No. of Hours Container can work	**2.94 h**

Flight Software (FSW) Design

Vivaswat Sinha

FSW Overview (1/2)

Overview of the CanSat FSW design

The **necessary data** from the sensors will be **transmitted** to the **Ground Station** using **XBEE**. The data will be stored on a **SD Card**.

Programming Language

Python

Development Environment

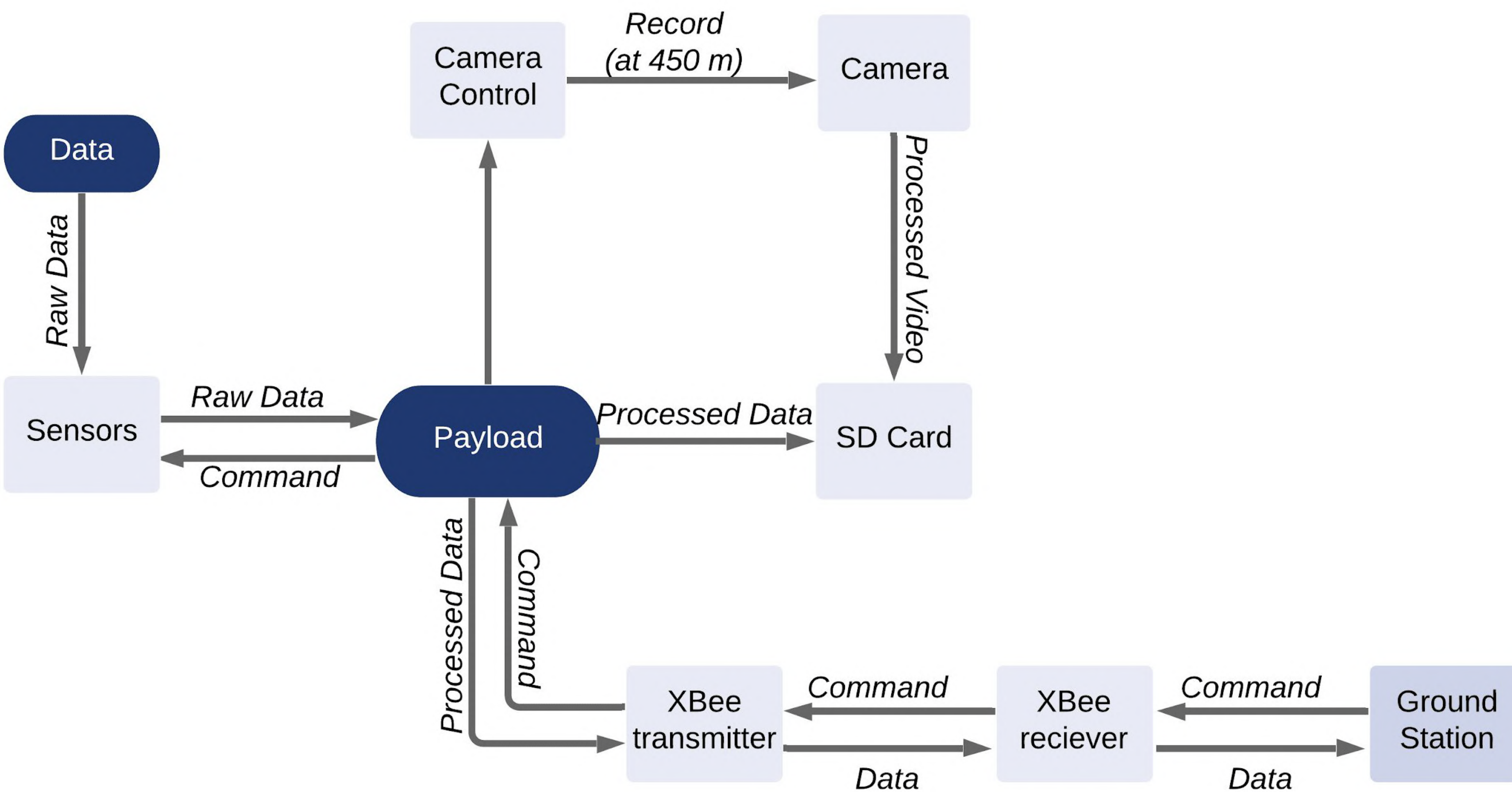
Arduino IDE

Brief Summary of the FSW tasks

- To **collect data** and **release** the payload at **450 meters**.
- To **control camera** and **record video** of **descent** of payload.
- To **send data** from transmitter **XBEE** to receiver **XBEE** at a frequency of **1 Hz in real time**.
- To **save data and video** in a **SD Card**.
- To **recover** from a **sudden power loss** and **continue** from the **last reset point**.

FSW Overview (2/2)

FSW Architecture



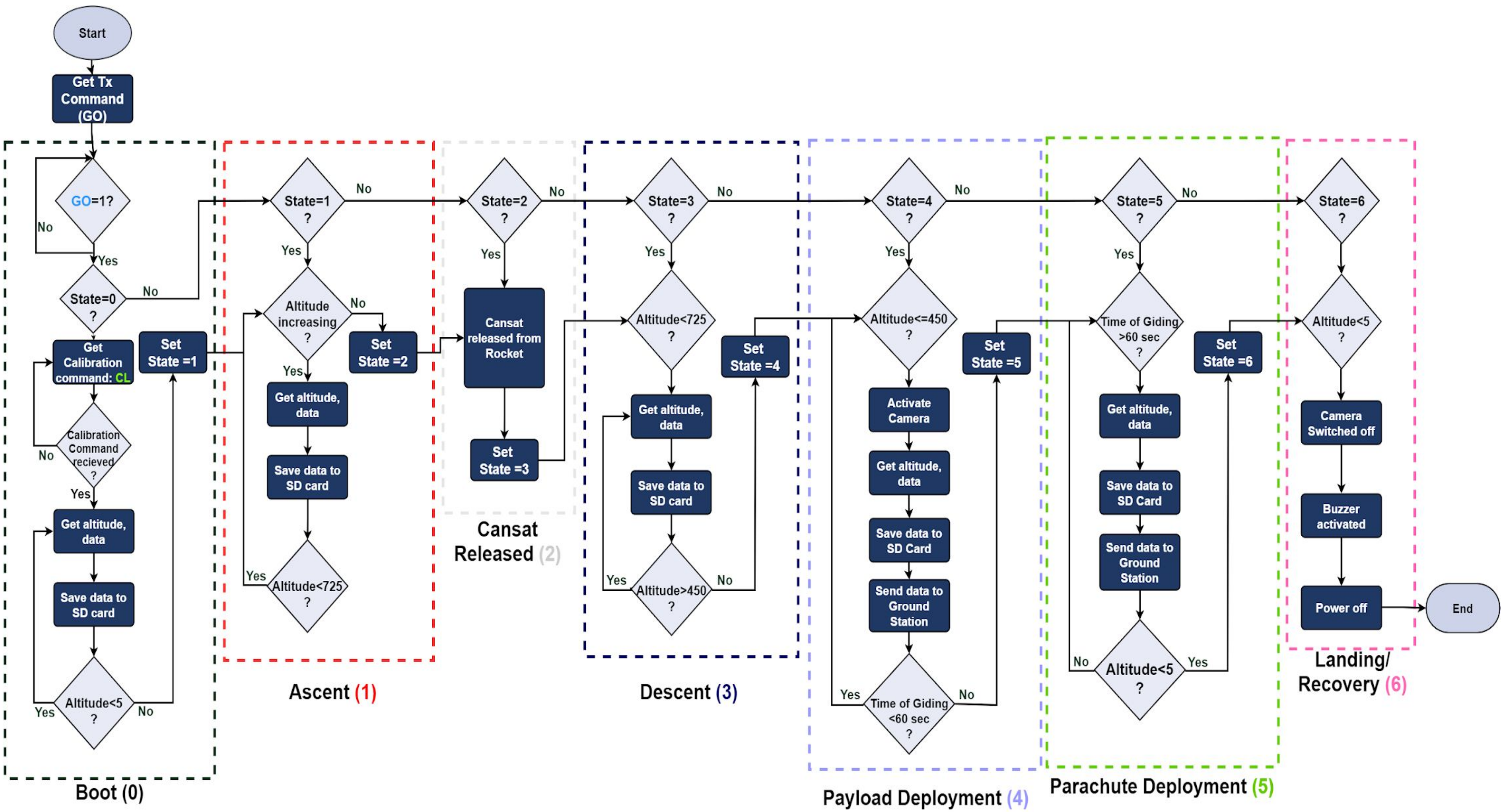
FSW Requirements (1/2)

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
FSWR-1	The payload shall sample all the sensor data at a rate of 1Hz.	CReq	BR-29	The data is sent at 1Hz	Very High		✓	✓	✓
FSWR-2	All the sensor data shall be transmitted through telemetry via XBEE radios.	CReq	BR-32	The sensor data is transmitted via XBEE radios	Very High	✓	✓	✓	
FSWR-3	The flight software maintains a count of the number of packets transmitted, it increments its value after sending each packet. The packet count value is maintained even if the processor resets.	CReq	BR-47	The count of packets is maintained by the software	Very High	✓	✓	✓	✓
FSWR-4	The microcontroller is programmed using Arduino IDE to acquire all the sensor data and transmit it through telemetry.	CReq	-	The microcontroller has been programmed	Very High			✓	✓

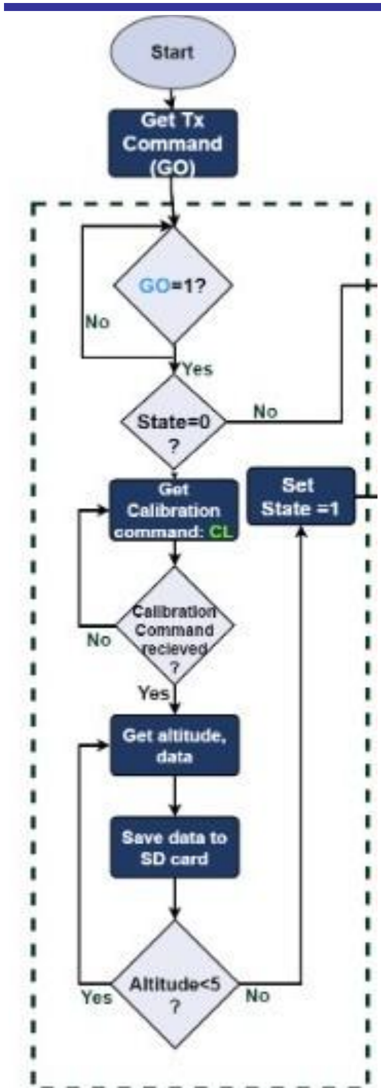
FSW Requirements (2/2)

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
FSWR-6	All the sensors shall calibrate or reset when the payload sits on the Launchpad.	CReq	BR-31	The sensors will calibrate in the given situation	High	✓	✓	✓	
FSWR-7	SD card is also used to store all the telemetry data during flight and descent.	In order to store a copy of the .csv file generated by the sensors	-	SD card is used to store the telemetry data	High		✓	✓	
FSWR-8	The flight software shall open the container when altitude is 450m, and the software state will change.	In order to activate the Servo at the given altitude	-	The container will be opened at the given altitude	Very High	✓			
FSWR-9	Once the payload lands, all the telemetry shall stop with the activation of audio beacon.	CReq	-	The telemetry shall stop and the audio beacon will activate at landing	Very High		✓	✓	

Payload FSW State Diagram (1/6)



Payload FSW State Diagram (2/6)



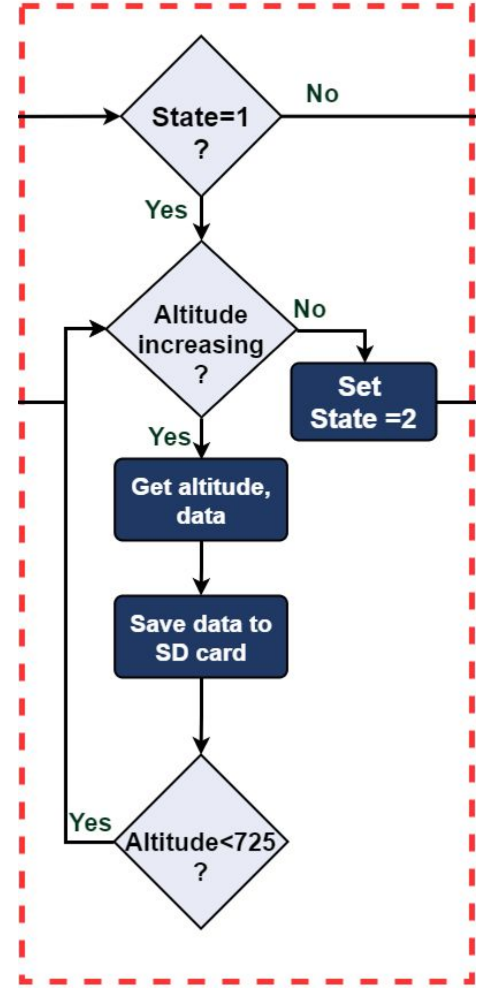
Boot (0)

Boot (0)

- This State is represented by **BLACK colour**.
- The rocket is on launchpad.
- State counter is set to 0.
- Software implements a listener function for start command **GO.**
- Further check for calibration command **CL** is made.
- When the altitude becomes greater than 5m, to software moves to State 1.

