University of Petroleum and Energy Studies
CanSat 2017
Preliminary Design Review (PDR)
Version 2.0

#2232

Team Astral

February 1, 2017

Presentation Outline

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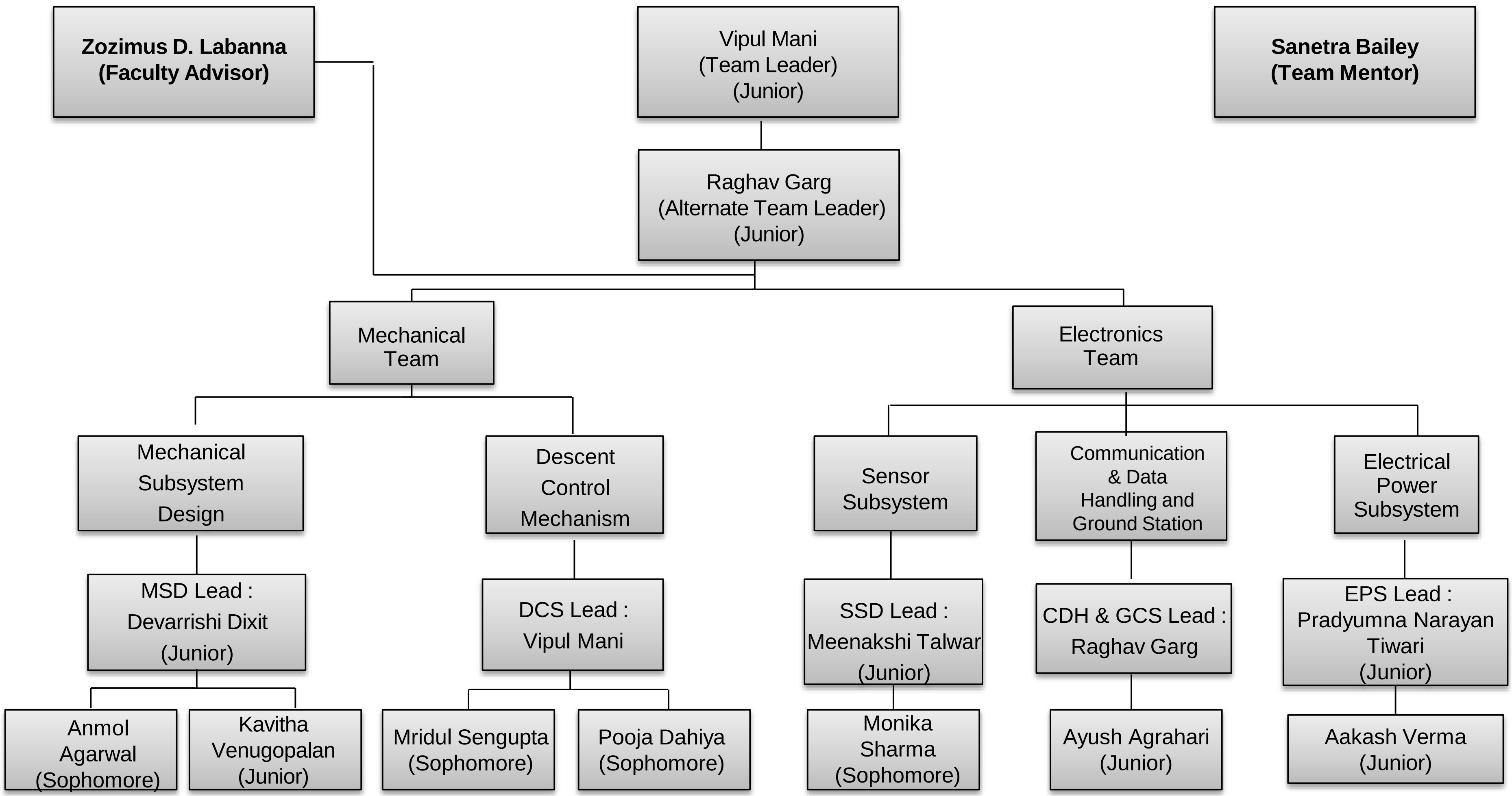
Electrical Power Subsystem Design	Pradyumna Narayan Tiwari
Flight Software Design	Raghav Garg
Ground Control Systems Design	Mridul Sengupta
Cansat Integration and Test	Aakash Verma and Anmol Agarwal
Mission Operation and Analysis	Monika Sharma
Requirement Compliance	Kavitha Venugopalan
Management	Kavitha Venugopalan and Vipul Mani

Team Organization



Acronyms

• A	Analysis
• A/A	Air to Air
• A-G	Air to Ground
• AoA	Angle of Attack
• ADC	Analog to Digital Converter
• A&S	Alignment And Stabilization
• A&T	Assembly And Test
• CDH	Communication and Data Handling
• CDR	Critical Design Review
• CG	Center of Gravity
• D	Demonstration
• DCS	Descent Control System
• GCS	Ground Control Subsystem
• GS	Ground Station

Acronyms

• **L/D**	**Lift to Drag Ratio**
• **I**	**Inspection**
• **ICT**	**Information And Communication Technology**
• **MC**	**Microcontroller**
• **MS**	**Mechanical System**
• **PCB**	**Printed Circuit Board**
• **PDR**	**Preliminary Design Review**
• **RTC**	**Real Time Clock**
• **SS**	**Sensor Subsystem**
• **SV**	**Science Vehicle**
• **T**	**Testing**
• **USB**	**Universal Serial Bus**
• **VM**	**Verification Method**

Systems Overview

Vipul Mani

Mission Summary

MISSION OBJECTIVES

- **To simulate a solar powered sensor glider traveling through a planetary atmosphere sampling the atmospheric conditions during flight.**
  - A container shall hold in the glider to protect it from the abrupt deployment.
  - The glider and container shall transmit the telemetry data to ground station at 1 Hz rate.
  - Safely release the glider from the re-entry container at 400 meters +/- 10 m.
  - Glider shall glide in a circular pattern with diameter not more than 1000 meters.
  - All glider electronics shall be powered by a solar source.
  - The glider shall include a magnetometer and a pitot tube to measure direction and speed.
  - Post landing, transmission shall automatically stop and an audio beacon shall be activated automatically for recovery.

BONUS OBJECTIVE

- A **Camera** shall click images of the ground as often as possible and storing them onboard.

EXTERNAL OBJECTIVE

- 3D simulation of glider using LabView software.
- Obtain funding for the fabrication of our CanSat and to cover travel of all team members.

System Requirement Summary (1 of 4)

ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-01	Total mass of the CanSat (container and glider) shall be 500 grams +/- 10 grams	Competition Requirement	HIGH	DCS01, MSR13	✓	✓		
SR-02	The container should fit within a container of 125mm x 310 mm	Competition Requirement	HIGH	DCS02, MSR02	✓	✓		
SR-03	The container must descend with the aid of a parachute.	Competition Requirement	HIGH	DCS03,04,05 MSR 05,15	✓	✓		
SR-04	The container shall not have any sharp edges or protrusions	To Facilitate Deployment	HIGH	DCS03, 14 MSR 05,15	✓	✓		✓
SR-05	Rocket airframe shall not be used to restrain any deployable parts or as part of CanSat operations.	Competition Requirement	HIGH	MSR17	✓		✓	
SR-06	The Glider must be released from the container at 400 meters +/- 10 m	Competition Requirement	HIGH	DCS05	✓	✓		

System Requirement Summary (2 of 4)

ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-07	The Glider must be fixed to glide in a preset circular pattern of no greater than 1000 meter diameter.	Competition Requirement	HIGH	DCS-09	✓	✓		
SR-08	All electronic components shall be enclosed and shielded from the environment with the exception of sensors	For easy deployment from re-entry container	HIGH	DCS-07, 11 MSR-05	✓		✓	
SR-09	All structures shall be built to survive 30Gs of shock.	Competition Requirement	HIGH	MSR-20	✓	✓		
SR-10	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	For accurate descent of the Glider	HIGH	DCS-12, MSR-14	✓	✓	✓	
SR-11	Mechanisms shall not use pyrotechnics or chemicals.	To avoid the risk of fire	HIGH	DCS-11, MSR-24	✓	✓		
SR-12	During descent, the glider shall collect air pressure, outside air temperature, compass direction, air speed and solar power voltage once per second	Competition Requirement	HIGH	SSR-02, 03, 04, 05	✓		✓	

System Requirement Summary (3 of 4)

ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-13	XBEE radios shall be used for telemetry to transmit telemetry	Competition Requirement	HIGH	MSR-18	✓	✓	✓	
SR-14	The Glider shall have an imaging camera installed and pointing toward the ground	Competition Requirement	HIGH	DCS-09	✓	✓		
SR-15	The Ground Station shall include a laptop, an antenna and a X-bee Radio for receiving	Setup for Receiving Telemetry	HIGH	MSR-07	✓	✓	✓	
SR-16	All telemetry shall be displayed in real time and engineering units during descent.	Competition Requirement	HIGH	MSR-08	✓	✓		
SR-17	Cost of the CanSat shall be under $1000	Cost Effectiveness	HIGH	DCS-17	✓	✓		
SR-18	Flight Software shall maintain the count of packets received	For better monitoring of FSW states	HIGH	FSW-04	✓	✓		
SR-19	The Glider shall be a fixed wing Glider	Competition Requirement	HIGH	DCS-05, MSR-09,12	✓		✓	

System Requirement Summary (4 of 4)

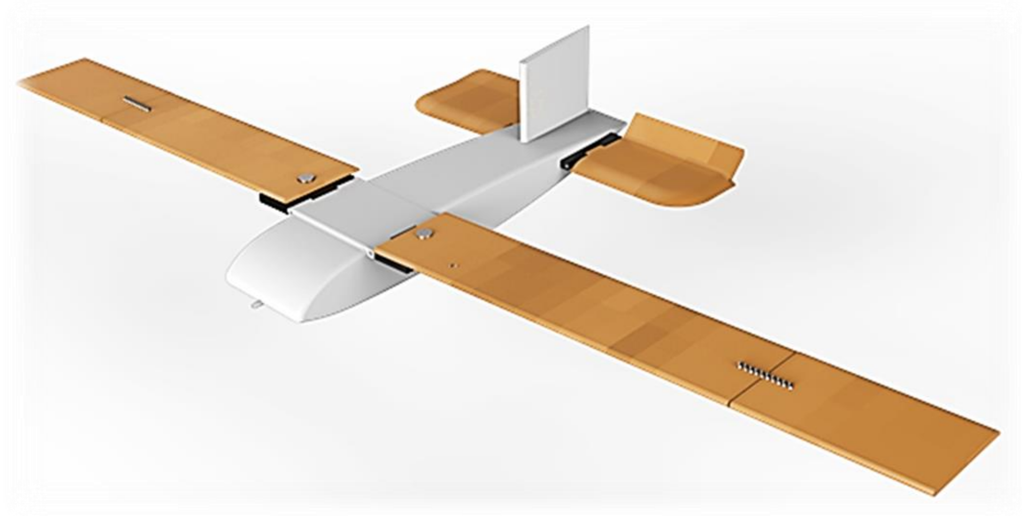
ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-20	The glide duration should be close to two minutes	Competition Requirement	HIGH	DCS-03, 05	✓			
SR-21	The glider electronics must be all solar powered except for the time keeping device	Competition Requirement	HIGH	EPS-01	✓	✓		
SR-22	The Glider shall receive a command to capture an image of the ground and store the image on board for later retrieval	Bonus Objective	HIGH	SSR-22		✓		
SR-23	The container electronics shall be powered by only alkaline batteries	Competition Requirement	HIGH	EPS-05	✓	✓		
SR-24	The Container should be of fluorescent color	Competition Requirement	HIGH	DCS-13, MSR-16		✓		
SR-25	Solar powered audio beacon required for the glider	Competition Requirement	HIGH	EPS-01	✓	✓	✓	
SR-26	The CanSat container shall have a payload release override command	Emergency payload release mechanism	HIGH	FSW-02	✓	✓		

CONFIGURATION 1 :

UNEQUAL AREA OF GLIDER WINGS AT EITHER SIDES WITH ELEVATORS AT DIFFERENT ANGLE OF ATTACK AND FULL RUDDER IN DIRECTION OF ROTATION.

PROS:

- Ease of machining
- High glide time
- Significant stability
- Large wetted area
- Ease in wing folding

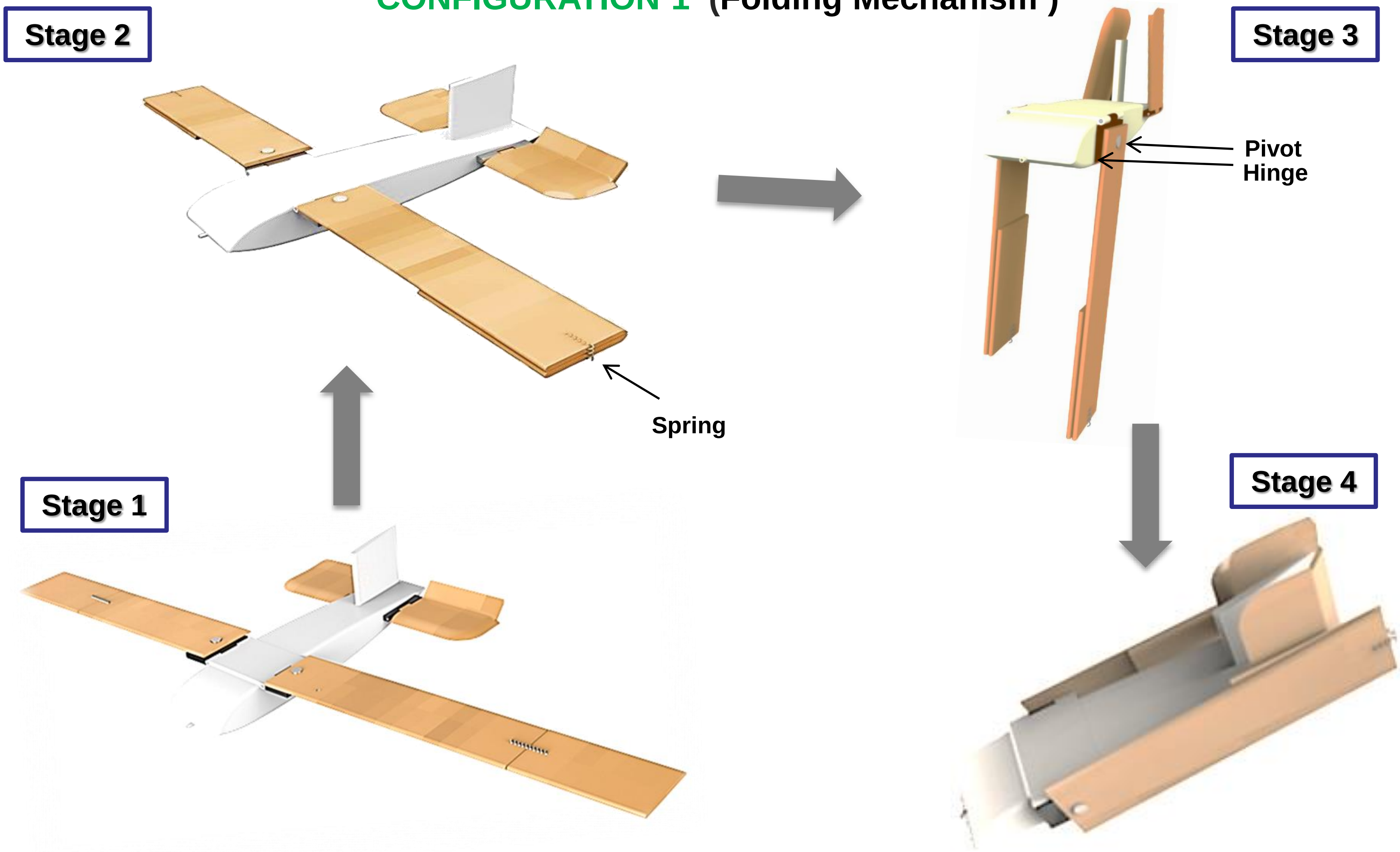


CONS:

- Greater drag due to high aspect ratio
- Difficult to balance CG
- Extra mass add-on

System Level CanSat Configuration Trade & Selection

CONFIGURATION 1 (Folding Mechanism)



CONFIGURATION 2 :

CANARD WING FORMATION OF GLIDER WITH FULL RUDDER AT THE DIRECTION OF ROTATION.

The CANARD structure would provide a helical glide on descent owing to difference in slackness of the two wings.

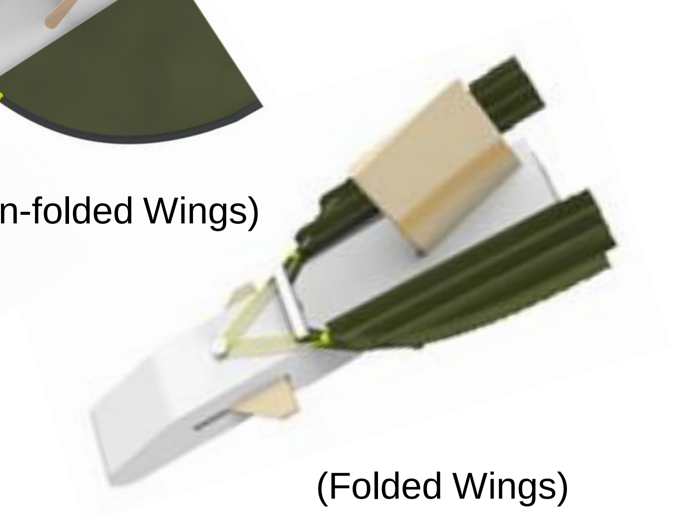
PROS:

- Substantial glide time
- Decreased main wing turbulence

(Un-folded Wings)

CONS:

- Complex fabrication
- Complex folding
- High speed of descent
- Difficult to fit in and fold the solar cells



(Folded Wings)

System Level CanSat Configuration Trade & Selection

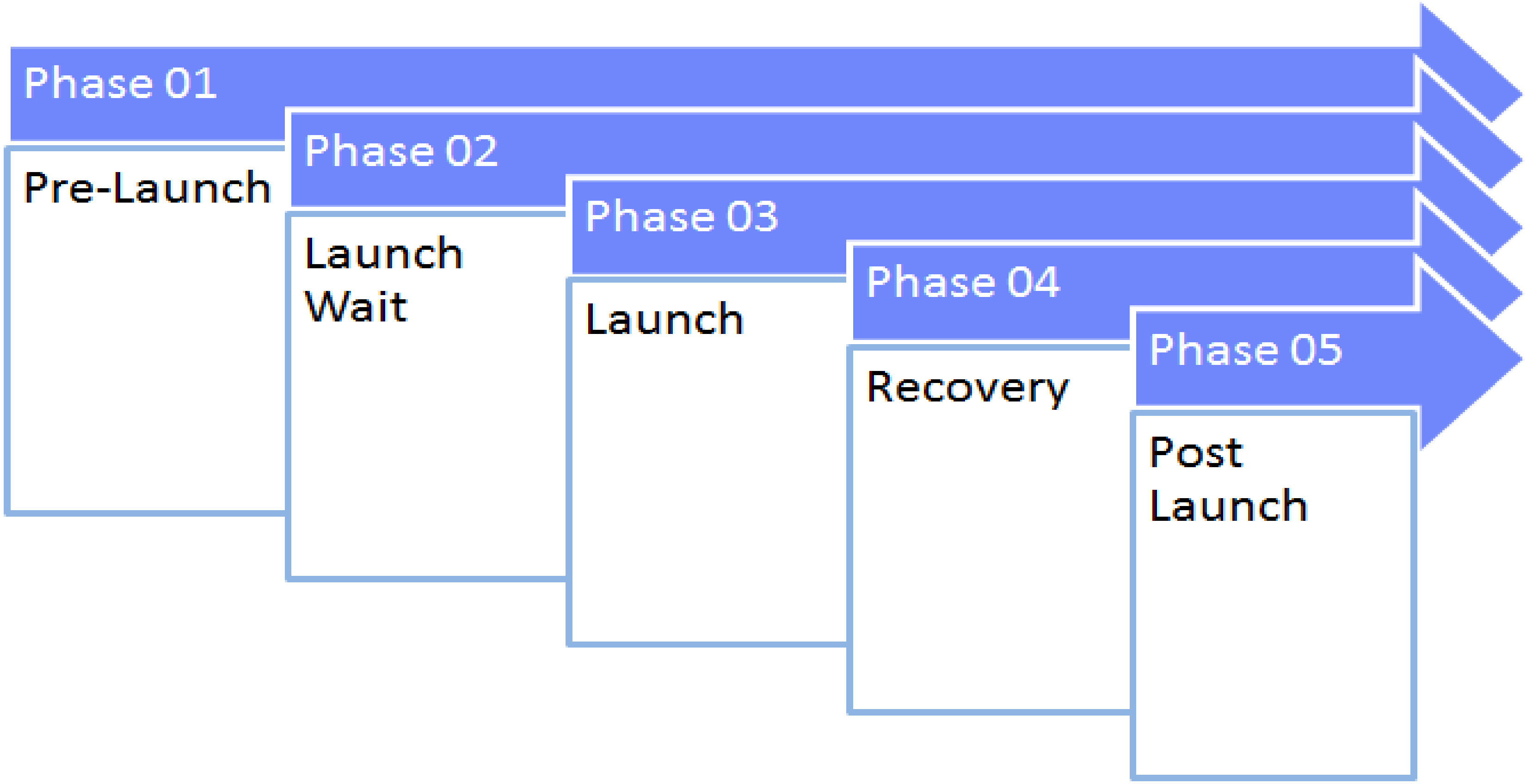
S.NO	CONFIGURATIONS	STRENGTH	EASE OF FABRICATION	STABILITY	COST
1	Unequal length of glider wings at either sides with full rudder in direction of rotation	9	9	8	10
2	Canard wing formation of glider with rudder in the direction of rotation	6	5	8	4

Grading (0-10):
0 – Least
10 - Most

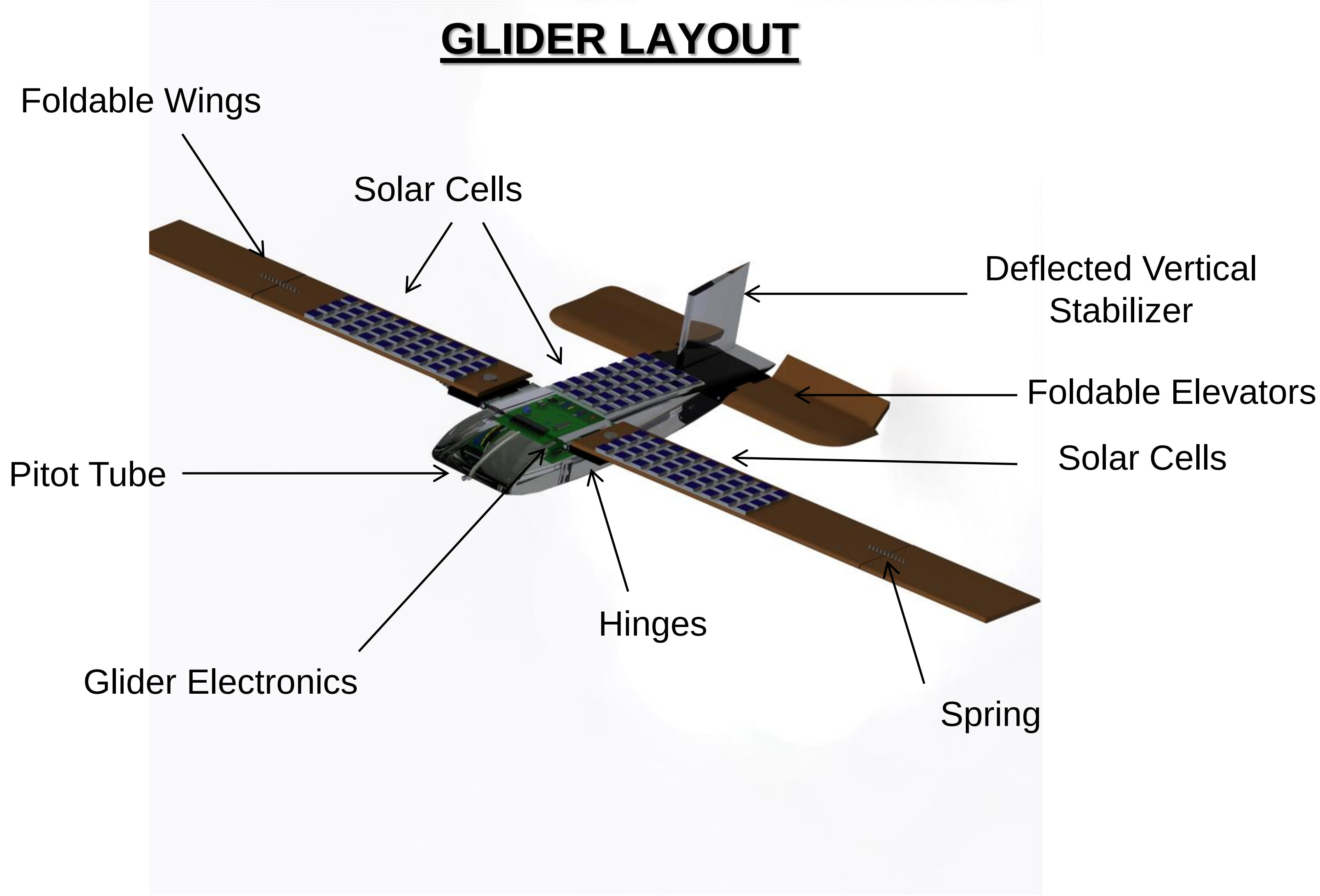
We chose **CONFIGURATION 1** i.e. glider having unequal wing area because of its higher strength, low cost and ease of fabrication.