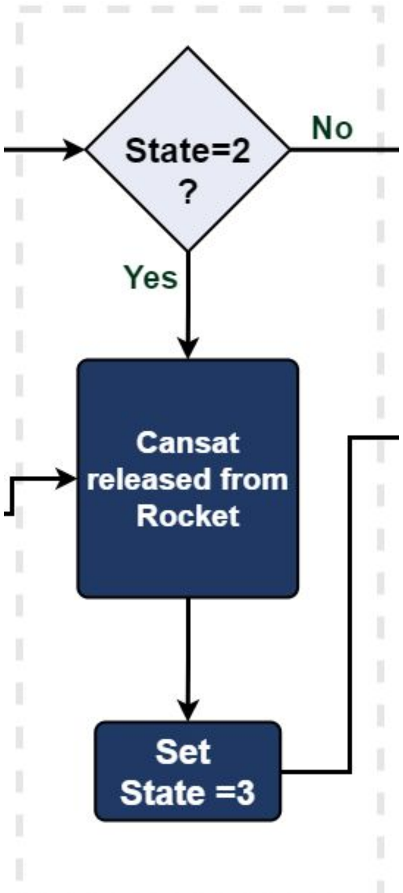
Ascent (1)

- This State is represented by **RED colour**.
- The rocket is ascending till 725m and the data is being collected from the sensors.
- The data is saved in a SD Card.
- When altitude starts decreasing, State counter becomes 2.



Ascent (1)

Payload FSW State Diagram (3/6)



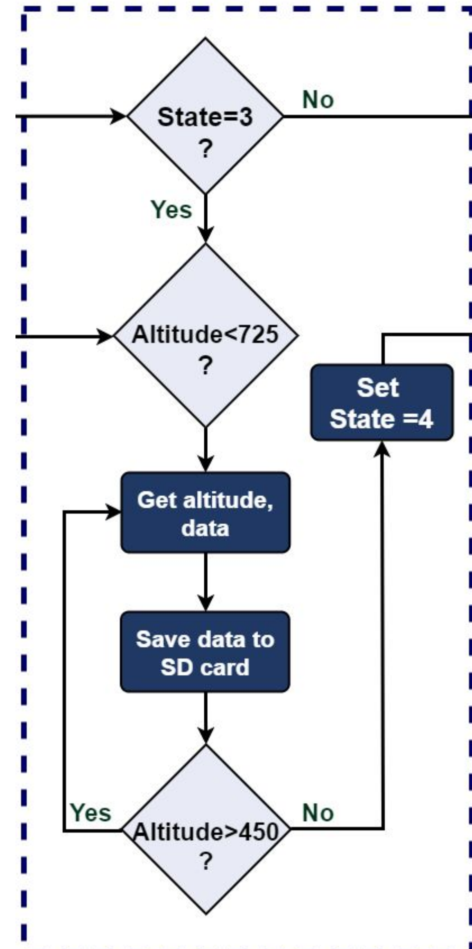
Cansat Released (2)

CanSat Release (2)

- This State is represented by Light Grayish Red colour.
- The CanSat is released from the Rocket.
- The state counter increases to 3

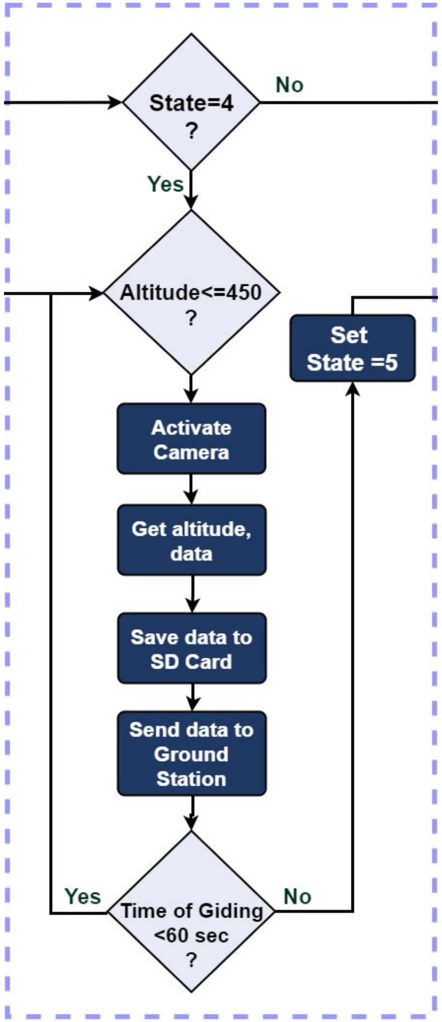
Descent (3)

- This State is represented by **DARK BLUE colour**.
- The data collected from the sensors is stored in SD Card.
- When altitude is equal to 450m, the State counter is increased to 4.



Descent (3)

Payload FSW State Diagram (4/6)



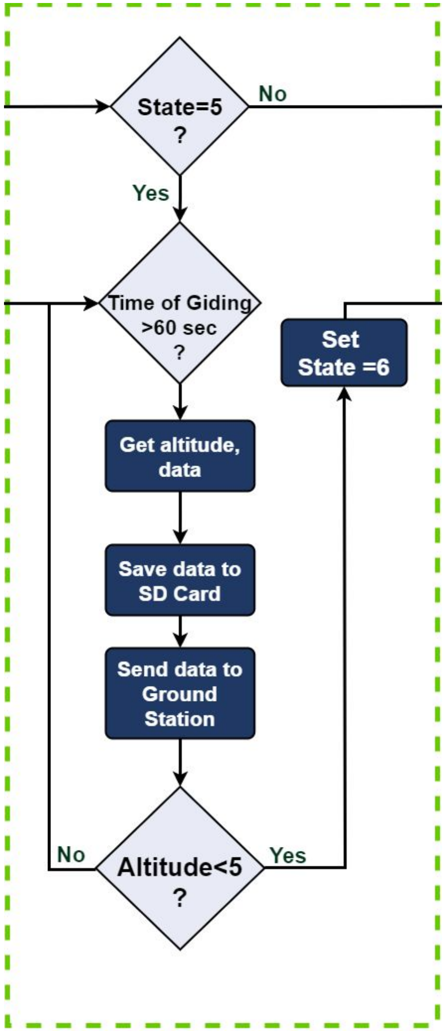
Payload Deployment (4)

Payload Deployment (4)

- This State is represented by **LIGHT BLUE colour**.
- The payload is deployed, camera starts recording and payload starts gliding.
- The data is collected from sensors and is saved in SD Card.
- The data is sent to Ground Station at 1Hz frequency.
- When the time of gliding becomes greater than 60 sec, State changes to 5.

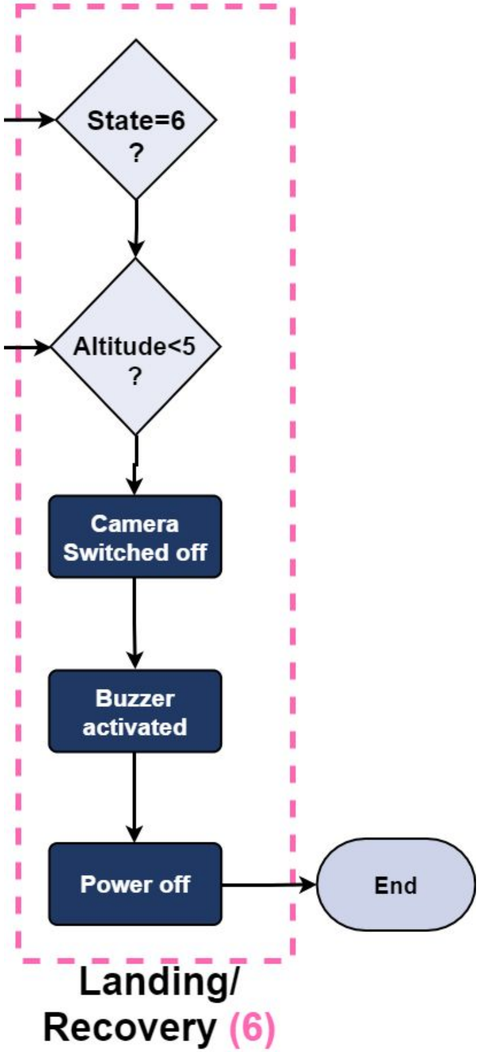
Parachute Deployment (5)

- This State is represented by **GREEN colour**.
- The parachute is deployed.
- The data collected from the sensors is stored in SD Card.
- The recorded video is stored in SD Card.
- All the data is sent to Ground Control at 1Hz.
- When the time of gliding becomes greater than 60 sec, the State counter increases to 6.



Parachute Deployment (5)

Payload FSW State Diagram (5/6)



Landing (6)

- This State is represented by **MAGENTA colour**.
- Buzzer is switched on.
- Power is turned OFF.

FSW recovery method

Altitude and **State counter** are used to **recover data** in **case of failure**. **During failure**, the program **resumes** from the **previous state**.

Causes of Failure

- **Failure** due to **high temperatures** affecting the microprocessor.
- **Failure** due to **temporary power loss**.

Payload FSW State Diagram (6/6)

Sensor Sampling

Sensor sampling takes place throughout **flight duration** at **1 Hz sampling frequency**.

Communications

RF based Payload and GCS **communication**. **Half duplex calibration** command from GCS to payload **using FXP830** patch antenna (payload), and **TL-ANT2424B** parabolic antenna(GCS).

Data Storage

SD card used to **store recorded camera feed** post camera initialization.

Mechanism Activation

Payload **release** from the container at **450 m** resulting in **wing deployment** of the glider (**not controlled by the software system**).

Major Logic Decision Points

Backup of FSW States throughout the flight.

Power Management

Teensy 3.2 is always kept on **standby mode**. It routinely **switches unused sensors** to **standby mode** in order to **conserve power.**

Container FSW State Diagram

No Container FSW State Diagram

- The electronics in the container consists of a **Servo motor**, **Lithium ion battery**, **Boost convertor** and a **Buzzer** connected through a **latch**.