System Level CanSat Configuration Trade & Selection

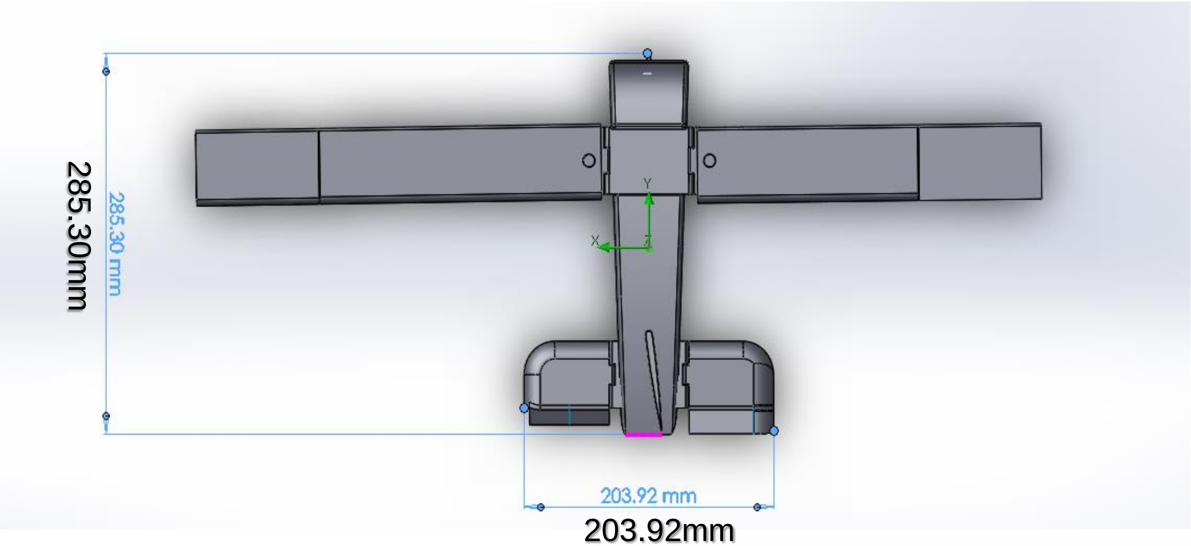
CONOPS VARIATION



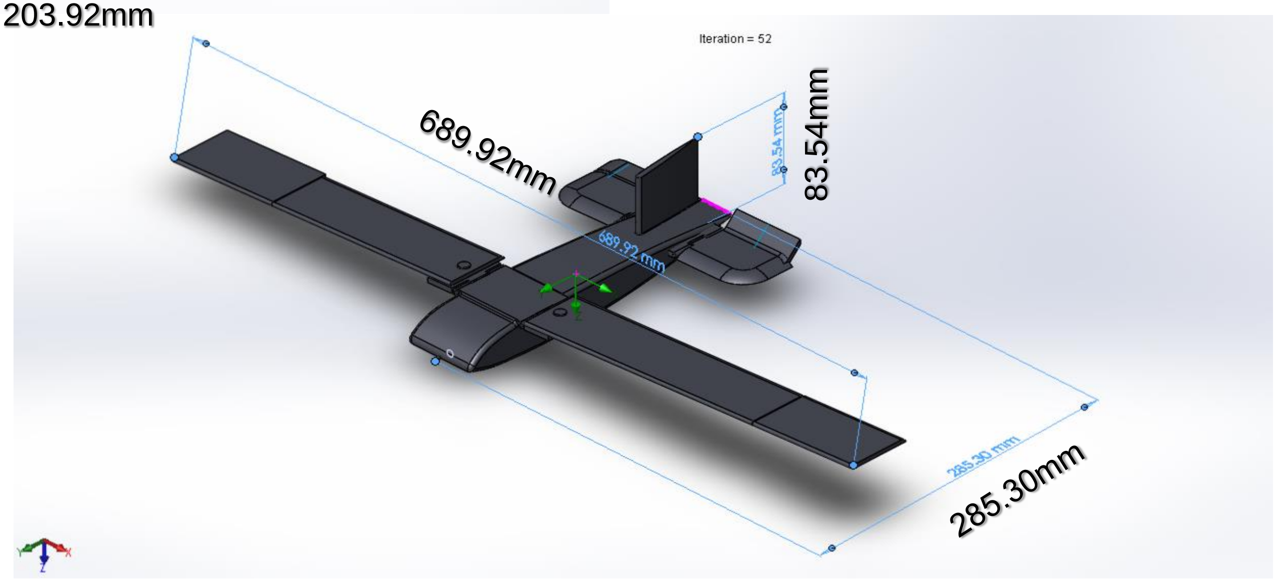
Physical Layout



Physical Layout

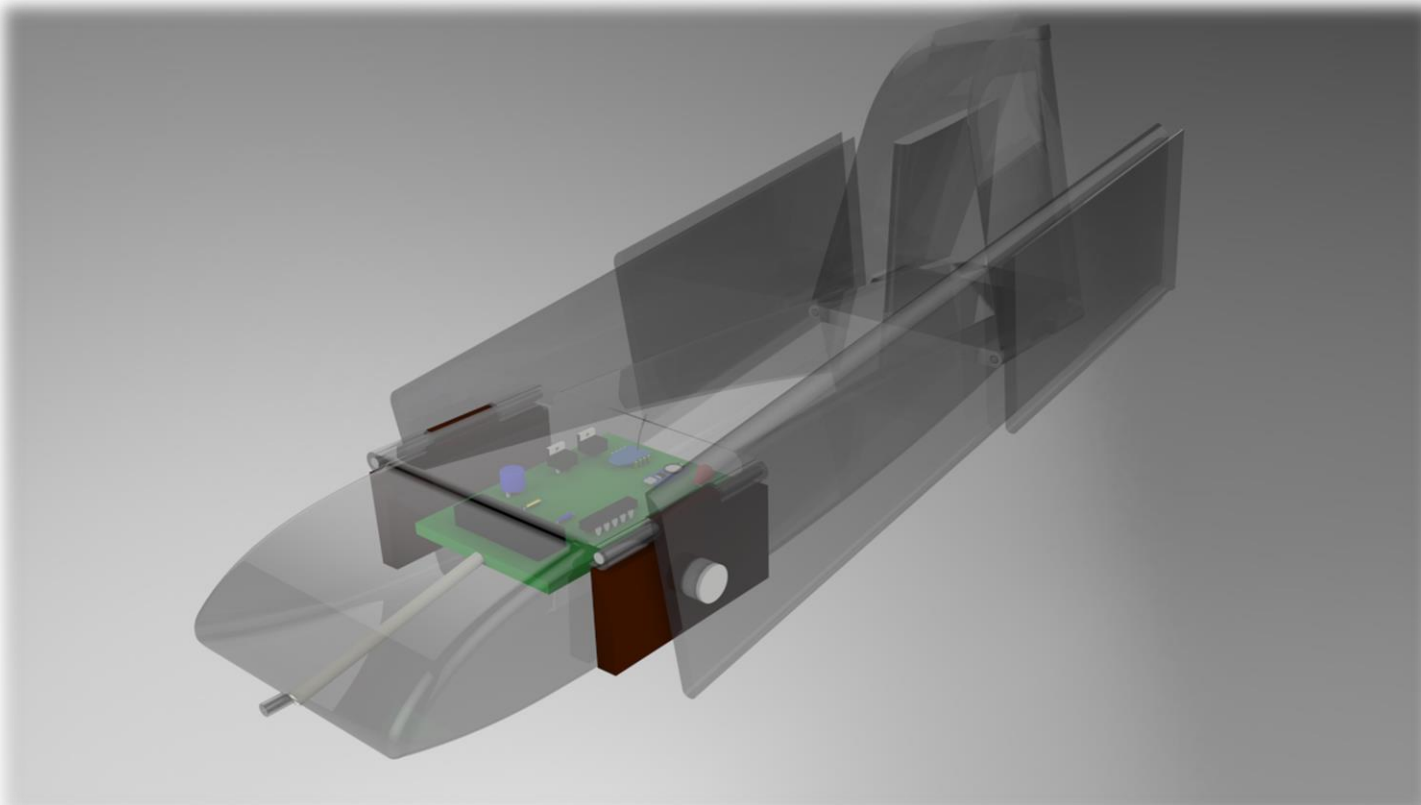


GLIDER DIMENSIONS



PLACEMENT OF COMPONENTS

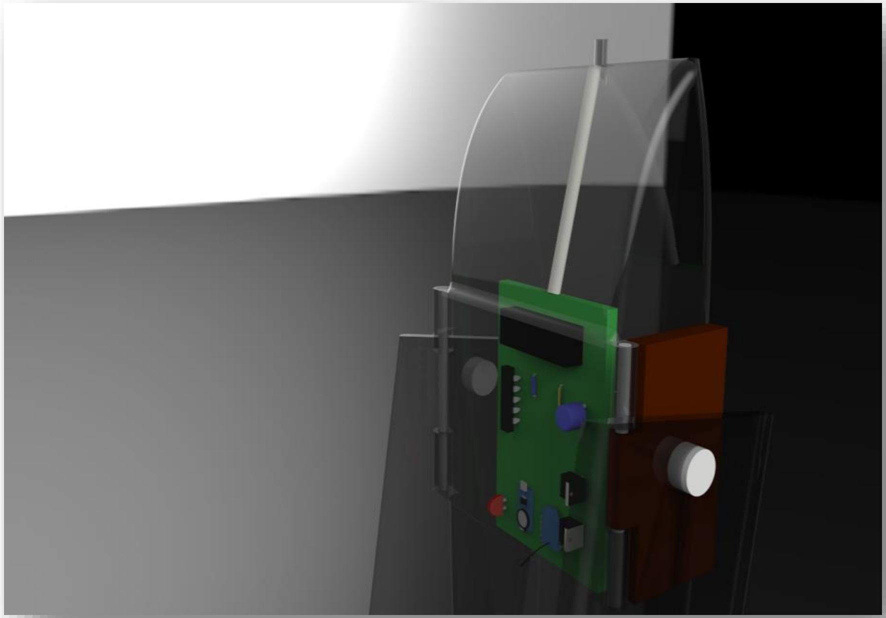
- **Oblique view of electronics inside the glider**



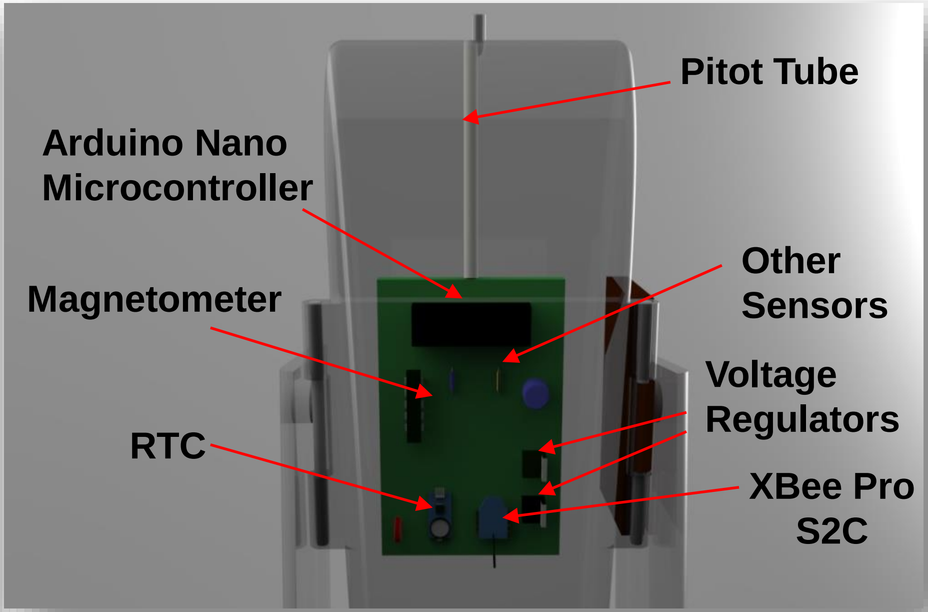
Physical Layout

- **Placement of electronics inside the glider**

Isometric View at 30^0

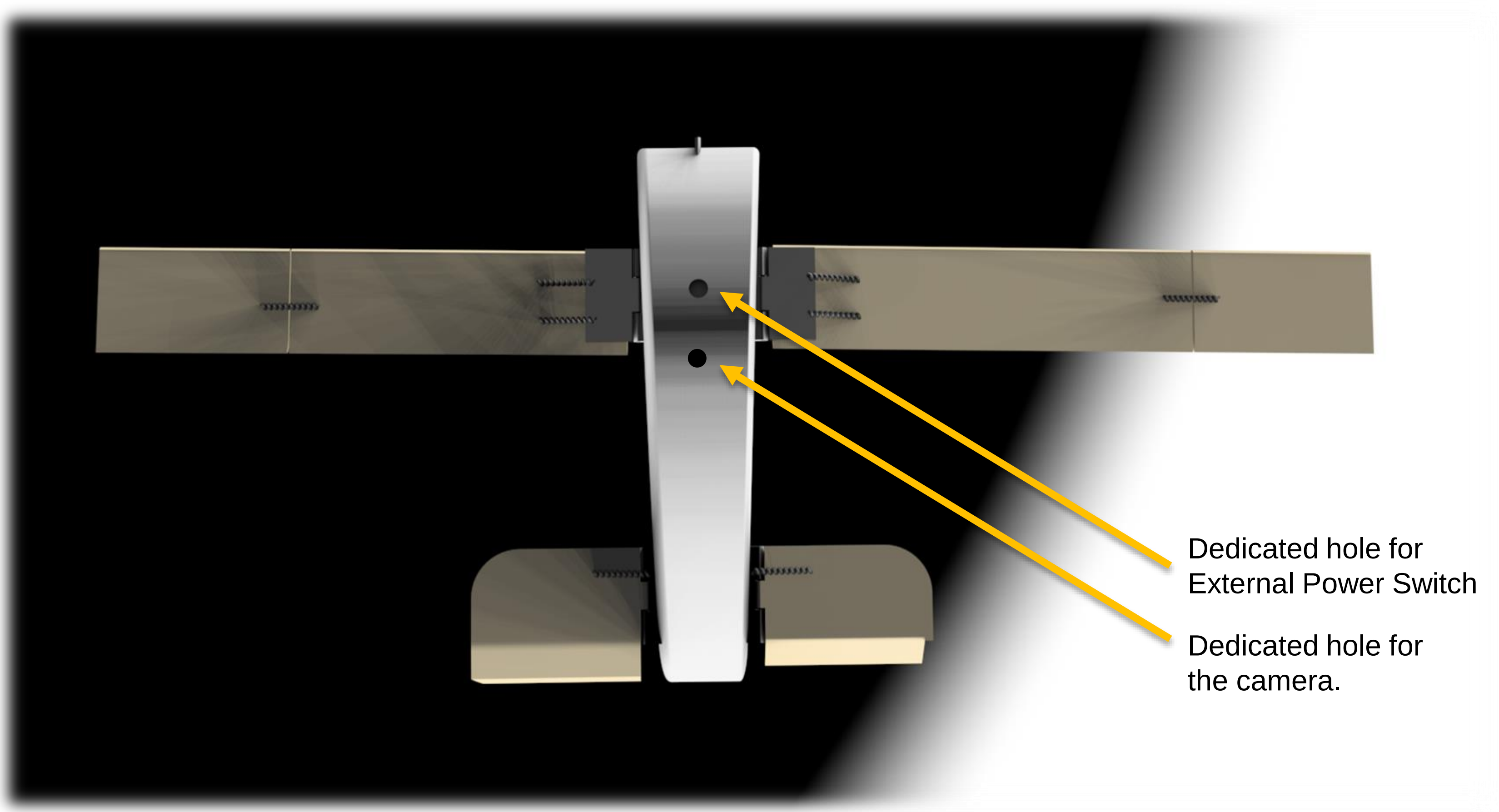


Top View



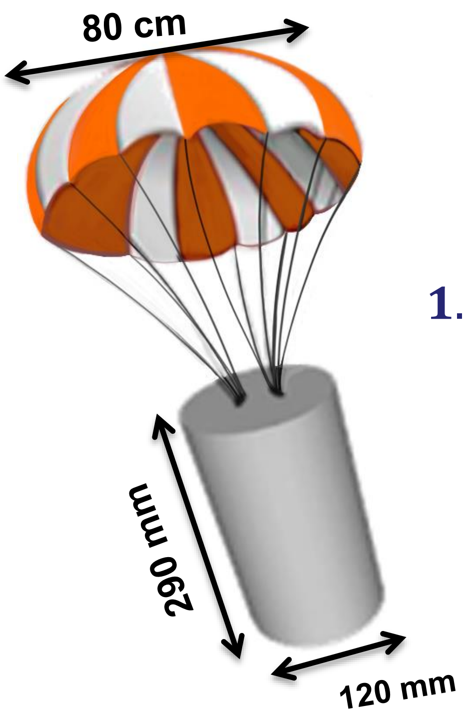
Physical Layout

- **Placement of camera and external switch on the glider.**

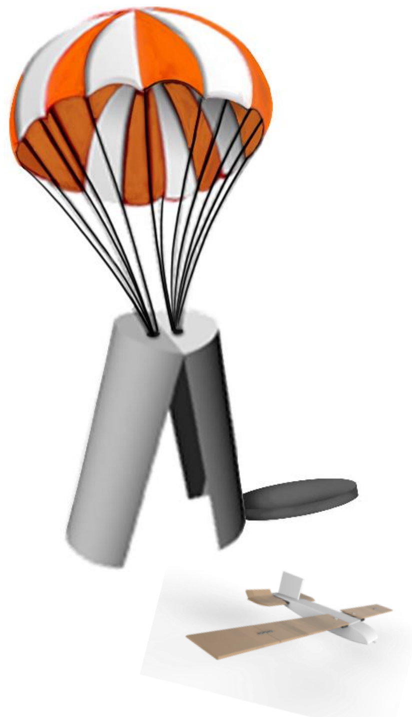


Physical Layout

CONTAINER WITH PARACHUTE CONFIGURATION



1.



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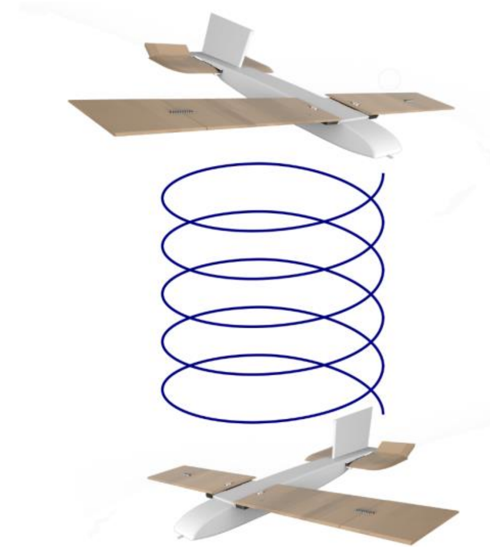


3.

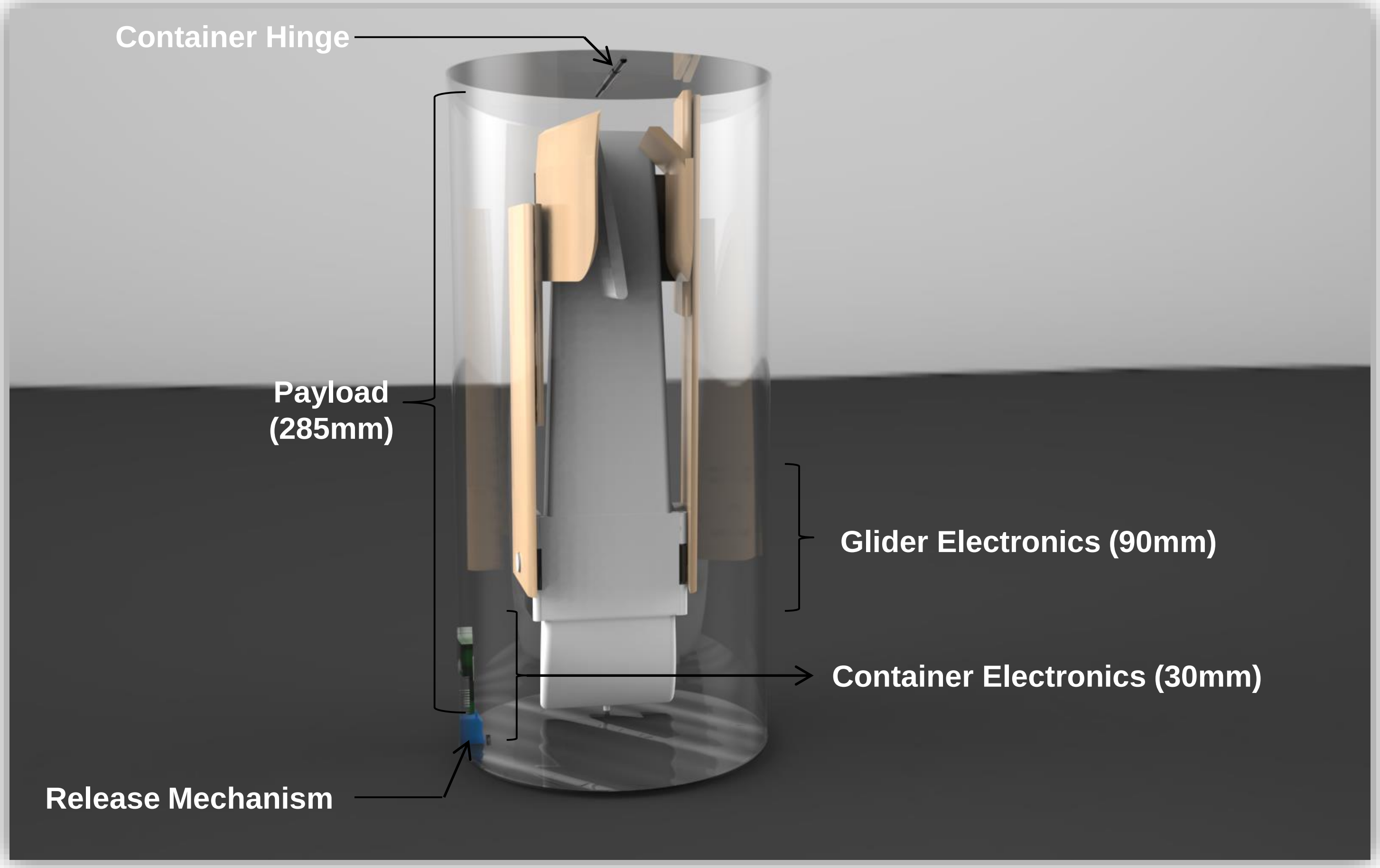
Deployment near Apogee

Configuration at Glider Separation

Helical trajectory followed by glider

1. **Re-entry container + Glider just after release from the rocket at ~900-1000 m.**
2. **Glider separated from the re-entry container at 400m ± 10m to resume its operations.**

CONTAINER DESIGN



GLIDER WITH NOSE DOWN IN THE CONTAINER

System Concept of Operations

Pre Launch

1. Pre Flight Briefing
2. Mechanical Testings
3. Electronic Controls Turned On
4. Taking Cansat To Competition Launch Site

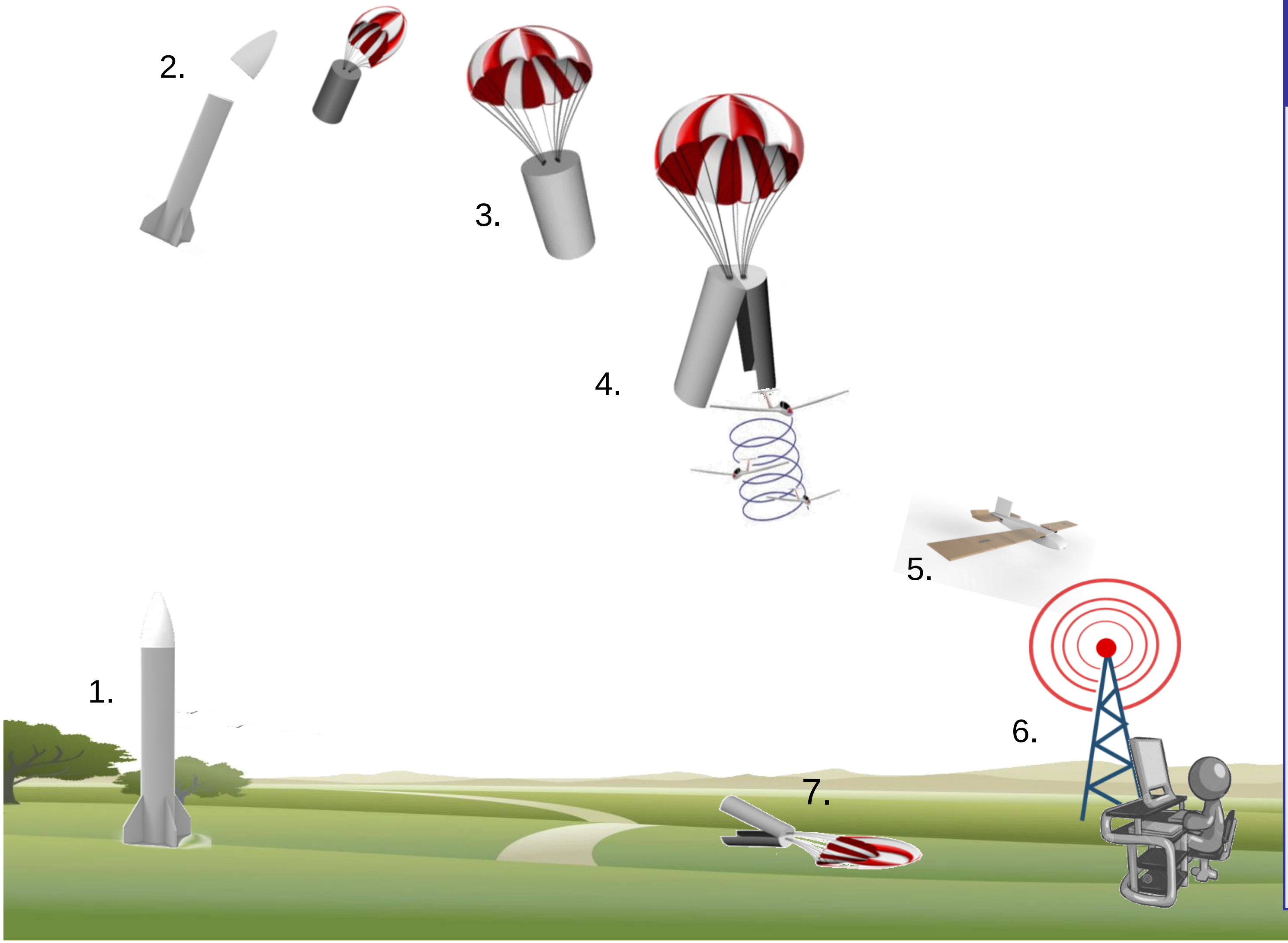
Launch

1. Placing Cansat into the Rocket
2. Rocket Launch
3. Container Data Telemetry Begins
4. Near Apogee Deployment
5. Deployment of Glider from Container at 400m ± 10m
6. Glider Data Telemetry Begins
7. Container Data Telemetry Stops
8. Descent of Glider in helical fashion within 1000m Diameter
9. Receiving Sensory Data at Ground Station
10. Telemetry Stops and Audio Beacon Activated. Locating the Glider and the Container

Post Launch

1. Saving Data in required format in GCS
2. Retrieving Data Card from Glider
3. Analyzing procured Data
4. Preparing and Presenting PFR

System Concept of Operations



OPERATIONS PROCEDURE

1. Launch
2. CanSat Deployment
3. Opening of Parachute
4. Glider Deployment and Data Telemetry
5. Descend
6. Data Processing Post Flight
7. Landed

Launch Vehicle Compatibility

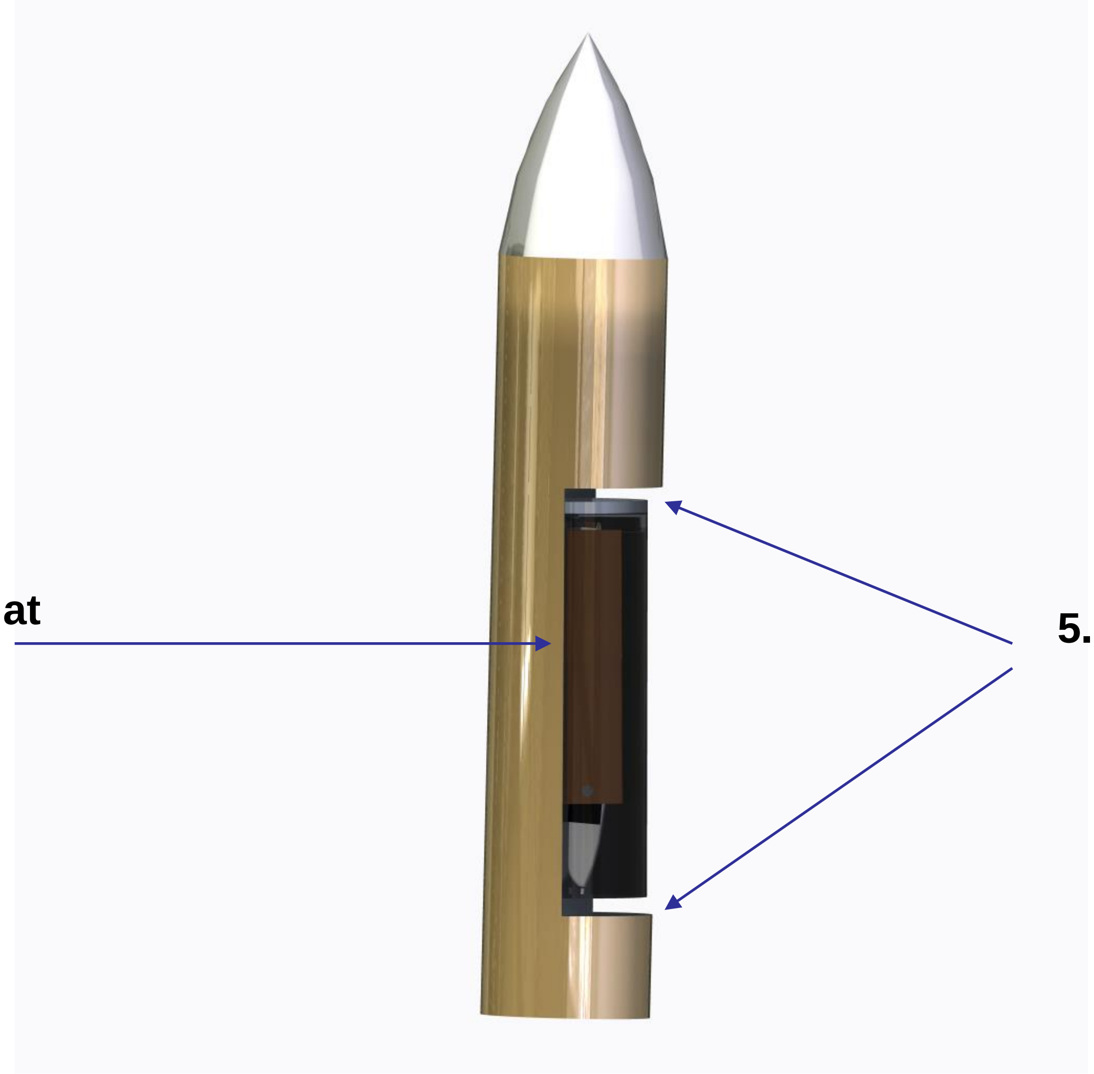
- The structure is designed in accordance with the CanSat parameters with safe tolerances.
- Re-entry container will be placed upside down in the rocket payload section.
- The compatibility of the launch vehicle would be tested a day before the day of launch.
- For smooth deployment, we have made sure that there are no protruding components outside the re-entry container.
- Tolerances of 4mm is given for width and 10mm for height.

Dimensions[mm] Section	Height (Length for Glider in mm)	Diameter (Width for Glider in mm)	Max. Height for glider (in mm)
Glider*	285	115	285
Container	290	120	-
Rocket Payload	310	125	-

*Glider Dimensions are for the Folded Glider

Launch Vehicle Compatibility

2.0mm gap at the sides



5.0mm gap at top and bottom

Sensor Subsystem Design

Meenakshi Talwar

Sensor Subsystem Overview

PAYLOAD			
SENSOR	**TYPE / MODEL**	**PURPOSE**	**QTY.**
Magnetometer	Digital Output Magnetic Sensor **Model - LIS3MDL**	The LIS3MDL is an ultra-low-power high-performance three-axis magnetic sensor that includes includes an I2C serial bus and an SPI interface.	1
Air Pressure Sensor	Barometric (Digital) Pressure Sensor **Model - BMP180**	BMP180 is preferred because it has a wide range of barometric pressure and altitude.	1
Pitot Tube	Analog Sensor **Model - MPXV7002DP**	Used to sense the air flow velocity. MPXV7002-GC6U is used as the Pitot tube sensor. It provides a 0.5 to 4.5V output	1
Air Temperature Sensor	Barometric (Digital) Pressure Sensor **Model - BMP180**	BMP180 is preferred because it has dual functionality to provide air pressure/altitude as well as temperature with one degree resolution thus reducing hardware, weight and system complexity.	1
Real Time Clock	**Model – DS1307 RTC Module**	DS1307 provides I2C Serial Interface to track and maintain record of Mission Time.	1
Solar Power Voltage Sensor	**Voltage-Divider Circuit (Analog)**	A voltage divider circuit is used to measure solar power voltage using the Analog-to-Digital Port of MCU.	1
Camera	**Serial-TTL JPEG Camera VC0706**	For clicking the nadir view pictures when asked. (BONUS OBJECTIVE)	1

Sensor Subsystem Overview

CONTAINER			
SENSOR TYPE	**MODEL NAME**	**PURPOSE**	**QUANTITY**
Air Pressure Sensor	Barometric (Digital) Pressure Sensor **Model - BMP180**	BMP180 is used to transmit container readings. as it consumes very less power (5µA at 1 sample / sec). (Telemetry Requirement) Based on the altitude readings of this sensor, the flight software state is identified; and separation mechanism is activated.	1
Air Temperature Sensor	Barometric (Digital) Pressure Sensor **Model - BMP180**	BMP180 is ultra low power and accurately measures temperature. (Telemetry Requirement)	1
Real Time Clock	**Model – DS1307 RTC Module**	To track and maintain record of Mission Time.	1
Battery Voltage Sensor	**Voltage-divider Circuit (Analog)**	The circuit allows a simple set up to accurately measure Battery voltage and provide an Analog Voltage reading. (Telemetry Requirement)	1

Separation Mechanism: A 9g Servo Motor is employed to implement mechanism to separate the Payload from the Container.

Sensor Subsystem Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
SSR-01	All electronic components must be enclosed and shielded.	Competition Requirement	HIGH	SR-04, 10	✓			
SSR-02	Air-Pressure/Altitude Measurement (both payload and container)	Competition Requirement	HIGH	SR-12	✓	✓	✓	
SSR-03	Out-side air temperature (both payload and container)	Competition Requirement	HIGH	SR-12	✓	✓	✓	
SSR-04	CanSat glider heading measured by magnetometer.	Competition Requirement	HIGH	SR-12	✓	✓		
SSR-05	Air-Speed Measurement Through Pitot tube	Competition Requirement	HIGH	SR-11	✓		✓	
SSR-06	Solar Powered Voltage Measurement (For Payload)	Competition Requirement	HIGH	SR-11,12	✓		✓	
SSR-07	Container should measure altitude and temperature	Competition Requirement	HIGH	SR-12	✓	✓	✓	
SSR-08	Battery Voltage measurement of Container	Competition Requirement	HIGH	SR-10,11	✓		✓	

Magnetometer Trade & Selection

DEVICE NAME	INTERFACE	OPERATING VOLTAGE	CURRENT CONSUMPTION	SIZE	WEIGHT
LIS3MDL	I2C/SPI	1.9 V to 3.6 V	270 µA	2 x 2 x1 mm^3	0.6 g
MAG3110	I2C	1.95 V to 3.6 V	900 µA	2 x 2 x 0.85 mm^3	0.5 g

Source: Datasheet

SELECTED : LIS3MDL- 3 Axis Magnetometer

- I2C/SPI digital output interface
- Wide supply voltage, 1.9 V to 3.6 V
- ±4/ ±8/ ±12/ ±16 gauss selectable magnetic full scale
- **Resolution:** 16 bit
- **Current - Supply (Max):** 270µA (Typical)
  - Low power consumption 270µA in High resolution mode (@ODR=20Hz)
  - 40µA in Low power mode (@ODR=20Hz)
  - 1µA in Power down mode

Payload Air Pressure Sensor Trade & Selection

DEVICE NAME	INTERFACE	OPERATING PRESSURE	SIZE	WEIGHT	ACCURACY	SUPPLY VOLTAGE
BMP180	I2C	300-1100hPa	5 x 5 mm^2	1 g	+/-2.5h Pa	1.8-3.6V
BMP085	I2C	300-1100hPa	16.5 x 16.5 mm^2	1.6 g	+/-2.5h Pa	1.6-3.6V
MPXAZ4115A	I2C	150-1150hPa	10.7 x 10.7 mm^2	1 g	+/-1.5h Pa	4.85-5.35V

Source: Datasheet

SELECTED : BMP180 Barometric Pressure Sensor

- Upgraded version of BMP085 with High Accuracy and Increased Sampling Rate.
- Low cost and fully calibrated
- Integrated temperature sensor
- Resolution: 0.01 hPa
- Low noise and very low current drawn (I_{peak} = 650µA)

$$\text{Absolute Altitude} = 44330 \times \left[1 - \left(\frac{P}{P_0}\right)^{1/5.255}\right]$$

Where,
P_0= Pressure at sea level (hPa)
P = Measured pressure (hPa)

Container Air Pressure Sensor Trade & Selection

DEVICE NAME	INTERFACE	OPERATING PRESSURE	SIZE	WEIGHT	ACCURACY	SUPPLY VOLTAGE
BMP180	I2C	300-1100hPa	5 x 5 mm^2	1 g	+/-2.5h Pa	1.8-3.6V
BMP085	I2C	300-1100hPa	16.5 x 16.5 mm^2	1.6 g	+/-2.5h Pa	1.6-3.6V
MPXAZ4115A	I2C	150-1150hPa	10.7 x 10.7 mm^2	1 g	+/-1.5h Pa	4.85-5.35V

Source: Datasheet

SELECTED : BMP180 Barometric Pressure Sensor

- High Accuracy – provides accurate operating state of software
- Low cost and fully calibrated
- Integrated temperature sensor
- Resolution: 0.01 hPa
- Low noise and very low current drawn (I_{peak} = 650µA)

$$\text{Absolute Altitude} = 44330 \times \left[1 - \left(\frac{P}{P_0}\right)^{1/5.255}\right]$$

P_0= Pressure at sea level (hPa)
P = Measured pressure (hPa)

Payload Pitot Tube Trade & Selection

DEVICE NAME	SUPPLY VOLTAGE	PROTOCOL	WEIGHT	ACCURACY	COST
MPXV7002DP	4.75-5.25V	ADC	4g	+/-6.25kph	26.99$
MS4525DO	2.7-5.5V	I2C	6g	+/-0.4kph	54$

Source: Datasheet

SELECTED: MPXV7002DP

- Cost effective and Easy interfacing.
- Relatively light weight.
- -2 to 2 kPa pressure range
- High accuracy of +/-6.25kph.
- 10-60 Celsius operating temperature
- Maximum pressure of device is 75kPa with supply current of 10mA.

Pitot Tube Equation: $V^2 = \frac{[2\times(P_t-P_s)]}{r}$

P_t = total pressure
P_s = static pressure

Payload Air Temperature Sensor Trade & Selection

DEVICE NAME	TYPE	OPERATING TEMPERATURE	SIZE	WEIGHT	ACCURACY	SUPPLY VOLTAGE	COST
BMP180	Analog	-40 to +85 °C	5x5 mm^2	1 g	±0.1 °C	1.8-3.6V	3.70 $
BMP085	Analog	-40 to +85 °C	16.5 x 16.5 mm^2	1.6 g	±0.2 °C	1.6-3.6V	8.15 $
LM35	Analog	-55 to +150 °C	4.7 × 4.7 mm^2	1 g	±0.5 °C	4 - 30 V	1.5 $

Source: Datasheet

SELECTED: BMP180 Barometric Pressure Sensor

- V_{in}: 1.8-3.6 V DC
- I2C interface
- Pressure sensing range: 300-1100 hPa
- Resolution : 0.1°C
- -40 to +85°C operational range

BMP180 is preferred because it has dual functionality to provide air pressure/altitude as well as temperature with one degree resolution thus reducing hardware, weight and system complexity.

Container Air Temperature Sensor Trade & Selection

DEVICE NAME	TYPE	OPERATING TEMPERATURE	SIZE	WEIGHT	ACCURACY	SUPPLY VOLTAGE	COST
BMP180	Analog	-40 to +85 °C	5x5 mm^2	1 g	±0.1 °C	1.8-3.6V	3.70 $
BMP085	Analog	-40 to +85 °C	16.5 x 16.5 mm^2	1.6 g	±0.2 °C	1.6-3.6V	8.15 $
LM35	Analog	-55 to +150 °C	4.7 × 4.7 mm^2	1 g	±0.5 °C	4 - 30 V	1.5 $

Source: Datasheet

SELECTED: BMP180 Barometric Pressure Sensor

- V_{in} = 1.8-3.6 V DC
- I2C interface
- Pressure sensing range: 300-1100hPa
- Resolution : 0.1°C
- -40 to +85°C operational range

Dual functionality to provide altitude as well as temperature

Helps to calculate accurate operating state of software.

Payload Solar Power Voltage Sensor Trade & Selection

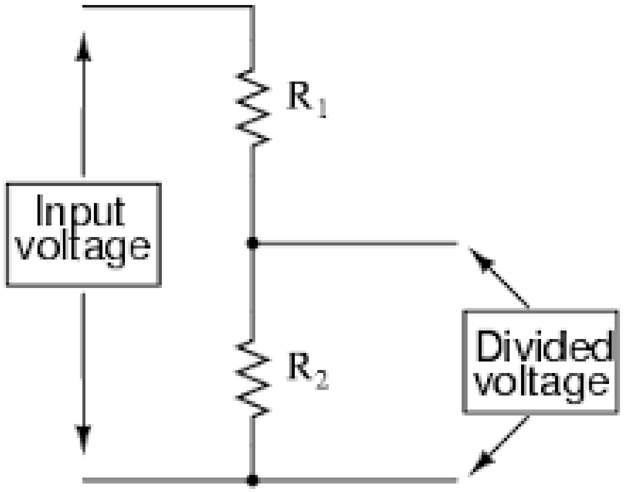
SENSOR	INTERFACE	RESOLUTION	WEIGHT	SIZE	COST
MAX17043G+U	I2C	1.25 mV	1g	2mm x 3mm	3$
Voltage Divider circuit	ADC Port	23.4 mV	N/A	Discrete Circuit	~$ 1.00

Source: Datasheet

SELECTED: VOLTAGE DIVIDER CIRCUIT

Voltage divider circuit using ADC port

- It uses just two series resistors
- Easy implementation
- Uses Analog-to-Digital (ADC) Port
- No external hardware required



A voltage divider circuit consisting of two resistors in series will divide the input voltage to bring it within the range of the Arduino Analog inputs.

Container Battery Voltage Sensor Trade & Selection

SENSOR	INTERFACE	RESOLUTION	WEIGHT	SIZE	COST
MAX17043G+U	I2C	1.25 mV	1g	2mm x 3mm	3$
Voltage Divider circuit	ADC Port	23.4 mV	N/A	Discrete Circuit	~$1.00

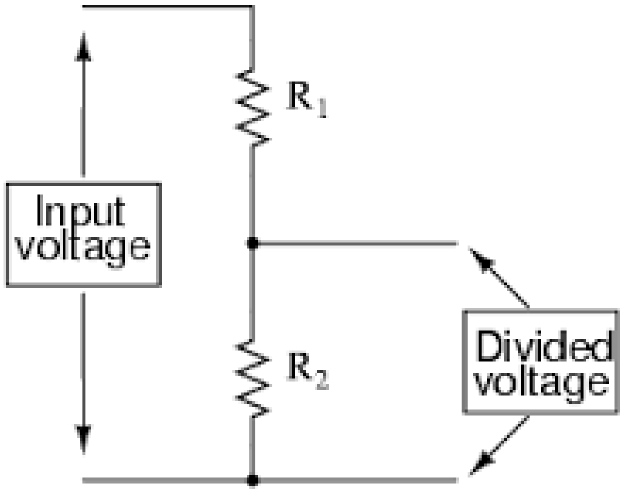
Source: Datasheet

SELECTED: VOLTAGE DIVIDER CIRCUIT

Voltage divider circuit using ADC port.

The circuit with following resistance values:
R1 = 1MΩ and
R2 = 100kΩ

has an input impedance of 1MΩ + 100kΩ = 1.1MΩ and is suitable for measuring DC voltages up to about 50V.



A voltage divider circuit consisting of two resistors in series will divide the input voltage to bring it within the range of the Arduino Analog inputs.

Bonus Camera Trade & Selection

MODEL	SIZE	RESOLUTION	SCANNING FREQUENCY	OPERATING VOLTAGE
CMOS SEN11745 ROHS	Medium	728x488	15.625 KHz	6-20 V
CMOS OV7670	Medium	640x480	17 KHz	1.7-3 V
Serial TTL Camera VC0706 Processor	Medium	640x480	Progressive Scanning	5 V

Source: Datasheet

SELECTED CAMERA: Adafruit Serial TTL JPEG Camera

- Size: 32mmx32mm
- Operating Voltage: 5 V
- Baud Rate: 38400
- Current Draw: 75 mA
- Resolution: 640x480 pixels
- Communication: 3.3V TTL(UART Protocol using Rx/Tx)

Reason : Good Resolution of 640x480 with Easy Interfacing and Programming.

Descent Control Design

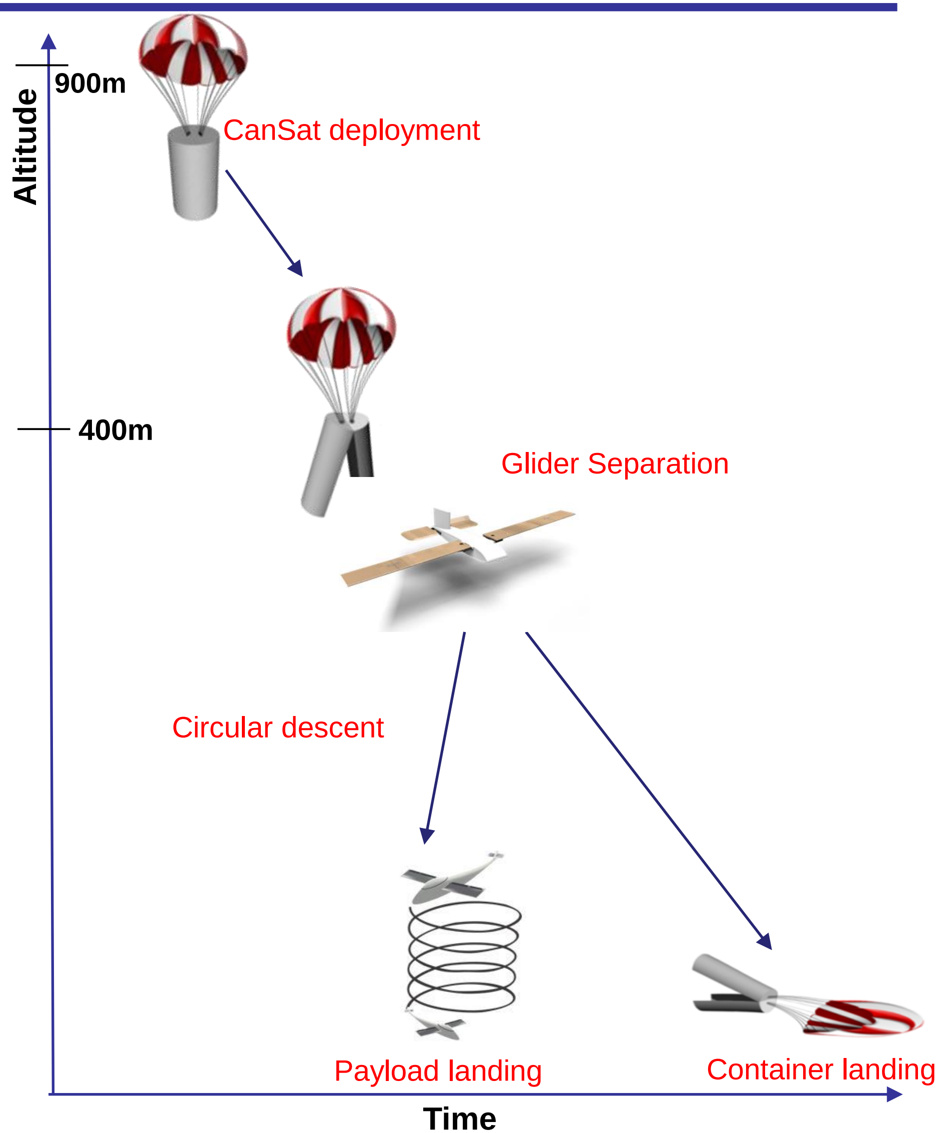
Pooja Dahiya

Container Descent Control System

- Descent control system consists of a parachute having base diameter of 80 cm for container, with a spill hole diameter of 4 cm to provide stability.

Glider Descent Control System

- Fixed wing glider configuration having unequal wing area and elevators at different angle of attack with full rudder in direction of rotation.
- At approx. 400m re-entry container is opened and glider is released.
- Post separation, glider shall automatically descent due to its weight and owing to its design, it will glide in a circular pattern.
- Glider has an audio beacon on-board which activates once it lands.
- The container system and the payload system are controlled separately using Arduino Nano.



Descent Control Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
DCS-01	Total mass of the CanSat (container and payload) shall be 500 grams +/- 10	Competition Requirement	HIGH	SR-01	✓	✓		
DCS-02	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm	Competition Requirement	HIGH	SR-02		✓	✓	
DCS-03	The container shall use a passive descent control system	Competition Requirement	MEDIUM	SR-03	✓		✓	
DCS-04	Parachute must be designed to avoid tangling of shroud lines while descending	Prevent tangling during descent that could lead to a failed recovery	HIGH	SR-03		✓		✓
DCS-05	Parachute with spill hole should provide a descent rate of 8.95m/s to the CanSat before 400m	To provide an optimum velocity to Glider after getting deployed	HIGH	SR-03	✓			

Descent Control Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
DCS-06	The parachute shall not exceed a packing depth of 10 mm at the top of the re-entry container	Allow for sufficient space allocated to the rest of the systems	MEDIUM	SR-12	✓	✓		
DCS-07	Both parachute and Glider must be reasonably light	Keep the weight budget from exceeding 500 g	MEDIUM	SR-01	✓	✓	✓	
DCS-08	The container and glider need to be separated at an altitude above 400m	Competition Requirement	HIGH	SR-06		✓	✓	
DCS-09	The Glider must be fixed to glide in a preset circular pattern of no greater than 1000 meter diameter	Competition Requirement	HIGH	SR-07	✓		✓	

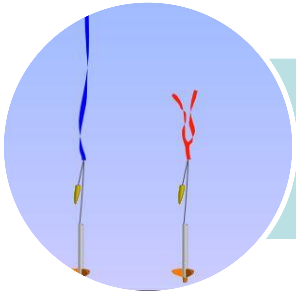
Descent Control Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
DCS-10	Glider shall be a fixed wing glider	Competition Requirement	HIGH	SR-19	✓	✓		
DCS-11	The glide duration should be 2 minutes	Competition Requirement	HIGH	SR-20	✓	✓	✓	
DCS-12	Decent Control System shall not use flammable or pyrotechnic devices	Competition Requirement	HIGH	SR-11	✓		✓	
DCS-13	Materials used to be light and flexible	To minimize mass and volume requirements	MEDIUM	SR-01		✓		

Container Descent Control Strategy Selection and Trade

Parachute with a spill hole can reduce the speed as per the requirements, and easy to fabricate.

Para-foils can reduce the speed as per the requirements but it is very difficult to fabricate and examine the landing position**.**



Streamers can provide vertical landing but they are used for light weight objects (10-20 gm).

Selected Container Descent Control Strategy**: Parachute**

Container Descent Control Strategy Selection and Trade

Reasons behind selecting Parachute are-

- Parachute is considered optimal for higher drag.
- They are compact and light weight.
- Descent Rate can be easily adjusted.
- Deployment is easy and soft.

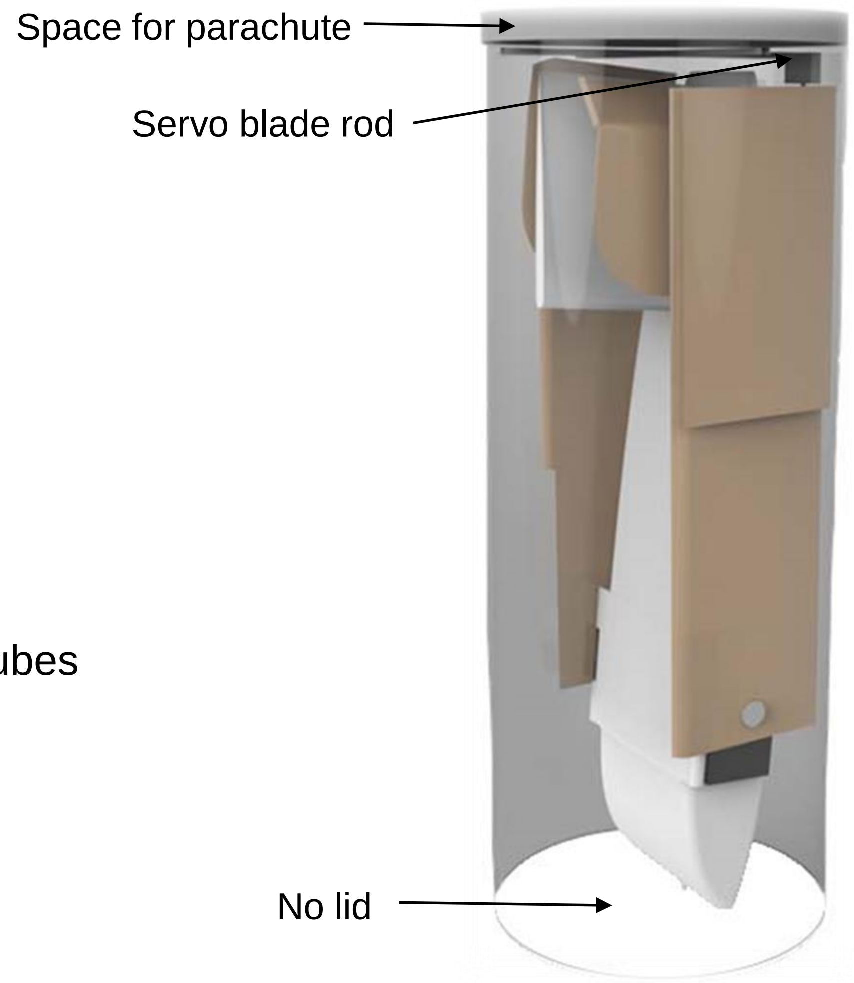
- Color used is Florescent Orange.
- **Connections:** To increase stability, the swivel is used to attach the parachute to the nylon wire, preventing shroud lines from entangling.
- Length of the shroud lines is 1.15 times the base diameter of parachute.

Pre Flight Testability-

- Inspection for wings deployment.
- Verify parachute deploys correctly.

Note: In case the parachute fails, the Re-entry container is tested to survive 30 Gs of shock. **(Simulation tests passed)**

A. Servo-cutting Payload release mechanism



PROS

- No loose parts
- Less complicated overall design

CONS

- Inefficient use of space available
- High probability deployment failure
- Weight addition by reinforcement tubes

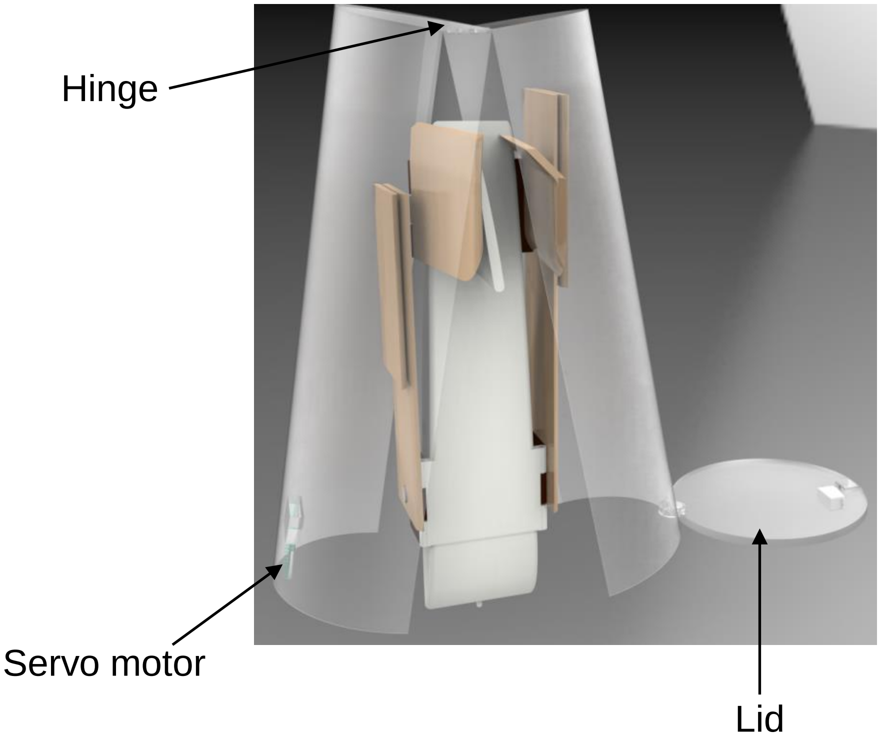
B. Servo-Locked Payload Release Mechanism

PROS

- Very low chances of deployment failure
- Efficient use of available volume
- High toughness

CONS

- Complex fabrication
- Loose parts
- Chances for abrupt deployment



Container Descent Control Strategy Selection and Trade

MODEL	STRATEGY	STRENGTH	EASE OF FABRICATION	EASE OF DEPLOYMENT	COST
A	Servo-cutting container	8	7	5	7
B	Servo Locked Payload Release Mechanism	8	7	8	8

We chose **Model B**: **Servo Locked Payload Release Mechanism** because of its ease of fabrication, lower chances of payload deployment failure and cheap cost.

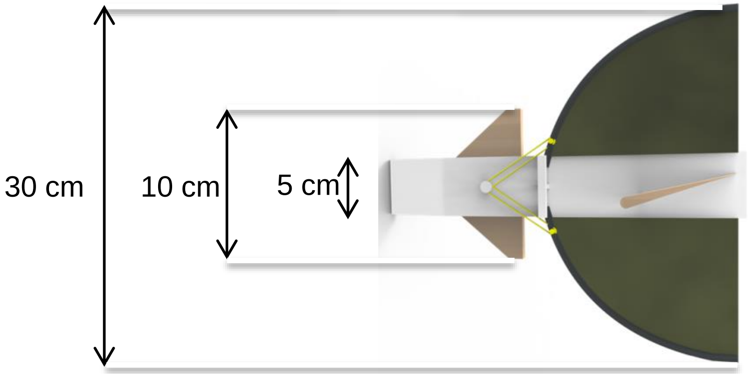
Grading (0-10):
0 – Least
10 - Most

Payload Descent Control Strategy Selection and Trade

A. Canard formation with elevators at different angle of attack and full rudder in direction of rotation.

PROS

- Highly stable
- Canard decreases main wing turbulence
- Dual lifting surfaces increases lift



(Deployed)

CONS

- High descent speed
- Difficult to fabricate
- Complex wing folding mechanism
- Less surface available for placement of solar panels.

Glide Ratio: 0.775

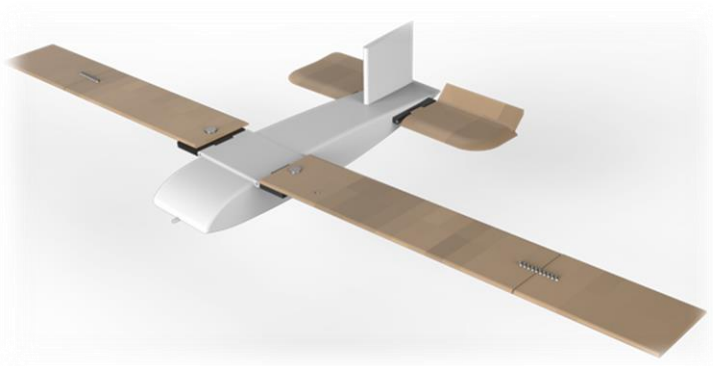
(Stowed)

Payload Descent Control Strategy Selection and Trade

B. Wings with different area with elevators at different angle of attack and rudder full deflection

PROS

- Easy to fabricate
- Better Glide time
- Appreciable stability
- Adequate surface for placement of solar panels



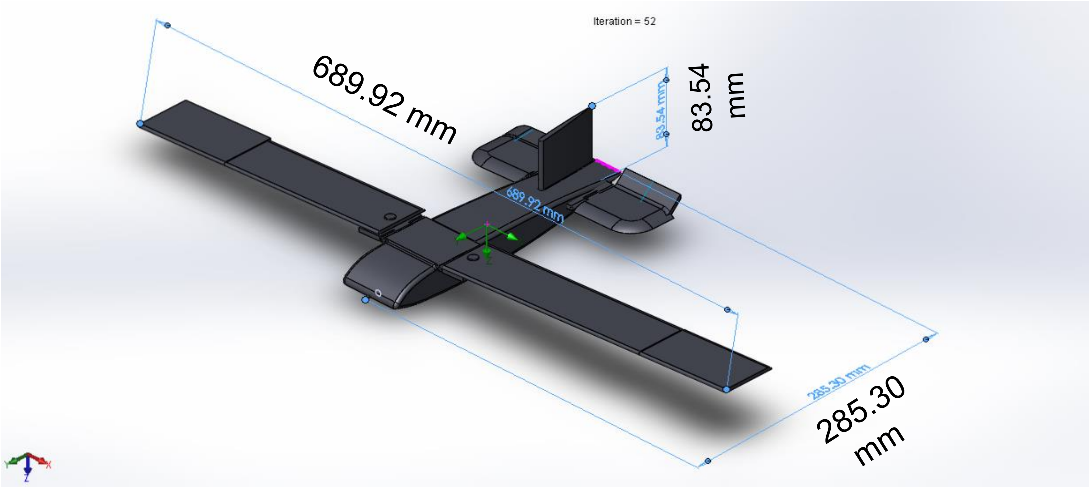
(Deployed)

(stowed)

CONS

- More drag due to high aspect ratio
- Greater wing loading

Glide Ratio – 1.525



Payload Descent Control Strategy Selection and Trade

MODEL	STRATEGY	STRENGTH	EASE OF FABRICATION	STABILITY	COST
A	Canard formation With elevators at different angle of attack and rudder at full deflection	5	5	8	5
B	Wings with different area with elevators at different angle of attack and rudder at full deflection	8	8	7	8

SELECTED: Model '**B**' because of its higher strength, greater stability, ease of wing folding mechanism and lower cost.

Grading (0-10):
0 – Least
10 - Most

Payload Descent Control Strategy Selection and Trade

Reasons for choosing wings with different areas with elevators at different angle of attack and rudder in full deflection

- This design will ensure glide in a preset circular pattern which was noticed during the testing phases.
- Glider wings without any control surfaces can be easily folded and occupies less space which is in the favor of the volume constraints.
- The Glider fuselage will be made of Depron using 3-D printing technique, the wings will be of Balsa wood, hinges will be made of ABS material using 3-D printing technique.
- Glider with wings having different wing area has less complex folding mechanism than the other design and that is provides ample space for the solar panels to be placed.

Note: The Glider shall be colored **Fluorescent Orange** for visual aid during helical decent and landing.

Descent Rate Estimates

Formulae Used For Calculating Descent Rate:

Equations:

1. $L = \frac{1}{2}\rho v^2 S C_L$

L = Lift Force
C_L = Coefficient of Lift
S = Surface area
ρ = Air density at deployed altitude (1.205 kg/m^3)

2. $v = \frac{d}{t}$

v = Descent Velocity
d = Distance from Ground
t= Time Taken for descent.

3. $R_p = \sqrt{\frac{2F_{Drag}}{\pi \rho V^2 C_d}}$

F_{Drag} = Drag force on parachute
g = Acceleration due to Gravity (9.81 m/s^2)
C_d = Coefficient of Drag (assumed 0.21)

4. $A = 0.95\pi R_p^2$

R_p = Radius Of Parachute with 5% spill hole radius
A = Area of Parachute.

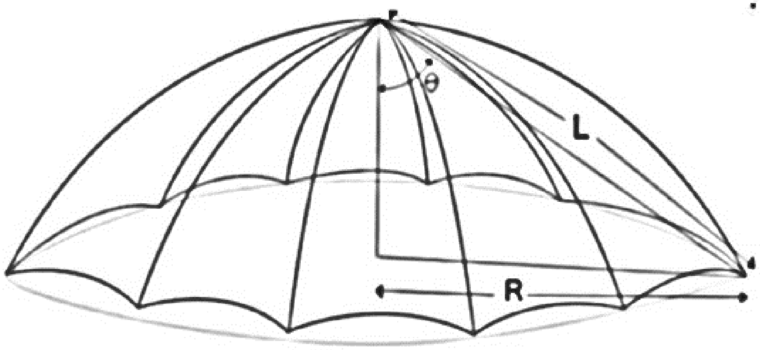
Conservation Of Energy is Used for finding Velocity of Container Post glider separation.
Initial P.E + Initial K.E = Final P.E + Final K.E

Descent Rate Estimates

Decent Rate Estimation of Container

- To govern the Decent Rate of the Container a **Hemispherical Chute** will be used which will oversight it's track.
- To obtain the desired parameters such as Drag, Radius of Parachute and vertical velocity, formula used is:

$$R = \sqrt{\frac{2F_{Drag}}{\pi\rho V^2 C_d}}$$



Where-

- R= Radius of the Chute 40 cm
- $\pi = 3.14159265359$
- $\rho = 1.12429$ kg/m^3 (density of air as of Stephenville average temperature 32℃ above 500m level)
- $C_d = 0.21$(co-efficient of Drag for parachute)
- $F_{drag} = 4.905\ kg.m/s^2$

Descent Rate Estimates

Decent Rate Estimation of Container

For Recovery;

Drag = Weight

& R $\propto \frac{1}{v}$

i.e. Increasing Radius will Decrease the Velocity.