- The **buzzer** gets **activated** when the container **splits up** from the payload (i.e. when **servo motor** gets the **PWM signal** from the **Payload**), the PWM signal **triggers the Latch** which further **turns the buzzer on.**

Software Development Plan (1/4)

Prototyping and Prototyping Environment

- **Parallel** operation of **prototyping, testing, equipment acquisition** and **coding**.
- **2 week** appropriate **deadline placement** and report **generation schemes**.
- **Correction measures** for off-schedule work.
- **2 week** scheduled **buffer** before **event start**.
- **Troubleshooting period** used for **left task completion**.
- **Close compliance** to on-board equipment testing **environment guidelines**.

Plan Against Risk of Late Software Development

- **Early procurement** and **use of required tools**.
- **Developmental modularity**, easing **integration process**.
- **Troubleshooting** period **avoids** late software development risks.

Test Methodology

- The test methodology followed is **Functional Testing**.
- The sequence of the various types of testing:
  - ***Unit Testing***: Each module is tested independently.
  - ***Integration Testing***: The unit tested modules are integrated and tested.
  - ***System Testing***: The entire system is tested for bugs and errors.
  - ***Functional Testing***: Full system check for seamless requirements fulfillment.

Software Development Plan (2/4)

Software Subsystem Development Sequence

ID	Task List	Situation	Deadline
SDP-1	Creation of basic idea of operations to be performed.	Completed	September Mid
SDP-2	Selection of Sensors.	Completed	September End
SDP-3	Individual Sensor Test.	Completed	October End
SDP-4	Code Development.	Completed	November Mid
SDP-5	Sensor Integration.	Completed	December End
SDP-6	Serial Communication Test with Ground Station and Storing Data Packets in SD Card.	Completed	December End
SDP-7	Calibration Command for all the Sensors are set.	Completed	January Mid

Software Development Plan (3/4)

Software Subsystem Development Sequence

ID	Task List	Situation	Deadline
SDP-8	Software Compatibility Test.	Completed	January Mid
SDP-9	PCB designed and Ordered.	Completed	January End
SDP-10	PCB Compatibility Test.	Completed	January End
SDP-11	Wireless Communication Test with Ground Station.	In Progress	February Mid
SDP-12	Video Audio Streaming and Storage of Video with SD Card.	Not Completed	March End
SDP-13	Editing and devising for even better logical code and capabilities.	Not Completed	April End

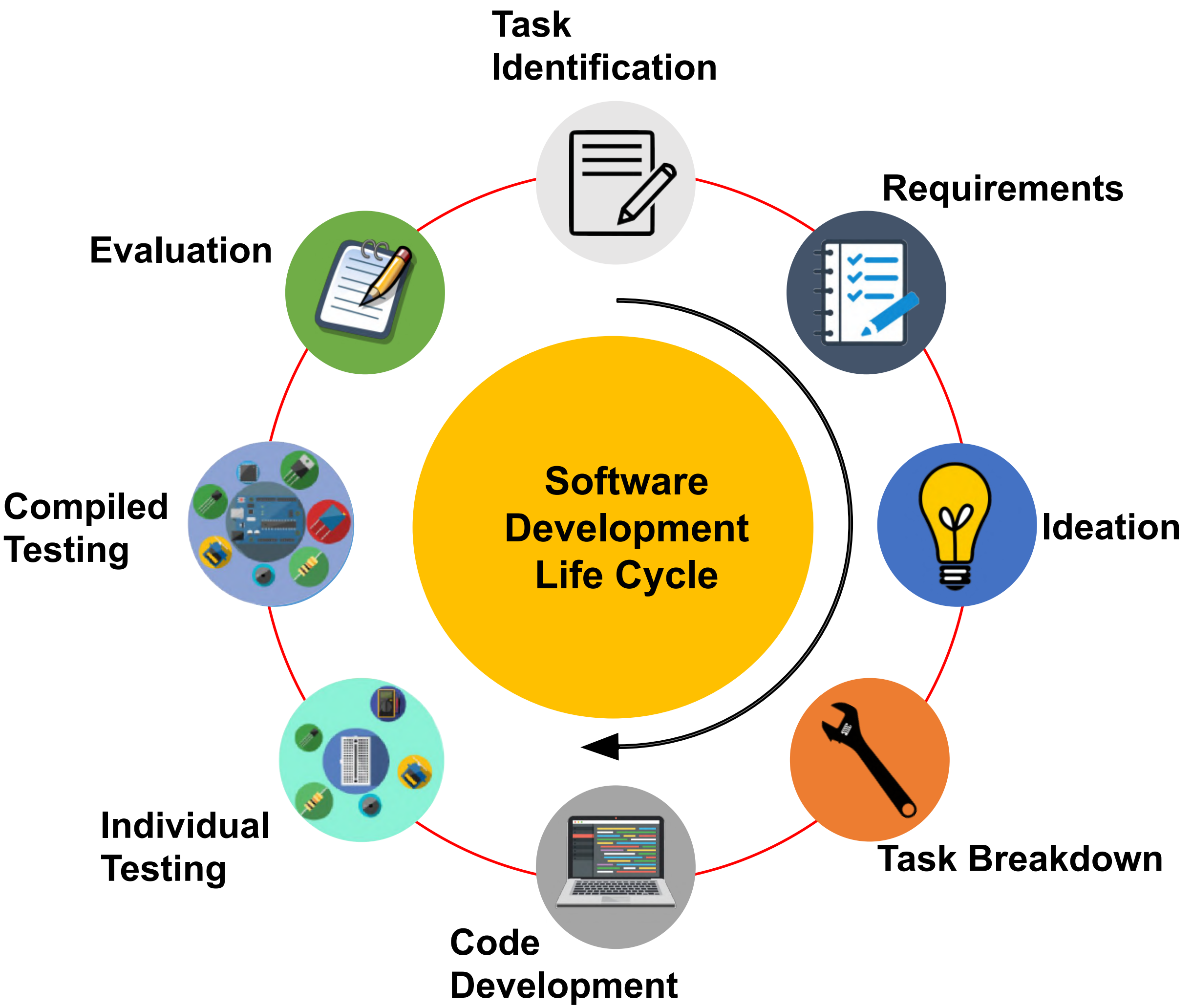
Software Development Plan (4/4)

Software Development Team

- Keshav Gupta
- Vivaswat Sinha

Software Subsystem Development Sequence

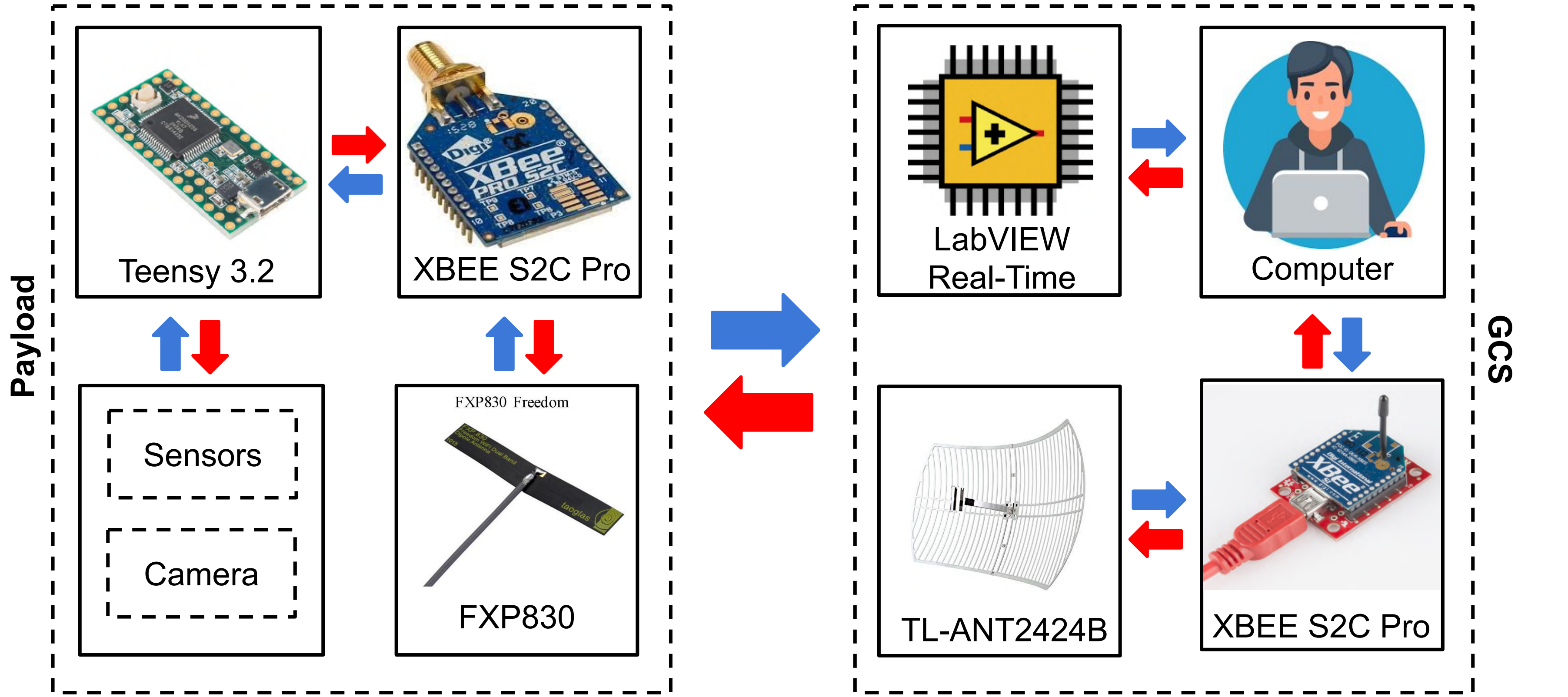
- **Waterfall Software Development Life Cycle Model** with a well-defined **Risk Management System.**
- Defining **FSW Functions**, **states, interactions and requirements**.
- **Proper interfacing** of sensors with processor and **unit testing.**
- **Integrated Sensor subsystem module** will be made.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



Ground Control System (GCS) Design

Vaibhav Sharma

GCS Overview



Data Transmission From Payload To Ground Station
XBEE S2C Pro in payload **transfers data** with antenna from **Teensy 3.2** to the **XBEE S2C Pro** in the **ground station**.

Data Transmission From Ground Station To Payload
XBEE S2C Pro, **explorer module** and **antenna** are used to **transmit** calibrated command to **ground station**. **GCS** will send **calibration signal** and the **telemetry** will **start** after the **signal is received** by the **payload**.