Some General Estimates of Parachute, with 5% radius of spill holes:

General Rates (m/s)	Diameter of Chute (cm)
5 m/s	120 cm
7.5 m/s	92 cm
8.95 m/s	**80 cm (Selected)**
10 m/s	60 cm

Descent Rate Estimates

Decent Rate Estimation of Glider

- $a = \frac{W-L}{m}$
- $v = u + at \quad (u = 0)$
- $t = \frac{v\,m}{(W-L)}$

a = Acceleration
W= Weight of glider
L = Lift
v = Terminal velocity
u = Initial velocity
t = Time of flight
m = Mass of glider

Assumptions:

- Density of air remains constant

The experimental and theoretical calculations were approximately same

- A Test Model of the Glider was taken airborne using Quadcopter.
- The Glider was taken up to a height of 190m which was measured using Sextant.
- Its descent time was clocked at 30s

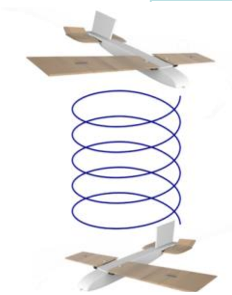
Descent Rate Estimates

Estimated Descent Rate of **container with payload** using the formula-

$$R = \sqrt{\frac{2F_{Drag}}{\pi \rho V^2 C_d}}$$

495 g

v= 8.95 m/s



Descent Rate of **Glider** after multiple drop tests comes out to be-

v= 6.33 m/s

250 g

Descent Rate of **Containe**r calculated using Conservation of Energy-

v= 6.9 m/s

245 g

Note: Video of testing shall be provided upon request.

Descent Rate Estimates Summary

Configuration	Mass (g)	Descent Rate Estimate (m/s)
Container With Glider	495	8.95
Container Only (With Parachute attached)	245	6.90
Glider Only	250	6.33

Mechanical Subsystem Design

Devarrishi Dixit

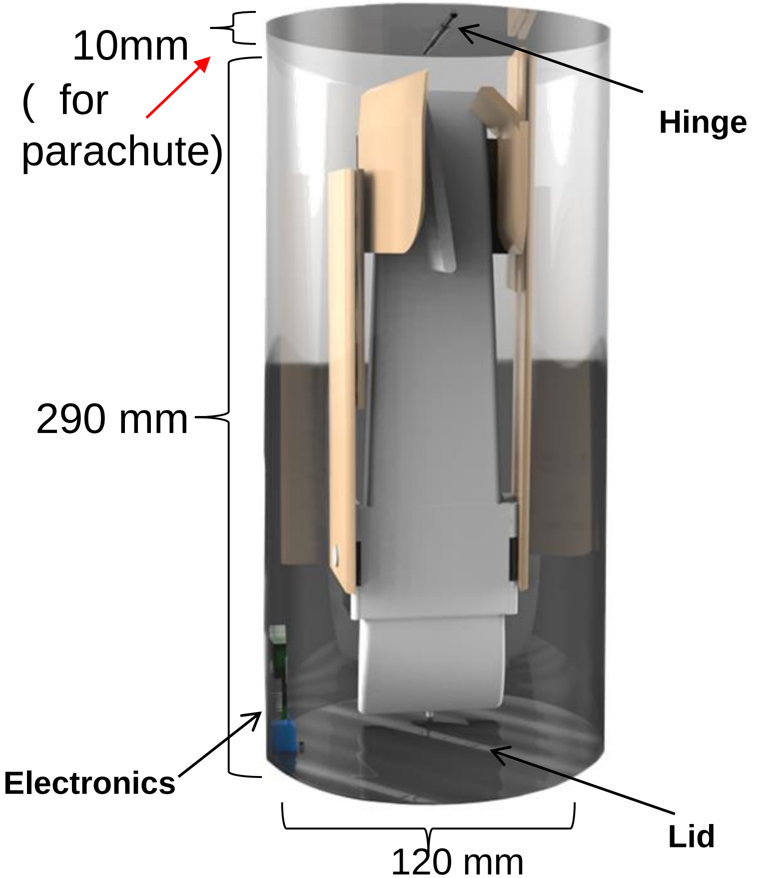
Mechanical Subsystem Overview

Major structural components of the CanSat includes the **Container** and the **Glider**. Total mass would be 500 grams ± 10 grams.

CONTAINER

- **Structure:** to be made from Acrylic sheets having high strength to weight ratio.
- **Descent Control Mechanism**: consists of a hemispherical parachute of base diameter of 60mm with a spill hole of diameter 6mm.
- **Electronics**: Electronics in the re-entry container includes a Arduino Nano, BMP180, Xbee Pro S2C, Voltage divider circuit and a servo latch.

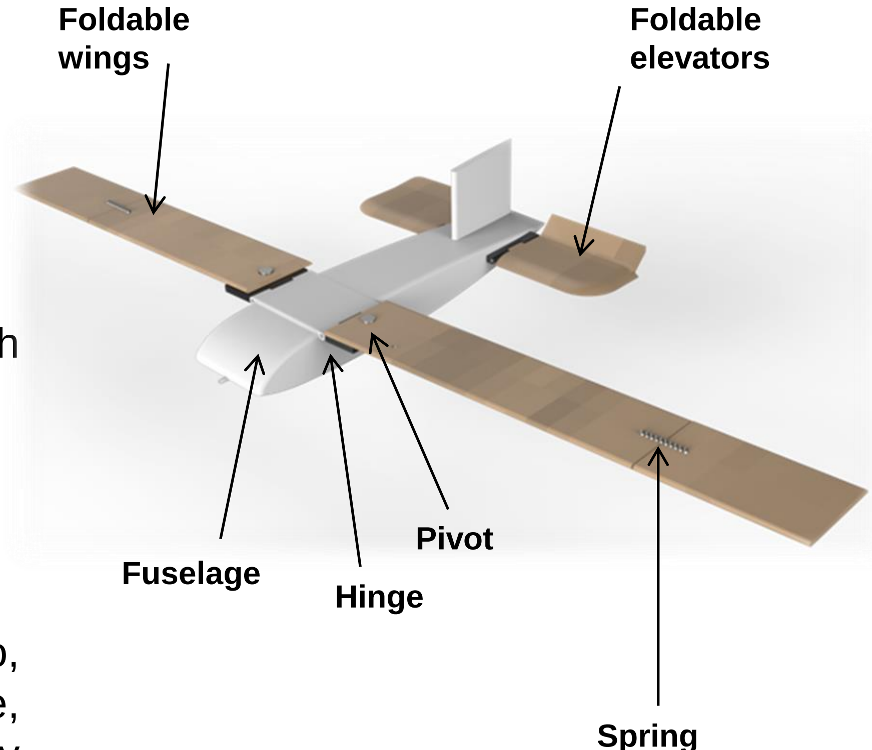
The glider wings and stabilizers are folded and kept inside the container.



GLIDER

- **Structure:**
  - Fuselage would be made of **Depron** material.
  - Solar cells placed on top of wings.
  - Wings and stabilizers made of Balsa wood.
  - Hinges would be 3-D printed of ABS material.
  - Wings and stabilizers would unfold itself with restoring force of springs.
  - PCB bolted to fuselage.

- **Electronics:**
  - Glider electronics includes : Arduino Nano, Xbee Pro S2C, BMP180, Camera, Pitot Tube, Magnetometer, Audio Beacon - all powered by Solar Cells.



Mechanical Sub-System Requirements

ID	Requirement (GLIDER)	Rationale	Priority	Parent	VM			
					A	I	T	D
MSR-01	The glider shall be completely contained in the container	Competition Requirement	HIGH	SR-02, 04	✓	✓	✓	
MSR-02	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm	Competition Requirement	HIGH	SR-02		✓	✓	
MSR-03	The glider must be released from the container at 400 meters +/- 10 m	Competition Requirement	HIGH	SR-06	✓		✓	
MSR-04	The glider shall not be remotely steered or autonomously steered	To Facilitate Deployment	HIGH	SR-07		✓		✓
MSR-05	All electronic components shall be enclosed and shielded from the environment with the exception of sensors	Competition Requirement	HIGH	SR-08	✓	✓		
MSR-06	All structures shall be built to survive 15 Gs acceleration	Competition Requirement	HIGH	SR-09		✓	✓	

Mechanical Sub-System Requirements

ID	Requirement (GLIDER)	Rationale	Priority	Parent	VM			
					A	I	T	D
MSR-07	All structures shall be built to survive 30 Gs of shock	Competition Requirement	HIGH	SR-09	✓	✓		
MSR-08	Both the container and glider shall be labelled with team contact information	Competition Requirement	HIGH	SR-13		✓	✓	
MSR-09	The glider must include an easily accessible power switch	Competition Requirement	HIGH	SR-15	✓		✓	
MSR-10	Glider shall be a fixed wing glider	Competition Requirement	HIGH	SR-19	✓	✓		
MSR-11	The glider shall use a time keeping device to maintain mission time	Competition Requirement	HIGH	SR-21	✓		✓	
MSR-12	An audio beacon for the glider shall be included and powered off of the solar power	Competition Requirement	HIGH	SR-19		✓	✓	✓

Mechanical Sub-System Requirements

ID	Requirement (Container)	Rationale	Priority	Parent	VM			
					A	I	T	D
MSR-13	Total mass of the CanSat (container and glider) shall be 500 grams +/- 10 grams	Competition Requirement	HIGH	SR-01	✓	✓		
MSR-14	The container shall use a passive descent control system	Competition Requirement	HIGH	SR-02		✓	✓	
MSR-15	The container shall not have any sharp edges	Competition Requirement	HIGH	SR-03	✓	✓		
MSR-16	The container shall be a florescent colour, pink or orange.	Competition Requirement	HIGH	SR-24	✓		✓	
MSR-17	The rocket airframe shall not be used to restrain any deployable parts of the CanSat	Competition Requirement	HIGH	SR-05	✓	✓		✓
MSR-18	The rocket airframe shall not be used as part of the CanSat operations	Competition Requirement	HIGH	SR-05	✓	✓		

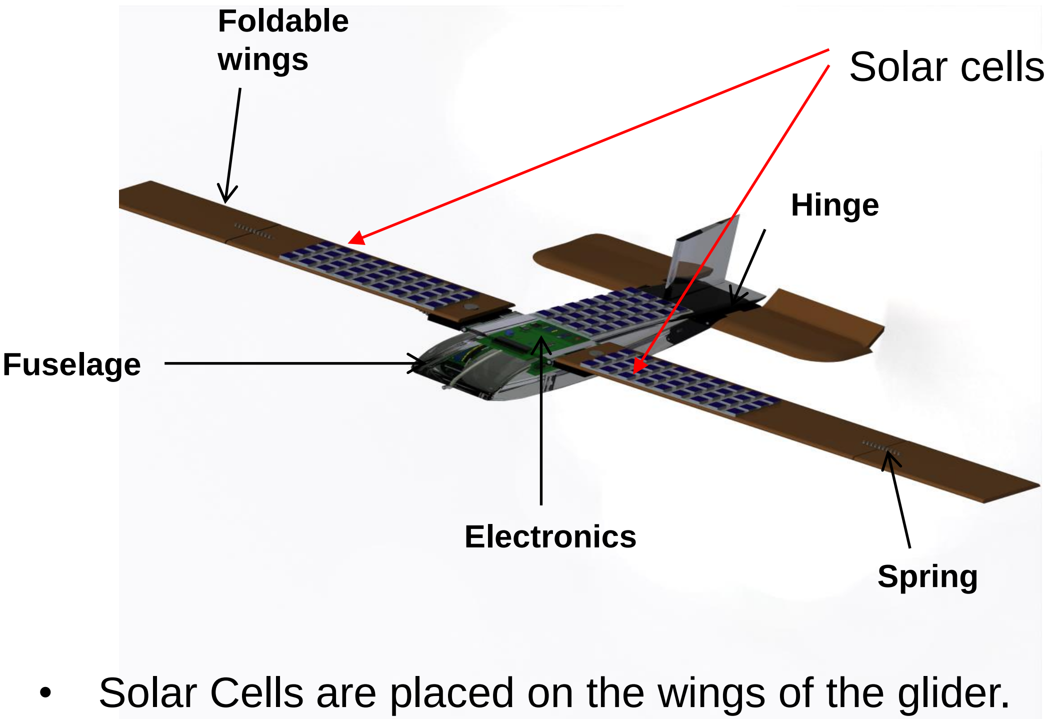
Mechanical Sub-System Requirements

ID	Requirement (Container)	Rationale	Priority	Parent	VM			
					A	I	T	D
MSR-19	The CanSat shall deploy from the rocket payload section	Competition Requirement	HIGH	SR-05	✓			
MSR-20	All descent control device attachment components shall survive 30 Gs of shock	Competition Requirement	HIGH	SR-09	✓	✓		
MSR-21	All descent control devices shall survive 30 Gs of shock	Competition Requirement	HIGH	SR-09	✓	✓		
MSR-22	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives	Competition Requirement	HIGH	SR-10			✓	✓
MSR-23	All mechanisms shall be capable of maintaining their configuration or states under all forces	Competition Requirement	HIGH	SR-07		✓	✓	
MSR-24	Mechanisms shall not use pyrotechnics or chemicals	Competition Requirement	HIGH	SR-11	✓		✓	

Mechanical Sub-System Requirements

ID	Requirement (Container)	Rationale	Priority	Parent	VM			
					A	I	T	D
MSR-25	Mechanisms that use heat shall not be exposed to the outside environment	Competition Requirement	HIGH	SR-09	✓		✓	
MSR-26	The CanSat container shall have a payload release override command	Competition Requirement	HIGH	SR-13	✓		✓	
MSR-27	An audio beacon is required for the container	Competition Requirement	HIGH	SR-21	✓	✓		

Payload Mechanical Layout of Components Trade & Selection

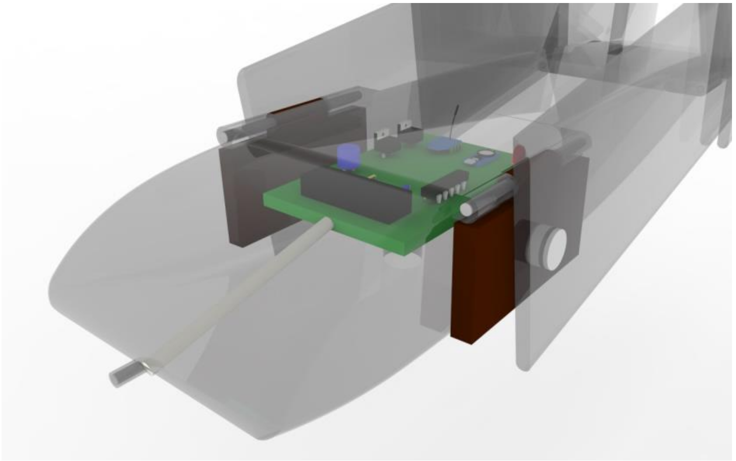


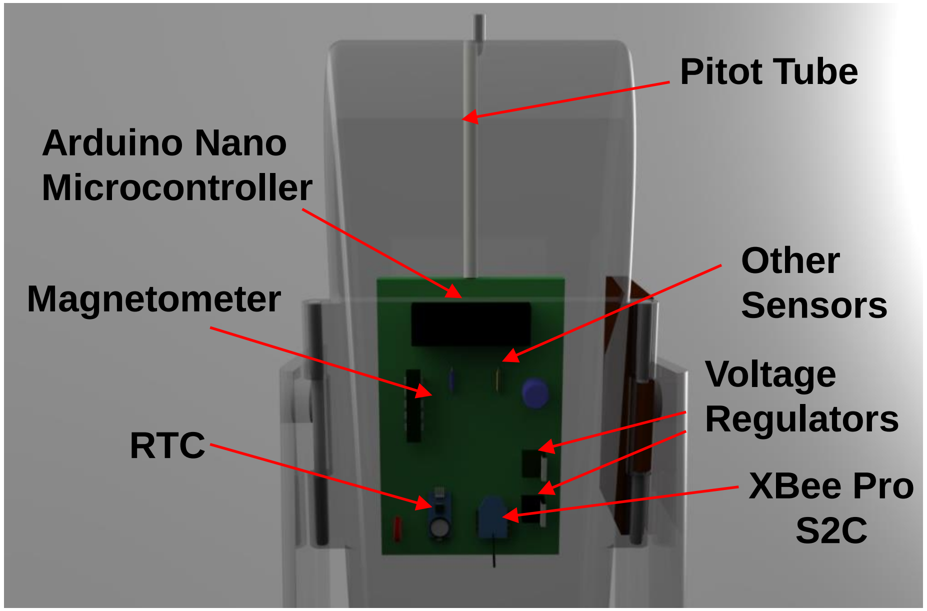
STRUCTURE OF PAYLOAD

- Solar Cells are placed on the wings of the glider.
- The electronics are enclosed inside the fuselage of the payload with opening at the bottom part to place the camera and the external switch.
- The Pitot Tube is placed on the nose of the glider.
- Foldable Wings are used in the glider to save space.

Location Of Electrical Components:

- All electrical components and wires will be placed inside the fuselage with the electronic components.
- Servo motor will be fixed at the bottom lid of the re-entry container.
- Batteries will be applied for the components placed inside the container.

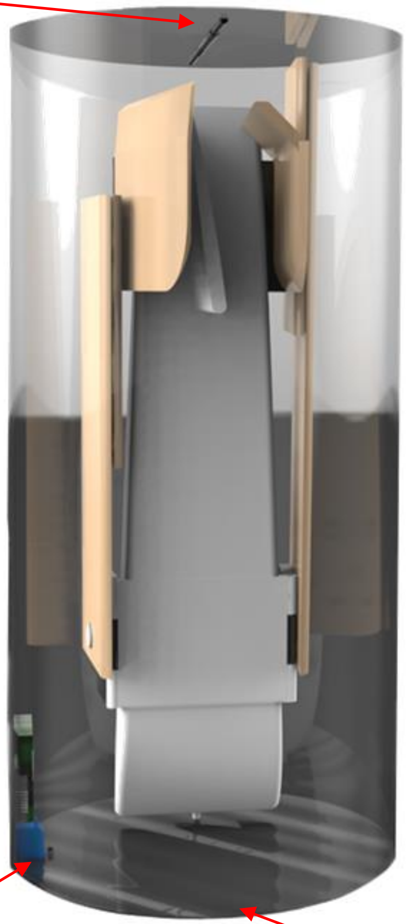




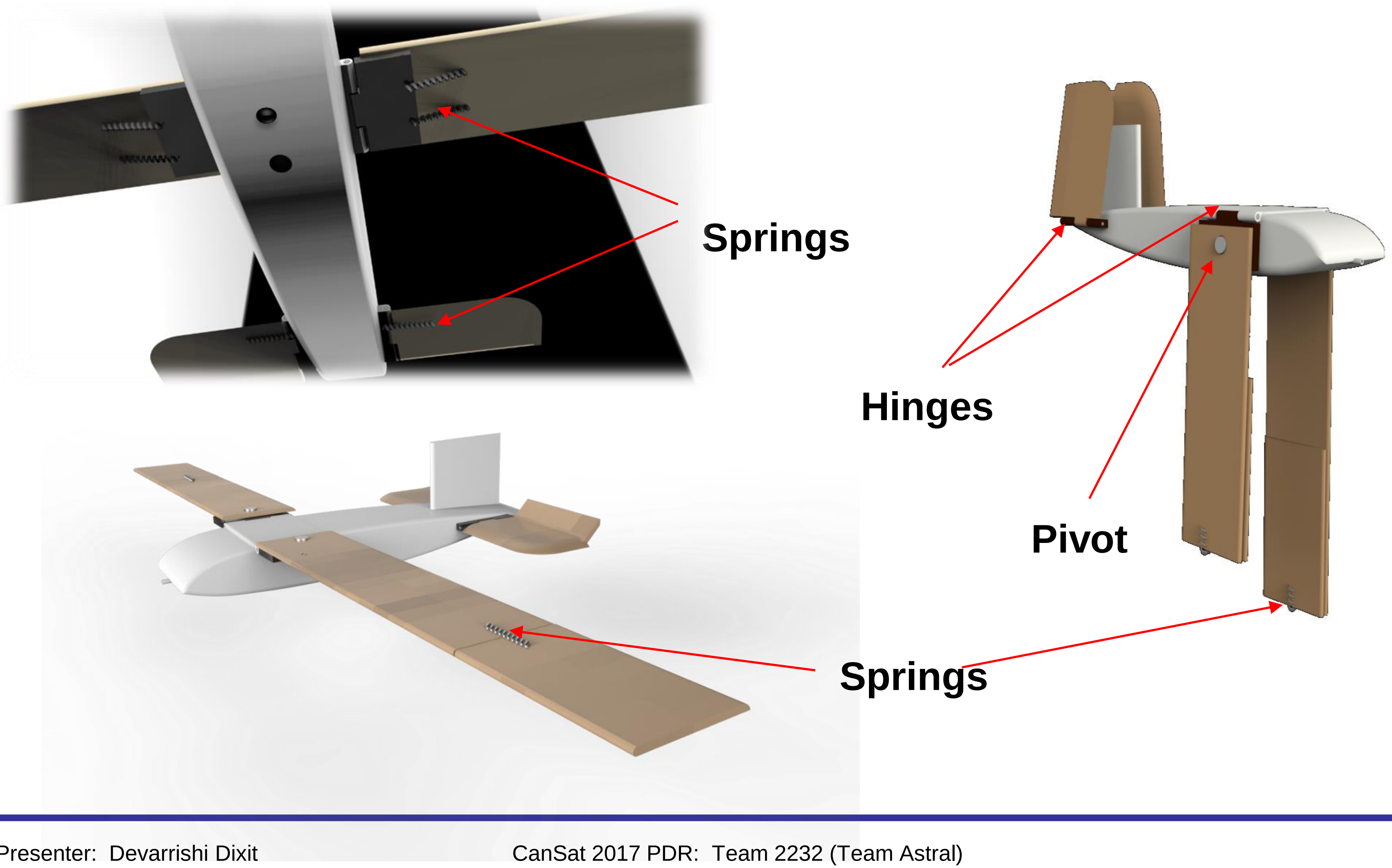
Payload Mechanical Layout of Components Trade & Selection

Container attachment points:

- Glider will be supported by the bottom lid of the container made of acrylic sheets of desired thickness.
- Initially the lid is being locked by the servo motor placed at the bottom of the container.
- The altitude sensor on the container will sense the altitude at 400 ± 10 m and command the servo to rotate and opens the lid.



Hinges with **springs** will be used for the folding and control mechanism of the wings.



Payload Mechanical Layout of Components Trade & Selection

Parameters for Materials selection

- High strength to weight ratio
- Ease of availability
- Economically feasible
- Low interference with electronics

Material selection for **<u>Fuselage</u>**:

MATERIALS	COST	DENSITY	TENSILE STRENGTH	PROS	CONS
Glass fiber reinforced epoxy resin	\$ 0.7-1.15/kg	1.060-1.080 gm. cm^{-3}	60 MPa	• Good surface finish. • High strength to weight ratio	• Low resistance towards UV light • High density
Depron	\$1.96/kg	$33 kg/m^3$	1.30 MPa	• Relatively in-expensive. • Good strength to weight ratio • Wear resistant	• Thermally reactive to adhesives • Requires sturdy reinforcements.

Fuselage Selection and Grade :

MATERIAL	WEIGHT	STRENGTH	EASE OF MACHINING	COST
Depron	9	8	9	9
Glass fiber reinforced epoxy resin	2	9	6	5

SELECTED : **DEPRON**

Reasons:-

- Low density
- Appreciable strength
- Substantial ease of machining

Grading (0-10):
0 – Least
10 - Most

Payload Mechanical Layout of Components Trade & Selection

Wings Selection and trade:

MATERIALS	COST	DENSITY	TENSILE STRENGTH	PROS	CONS
Balsa Wood	$1.5 per sheet	163kg/m^3	19.9 MPa	• Easy machining • Vibration absorbent property • Light weight	• Poor toughness. • Low resistance to shear forces
Nylon Cloth	$5 per meter	115kg/m^3	400 MPa	• High Tensile strength • High Abrasion resistance	• Unable support heavy solar panels • Rapid moisture absorber

Payload Mechanical Layout of Components Trade & Selection

Wings Selection and Grade :

MATERIAL	WEIGHT	STRENGTH	EASE OF MANUFACTURING	COST
Balsa Wood	8	8	8	8
Nylon Cloth	9	6	9	5

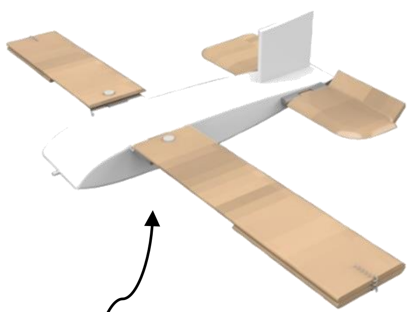
- Due to comparatively **higher shear strength,** **Balsa Wood** is selected.

Grading (0-10):
0 – Least
10 - Most

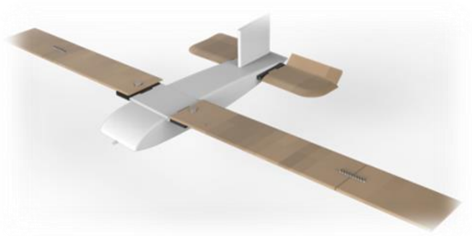
Payload Pre Deployment Configuration Trade & Selection

- The wings chosen for the glider are made of balsa wood and folded using springs and hinges along the length of the fuselage and kept in nose down position inside the container.

  The wings will unfold itself once the glider comes out of the container.
- Any other mode of placement such as using nylon cloth would cause slagging, which will not support required positioning of solar cells, hence rejected.



Stage-2

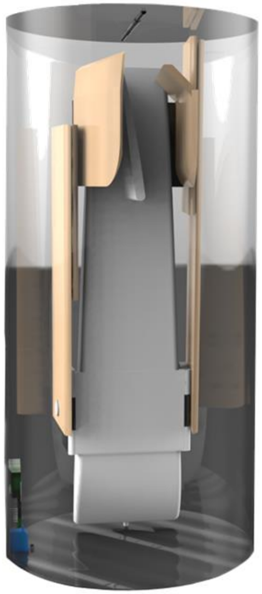


Stage-1

Stage-3

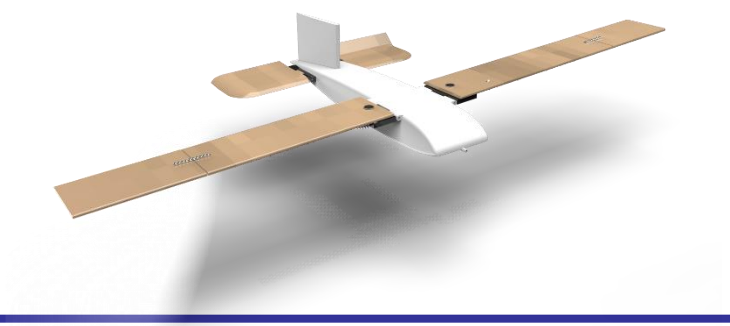
Stage-4

Payload kept in stowed configuration inside the glider



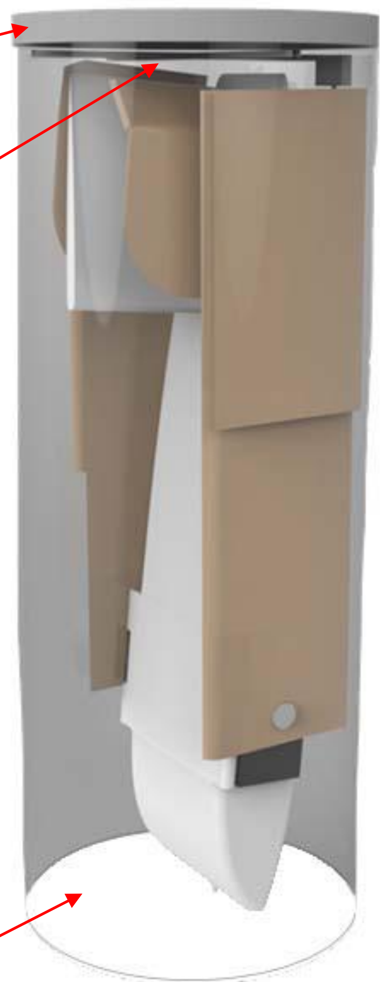
Payload Deployment Configuration Trade & Selection

- As soon as the payload separates from the container, the wings which were folded against the fuselage shall unfold itself with the help of hinges and spring mechanism as proposed.
- Any other changes like usage of rubber bands instead of springs and hinges would prove to be a failure due to high wear, hence not selected.

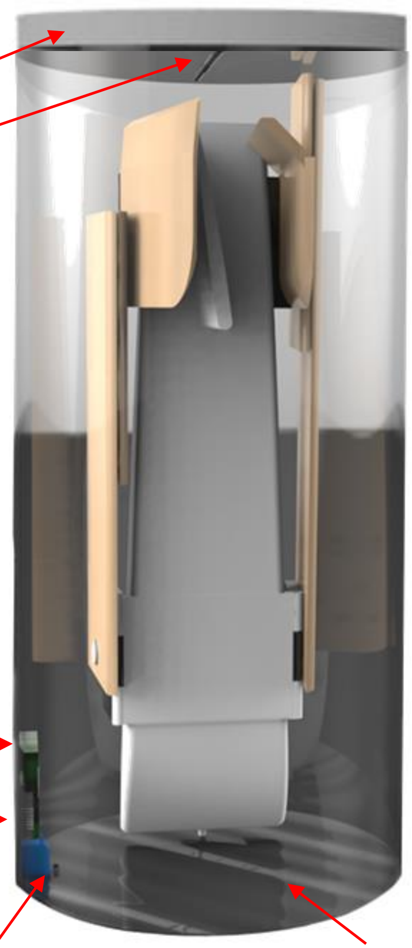


Container Mechanical Layout of Components Trade & Selection

Model -I



Model - II



SELECTED: Model -II

Reason:

- Ease of Fabrication
- Low chances of Payload deployment failure.
- Efficient use of available volume
- Higher toughness

Following materials were considered for container:

Materials	Cost	Density	Tensile Strength	Pros	Cons
Acrylic Sheet	$3.42 per sq.ft.	1190 kg/m^3	69 MPa	• Easy machining • Flexible to resist damage	• Lesser tensile strength compared to other
Aluminum	$0.5 per sq.ft.	2700 kg/m^3	300 MPa	• High durability	• High Density
Carbon Fiber	$30 per kg	1550 kg/m^3	3.5 GPa	• High Strength	• Uneconomical

Container Mechanical Layout of Components Trade & Selection

Container Body Selection and Grade:

MATERIAL	WEIGHT	STRENGTH	EASE OF MACHINING	COST
Acrylic Sheet	8	6	8	6
Aluminum	5	7	6	9
Carbon Fibre	7	9	3	2

Grading (0-10):
0 – Least
10 - Most

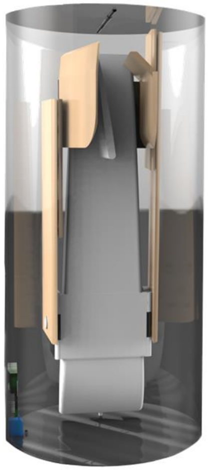
Acrylic Sheet is selected to meet required mission objectives within minimum costs.