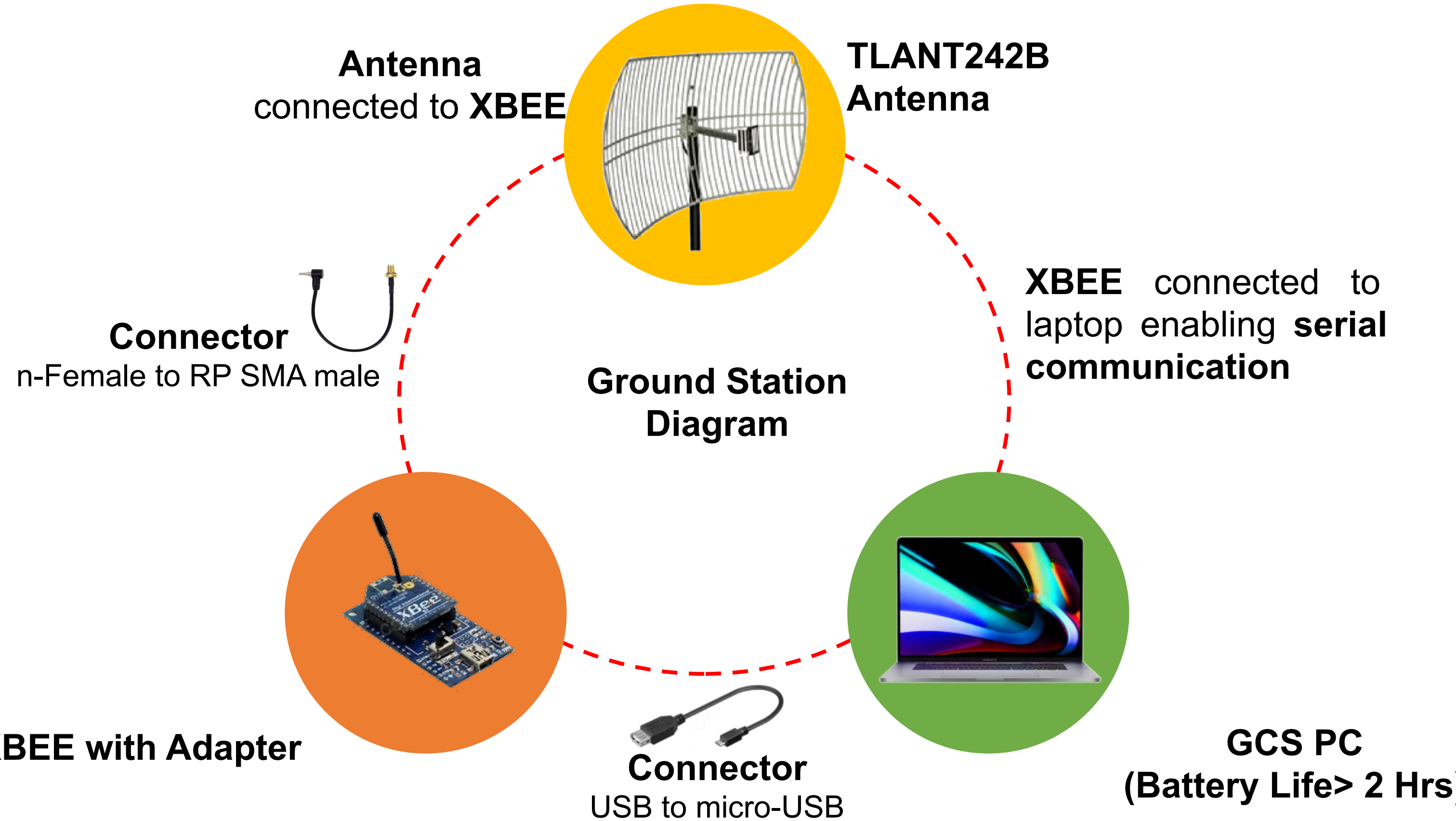
GCS Requirements (1/2)

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
GCSR-1	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.	CReq	BR - 31	Command for transmission of telemetry will be given	Very High	✓	✓	✓	
GCSR-2	The ground station shall generate a CSV file of all sensor data as specified in the telemetry section.	CReq	BR - 32	The CSV file will be generated as specified	Very High	✓	✓	✓	
GCSR-3	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.	CReq	BR - 33	Mission time shall be maintained in the vent of a reset	Very High	✓		✓	
GCSR-4	Configuration states such as if commanded to transmit telemetry shall be maintained in the event of a processor reset during launch and mission.	CReq	BR - 34	Configuration states shall be maintained in case of reset	Very High	✓	✓	✓	
GCSR-5	Each team shall develop their own ground station	CReq	BR - 39	The ground station has been developed	Very High	✓	✓	✓	✓

GCS Requirements (2/2)

ID	Requirement	Rationale	DP	Fulfilment	Priority	VM			
						A	I	T	D
GCSR-6	All telemetry shall be displayed in real time during descent.	CReq	BR - 40	Telemetry will be displayed in real time	Very High	✓	✓	✓	
GCSR-7	All telemetry shall be displayed in engineering units (metre, metre/sec, Celsius, etc).	CReq	BR - 41	Telemetry will be displayed in engineering units	Very High	✓		✓	✓
GCSR-8	Teams shall plot each telemetry data field in real time during flight.	CReq	BR - 42	Telemetry data shall be plotted in real time	Very High	✓	✓	✓	✓
GCSR-9	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	CReq	BR - 44	The components will be included	Very High	✓		✓	
GCSR-10	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.	CReq	BR - 45	The ground station is portable	Very High	✓	✓		

GCS Design (1/2)



- The **GCS laptop** has a battery life of **10 hours**.
- The **laptop** is **supported** with an **external cooling fan** equipped with **battery** to **avoid overheating**.
- **Direct exposure** to sunlight is **avoided** by an **umbrella**.
- **Auto update function** is disabled to from **windows update center** on windows OS **before the launch.**

GCS Design (2/2)

Connector Name	Frequency (GHz)	Application
RP SMA	<17	WiFi, Commercial Grade Wireless General High Frequency RF
N - Female	<11	Antennas, Base Stations, Instrumentation, Satellite systems, WLAN, Radar systems, Broadcast, Surge protection

RP SMA to n-Female connector

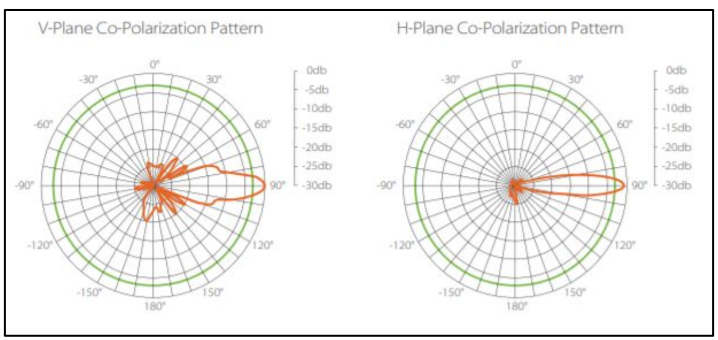
USED CONFIGURATION: RP SMA to N- Female Connector

- Ground Station Antenna is connected to GS XBEE Module (Co-ordinator Mode) using n - Female connector to RP SMA coaxial cable.
- The connector is used for connecting RP SMA with n - Female technologies.

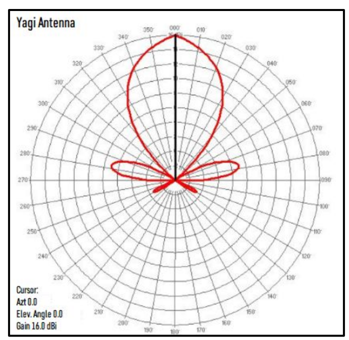
GCS Antenna Trade & Selection (1/2)

Antenna	Type	Gain (dBi)	Polarisation	VSWR	H/V Bandwidth	Cost ($)
TL-ANT2424B	**Parabolic Grid Directional**	**24**	**Linear, Vertical**	**< 1.5 : 1**	**10°/14°**	**50.39**
Yagi Antenna	Directional	16	Vertical, Horizontal	< 1.5	40°/36°	51.91
TL-ANT2415D	Omni-Directional	15	Vertical	< 2.0:1	360°/9°	55.40

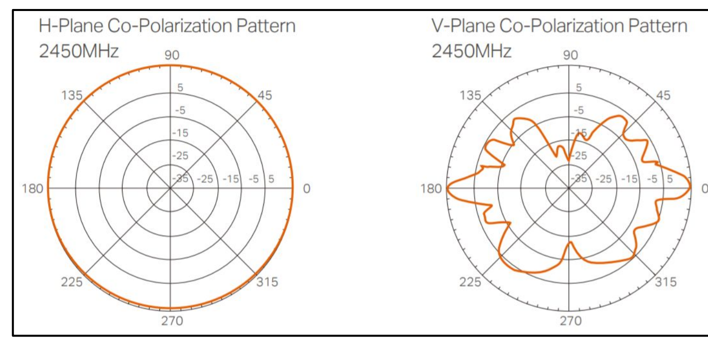
Radiation Pattern Comparison



TL-ANT2424B

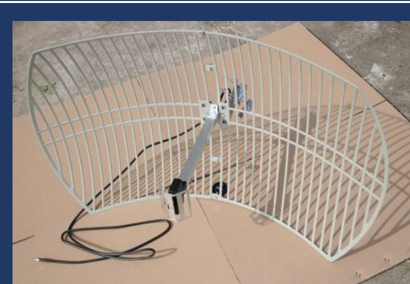


2.4 GHz Yagi



TL-ANT2415D

GCS Antenna Trade & Selection (2/2)

Mounting Type	Tabletop	Handheld
Representation		
Features	Low Portability	High portability
	Provides antenna stability	Provides aim flexibility

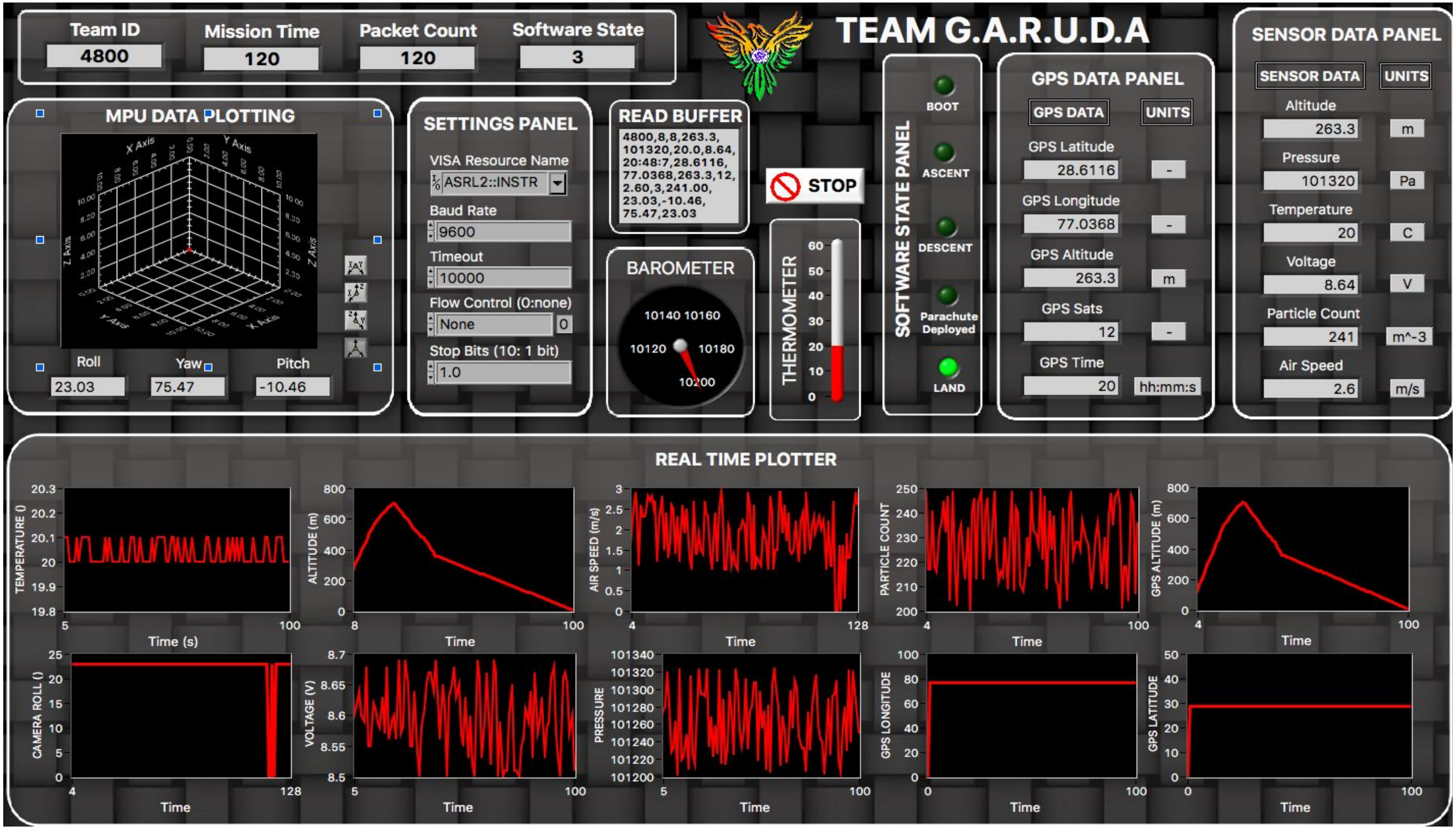
ANTENNA TL-ANT2424B

SELECTED: TP-LINK GRID PARABOLIC (HANDHELD)

Rationale (Antenna):
- 24 dBi gain provides high directionality and range
- Weatherproof design provides design ruggedness.
- Ideal storage and operating temperatures.

Rationale (Mount):
- Provides higher aim flexibility in case of a rapidly moving target
- Removes bulk and cost of an additional component

Real-time Plotting Software Design and Demonstration



Our GCS Testing: https://youtu.be/73C1BXET9IU

GCS Software (2/2)

Payload Transmission Format

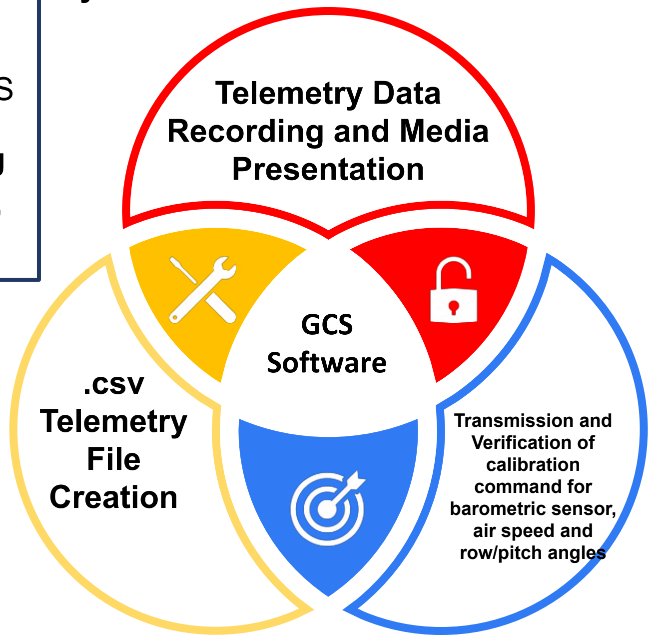
<TEAM ID>,<MISSION TIME>,<PACKET COUNT>,<ALTITUDE>, <PRESSURE>, <TEMP>,<VOLTAGE>,<GPS TIME>,<GPS LATITUDE>,<GPS LONGITUDE>,<GPS ALTITUDE>,<GPS SATS>,<AIR SPEED>,<SOFTWARE STATE>, <PARTICLE COUNT>, ***<IMU ROLL>, *<IMU PITCH>, *<IMU YAW>, *<CAMERA PAN ANGLE>**

.csv Telemetry File Creation

The **path** to an empty .csv file of the name **'Flight_4800.csv'** is given to the **Python program**. First the **header row** is set using a simple command from the **.csv package on Python.**

Telemetry Data Recording and Media Presentation

Telemetry data is **written** on **Flight_4800.csv** file in real time using **Python CSV module.**



Commercial off the shelf (COTS) Software used

- XCTU (XBEE program Software)
- LabVIEW

Transmission and Verification of calibration command for barometric sensor, air speed and row/pitch angles

The **ground station** will have many commands to **call different functions** in the **payload**.
To **calibrate BMP180, MS4525DO and MPU**, a **command codeword** will be typed and **sent** from **X - CTU** software **through XBEE**

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
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
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
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

Telemetry display prototype

CanSat Integration and Test

Keshav Gupta

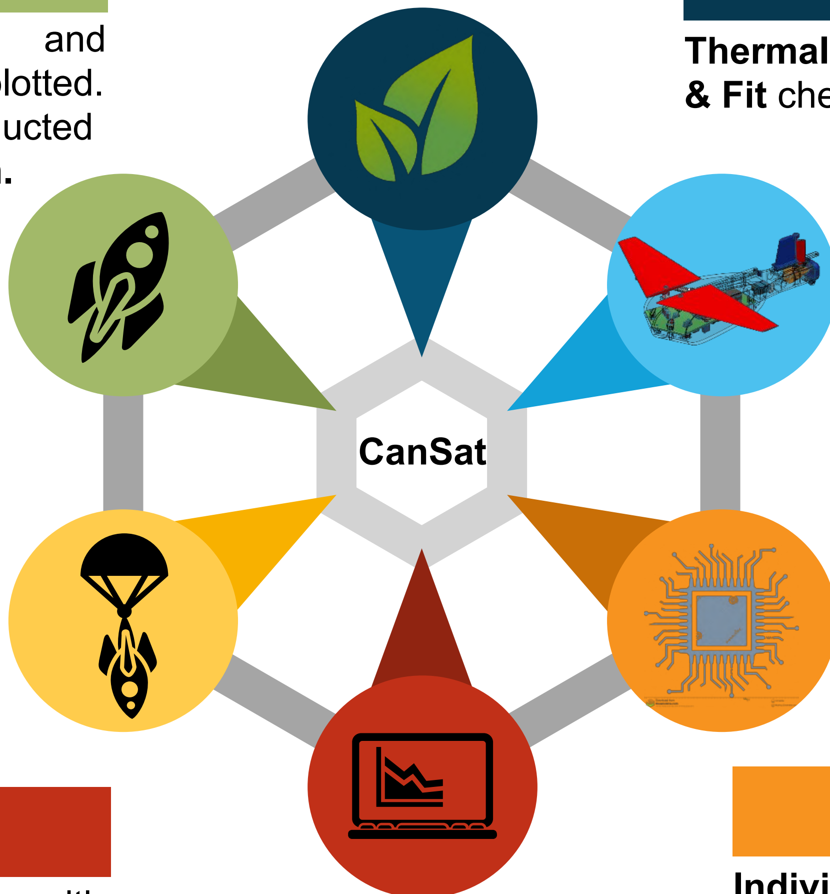
CanSat Integration and Test Overview

Mechanical

Shock simulations and **stress-strain curve** plotted. **Strength test** conducted during drop from **200m.**

Environmental

Thermal, Vibration, Drop & Fit check performed.



Descent

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

Payload

Payload deployment mechanism checked.

Software

Real time plotting with **dummy data** checked.

Electronics

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

Subsystem Level Testing Plan (1/2)

Sensor Subsystem

- **Sensors** are **tested** and **calibrated** as per requirement.

Radio Communication

Range

- The **range** of radio communication is **tested** by **sending and receiving signals** across various ranges.
- It is **verified** that the **range is enough** for **communication of CanSat and GCS**.

Quality

- **Accuracy** of the communication **between the 2 XBEE Pro S2C** modules is checked by **testing** them under **different environmental conditions**.

EPS Subsystem

- **Electrical voltage** across all components is **measured** using **multimeter** and it is made sure **proper voltage differences** are present **across each component**.
- **Current** across each component is also **measured** and it is made sure that the **current does not exceed the max limit labelled on the device**.

CDH Subsystem

- **Teensy microprocessor:** It is checked that **Teensy 3.2** microprocessor is **properly communicating** with the **sensors** and **XBEE module**.
- **XBEE PRO S2C: Radio communication** between **transmitter** and **receiver** is checked.
- **SD Card: Data storage capability** is checked in **accordance with the mission guideline**.
- **Antenna:** The **signal gain and range** should **meet the mission requirements.**

Descent Control

- It would be checked that **descent is stable with the parachute.**
- The **helical path** that should be followed by the science payload will be **verified using drone assisted glide tests.**

Flight Software

Algorithm Test

- **Working of code** at **each Stage** of flight, from boot to landing , has been **checked.**
- **Proper recording** and **storage of video** is ensured.

State Recovery

- It will be made sure that **in case of sudden shut down** of the CanSat the **recovery algorithm works as predicted** in any state of FSW.

Mechanical Subsystem

Weight

- It is made sure the the **weight of the CanSat** i.e. payload + container are **within the given range of 600 ± 10 grams**.

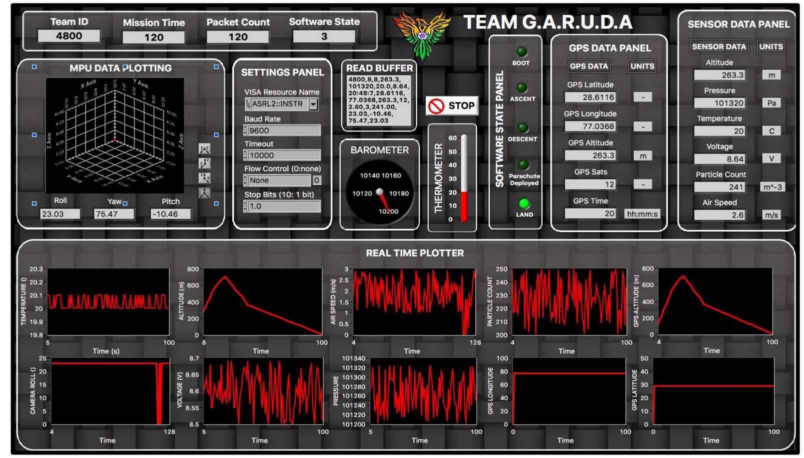
Servo Motor

- **Servo motor** is **tested multiple times** and it is made sure that it is **able to release** the payload from container without fail.

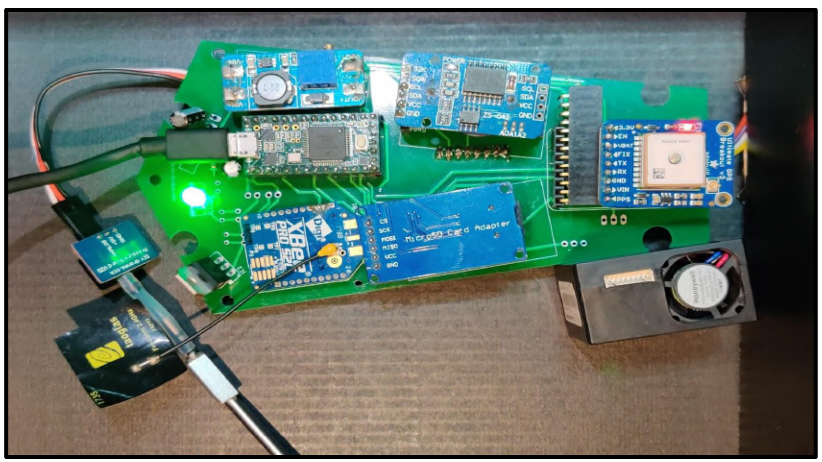
Subsystem Level Testing Plan (2/2)

Radio Communication

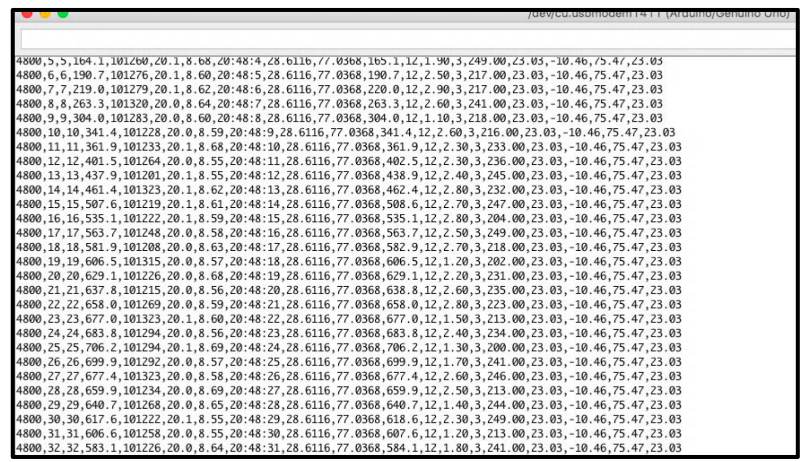
Flight Software



Sensor Subsystem



CDH Subsystem



Our Sensor Testing and CDH Demonstration: https://youtu.be/lld6W9Cw1-o

Integrated Level Functional Test Plan (1/2)

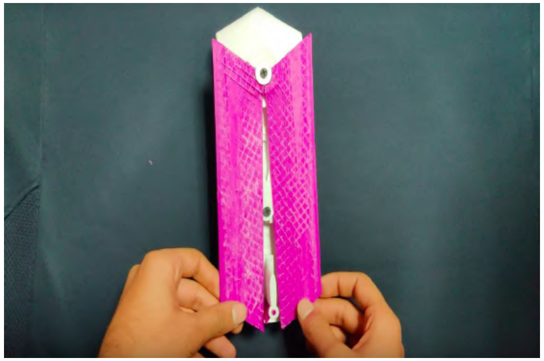
Descent Testing

- The model **CanSat body** will be **dropped with the sensors**, and **parachute attached**. The **telemetry** will be **tested** on the **ground station** and **plotted**. The **descent rates** will also be **measured**.
- In our **final testing**, the entire **CanSat system** along with the electronics will be **tested using a drone** from a height of around **700 m**.
- Using the above test we will be able to **test** our **telemetry**, **sensors**, **descent rate** and **deployment of glider** very well.