Payload Release Mechanism

The re-entry container shall be releasing the glider at an altitude of 400 m.

The re-entry container make use of altitude readings to detect accurate altitudes and activates the servo latch to open the lid, hence releasing the payload.
The re-entry container shall be opening along the length into two halves.
The glider shall free fall due to it’s self weight and the gravity acting on it downwards.
The glider shall release itself and drop down as soon as the re-entry container opens itself.
The wings of the glider shall unfold as soon as the glider escapes the container with the help of hinges on the wings of the glider.
The glider shall take the preset circular path.

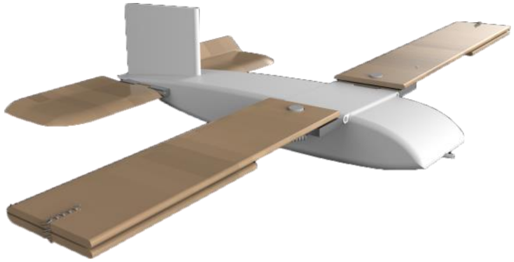
Payload Release Mechanism



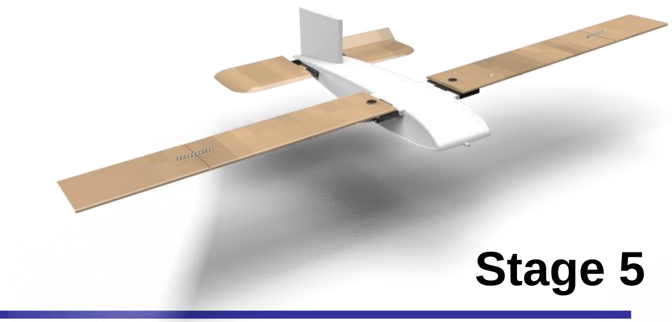
Stage 1

Stage 2

Stage 3



Stage 4



Stage 5

Electronics Structural Integrity

Mounting	• PCB'S will be secured with circuits board standoff and bolts • No electronics are exposed to the outside atmosphere except for the sensors.
Electronics Enclosure	• Electronics shall be enclosed inside the fuselage of the glider and fastened with stand-offs and screws
Connection	• All electrical connections are verified and secured using insulated tape and poping tape.
Descent control Attachments	• Usage of nylon chord for attaching parachute with the container
Test	• Scale model was tested using SolidWorks and the result showed no deformation • Drop test observation for Re-entry Container.

Note: Scaled 3D models were simulated in SolidWorks for Structure Survivability Trades as follows:

Electronics Structural Integrity

Drop Test Result

STRUCTURE MADE OF	WEIGHT	STRENGTH	EASE OF MANUFACTURING	DROP TEST RESULT (Solid works)
Glass fiber reinforced epoxy resin	6	7	7	7
Polypropylene	9	6	9	8
Carbon Fibre	7	9	8	8

Grading (0-10):
0 – Least
10 - Most

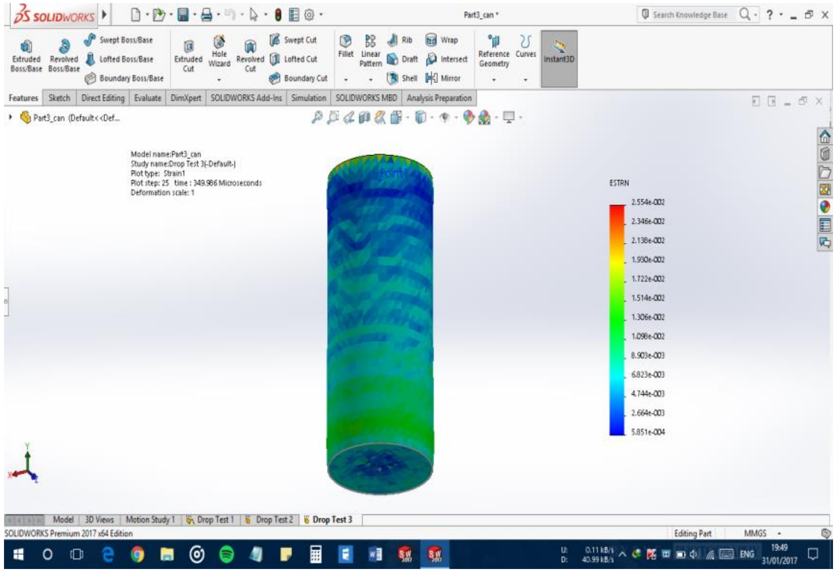
Structure material chosen: **Polypropylene**
Owing to its lightweight and ease of manufacturing

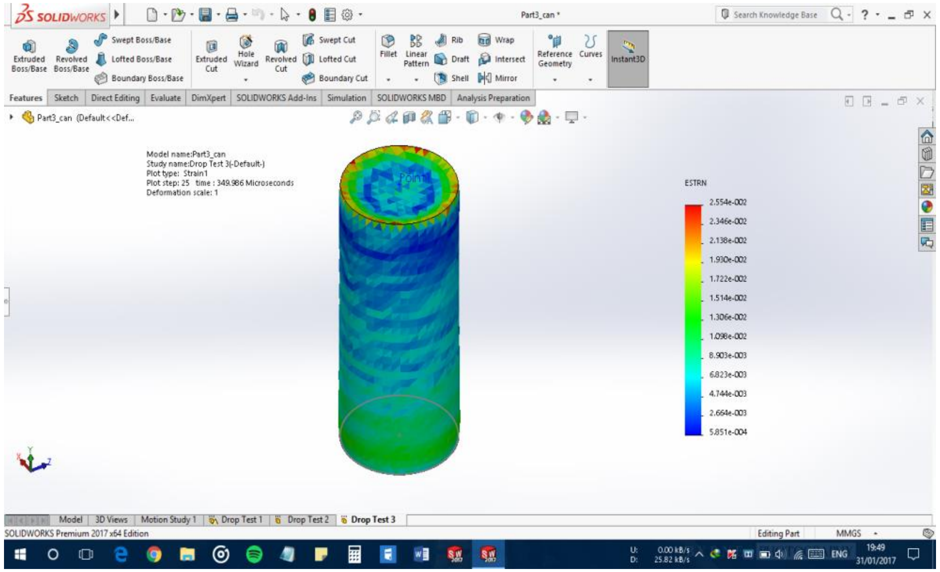
(Experimental)
Drop Test Observation Glider using Quadcopter

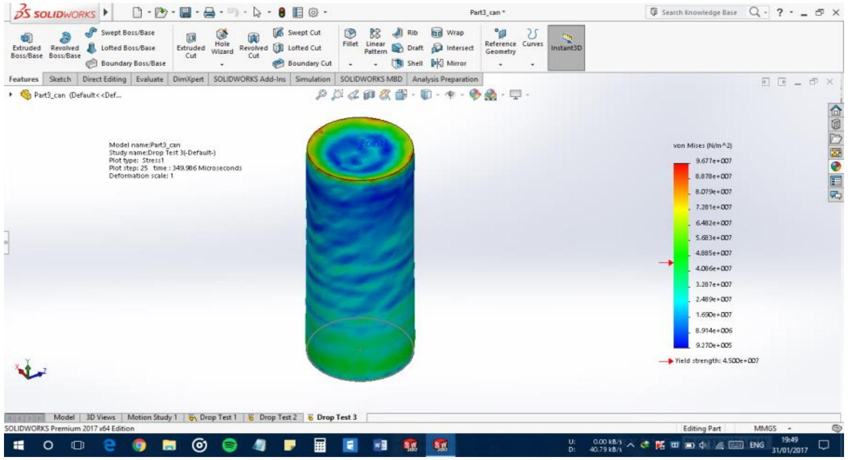
- Quardcopter Drone carried the Glider and dropped it from a height of 200m.
- Glider descended on covering a circular diameter.
- Telemetry Parameters were transmitted and collected.
- No visible damage to the Glider during the drop test.

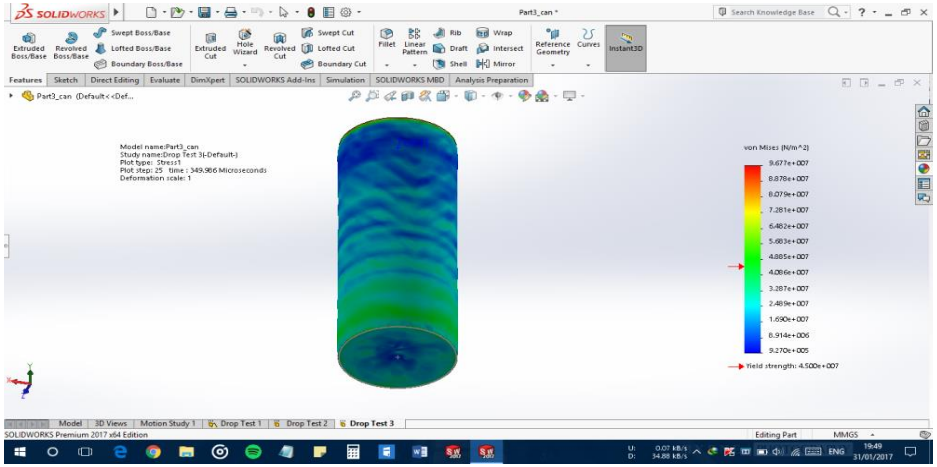
Electronics Structural Integrity

Container Drop Test Simulation for Stress and Strain variation



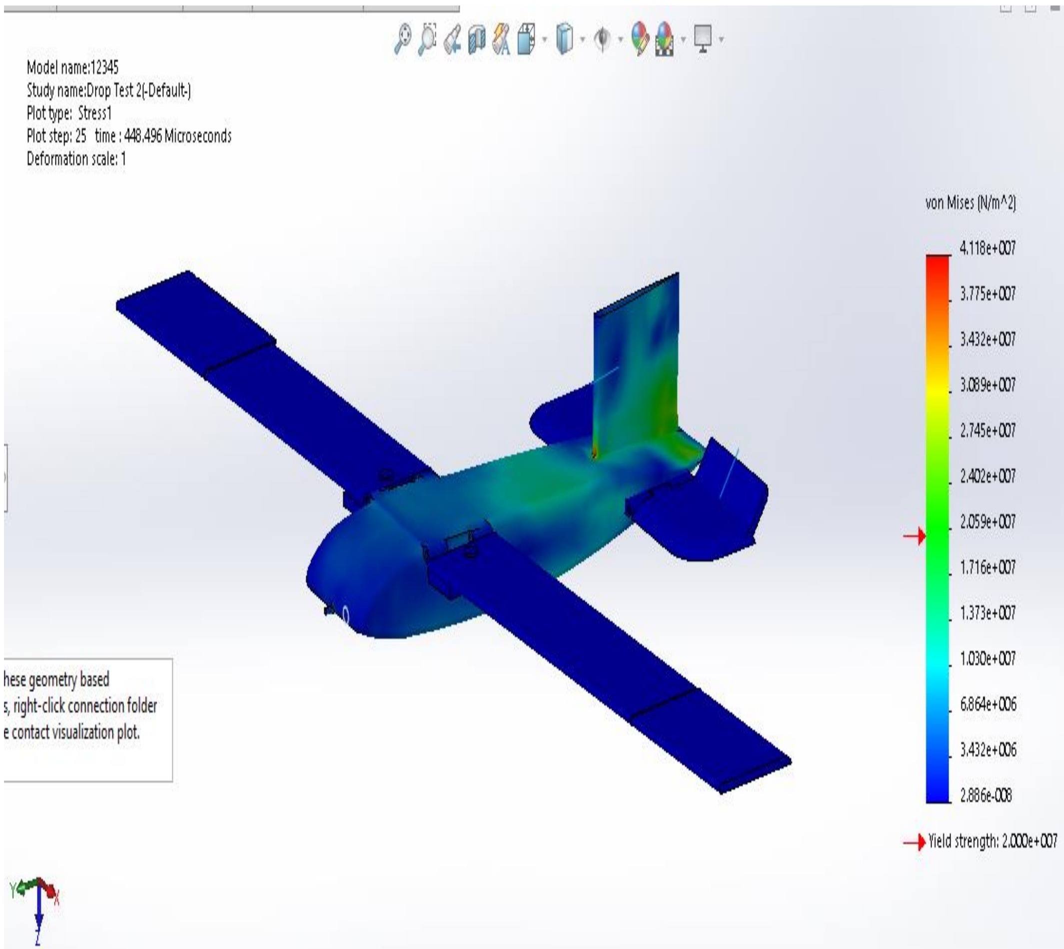


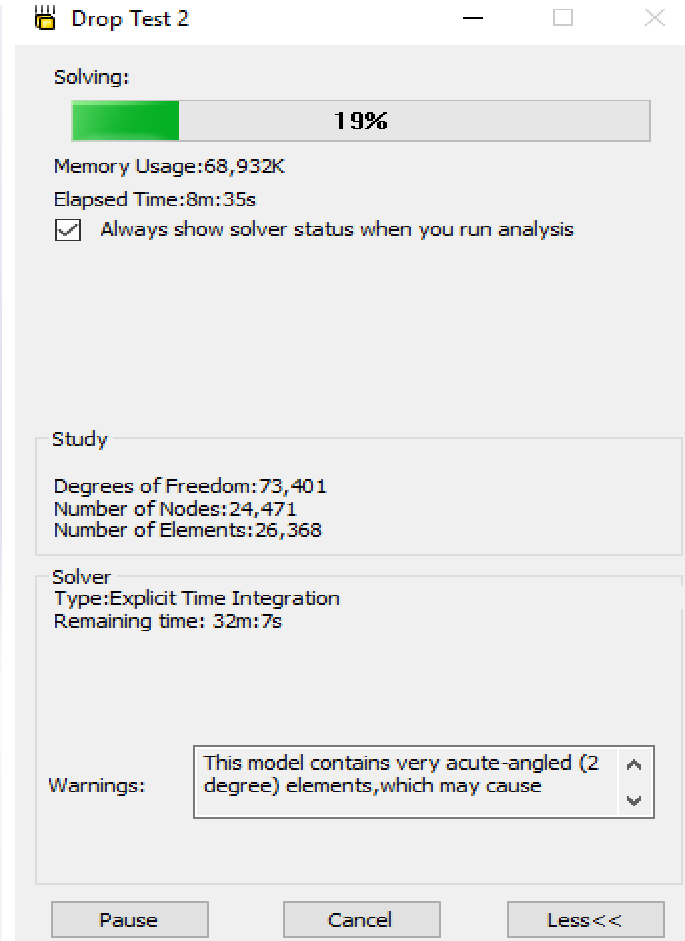




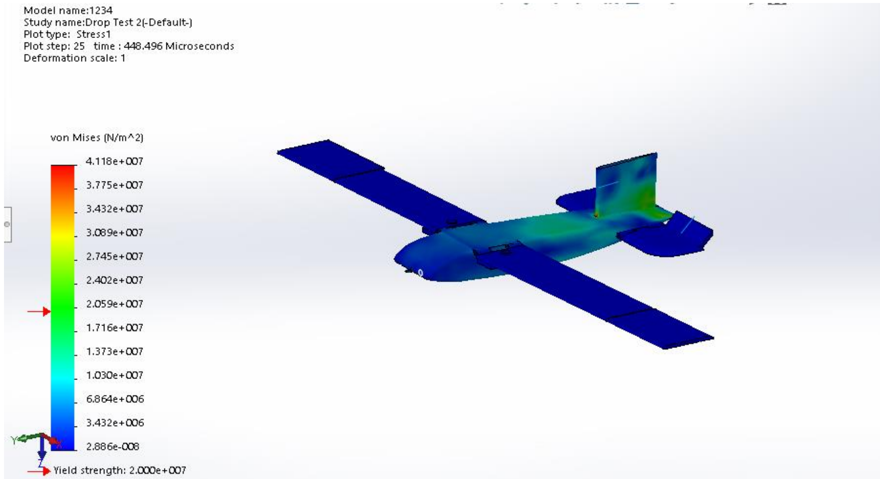
Electronics Structural Integrity

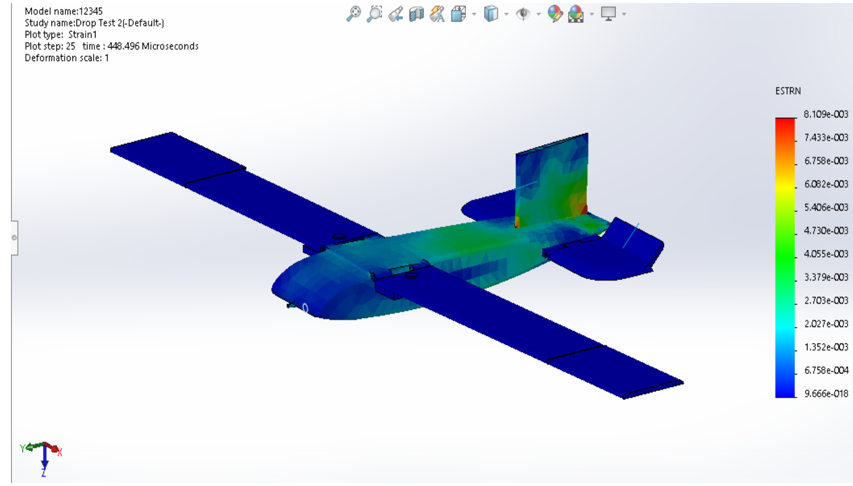
Drop test simulations were done in SolidWorks and the results are as below.
It shows the structure survives 30Gs of acceleration and 15Gs of shock.

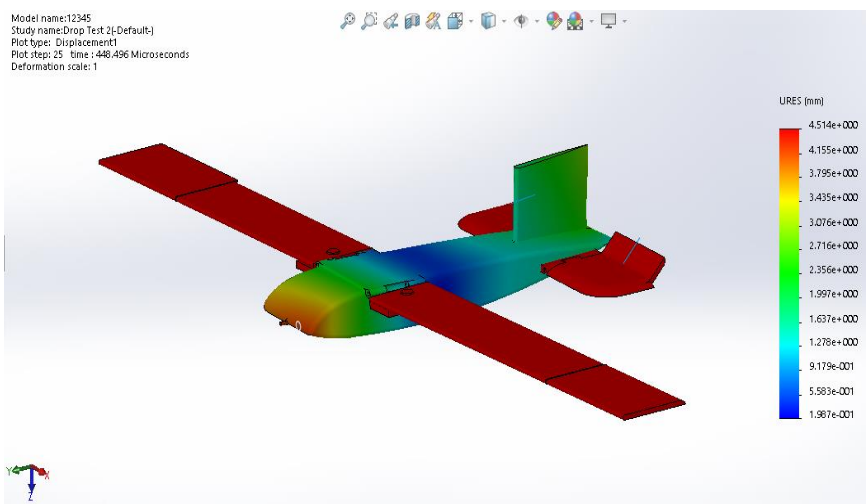


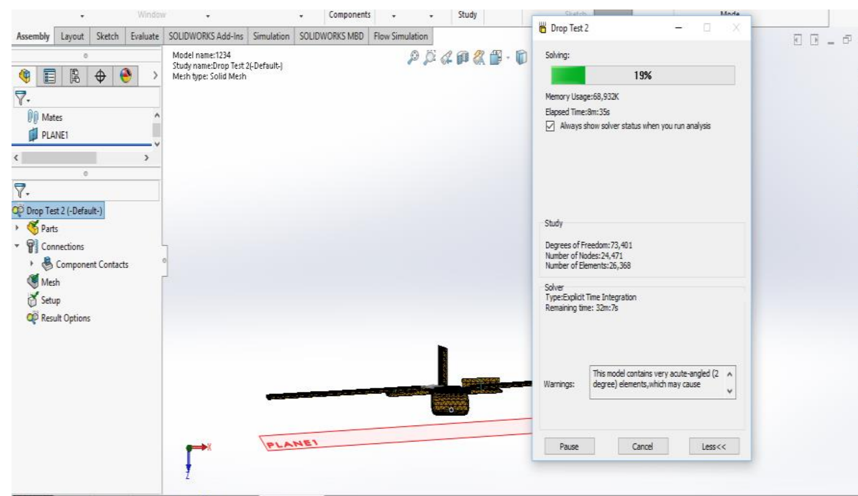


Electronics Structural Integrity







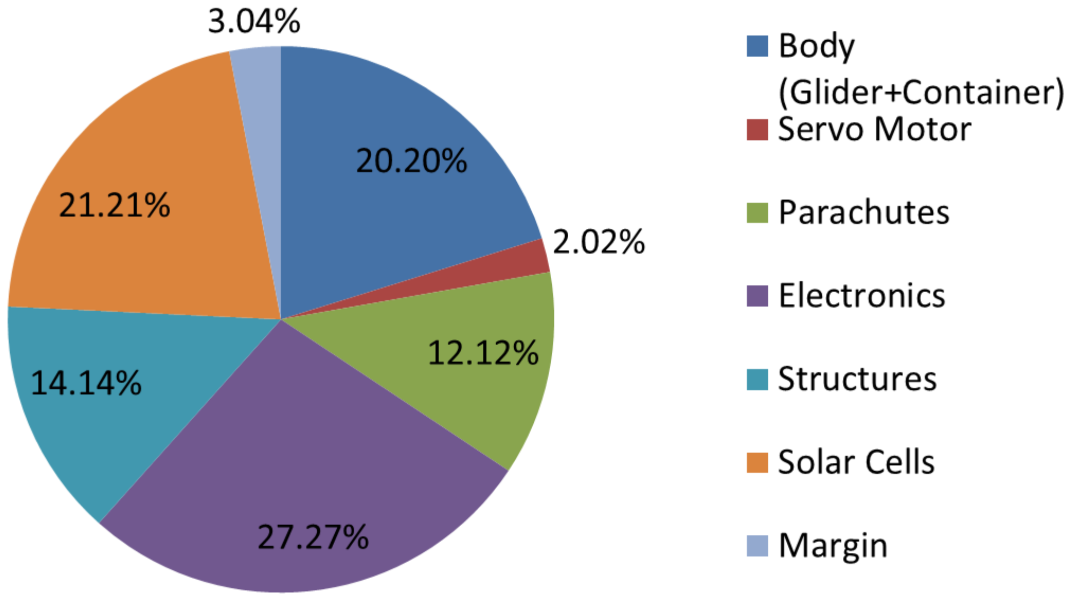


Mass Budget

SYSTEM	SUBSYSTEM	SUBSYSTEM MASS (g)	PERCENT	VM
Re-Entry Container	Body	100	40.8	Actual
	Servo Motor	10	4.08	Actual
	Parachutes	60	24.48	Estimate
	Electronics	75	30.64	Estimate
	TOTAL	245	100	
Glider	Structures	70	28	Estimate
	Solar cells	105	42	Actual
	Electronics	60	24	Estimate
	Margin	~(10-15)	6	Estimate
	TOTAL	~250	100	

Mass Budget

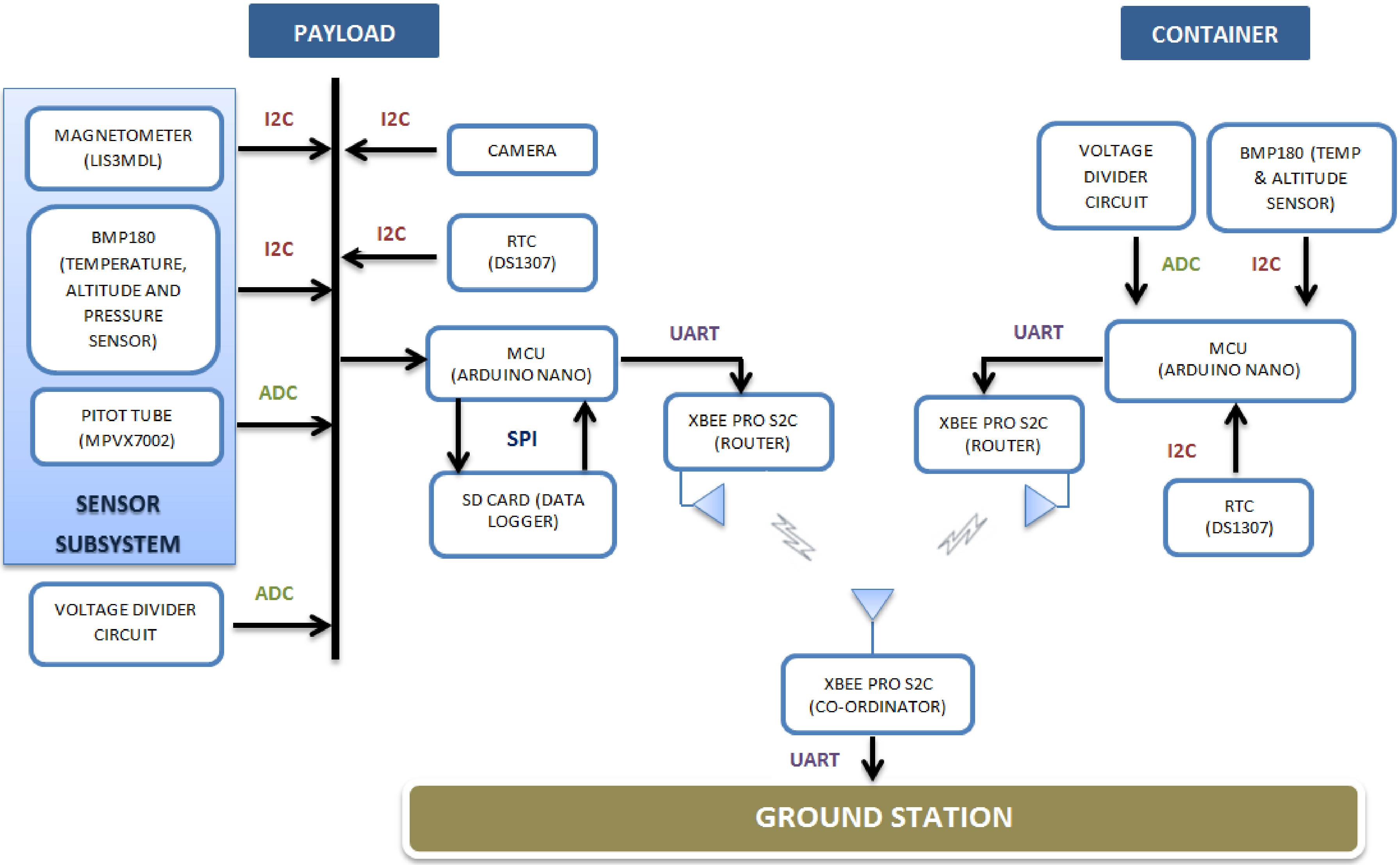
COMPONENT	MASS (g)
Container	245
Glider	250
Total	**495**



Communication and Data Handling (CDH) Subsystem Design

Ayush Agrahari

CDH Overview



CDH Overview

S. No.	Component	Model	Function
01	Magnetometer	LIS3MDL	Measuring Heading
02	Pressure/Temperature	BMP180	Temperature, Altitude, Pressure Measuring
03	Pitot Tube	MPXV7002	Velocity Measurement
04	Real Time Clock	DS1307	Flight Time Measurement
05	Micro-Controller	Arduino Nano	Control Unit
06	XBee Radio Modules	Pro S2C	Communication

CDH Requirements

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
CDH-01	During descent, the glider shall collect air pressure, outside temperature, compass direction, air speed and solar power voltage per second .	Descent telemetry package (1 Hz rate)	SR-12	HIGH	✓	✓		
CDH-02	It should tag time the data with mission time.	Mission Requirement	SR-21	HIGH	✓	✓		
CDH-03	The container and glider telemetry shall be transmitted once per second.	Descent telemetry package(1 Hz rate)	SR-13	HIGH	✓		✓	
CDH-04	2.4 GHz XBEE radios shall be used for telemetry.	Mission Requirement	SR-13	HIGH	✓		✓	
CDH-05	XBEE shall have their NETID/ PANID set to their team number.	Mission Requirement	SR-13	HIGH	✓	✓	✓	✓
CDH-06	XBEE shall not use broadcast mode.	Mission Requirement	SR-13	HIGH				✓
CDH-07	The glider shall use a time keeping device to maintain mission time.	Mission Requirement	SR-21	HIGH	✓	✓		

Payload Processor & Memory Trade & Selection

DEVICE NAME (MCU)	OPERATING VOLTAGE	CLOCK FREQUENCY	POWER REQUIREMENT		EEPROM	FLASH MEMORY	POWER DOWN
			IDLE	ACTIVE			
ATMEGA16	4.5-5.5V	0-16 MHz	0.35 mA	1.1 mA	512 bytes	16 KB	<0.1 µA
ARDUINO NANO	5 V	UPTO 16 MHz	0.75 x 10^{-3} mA	28 mA	1 KB	32 KB	<0.1 µA

Selected: ARDUINO NANO

- Ease of Programming (Arduino IDE)
- **Low power consumption** in idle mode
- Larger Memory

INTERFACES	NUMBER
I2C	1
UART	1
ADC	6 (2 utilised)
SPI	1

Note: Three sensors (BMP180, LIS3MDL and DS1307) are connected to the single I2C bus.