Deployment

- Initially **payload release and deployment** will be **tested** using a **quadcopter**. Payload 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 descent test** from 700 m will be performed. Since the **altitude of deployment** will be **similar** to the **altitude during the actual launch**, we will be able to **test our payload release** and **deployment very well.**

Our Payload Deployment Testing: https://youtu.be/e4_xvc8lOVI



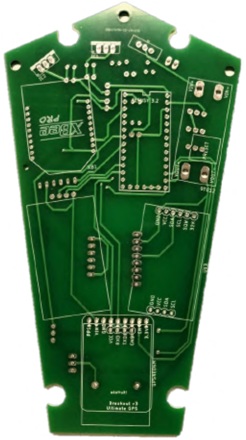
Integrated Level Functional Test Plan (2/2)

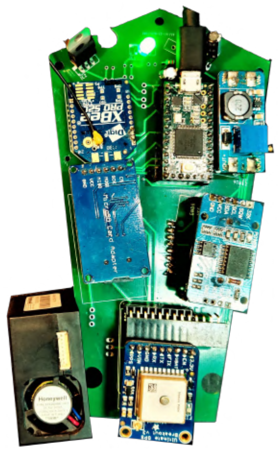
Mechanism Testing

- To **test** the **deployment mechanism** as well as the **wings opening mechanism** of the glider, 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**.

Sensor Testing

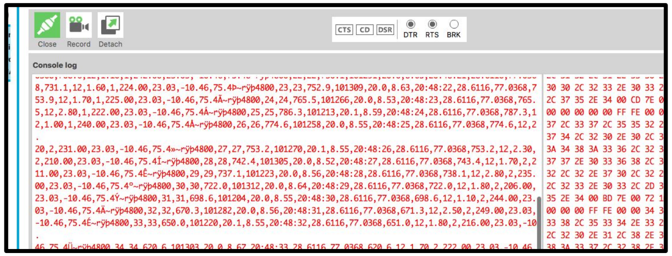
- All the **sensors** were **individually tested** first and **integrated into the PCB**.
- All **calibration** was done **prior to integration** and the values were **plotted over arduino serial monitor and GUI**.





Communications Testing

- 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 **plotted and checked** with the **known data values**.
- In our **final test**, since we conducted the launch at an **altitude** similar to the **actual launch,** both our antennas at the ground station and inside the CanSat were **tested completely.**



Environmental Test Plan

Fit Check

- CanSat container size is manufactured **with respect to probe size**.
- Fit check is performed. CanSat **easily deploys from rocket**.
- Container **passes smoothly**. The test is considered as successfully done.

Vibration Test

- This test is designed to **verify the mounting integrity** of all components, mounting connections, structural integrity, and battery connections.
- This test takes advantage of the **power up and power down phases of the sander**.
- This test requires the sander to be **cycled regularly over a one minute duration** exposing the CanSat to vibrations from 0 Hz to 233 Hz.

Drop Test

- This test is designed to verify that the container parachute and attachment point **survives the deployment** from the rocket payload section which can be very violent.
- The **release mechanism is tested**. It can hold the science vehicle in the container.
- Component mounts and battery mount are tested. The drop test generates about **30 Gs of shock** to the system.

Thermal Test

- This test is to verify the CanSat and container can **operate in a hot environment**.
- This test determines if **any materials warp, weaken, change characteristics, or fail to function** at temperatures up to 35° C.
- This test requires a method to **heat** the CanSat to 60° C for a **period of 2 hours**. This allows the components to rise to heat, and verify that they continue to function.

Mission Operations & Analysis

Abhinav Goel

Overview Of Mission Sequence Of Events (1/3)

1 Arrival

- Specific roles are assigned to each one of the team member.
- 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 verified.
- Weight check of CanSat is done.

2 Pre Launch Checklist

- Parachute deployment mechanism is checked.
- All PCB connections are verified.
- Working of sensors and camera trigger is verified.
- CanSat landing zone is estimated.
- Camera stabilization system is verified.
- CanSat is inspected for physical damage.
- Glider's deployment and release mechanism are checked.

3 Preparing CanSat

- Parachute is folded and placed into its designated compartment.
- The CanSat electronics are switched ON.
- Communications are verified.
- The CanSat assembly is placed into the payload section of the rocket.

Overview Of Mission Sequence Of Events (2/3)

4 Launch

- Rocket takes off from the launchpad.
- Telemetry is being received for the ascent by the GCS.
- CanSat separation from rocket at 700m.
- CanSat is released and parachute is deployed immediately.
- Telemetry transmission for descent starts.
- Payload is released at 450 meters and glider wings are deployed and the camera stabilisation system activates and the camera is turned on.
- Audio beacon activates at landing.

5 CanSat Recovery

- Recovery crew starts the hunt for the CanSat and accompanies the field judge during the score.
- Received telemetry helps in locating the CanSat using GPS values.
- Container and payload are painted fluorescent orange for high visibility.
- Audio beacon pinpoints the location of container and payload.
- Container and payload are recovered and examined for possible damages that may occur on impact.

6 Data Analysis and PFR preparation

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

Overview Of Mission Sequence Of Events (3/3)

Roles & Responsibilities

Name	Role/Responsibility
Nitish Sehgal	Mission Control Officer
Abhinav Gupta	CanSat Crew
Aryan Mishra	CanSat Crew
Abhinav Goel	CanSat Crew
Amey Khairnar	Ground Station Crew
Piyush Sharma	Ground Station Crew
Vivaswat Sinha	Ground Station Crew
Himanshu Singhal	Recovery Crew
Vaibhav Sharma	Recovery Crew
Keshav Gupta	Recovery Crew

Mission Operations Manual Development Plan

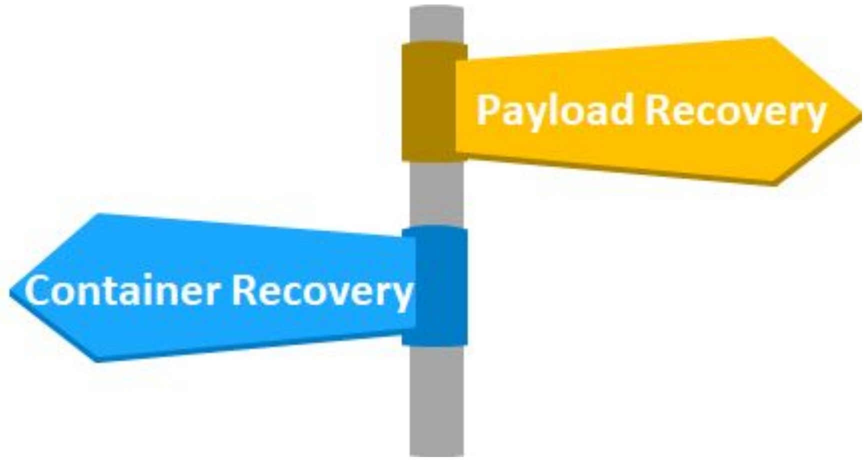
- It will consist of **checklists and pointers** that will **help** the team members **throughout the competition**.
- This ensures that **every member** understands his work properly and **complies with the competition rules**.

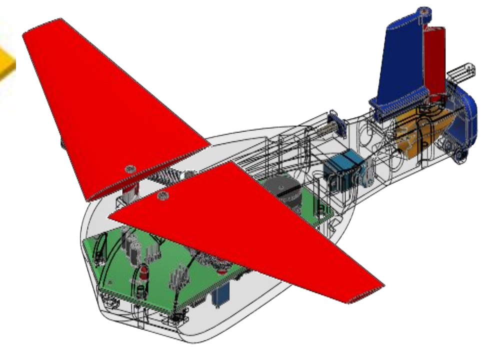
Special Pointers

1. CanSat Integration
2. Testing Operations
3. Pre Launch Operation
4. Launch Operation
5. Descent Control
6. GCS Operations
7. Recovery Operations
8. Data Analysis Operations

- **Mission Operations Manual Development Plan** ends when every operational task finishes. It helps in **improving accuracy**.
- Its complete development will start from April 21, 2019.

CanSat Location And Recovery





The **container** is painted **orange** in colour with **team leader's** name, **team name**, **team ID**, team leader's **email id** written on it.	The **payload** is painted **orange** in colour with the **team leader's name**, **team name**, **team ID**, team leader's **email id** written on it.
The choice of paint is **orange** because it has high wavelength and can be **easily seen** from distance.	It has a **buzzer** which gets **activated after the flight.**
It also has a **buzzer** which gets **activated** just after the **payload releases** from it.	The payload will send its last **GPS coordinates** throughout the flight.
With the help of **buzzer** and **orange** colour of the container the recovery crew can easily find the container in the field.	With the help of the **last GPS coordinates**, **buzzer** and the **colour** of the payload the recovery crew can easily find the payload in the open fields.

Requirements Compliance

Amey Khairnar

Requirements Compliance Overview

- All the requirements mentioned in the guidelines were taken with the highest priority. All departments worked within the guidelines stated.
- Most of the Requirements are complied.
- We have even worked on the bonus objective and hope to fulfill it.
- Various test will be conducted to check the impact severity and hopefully our CanSat will withstand it.
- Overall CanSat shows great results but if there will be any possibility of loopholes ,then improvements and optimizations will be made and will be uploaded to the CDR.
- The following slides trace and demonstrate compliance with all the requirements. Comments have been added where necessary.
- The table filled according to requirements based compliance helps us to see which subsystem needs to be developed.
- The legend gives colour coding if a requirement is met.

No Comply	Partial	Comply

Requirements Compliance (1/5)

ID	Requirement	Comply/No Comply/ Partial	X-Ref/slides Demonstrating Compliance	Comment
1.	Total mass of the CanSat (science payload and container) shall be 600 grams +/- 10 grams.		86	Mass Budget
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.		25	Launch Vehicle Compatibility
3.	No Sharp edges will be designed in the container so that it doesn't get stuck in the rocket payload section which is made up of cardboard.		25	Launch Vehicle Compatibility
4.	Color of container- Fluorescent color maybe pink, red or orange.		155	CanSat Location And Recovery
5.	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.		25	Launch Vehicle Compatibility
6.	The rocket airframe shall not be used as part of the CanSat operations.		25	Launch Vehicle Compatibility
7.	The container parachute shall not be enclosed in the container structure. It shall be external and attached to the container so that it opens immediately when deployed from the rocket.		82	Payload Release Mechanism
8.	The science payload shall be a delta wing glider.		19	Physical Layout
9.	After one minute of gliding, the science payload shall release a parachute to drop the science payload to the ground at 10 meters/second, +/- 5 m/s		59	Descent Rate Estimates (6/7)

Requirements Compliance (2/5)

ID	Requirement	Comply/No Comply/ Partial	X-Ref/slides Demonstrating Compliance	Comment
10.	All descent control device attachment components shall survive 30 Gs of shock.		149	Environmental Test Plan
11.	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.		85	Electronics Structural Integrity
12.	All structures shall be built to survive 15 Gs of launch acceleration.		149	Environmental Test Plan
13.	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.		82	Payload Release Mechanism
14.	The science payload shall measure altitude using an air pressure sensor.		29	Air Pressure Sensor Trade & Selection
15.	The science payload shall provide position using GPS.		31	GPS Sensor Trade & Selection
16.	The science payload shall measure its battery voltage.		32	Power Voltage Sensor Trade & Selection
17.	The science payload shall measure outside temperature.		30	Air Temperature Sensor Trade & Selection
18.	The science payload shall measure particulates in the air as it glides.		34	Particulate Dust Sensor Trade & Selection

Requirements Compliance (3/5)

ID	Requirement	Comply/No Comply/ Partial	X-Ref/slides Demonstrating Compliance	Comment
19.	The science payload shall measure air speed.		33	Air Speed Sensor Trade & Selection
20.	The science payload shall transmit all sensor data in the telemetry.		101	Payload Telemetry Format (2/2)
21.	Telemetry shall be updated once per second.		101	Payload Telemetry Format (2/2)
22.	The ground system shall command the science vehicle to start transmitting telemetry prior to launch.		142	GCS Software (2/2)
23.	The ground station shall generate a csv file of all sensor data as specified in the telemetry section.		142	GCS Software (2/2)
24.	XBEE radios shall be used for telemetry. 2.4 GHz Series radios are allowed. 900 MHz XBEE Pro radios are also allowed.		98	Payload Radio Config (1/2)
25.	XBEE radios shall have their NETID/PANID set to their team number.		99	Payload Radio Config (2/2)
26.	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.		164,165,166	CanSat Budget-Hardware
27.	Each team shall develop their own ground station.		134	GCS Overview

Requirements Compliance (4/5)

ID	Requirement	Comply/No Comply/ Partial	X-Ref/slides Demonstrating Compliance	Comment
28.	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)		100	Payload Telemetry Format (1/2)
29.	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.		137	GCS Design (1/2)
30.	No lasers allowed.		109	Payload Electrical Block Diagram
31.	The probe must include an easily accessible power switch that can be accessed without disassembling the CanSat and in the stowed configuration.		107	EPS Overview
32.	The probe must include a power indicator such as an LED or sound generating device that can be easily seen without disassembling the CanSat and in the stowed state.		109	Payload Electrical Block Diagram
33.	The audio beacon must have a minimum sound pressure level of 92 dB, unobstructed.		88	Payload CDH Overview
34.	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.		110	Payload Power Trade & Selection
35.	Spring contacts shall not be used for making electrical connections to batteries. Shock forces can cause momentary disconnects.		110	Payload Power Trade & Selection

Requirements Compliance (5/5)

ID	Requirement	Comply/No Comply/ Partial	X-Ref/slides Demonstrating Compliance	Comment
36.	The CanSat must operate during the environmental tests laid out in Section 3.5.		149	Environmental Test Plan
37.	The descent rate of the CanSat (container and science payload) shall be 20 meters/second +/- 5m/s		39	Descent Control Overview(1/3)
38.	The container shall release the payload at 450 meters +/- 10 meters		39	Descent Control Overview(1/3)
39.	Payload/Container shall operate for a minimum of two hours when integrated into rocket.		113	Payload Power Budget(3/3)
40.	The science payload shall glide in a circular pattern with a 250 m radius for one minute and stay above 100 meters after release from the container.		39	Descent Control Overview(1/3)
41.	A video camera shall be integrated into the science payload and point toward the coordinates provided for the duration of the glide time. Video shall be in color with a minimum resolution of 640x480 pixels and 30 frames per second. The video shall be recorded and retrieved when the science payload is retrieved.		35	Bonus Camera Trade & Selection

Management

Nitish Sehgal

CanSat Budget – Hardware (1/4)

Category	Component	Model	Quantity	Unit Cost ($)	Total Cost ($)	Determination
Sensors	**Air Pressure sensor Temperature sensor**	BMP180	2	3.00	6.00	Actual
	GPS	Adafruit Ultimate GPS	1	39.95	39.95	Actual
	PM 2.5 sensor	Honeywell HPMA 115S0	1	55.00	55.00	Actual
	Air speed sensor	MS4525DO	1	54.69	54.69	Actual
	RPY Sensor	MPU6050	1	2.12	2.12	Actual
Clock	**Real time clock**	RTC 853231	1	4.00	4.00	Actual
Storage	**SD Card**	Sandisk 16GB	1	4.00	4.00	Actual
	SD card module	Street 27 SD card module	1	4.50	4.50	Actual
Bonus Task	**Bonus Task Camera**	Pixy - 2	1	59.90	59.90	Actual
	Bonus Task Communication Module	NRF24L01	1	1.39	1.39	Actual
Comm.	**XBEE**	XBEE PRO S2C	1	14.09	14.09	Actual
	Payload Antenna	FXP830	1	7.80	7.80	Actual

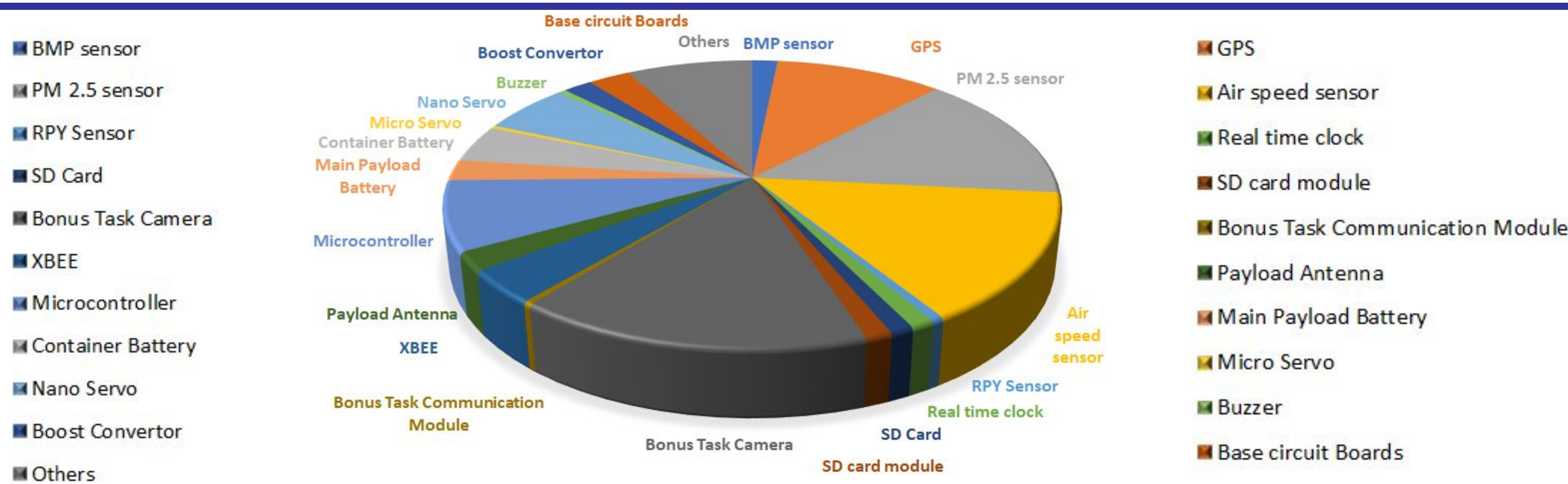
CanSat Budget – Hardware (2/4)

Category	Component	Model	Quantity	Unit Cost ($)	Total Cost ($)	Determination
uC	**Microcontroller**	Teensy 3.2	1	29.50	29.50	Actual
Battery	**Main Payload Battery**	Envie Rechargeable Battery (9V)	1	8.80	8.80	Actual
	Container Battery	Energizer CR2450	3	5.28	15.85	Actual
Servo	**Servo Motor**	Micro servo	1	1.35	1.35	Actual
	Servo Motor	Nano servo	2	10.45	20.90	Actual
Audio	**Buzzer**	-	2	1.00	2.00	Actual
Misc.	**Boost Convertor**	LTC3121	1	6.86	6.86	Actual
	Base circuit Boards	PCB	1	10.00	10.00	Actual
	Others	-	-	-	30.00	Estimate
TOTAL					**$378.7**	

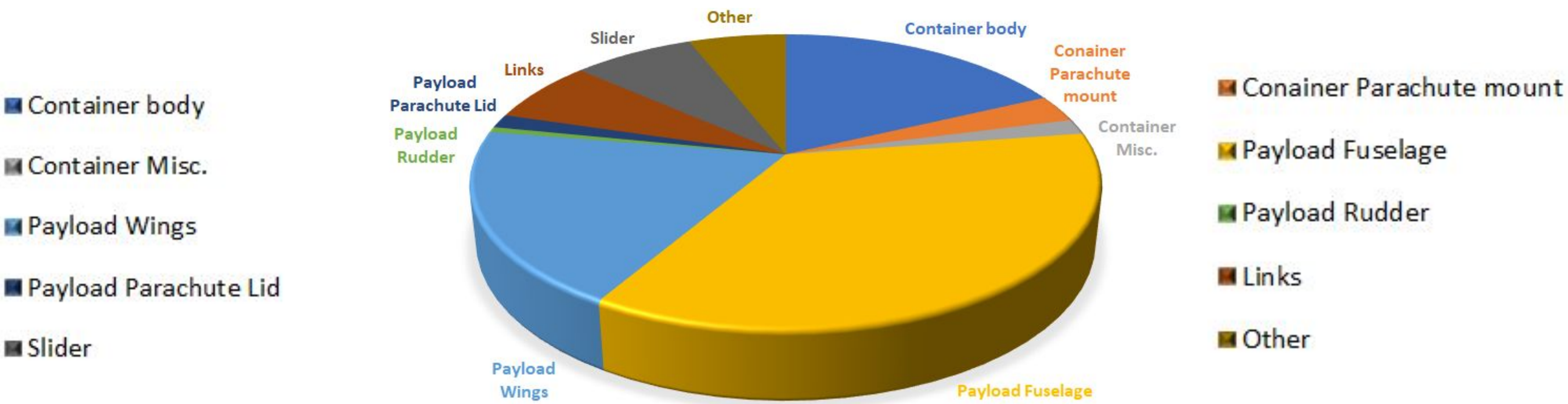
CanSat Budget – Hardware (3/4)

Category	Component	Model	Quantity	Printing Cost ($)	Total Cost ($)	Determination
Container	**Container body**	Polycarbonate	1	60	60.0	Actual
	Parachute mount	Polycarbonate	1	10	10.0	Actual
	Misc.	-	1	5.6	5.6	Actual
Payload	**Fuselage**	PLA 2200	1	120	120.0	Actual
	Wings	PETG	2	32	64.0	Actual
	Rudder	PLA 2200	1	2	2.0	Actual
	Parachute lid	PLA 2200	1	5	5.0	Actual
	Links	Carbon fibre	2	23	23.0	Actual
	Slider	Carbon fibre	1	25	25.0	Actual
Misc.	**Torsional springs, screw, nuts, bolts, thread, blades, adhesives etc.**	N.A	N.A	N.A	20.0	Estimated
TOTAL					**$334.6**	

CanSat Budget – Hardware (4/4)



Electrical Cost Budget



Mechanical Cost Budget

CanSat Budget - Other Costs (1/3)

	Part	Quantity	Total Cost ($)	Considerations
GCS Costs	**Laptop (Macbook Air)**	1	999.00	Actual
	XBEE Pro S2C	1	14.09	Actual
	Antenna TL-ANT2424B	1	57.80	Actual
Other Costs	**Prototyping**		1500.00	Estimated
	Test Facilities and Equipments		100.00	Estimated
	Travel (flight tickets)	10	12000.00	Estimated
	Visa (USA)	10	1600.00	Estimated
	Accomodation	10	1500.00	Estimated
	Food	10	800.00	Estimated
	CanSat Registration fees	1	200.00	Actual
TOTAL			**$18770.89**	

INCOME	
College	$1350
Sponsors	$810
TOTAL	**$2160**

CanSat Budget - Other Costs (2/3)

Total Cost of Mission

DEPARTMENT	COST ($)
Electrical	378.70
Mechanical	334.60
Other Cost	18770.89
TOTAL	19484.19

CanSat Budget - Other Costs (3/3)

SPONSORSHIP SPEEDS

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

SUBSONIC (Rs 10k+)

- Your **logo/name** will be printed on our team apparels.
- You will receive a **personalized Thank You mail**.
- Your support will be **acknowledged and thanked** through a special name in all our NASA presentations.