Payload Processor & Memory Trade & Selection

MODEL	SIZE	INTERFACING	PROGRAMMING
Mini TF Card Reader	Small	SPI	Ease of Programming
Slot Socket Reader Module	Medium (SD-card with Adapter)	SPI	Complex

Selected: Mini TF Card Reader

- Light Weight and Small Size
- No adapter required
- Ease of Programming

Payload Processor & Memory Trade & Selection

MODEL	SIZE	Capacity	Speed
Samsung Evo Plus	Small	16GB	48 Mb/s
Lexar Class 6	Medium (SD-card with Adapter)	8GB	35 Mb/s

Selected: Samsung EVO Plus

- Ease Retrieving of Data
- Supports all Format Data
- 0.12 mA in Cyclic write and 0.08 mA in Sleep mode

Container Processor & Memory Trade & Selection

MICROCONTROLLER	OPERATING VOLTAGE	CLOCK FREQUENCY	EEPROM	FLASH MEMORY	POWER REQUIREMENT (active)
ATMEGA16	4.5 - 5.5 V	UPTO 16MHz	512 Bytes	16KB	<1μA
ARDUINO NANO	5 V	UPTO 16 MHz	1KB	32KB	<0.1μA

Selected: ARDUINO NANO

- **Low power consumption** in idle mode
- Ease of Programming (Arduino IDE)
- Flash Memory: 32 KB
- EEPROM : 1 KB

INTERFACES	NUMBER
I2C	2
UART	1
ADC	1

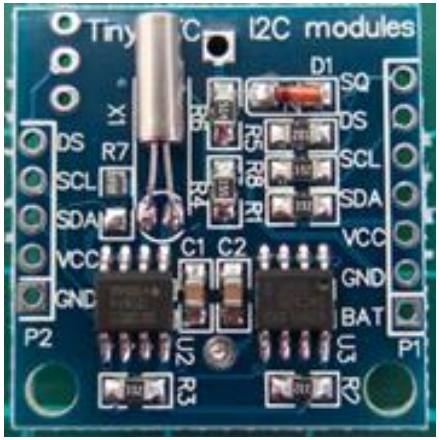
Payload Real-Time Clock

REAL TIME CLOCK (RTC) : To meet the mission requirement to include mission time in the telemetry and keep an official record of time of operations.

TYPE	ACCURACY	INITIATION TIME	SELECTION
Hardware	+0.1	2s	Selected
Software	+0.3	5s	-

<u>Selected RTC Type</u>: Hardware

- Faster Initialization
- I2C Bus Interfacing

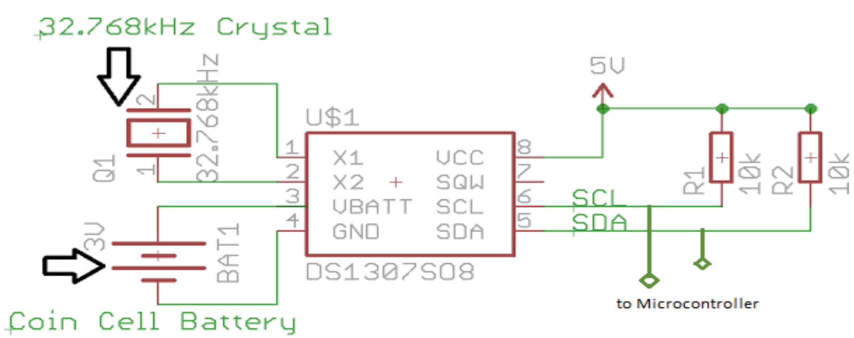


Payload Real-Time Clock

REAL TIME CLOCK	OPERATING VOLTAGE	CLOCK FREQUENCY	POWER REQUIREMENT (active)
DS1307	4.5 - 5.5 V	UPTO 16MHz	<1µA
BOB-12708	5 V	UPTO 16 MHz	<0.1µA

Selected RTC Type: DS1307

- I2C Bus Interfacing
- Lesser Power Consumption
- Highly Accurate



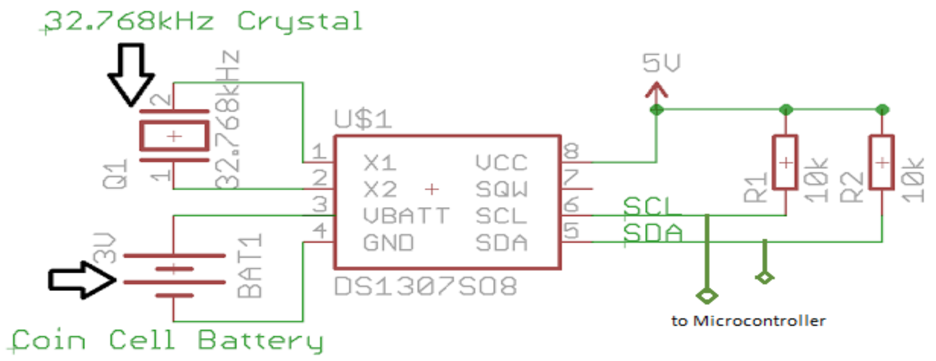
Container Real-Time Clock

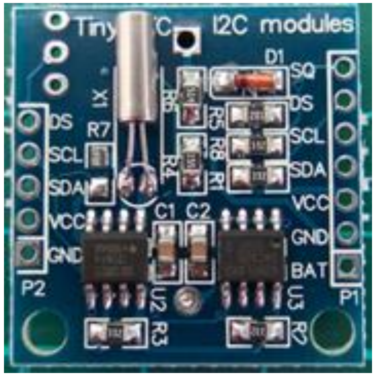
REAL TIME CLOCK (RTC) : To keep a record of time starting from the launch phase until 2 seconds after releasing the glider.

TYPE	ACCURACY	INITIATION TIME	SELECTION
Hardware	+0.1	2s	Selected
Software	+0.3	5s	-

Selected RTC: DS1307

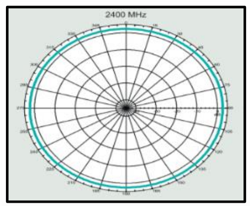
- Faster Initialization
- I2C Bus, which makes connection easy
- Tolerance Level is 100ppm





Payload Antenna Trade & Selection

S No.	Model	Type(and connector)	Peak Gain	Dimensions	Radiation Pattern	VSWR/Eff.	Frequency Range
01	**Pulse Engineering W1030**	Patch antenna (integrate with OEM designs)	2 dBi	100 x 37 mm	Omni directional	< 2.0	2.4 - 2.5 GHz
02	**Rubber Duck L-com Hg2402rd-rsf**	Patch antenna (SMA plug Connector)	2.2 dBi	100 mm(length) 10 mm (Diameter)	Omni directional	< 2.0	2.4GHz ISM Band
03	**Buccaneer Antenna PX0407**	Connector Supplied with SMB plug	2 dBi	105 mm (length) Diameter over coupling ring 19mm	Omni directional	<2.0	2.4 - 2.5 GHz



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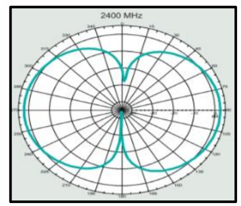
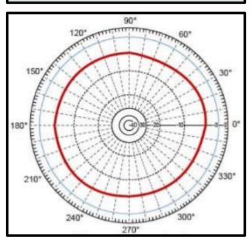


Vertical



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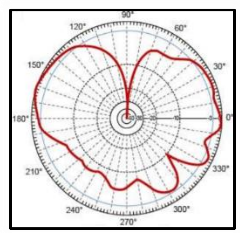

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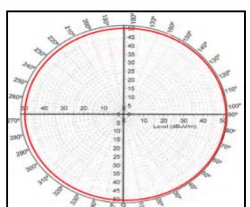

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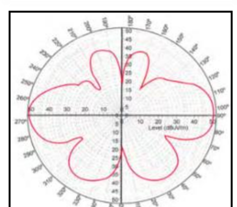

Vertical

Source:- Datasheet

Selected: Rubber Duck L-com Hg2402rd-rsf

- Omnidirectional
- Broad Coverage and High Gain
- High Range Antenna
- Compact size
- Tilt and Swivel design

Container Antenna Trade & Selection

S No.	Model	Type(and connector)	Peak Gain	Dimensions	Radiation Pattern	VSWR/Eff.	Frequency Range
01	**Pulse Engineering W1030**	Patch antenna (integrate with OEM designs)	2 dBi	100 x 37 mm	Omni directional	< 2.0	2.4 - 2.5 GHz
02	**Rubber Duck L-com Hg2402rd-rsf**	Patch antenna (SMA plug Connector)	2.2 dBi	100 mm(length) 10 mm (Diameter)	Omni directional	< 2.0	2.4GHz ISM Band
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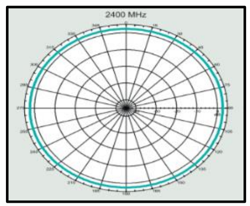

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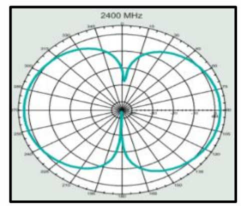

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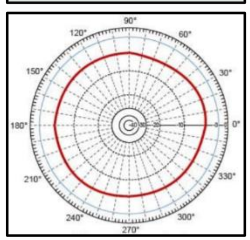

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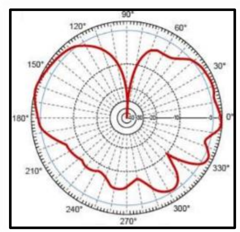

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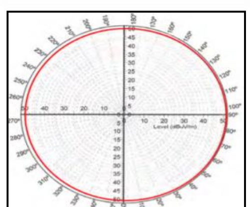

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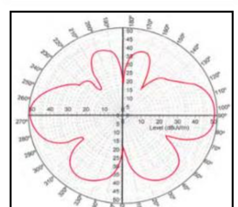


Vertical

Source:- Datasheet

Selected: Rubber Duck L-com Hg2402rd-rsf

- Omnidirectional
- Broad Coverage and High Gain
- High Range Antenna
- Compact size
- Tilt and Swivel design

Payload Radio Configuration

Model	Supply Voltage	Operating Current (Transmit)	Operating Current (Receive)	Operating Frequency	RF Data Rate	Transmit Power Output	Outdoor line of sight Range
XBEE-PRO S2C	2.1-3.6 V	33 mA	28 mA	ISM 2.4 GHz	250 Kbps	3.1 mW (+5 dBm)	4000 ft. (1200 m)
XBEE-PRO S2D	2.1-3.6 V	33 mA	28 mA	ISM 2.4 GHz	250 Kbps	3.1 mW (+5 dBm)	4000 ft. (1200 m)
XBEE-PRO S2B	2.7-3.6 V	205 mA\	47 mA	ISM 2.4 GHz	250 Kbps	63 mW (+18 dBm)	Up to 2 miles (3200 m)

Source:- Datasheet

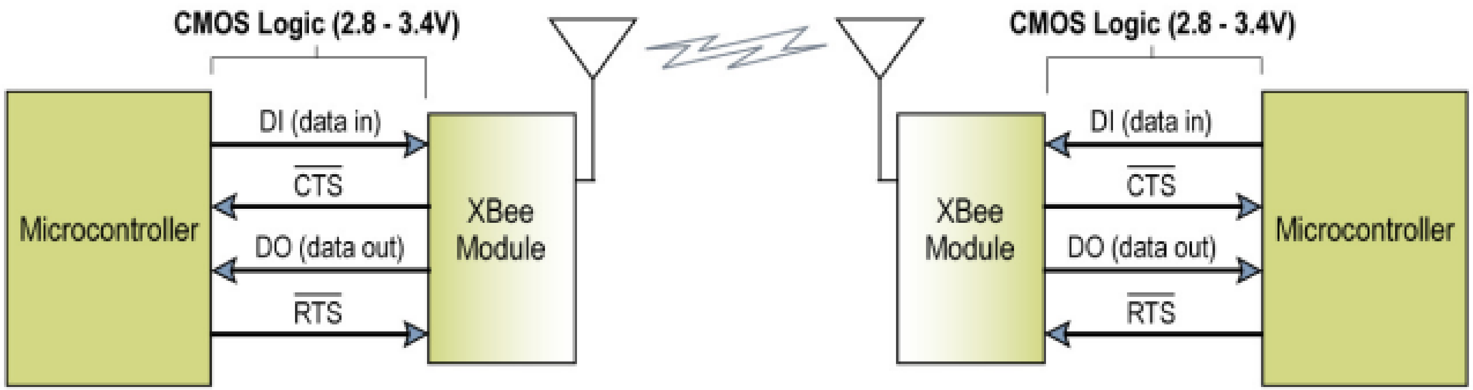
Selected: XBEE PRO S2C

- Good Range and Low Operating Current.
- **XBee Radio Module** is interfaced to the MCU through USART Communication Protocol.
- PAN ID for Data Communication will be **Team No- 2232**.
- The **XBEE Radio** is configured using AT Mode (Ground Station being Coordinator AT & Glider XBee as Router AT).

Payload Radio Configuration

- Though Omni-directional, Antenna for Glider will be facing downward for ease in transmission of data packages.
- RF communication is implemented between the user's computer and the Glider unit using two X-Bee Modules that follow the 802.15.4 communication protocol.
- These two modules transmit data packets to each other by serial communication.
- Through their serial ports, they can communicate with any logic and voltage compatible UART interface.

Modes in USART with XBEE PRO S2C	
Data Bits	8
Baud Rate	9600
Flow Control	None
Parity Counter	None
Transmission Mode	Asynchronous
Stop Bits	1
UART Receiver	On
UART Transmitter	On



Radio Prototyping and Testing is underway!

Container Radio Configuration

Model	Supply Voltage	Operating Current (Transmit)	Operating Current (Receive)	Operating Frequency	RF Data Rate	Transmit Power Output	Outdoor line of sight Range
XBEE-PRO S2C	2.1-3.6 V	33 mA	28 mA	ISM 2.4 GHz	250 Kbps	3.1 mW (+5 dBm)	4000 ft. (1200 m)
XBEE-PRO S2D	2.1-3.6 V	33 mA	28 mA	ISM 2.4 GHz	250 Kbps	3.1 mW (+5 dBm)	4000 ft. (1200 m)
XBEE-PRO S2B	2.7-3.6 V	205 mA	47 mA	ISM 2.4 GHz	250 Kbps	63 mW (+18 dBm)	Up to 2 miles (3200 m)

Source:- Datasheet

SELECTED : XBEE PRO S2C

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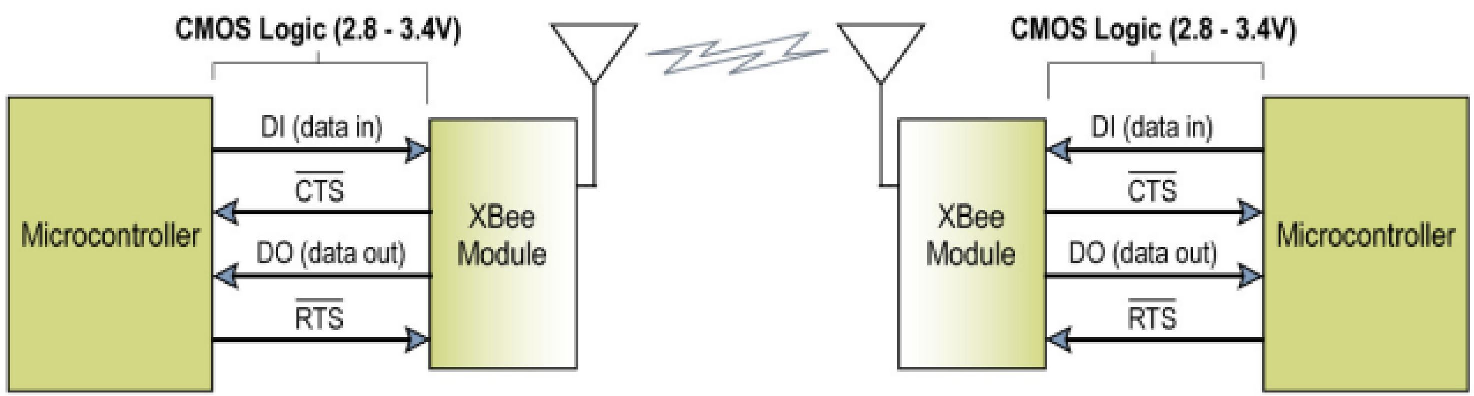
- PAN ID for Data Communication will be Team No- 2232.
- The **XBEE Radio** is configured using AT Mode (Ground Station being Coordinator AT & Glider Xbee as Router AT).

Container Radio Configuration

- Though Omni-directional, Antenna for the container will be facing downward for ease in transmission of data packages.
- RF communication is implemented between the user's computer and the Container using two XBee Modules that follow the 802.15.4 communication protocol.
- The XBee at Ground Station acts as a common module both for glider and the Container (at co-ordinator mode), recognizing each of their packet by checking the 2nd bit of the telemetry sent that is either 'GLIDER' data or 'CONTAINER' data.

Modes in USART with XBEE PRO S2C	
Data Bits	8
Baud Rate	9600
Flow Control	None
Parity Counter	None
Transmission Mode	Asynchronous
Stop Bits	1
UART Receiver	On
UART Transmitter	On



Payload Telemetry Format

The Telemetry comprises of :

1. Sensory Data in Standard Engineering Units
2. Data transmitted at default Baud Rate of 9600 in ‘Continuous Mode’.
3. Data transmitted at every 1 second in ASCII Format with values separated by a comma (,)

Telemetry Format:

<TEAM-ID>,GLIDER,<MISSION TIME>,<PACKET COUNT>,<ALT SENSOR>,<PRESSURE>,<SPEED>,<TEMP>,<VOLTAGE>,<HEADING>,<SOFT WARE STATE>, [<BONUS>]

<BONUS> - Denotes the **Camera Count** of the pictures signalled at Ground Station.

Example :
<2232>,GLIDER,<2>,<44>,<810.1234>,<101325>,<5.523>,<30.123>,<5.23>,<420 4>,<3>,[<4>]

The above format matches the competition guide requirements for CanSat 2017.

Container Telemetry Format

The Telemetry comprises of :

1. Sensory Data in Standard Engineering Units
2. Data transmitted at default Baud Rate of 9600 in continuous mode.
3. Data transmitted at every 1 second in ASCII Format with values separated by a comma (,)

<u>Telemetry Format</u>:

<TEAM ID>,CONTAINER,<MISSION TIME>,<PACKET COUNT>,<ALTITUDE>,<TEMPERATURE>,<VOLTAGE>,<SOFTWARE STATE>

<u>Example</u> :
<2232>,CONTAINER,<2>,<44>,<810.1234>,<30.123>,<8.23>,<3>

The above format matches the competition guide requirements for CanSat 2017.

Electrical Power Subsystem (EPS) Design

Pradyumna Narayan Tiwari

EPS Overview

For the Payload and Container, we use different electrical power system as per the requirement:

PAYLOAD

1. The payload sensor system is completely solar powered to acquire and telemeter the sensor readings and flight software states.
2. An energy storage device (1F Super Capacitor) is employed to manage power.
3. A 3.3V coin battery is used to separately power the Real Time Clock Module.
4. An external accessible switch is employed to switch On/Off the system.
5. Voltage Regulator is employed for sustained power supply to all components.
6. External verification of power : Voltage divider on MCU

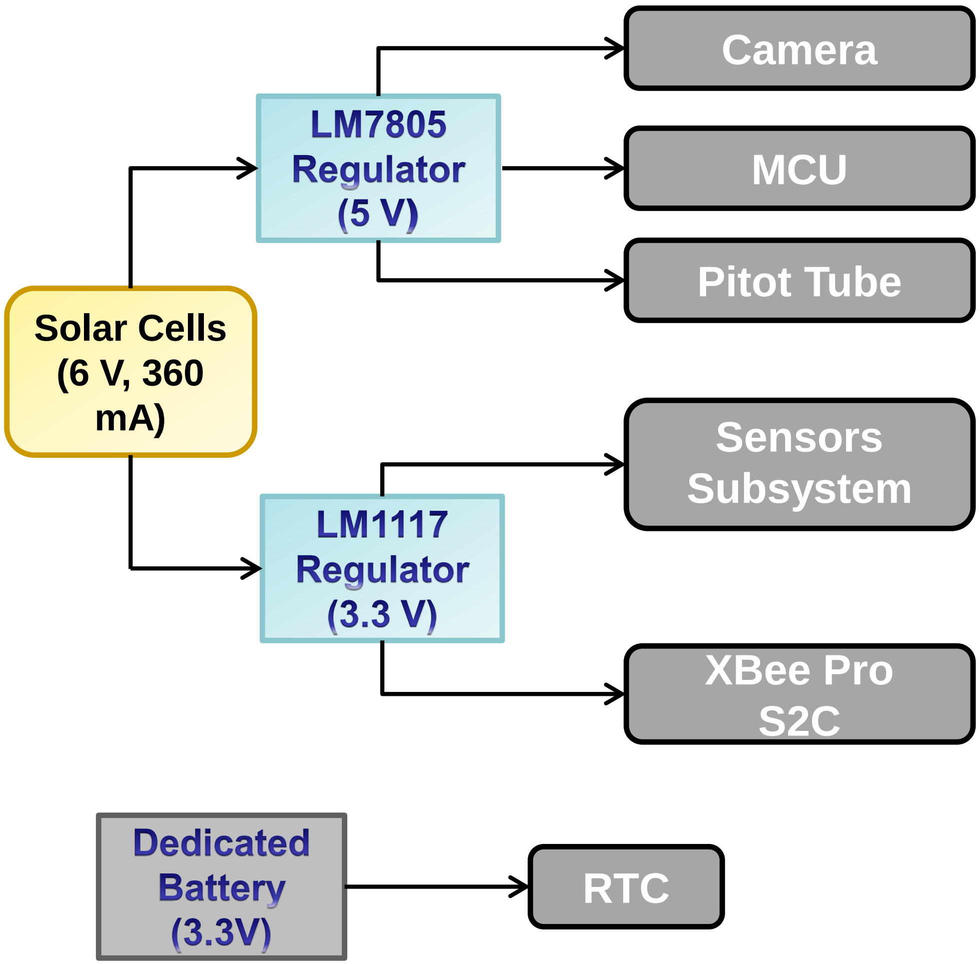
CONTAINER

A 9V DC Alkaline Battery will be employed for powering the Sensor Subsystem, Xbee Telemetry System and Payload Separation Mechanism in the Container.

1. A 3.3V coin battery is used to separately power the Real Time Clock Module.
2. An external accessible switch is employed to switch On/Off the system.
3. Voltage Regulator is employed for sustained power supply to all components.
4. External verification of power : Voltage divider on MCU
5. Test and Demonstration of all Container Subsystems using the power source (9V Alkaline Battery) to ensure functioning of the system.
6. Long duration usage by testing, to include potential one hour wait on the launch pad for the Container.

EPS Overview

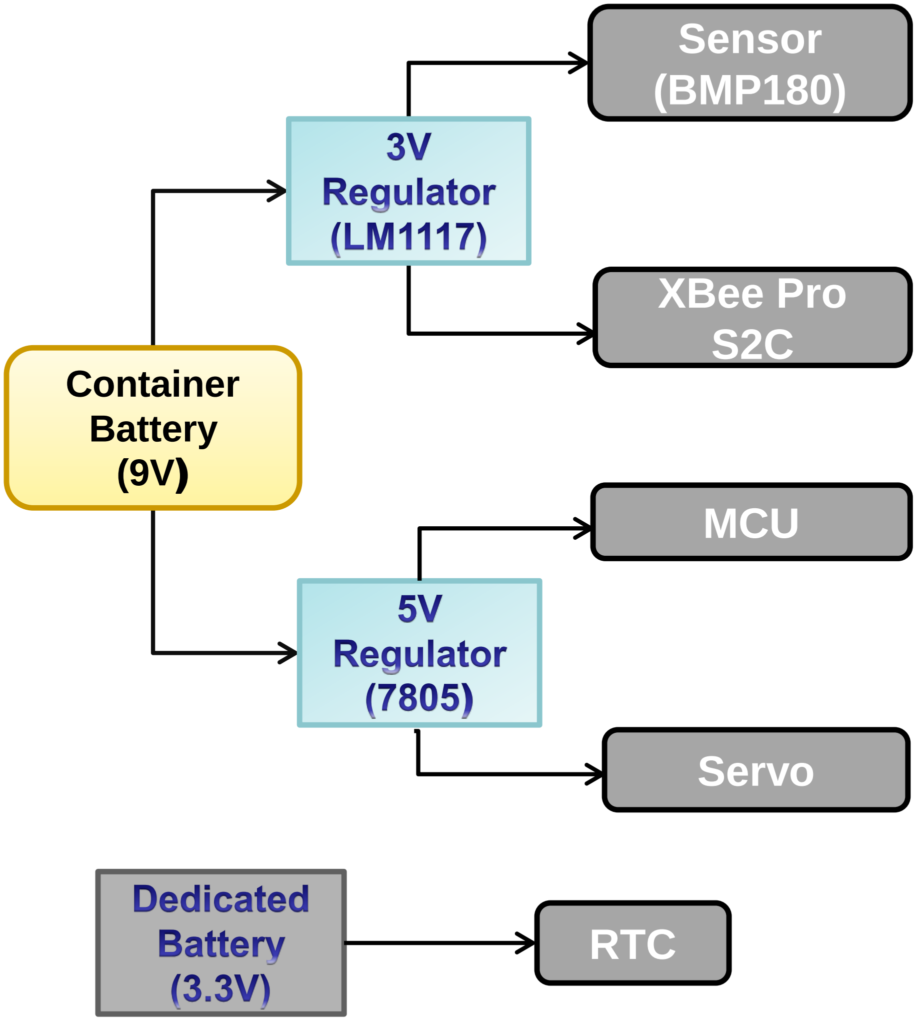
PAYLOAD



Key Components	Purpose
Solar Cells	Power providing Device for Payload.
LM1117 Regulator	Regulating 3.3V supply
LM7805 Regulator	Regulating 5V Supply
MCU	Interfacing Sensors and Camera
Camera	Capturing images when instructed
Sensors	Collecting sensory data information
XBee Pro S2C	Sending telemetry to GCS

EPS Overview

CONTAINER

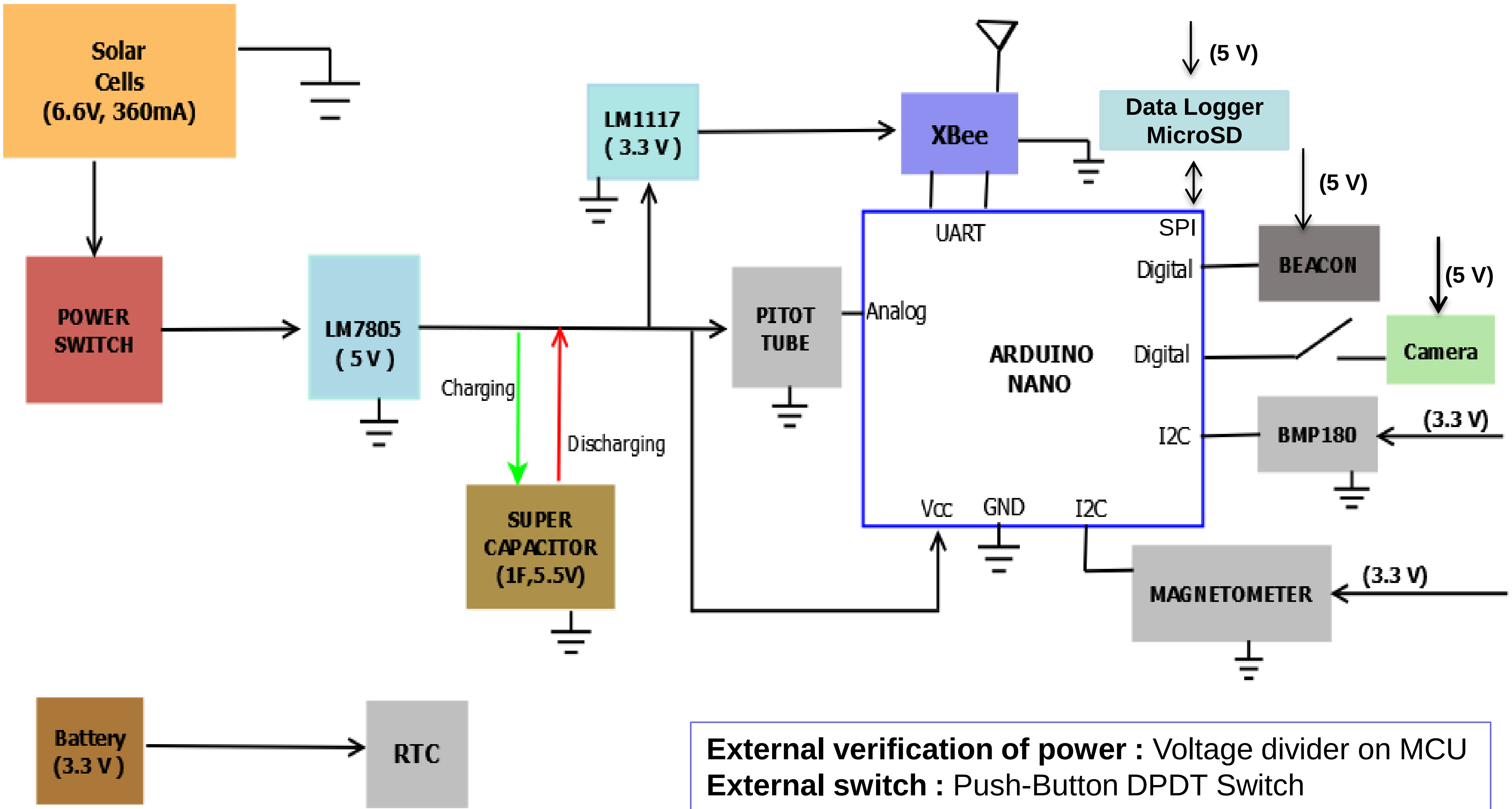


Key Components	Purpose
Container Battery	Power Source of Re-Entry Container
LM1117 Regulator	Regulating 3.3V supply
LM7805 Regulator	Regulating 5V Supply
Sensor	Collecting altitude and temperature data
Servo	Triggering separation mechanism.
XBee Pro S2C	Sending telemetry to GCS

EPS Requirements

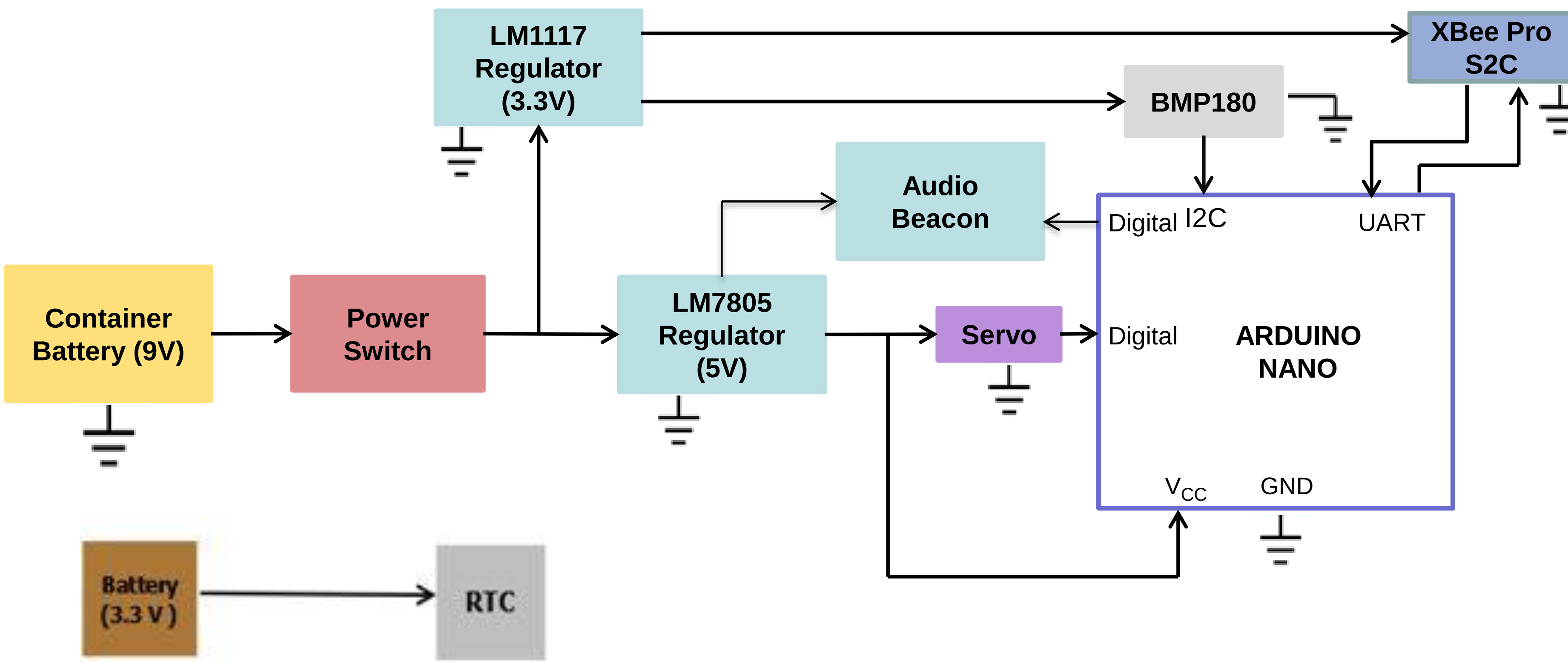
ID	REQUIREMENT	RATIONALE	PARENT	PRIORITY	VM			
					A	I	T	D
EPS-01	The glider electronics must be all solar powered.	Mission Requirement	SR-21	HIGH	✓	✓		
EPS-02	The glider must include an easily accessible power switch	Mission Requirement	SR-08	HIGH	✓	✓	✓	
EPS-03	Super capacitor shall be used for storing energy and for sustained telemetry	System Requirement	SR-21	MEDIUM	✓	✓		
EPS-04	Voltage regulator shall be used for sustained supply to all electronic components	System Requirement	SR-21	MEDIUM	✓	✓	✓	
EPS-05	The container electronics shall be powered only by alkaline batteries.	Mission Requirement	SR-23	HIGH	✓	✓	✓	
EPS-06	The time keeping device battery shall be a coin cell battery.	Mission Requirement	SR-21	HIGH	✓	✓	✓	

Payload Electrical Block Diagram



External verification of power : Voltage divider on MCU
External switch : Push-Button DPDT Switch
Umbilical Power source : USB Power and Power Supply (Full Wave Rectifier) Circuit

Container Electrical Block Diagram



External verification of power : Voltage divider on MCU
External switch : Push-Button DPDT Switch
Umbilical Power source : USB Power and Power Supply (Full Wave Rectifier) Circuit

Payload Solar Power Trade & Selection

S. No	Device Name	Conversion Efficiency	Voltage At Max Power (V)	Current At Max Power (I)	Open Circuit Voltage (V_{oc})	Short Circuit Current (I_{sc})	Dimension (cm x cm)	Source
1.	Crystalline silicon (c-Si)	12%	6.6	0.18	10.9	0.19	23.4 x 9.8	Datasheet
2.	Amorphous silicon (a-Si)	6%	44.8	0.90	1.16	0.19	63.5 x 121.5	Datasheet

SELECTED: Crystalline PV module (c-Si)

- High Conversion Efficiency.
- Compact Size.
- Stable Voltage Supply with efficient current supply.

Payload Energy Management Strategy Trade Study

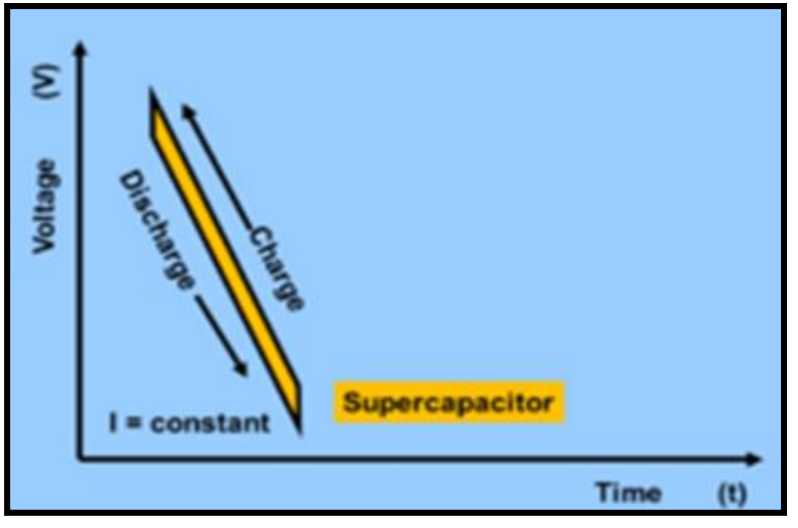
S NO.	Storage Device	Storage Capacity	Max operating voltage	Current Capacity	Temperature Range	Rationale
1.	Panasonic Gold Capacitor, KAMCAP (coin type)	1F	5.5 V D.C.	1.6 A	-25° C to 70° C	Competition Approved
2.	Panasonic EECHZOE335	3.3 F	2.5 V D.C.	1.25 A	-25° C to 70°C	Competition Approved
3.	Camelion Ni-MH, Rechargeable	200 mAh	9 V	-	-25° C to 70°C	Competition Disapproved

SELECTED: Panasonic Gold Capacitor, Coin Type (1F, 1.6 A)

- High max. operating voltage
- Compact size.
- High current capacity

Power Management

- Using 5V voltage regulator for sustained voltage on output.
- Using 1F Super capacitor, such that when solar cells are not providing the required power, the super-capacitor then can provide it to the load.
- Using X-Bee Pro S2C, which is a low-power radio communication device.



POWER PROFILE OVER TIME
(Charge and discharge patterns for super-capacitor)

Container Battery Trade & Selection

Battery (9V)	Capacity (mAH)	Operating Range	Rationale
Alkaline	570	-20 ºC to 54 ºC	Competition Approved
Lithium-ion	500	0 – 45 ºC	Competition Disapproved
Ni-MH	200	-20 ºC to 50 ºC	Competition Disapproved

SELECTED : 9V Alkaline Battery

Features:

- High Energy Density.
- High Current Capacity.
- Low internal resistance.
- Performs equally well in low and as well as high rate of discharge.

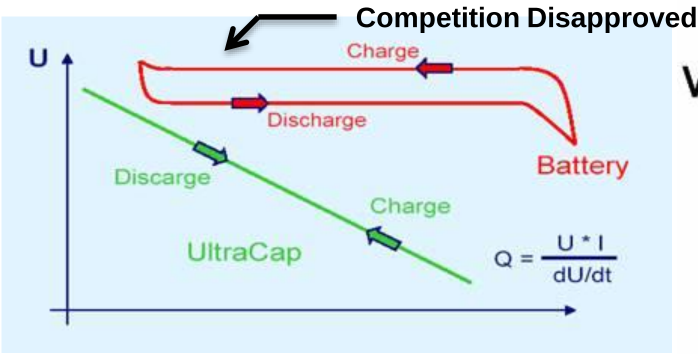
Payload Power Budget

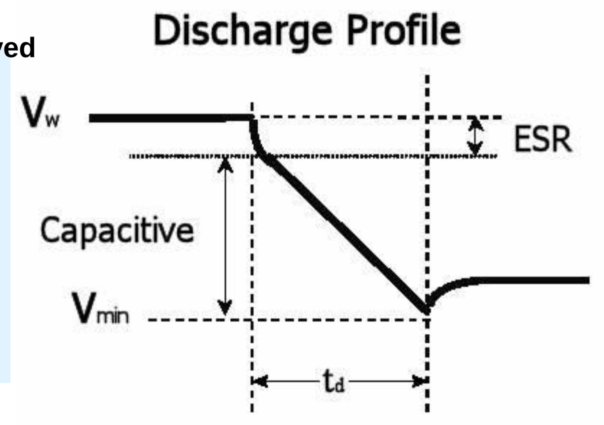
S. No	Power Source	Power Available	Device	Voltage (V)	Current (mA)	Power Required (10^{-3} W)	Duty Cycle
1.	2 Modules of Solar Cells	2.376 Watts	Arduino Nano	5	28	140	100%
2.			BMP180	3.3	0.012	0.039	100%
3.			XBee Pro S2C	3.3	61	201.13	100%
4.			Pitot tube	5	10	50	100%
5.			Camera	5	75	375	25%
6.			Magnetometer	3.3	0.1	0.33	100%

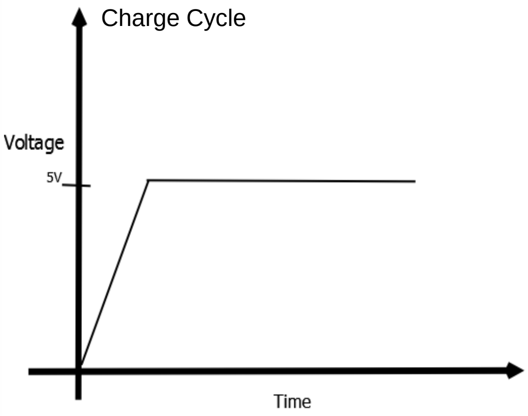
Source: Datasheet

Power Available	2.376 W
Total Power Required /Consumed	0.7665 W
Margins	1.61 W

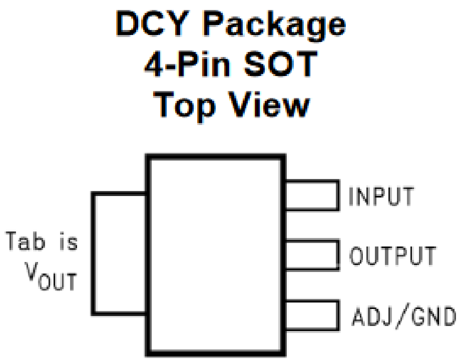
Power Storage Device : 1F 5.5V Super capacitor





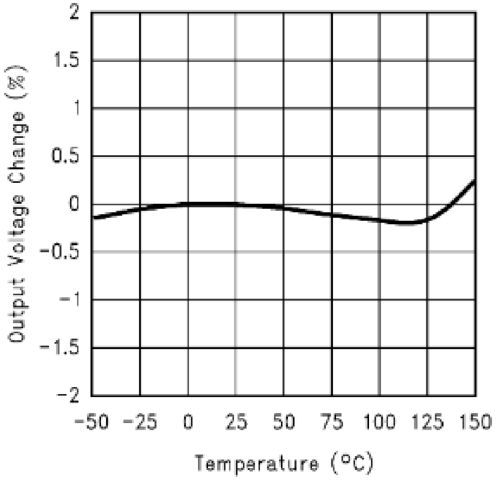


Voltage Regulator Specifications (LM1117 3.3V)

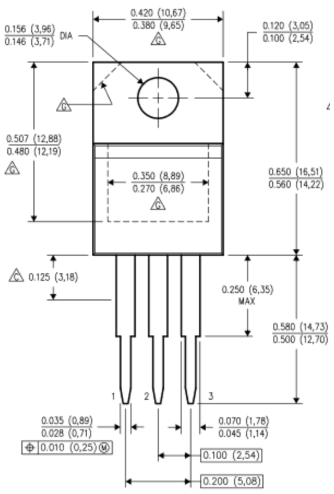


1 Features

- Available in 1.8 V, 2.5 V, 3.3 V, 5 V, and Adjustable Versions
- Space-Saving SOT-223 and WSON Packages
- Current Limiting and Thermal Protection
- Output Current 800 mA
- Line Regulation 0.2% (Maximum)
- Load Regulation 0.4% (Maximum)
- Temperature Range
  - LM1117: 0°C to 125°C



Voltage Regulator Specifications (LM7805)



IC 7805 Pin Configuration:

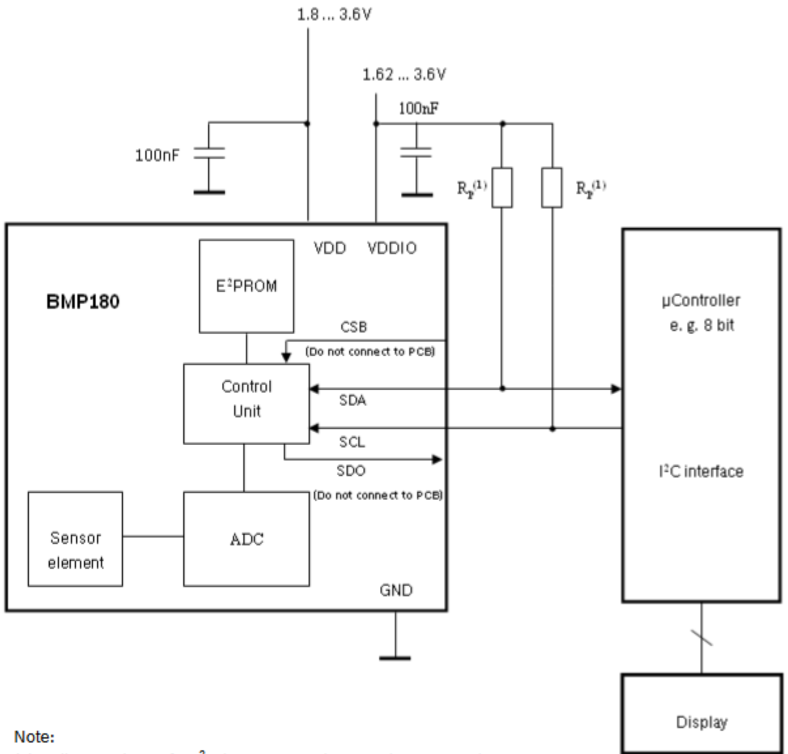
1. **Input**
2. **Ground**
3. **Output**

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

Table: Electrical Parameters

Payload Power Budget

BMP180 Barometric Pressure Sensor Specifications

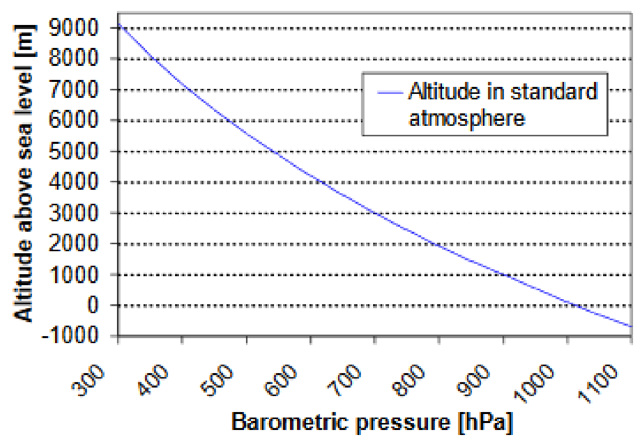


Note:
(1) Pull-up resistors for I²C bus, R_p = 2.2kΩ ... 10kΩ, typ. 4.7kΩ

Application Circuit: BMP180

Parameter	Symbol	Min.	Typ	Max.	Units
Clock input frequency	f_{SCL}			3.4	MHz
Input-low level	V_{IL}	0		0.2 * V_{DDIO}	V
Input-high level	V_{IH}	0.8 * V_{DDIO}		V_{DDIO}	V
Voltage output low level @ V_{DDIO} = 1.62V, I_{OL} = 3mA	V_{OL}			0.3	V
SDA and SCL pull-up resistor	$R_{pull\text{-}up}$	2.2		10	kOhm
SDA sink current @ V_{DDIO} = 1.62V, V_{OL} = 0.3V	I_{SDA_sink}		9		mA
Start-up time after power-up, before first communication	t_{Start}	10			Ms

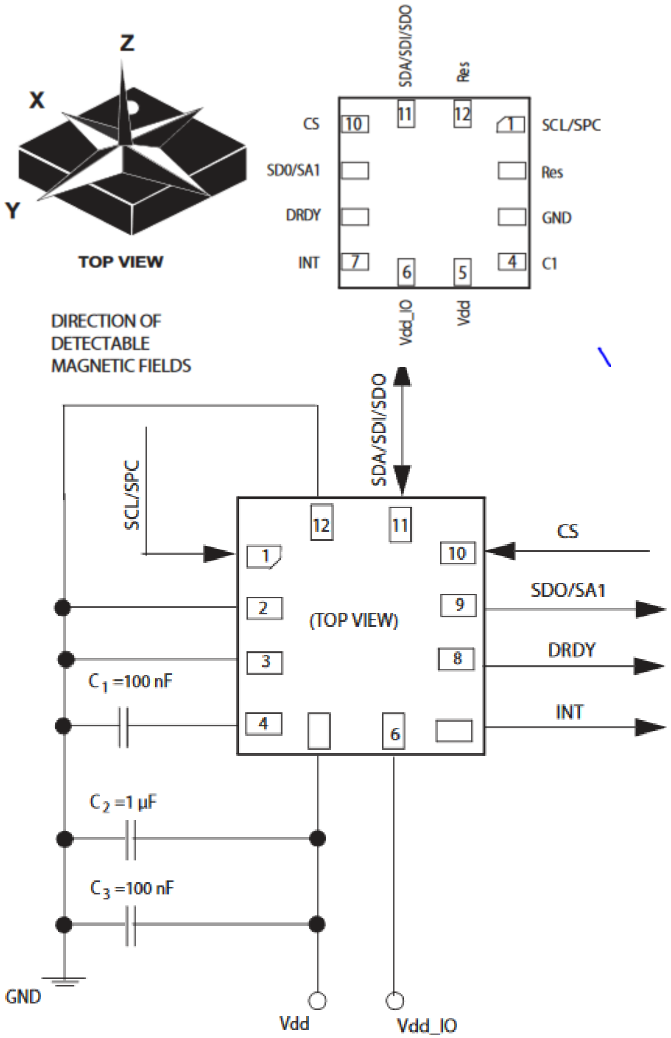
Table: Electrical Parameters of I2C Interface



Graph of Transfer function: Altitude over sea level – Barometric pressure.

Payload Power Budget

LIS3MDL Magnetic Sensor Specifications



Top and Bottom View with Pin Description

Symbol	Parameter	Test conditions	Min.	Typ.(1)	Max.	Unit
Vdd	Supply voltage		1.9		3.6	V
Vdd_IO	Power supply for I/O		1.71	1.8	Vdd+0.1	
Idd_HR	Current consumption in ultra-high-resolution mode	ODR = 20 Hz		270		µA
Idd_LP	Current consumption in low-power mode	ODR = 20 Hz		40		µA
Idd_PD	Current consumption in power down			1		µA
Top	Operating temperature range		-40		+85	°C

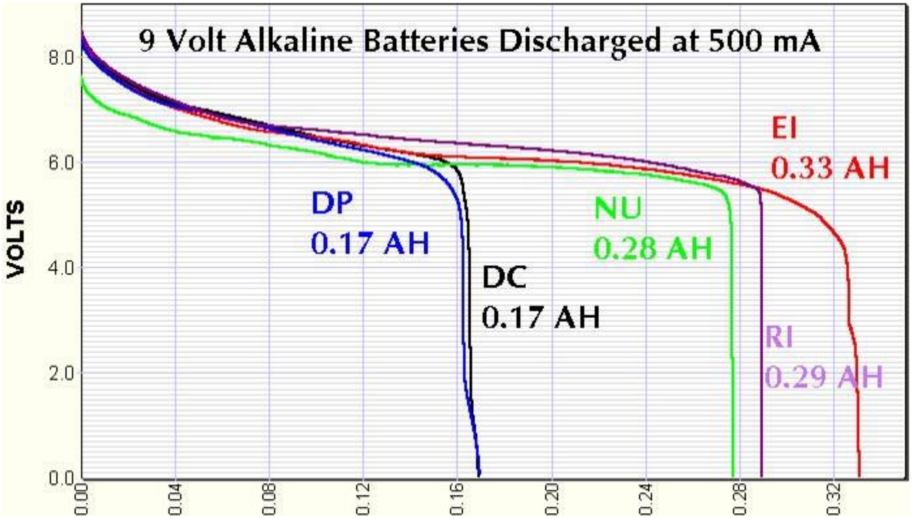
Table: Electrical Parameters

Container Power Budget

Device	VOLTAGE (V)	CURRENT (mA)	POWER (mW)	Duty Cycle	Source
Servo	5	250	1.250	25%	**Datasheet**
BMP180	3.3	0.012	0.0396	100 %	**Datasheet**
Arduino Nano	5	28	140	100%	**Datasheet**
XBee Pro S2C	3.3	61	201.13	100%	**Datasheet**

Power Source	Alkaline Battery
Power Available	9.5 W
Total Power Consumed	342.41mW
Margins	9.15 W

1 hour wait on the launch pad for the container is ensured.



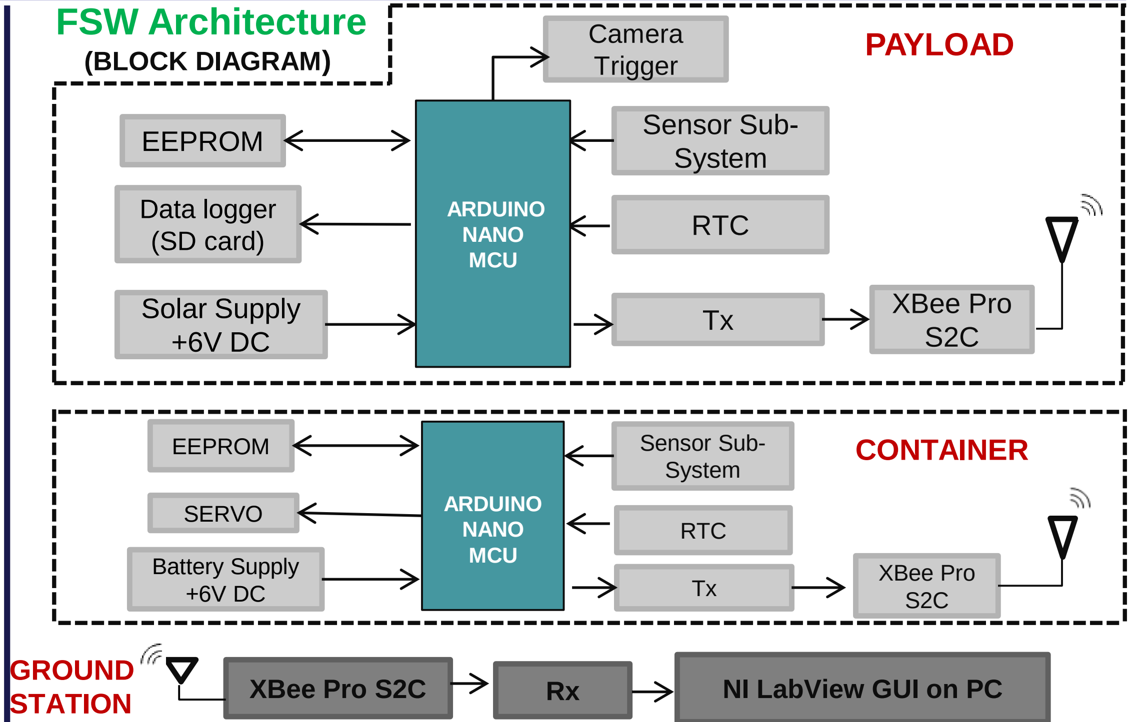
Flight Software (FSW) Design

Raghav Garg

FSW Overview

- A procedural programming approach is followed to simplify the glider and container telemetry operations.
- **Basic FSW architecture**
  - It tells what programming paradigm has to be employed to run on the hardware.
  - Gathers data and runs at a loop rate of 1 Hz.
- **Programming languages**
  - Arduino Programming
  - C/C++
- **Development environments**
  - Arduino IDE
- **Brief summary FSW tasks**

FSW Architecture
(BLOCK DIAGRAM)



GLIDER

- ✓ Receive and plot air pressure, altitude, air temperature, speed, heading data and solar voltage.
- ✓ Transmit all real time flight telemetry at a 1 Hz rate.
- ✓ Maintain packet counts transmitted + save the recorded data on system in a .CSV file.
- ✓ Capture image of ground numerous times and store them for later retrieval.

CONTAINER

- ✓ Receive and plot altitude, air temperature, and battery voltage.
- ✓ Transmit all real time flight telemetry at a 1 Hz rate until 2 seconds of the release of the glider.
- ✓ Maintain packet counts transmitted + save the recorded data on system in a .CSV file.

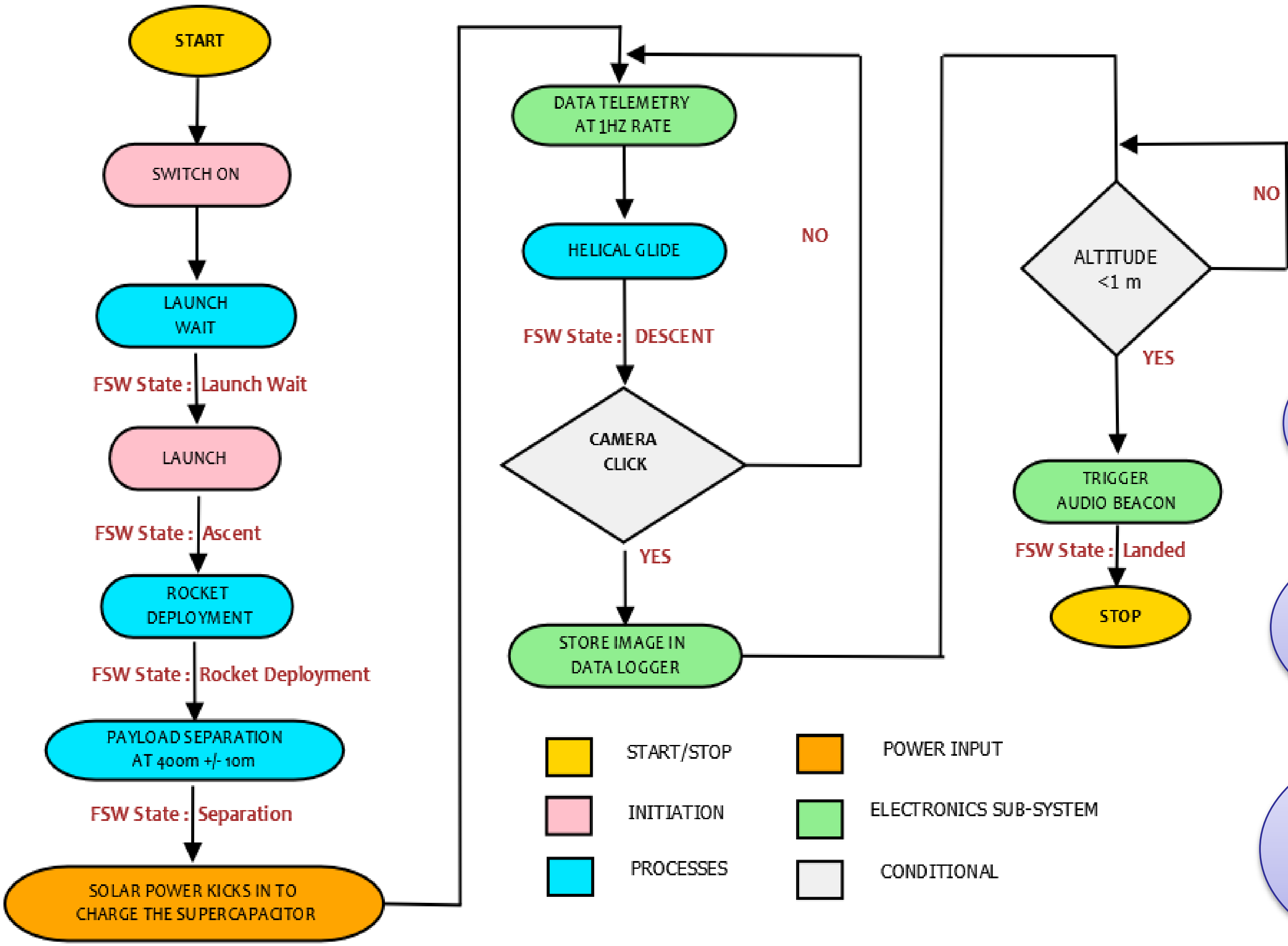
FSW Requirements

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
FSW-01	Detection of appropriate condition and initialization for payload deployment	Competition Requirement	SR-06	HIGH	✓	✓		
FSW-02	Sampling and collection of sensor data in processor	Competition Requirement	SR-12	HIGH		✓	✓	✓
FSW-03	The container shall transmit telemetry at 1 Hz rate from the time being turned on and placed on the launch pad until 2 seconds after releasing the glider.	Competition Requirement	SR-12,SR-13	HIGH	✓	✓		✓
FSW-04	During descent, the glider shall transmit all telemetry at 1 Hz rate	Competition Requirement	SR-13	HIGH	✓	✓		
FSW-05	Telemetry will include mission time with one second or better resolution	Competition Requirement	SR-12,SR-21	HIGH		✓	✓	
FSW-06	Telemetry can be transmitted continuously or in bursts.	Competition Requirement	SR-13	HIGH	✓		✓	
FSW-07	Telemetry data will be displayed in engineering units	Competition Requirement	SR-16	HIGH	✓			✓
FSW-08	Maintain the count of packets transmitted	Competition Requirement	SR-18	HIGH		✓		
FSW-09	Capture the image of ground when given command and store for later retrieval	Bonus Objective	SR-22	HIGH	✓		✓	