TRANSONIC (Rs 30k+)

- You are entitled to everything in the Subsonic reward title.
- Our exclusive **Team Merchandise** will be sent to you.
- An **e-certificate** will be sent via our mail.
- Your **name** will be featured in **exclusive team video** which will be featured on our YouTube channel, Website and Social Media.

SUPERSONIC (Rs 50k+)

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

HYPERSONIC (Rs 100k+)

- You are entitled to everything in the Supersonic reward title.
- Your **decal** will be printed on CanSat and you will become our **Official Title Sponsor.**
- You will be given a special **Memento of our prototype**.

Team G.A.R.U.D.A.

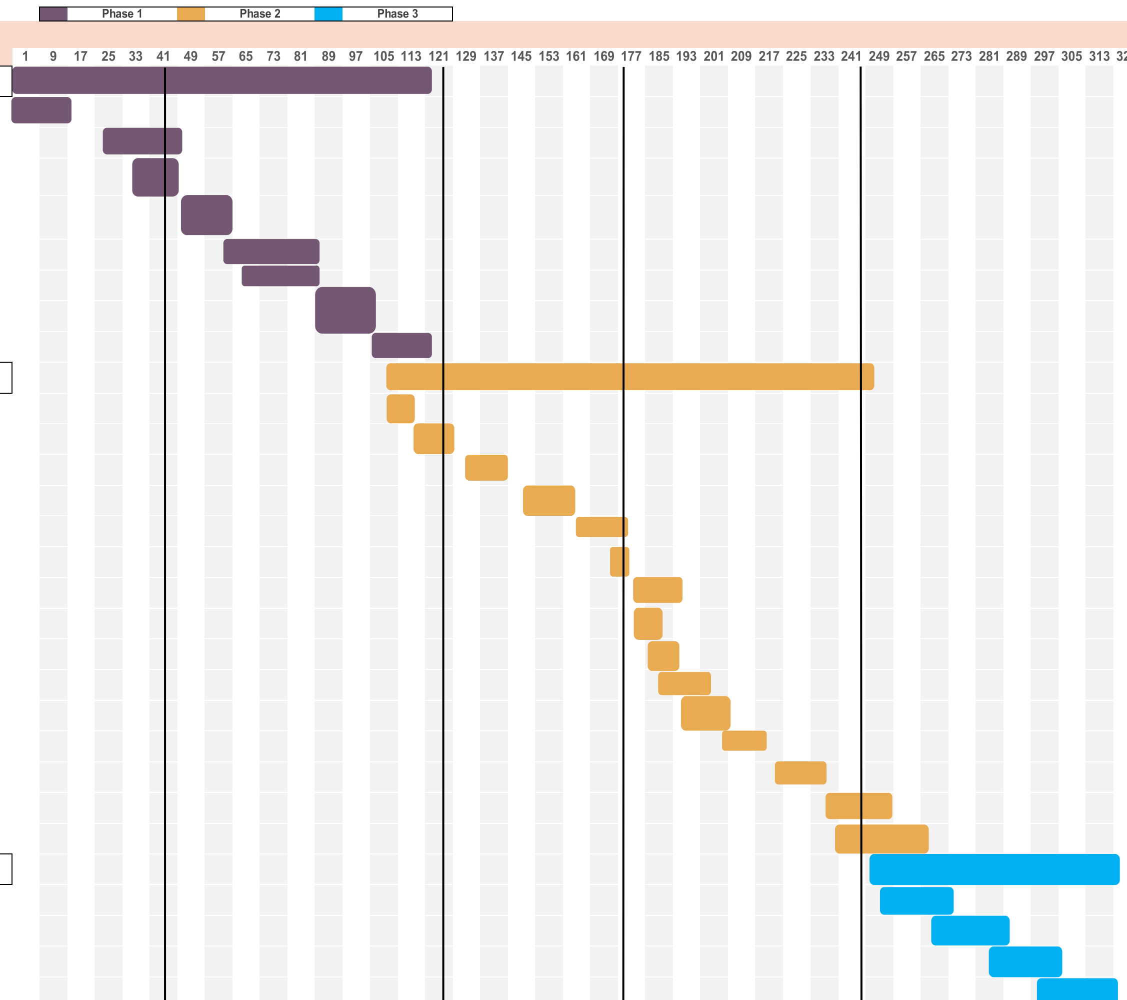
Glide Actuating Robust Unmanned Data Aggregator

Our Current Sponsors

Program Schedule Overview

PROGRAM SCHEDULE

S. No	ACTIVITY	PLAN START	PLAN END	PERCENTAGE COMPLETION
1	**Phase-1 (1st Educational phase)**	**21-04-19**	**31-12-19**	**100%**
2	Mission Operation Development started	21-04-19	24-05-19	100%
3	Team Selection and Mission Statement Analysis	07-09-19	17-09-19	100%
4	Subsystem alloted to each Team Member, Revisions in competition guidelines.	12-09-19	12-09-19	100%
5	Presentaion on Mission Statement prepaired for Faculty in-charge	18-09-19	25-09-19	100%
6	Design Selection and Sensor Researched	26-09-19	20-10-19	100%
7	Mid Semister Examination	14-10-19	20-10-19	100%
8	Electronic components were selected and ordered	24-10-19	18-11-19	100%
9	Working Prototype of Payload built and tested	17-11-19	31-12-19	100%
10	**Phase-2 (2nd Educational phase)**	**11-12-19**	**15-04-20**	**40%**
11	GCS and FSW Tentatively Designed	11-12-19	15-12-19	100%
12	Final Material selected and Trade selections ordered	05-12-19	08-12-19	100%
13	End Semester Theory Examination	15-12-19	30-12-19	100%
14	Antenna and XBEE configuration shall begin	12-01-20	12-01-20	100%
15	Cansat Fabrication will start	07-01-20	15-01-20	100%
16	final Components ordered, Component testing begins	15-01-20	15-01-20	100%
17	The PDR was compiled and mailed	20-01-20	31-01-20	100%
18	PCB were Soldered	20-01-20	20-01-20	100%
19	PCB Test and video Updated	22-01-20	28-01-20	100%
20	GCS and FSW Software will be Coded	25-01-20	06-02-20	45%
21	CFD calculations and simulations completed and verified	12-02-20	16-02-20	0%
22	Initiation of Drop Test	17-02-20	01-03-20	0%
23	Mid Semister Examination	22-02-20	05-03-20	0%
24	Final testing of software will be started	10-03-20	25-03-20	0%
25	CDR shall be compiled and mailed, Team members shall apply for U.S Visa	17-03-20	06-04-20	0%
26	**Phase 3 (Mission planning and preparation)**	**30-03-20**	**11-06-20**	**0%**
27	All final test shall be performed, final design of Cansat shall be fabricated	01-04-20	30-04-20	0%
28	End Semester Theory Examination	25-04-20	15-05-20	0%
29	Final preparation will be done	11-05-20	08-06-20	0%
30	Margin for unforseen problems, Team shall depart on 11 June 2020	01-06-20	11-06-20	0%



Task Assignment

Abhinav, Nitish, Amey, Keshav	Aryan, Abhinav, Piyush, Vivaswat	Full Team	Abhinav,Nitish, Aryan, Amey	Full Team

Detailed Program Schedule (1/3)

S No.	Start Date	End Date	Name	Task Duration (Days)
1	**21/04/19**	**31/12/19**	**Phase - I : 1 st Educational Phase**	**255**
2	21/04/19	24/05/19	Mission Operation Development Started	34
3	7/09/19	17/09/19	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	11
4	12/09/19	12/09/19	Revisions in competition guideline were taken into account and subsystems were allocated to team members	1
5	18/09/19	25/09/19	A presentation was prepared based on the CanSat mission requirements and competition guide, and presented to the faculty in-charge	8
6	26/09/19	20/10/19	Several designs were brainstormed and discussed. Sensors were researched	25
7	14/10/19	20/10/19	Mid Semester Theory Examinations	7
8	24/10/19	18/11/19	Electronic components were selected and ordered	26
9	17/11/19	31/12/19	A working prototype for the payload was built and tested.	45

Detailed Program Schedule (2/3)

S No.	Start Date	End Date	Name	Task Duration (Days)
10	**11/12/19**	**15/04/20**	**Phase - II : 2nd Educational Phase**	**127**
11	11/12/19	15/12/19	The GCS software and FSW were designed.	5
12	5/12/19	8/12/19	The final trade selections were done and materials were ordered.	4
13	15/12/19	30/12/19	End Semester Theory Examination	16
14	12/01/20	12/01/20	Antenna and XBEE configuration shall be performed.	1
15	7/01/20	15/01/20	The fabrication for the CanSat shall begin.	9
16	15/01/20	15/01/20	Proceeding with the final ordering of the components.Final testing of all EPS circuits, electronics and sensors, mechanisms.	1
17	20/01/20	31/01/20	The PDR was compiled and mailed	12
18	20/01/20	20/01/20	PCB were soldered.	1
19	22/01/20	28/01/20	PCB Test and Video Updated	7
20	25/01/20	6/02/20	Coding of the GCS software and FSW, and the design of all CanSat components were finalised.	13
21	12/02/20	16/02/20	CFD calculations and simulations were completed and verified	5

Detailed Program Schedule (3/3)

S No.	Start Date	End Date	Name	Task Duration (Days)
22	17/02/20	1/03/20	Initiation of drop tests.	14
23	22/02/20	5/03/20	Mid Semester Theory Examinations.	13
24	10/03/20	25/03/20	Final testing of software (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.	16
25	17/03/20	6/04/20	The CDR shall be compiled and mailed. Team members shall apply for U.S. visas.	21
26	**30/03/20**	**11/06/20**	**Phase - III : Mission Planning and Preparation**	**74**
27	1/04/20	30/04/20	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	30
28	25/04/20	15/05/20	End Semester Theory Examinations. Mission planning for the on-site competition shall be done.	21
29	11/05/20	8/06/20	Final preparations will be done.	29
30	1/06/20	11/6/20	Margin for any unforeseen problems. Any other miscellaneous needs shall be taken care of CanSat shall be carefully packaged for the journey to Virginia, VA. The team shall depart on 11 June 2020	11

Conclusions

Major Accomplishments

- All sensors were tested with Teensy 3.2 on breadboard and integrated on PCB.
- Telemetry has been tested and demonstrated.
- Descent rate estimates have been done.
- Mechanical design has been finalized.
- Mechanisms for payload deployment and container opening have been tested.
- Camera subsystem has been tested on Breadboard.
- Material selection and basic material testing has been done for all mechanical parts.

Major Unfinished Work

- Validation of descent rate estimation with actual testing.
- Camera stabilization system to be integrated with mechanical subsystem.
- Validation of FSW states/logics.

Preparation for Proceeding to Next Stage

- We have spent appropriate amount of time prototyping, developing, testing and troubleshooting.
- We have refined all our systems, and will continue to do so. Hence we feel we can face the challenges ahead.