FSW Requirements

ID	Requirement	Rationale	Parent	Priority	VM			
					A	I	T	D
FSW-10	Glider shall contain an audio beacon which must be activated post landing.	Competition Requirement	SR-25	HIGH	✓	✓		
FSW-11	Container shall contain an audio beacon which must be activated post landing.	Competition Requirement	SR-25	HIGH		✓	✓	
FSW-12	Recover from any momentary power loss or unexpected processor reset	Competition Requirement	SR-21	HIGH	✓	✓		
FSW-13	Telemetry storage on external flash memory	Provides backup if wireless transmission fails	SR-12	MEDIUM	✓		✓	

Payload FSW State Diagram



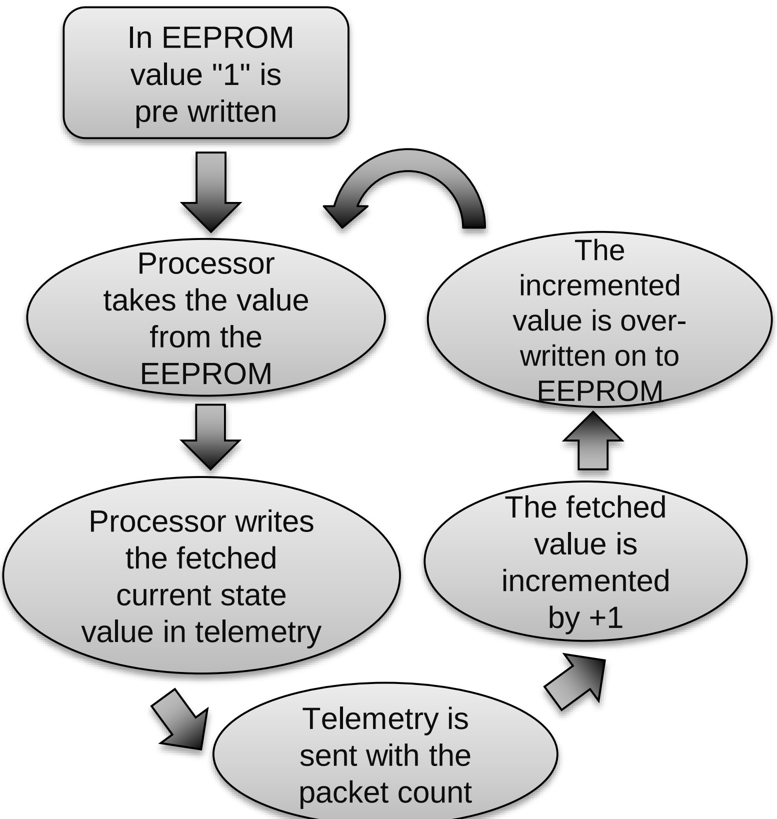
Sampling rate of 1 Hz is maintained for all sensor reading

Sensor Data saved on **data logger**, the on-board SD Card and on GCS

Data communication with the help of **XBEE** attached both at glider and Ground Station

Processor Reset Control

- ✓ To power the payload we are using solar cells.
- ✓ In exceptional cases it may face temporary power failure which is not good for our telemetry count.
- ✓ So to ***control the irregular pattern of the telemetry count,*** *some measures has to be taken.*



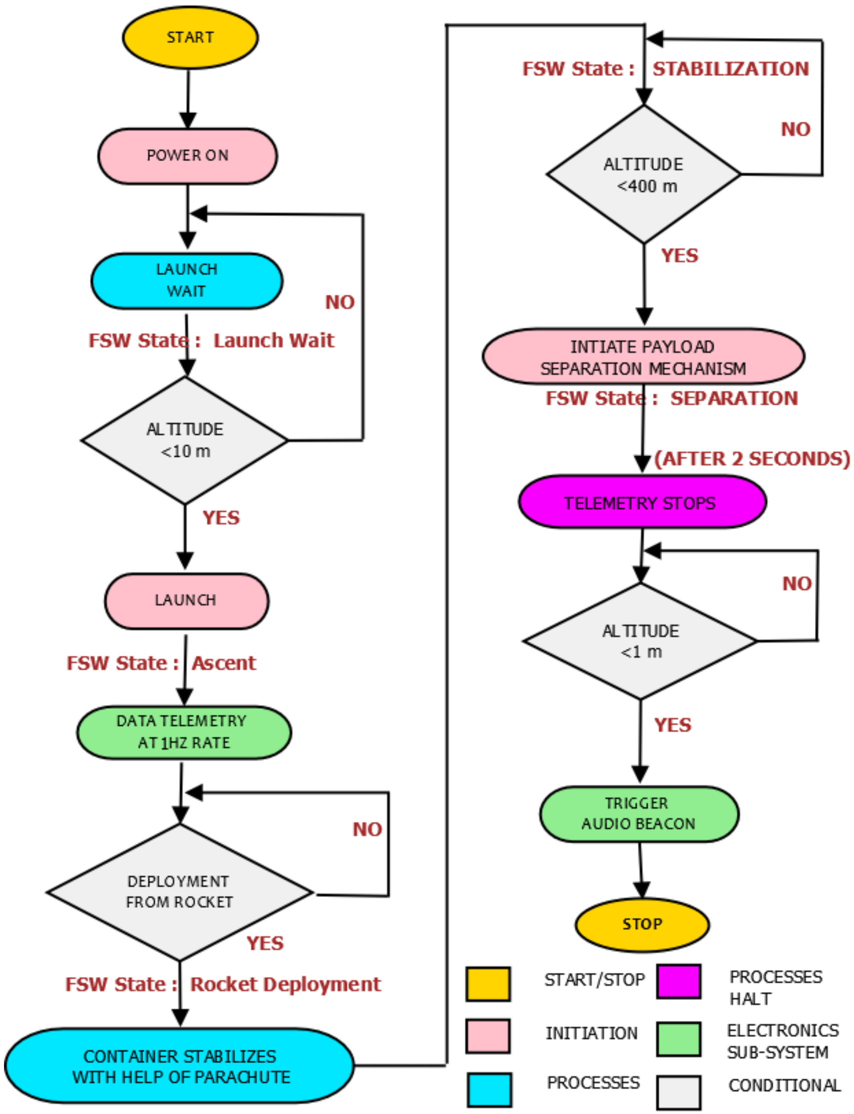
EEPROM (inside the Arduino Nano) will be controlling the irregular pattern of the telemetry count

(Selected)

Alternative solution :

We can recover *the FSW state data* from the continuously storing data in a .CSV file on system.

Container FSW State Diagram



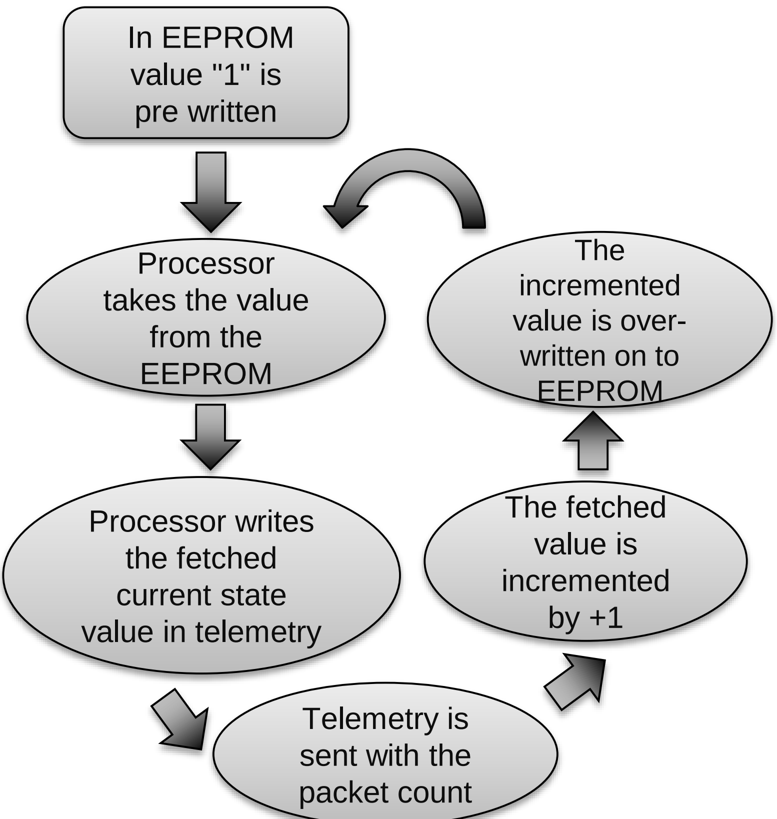
Sampling rate of 1 Hz is maintained for all sensor reading

Data communication with the help of **XBEE** attached both at container and Ground Station

Container FSW State Diagram

Processor Reset Control

- ✓ To power the container we are using Duracell 9V battery.
- ✓ In exceptional cases it may face temporary power failure which is not good for our telemetry count.
- ✓ So to ***control the irregular pattern of the telemetry count,*** *some measures has to be taken.*



EEPROM (inside the Arduino Nano) will be controlling the irregular pattern of the telemetry count

(Selected)

Alternative solution :

We can recover *the FSW state data* from the continuously storing data in a .CSV file on system.

Software Development Plan

- **Prototyping and prototyping environments :**

  – Prototypes are tested using Breadboard and Arduino serial monitor is used for Debugging.

- **To avoid late software development :**

  –Long slowdowns will be avoided and will try to work as continuously as possible.

  –The work pertaining to hardware development will be divided into small tasks.

  –Will try to keep the things planned to the schedule.

Software Development Plan

Software subsystem development sequence : The software subsystem development has been divided into 3 phases:

PHASE 1

- The working principles of Arduino will be recognized along with the other components like sensors, camera, memory card etc.
- Analyzing and defining the FSW requirements, functions and states.

PHASE 2

- Working on the functionalities of the subparts of FSW thereon verifying the data transfer between the sensors and the microcontroller.
- Testing different algorithms for checking various FSW-state operations and implementing in GUI.

PHASE 3

- Removing any potential bugs
- Final software will be integrated and tested in real time

CURRENT STATUS	
PHASE 1	Completed
PHASE 2	In Progress

Software Development Plan

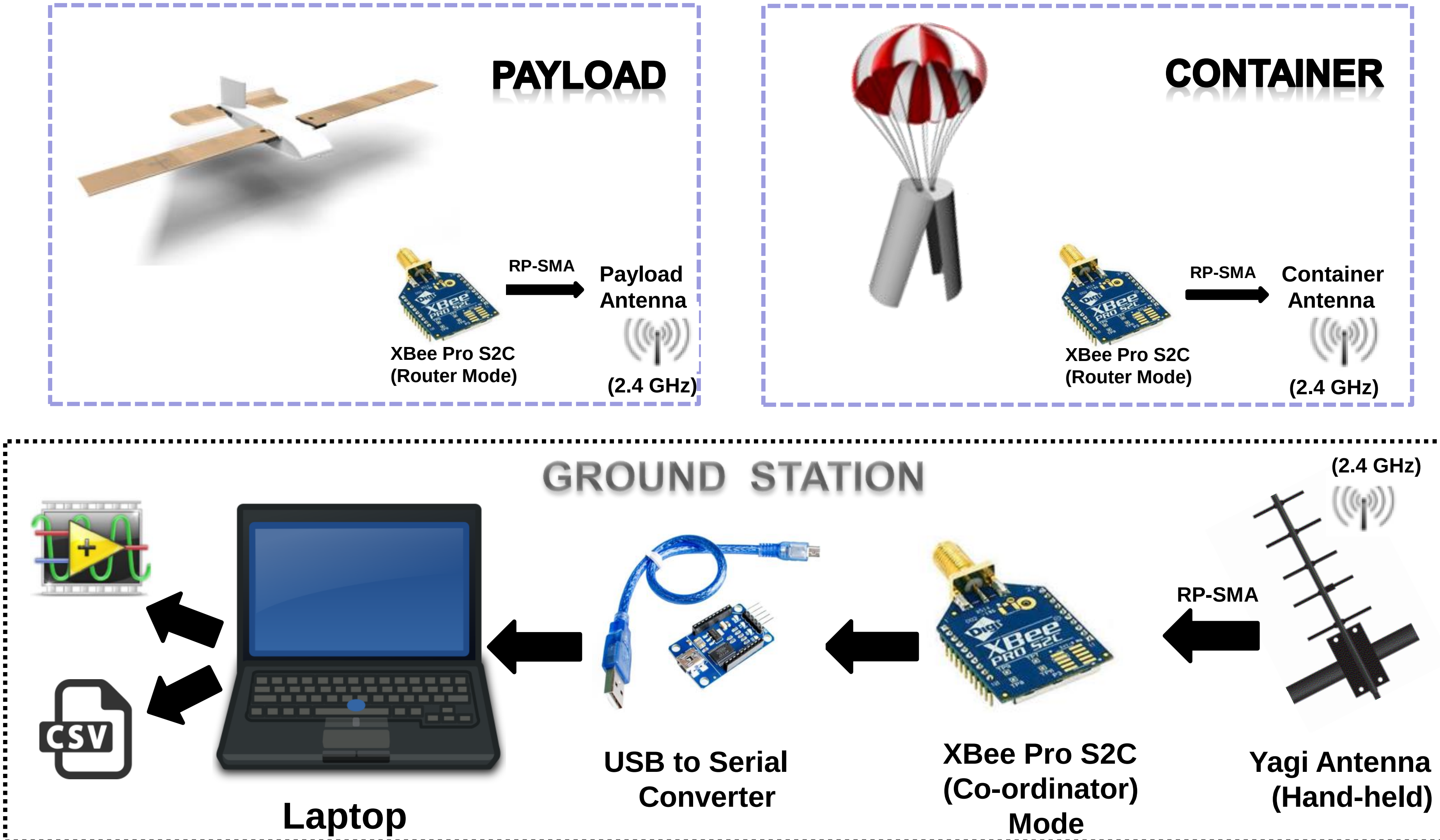
- **Development team:-**
  - Raghav Garg
  - Vibhor Karnawat
  - Aakash Verma

- **Testing Methodology**
  - Laboratory tests
  - Outdoor free-fall drops from top of the campus buildings
  - Wireless communication tests in open air
  - Weather Balloon Flights
  - Quad-copter Flights

Ground Control System (GCS) Design

Mridul Sengupta

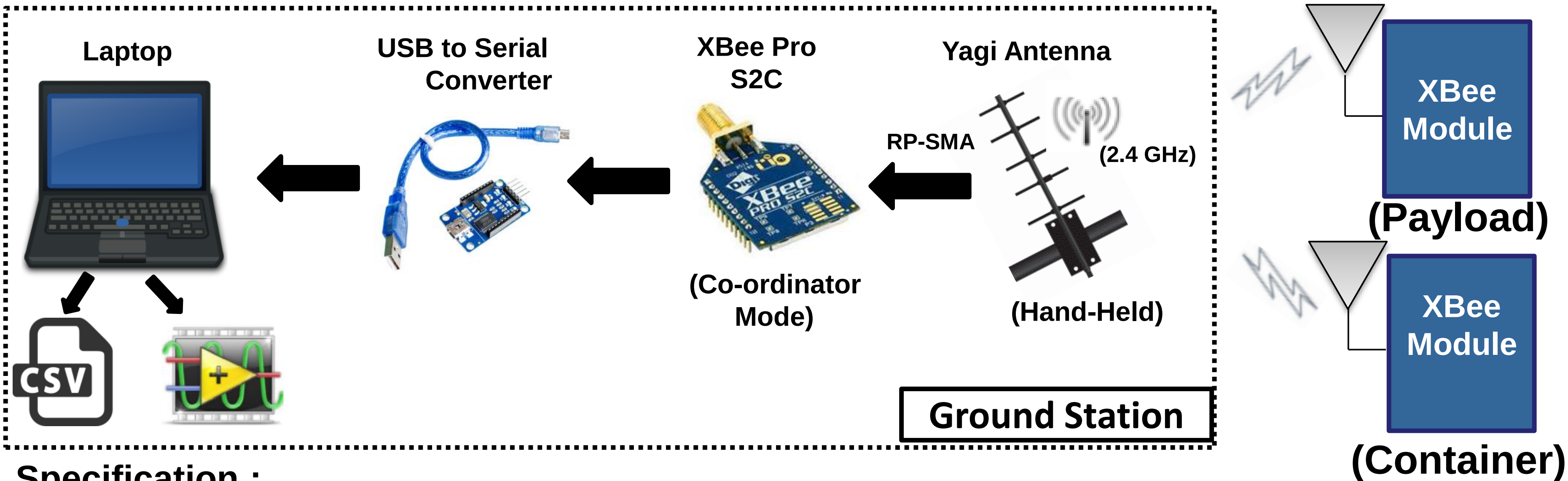
GCS Overview



GCS Requirements

ID	Requirement	Rationale	Priority	Parent	VM			
					A	I	T	D
GCS-01	Glider should be capable of sending telemetry data and ground station shall be capable of receiving telemetry data at 1Hz	Competition Requirement	HIGH	SR-12, SR-13	✓			✓
GCS-02	All the received telemetry data should be plotted on graphs in real time.	Competition Requirement	HIGH	SR-13	✓		✓	
GCS-03	GCS must be portable and have at least two hours of battery life	Competition Requirement	HIGH	SR-23	✓		✓	
GCS-04	GCS includes laptop computer, XBEE radio and hand held antenna	Competition Requirement	HIGH	SR-13,SR-15	✓	✓		
GCS-05	Antenna placement : Antenna must point upward, towards the CanSat	Better signal reception.	MEDIUM	SR-15	✓	✓		
GCS-06	All telemetry shall be displayed in engineering units	Competition Requirement	HIGH	SR-13, SR-16	✓	✓	✓	
GCS-07	To display a 2D map of estimated Glider Position based on speed and heading telemetry data	Competition Requirement	HIGH	SR-12	✓	✓		

GCS Design



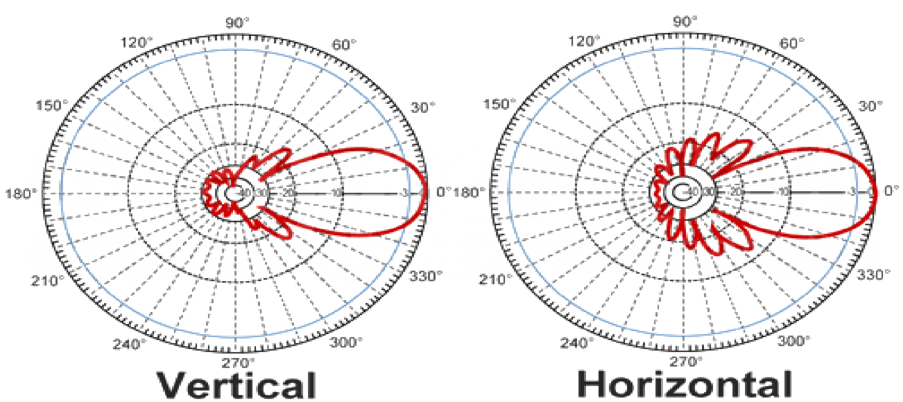
Specification :

- GCS must have at least two hours of battery life.
- To prevent over heating, unwanted Load will be minimized and a portable umbrella along with arrangements for a cooling pad shall be set up to prevent GS from the overhead sun.
- Required Configuration GCS will be used for the required software .
- Data will be logged to a plain text file with a .CSV extension and read from same file for plotting. Plotting and serial data monitoring occur in parallel.
- Will make sure that Windows is updated to latest versions and auto-updates are turned off.

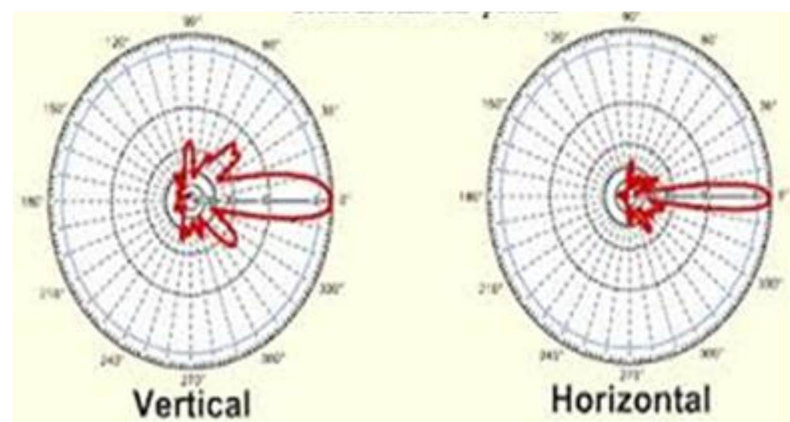
GCS Antenna Trade & Selection

ID	Type of Antenna	Gain	Directivity	Frequency	Polarization
GCS-01	YAGI 	10 dBi	Unidirectional	2.4 GHz	Vertical or Horizontal Polarity
GCS-02	GRID 	24 dBi	Unidirectional	2.4 GHz	Vertical or Horizontal Polarity

Yagi Radiation Patten



Grid Radiation Pattern



GCS Antenna Trade & Selection

- Antenna is **hand-held** by a member of GS crew with the help of antenna holder.
- Antenna holder is composed of PVC pipes.

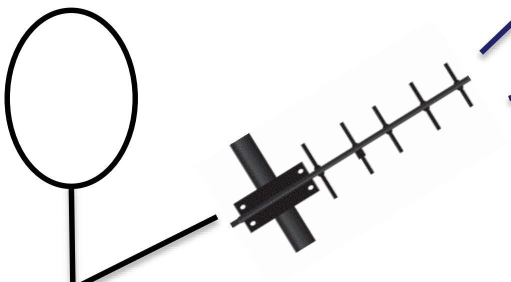
Distance Link Margin

$$FSL = 20\log(4\pi R f c)$$

Where:

R = 900m

f = 2.4GHz



As long as Yagi is pointed directly at CanSat with a margin of 10 degrees, the range of operations is around **900** meters.

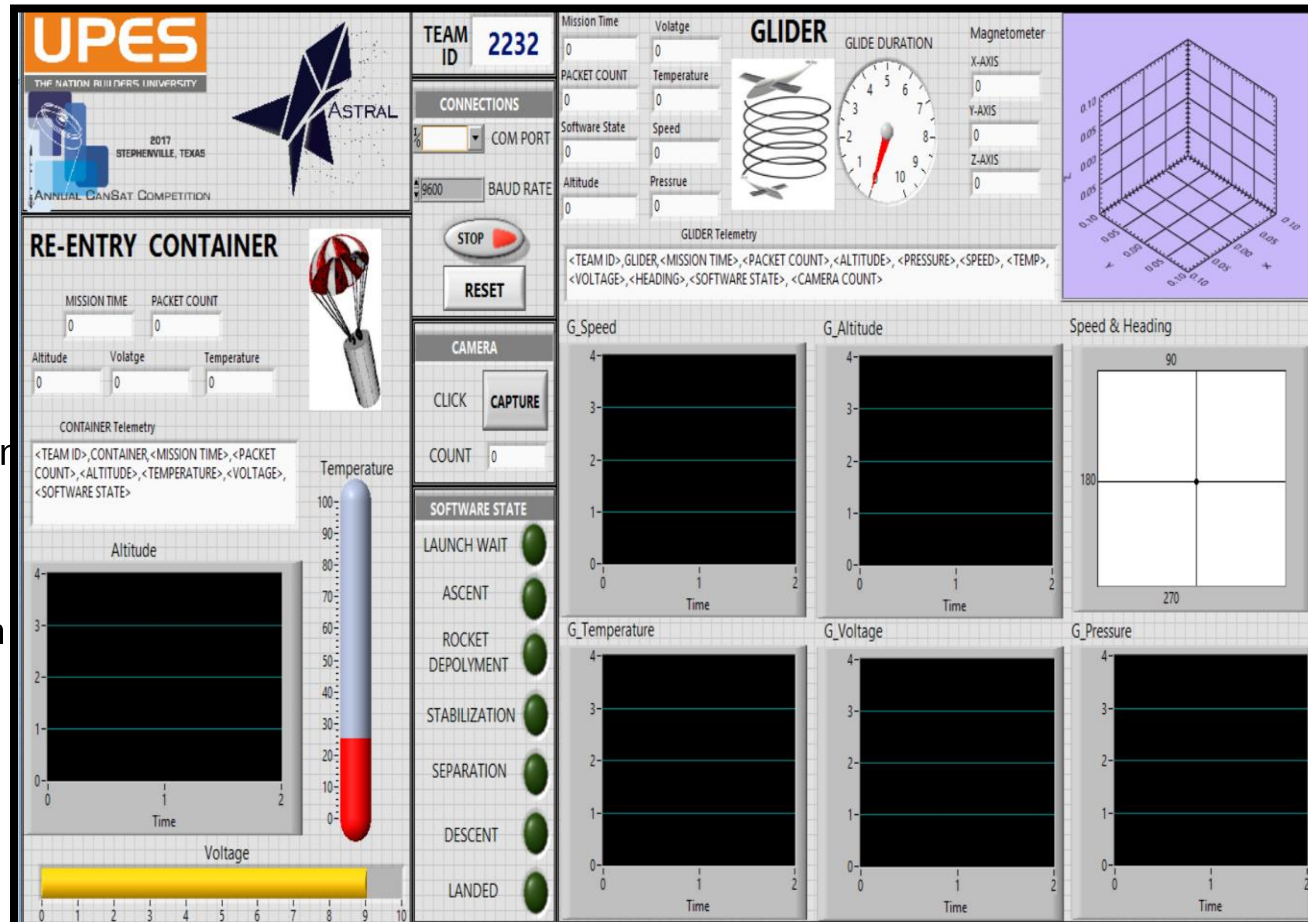
Selected: **Yagi Antenna**

- High Gain
- Polarization of this antenna is same as the polarization of glider antenna
- High Directivity
- Lightweight
- Inexpensive
- High Portability
- Acceptable radiation pattern

GCS Software

- For displaying telemetry, the LabVIEW application was created. It is Actor Frame work based application. Its modular structure enables the user to have a clear view of incoming telemetry data and provides easy access to command panel.

- Sends commands via serial through the XBee at the push of a button.
- Telemetry data recording & testing is done in X-CTU.
- MS-Excel will save data in a .CSV file on the ground station laptop which will then be provided to the Judges.
- Connection is established/ Reset using the Connection Setting.
- Push Button commands for picture clicking being provided in “Camera Controls”.



CanSat Integration and Test

Aakash Verma

Anmol Agarwal

CanSat Integration and Test Overview

GLIDER DESIGN

- A glider is designed and tested as per CanSat competition requirements.

ELECTRONICS

- PCB board is mounted with all the sensors in the fuselage of the glider.
- Solar cells are attached on the wings of the glider.
- Camera is mounted firmly at the bottom of the payload fuselage.

GLIDER & RE-ENTRY CONTAINER

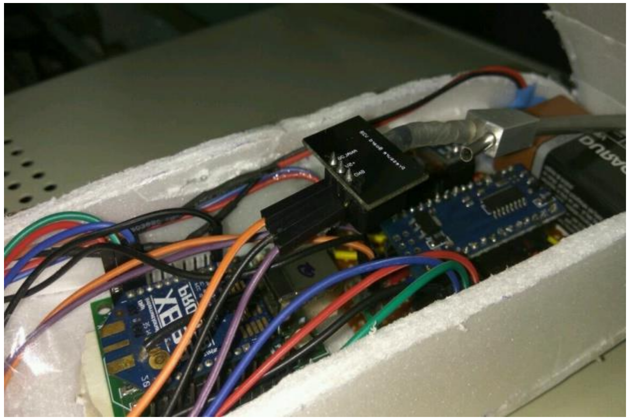
- The glider shall be placed in the re-entry container in pre-deployment configuration and the container bottom lid will be locked with the servo latch.
- The container shall be designed to open into two halves along the length for the deployment of the glider.

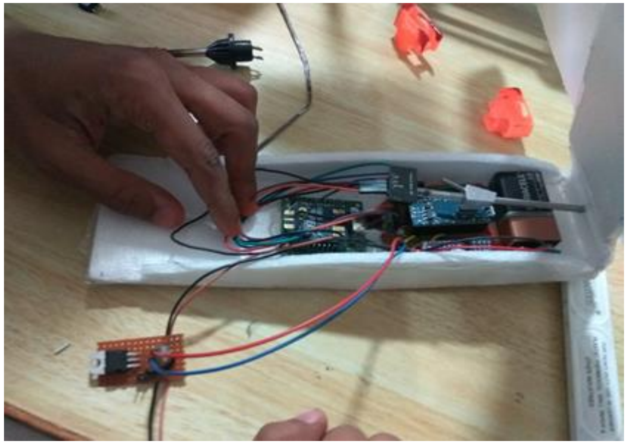
DESCENT CONTROL SYSTEM

- This is worked on initially as it is responsible for the desired helical pattern for the glider.
- The parachute is designed for the safe landing of the re-entry container.

CanSat Integration and Test Overview

Glider (prototype) integrated with Electronics succesfully passed Drop Testing through Quad-copter



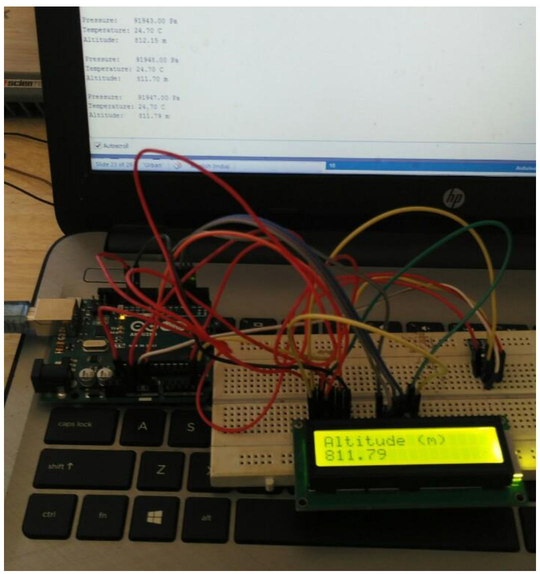


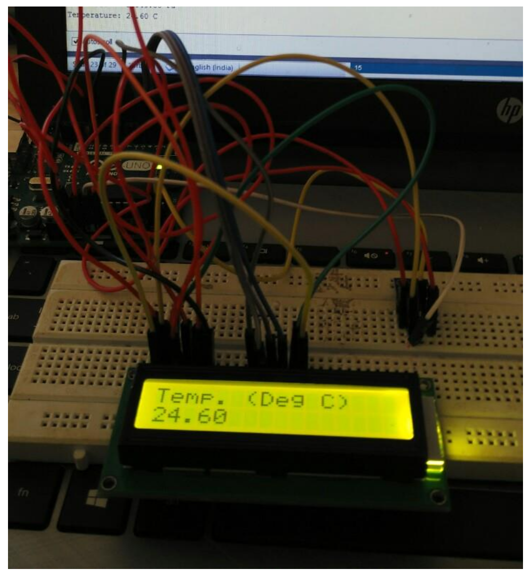
Note: Testing videos can be provided upon request

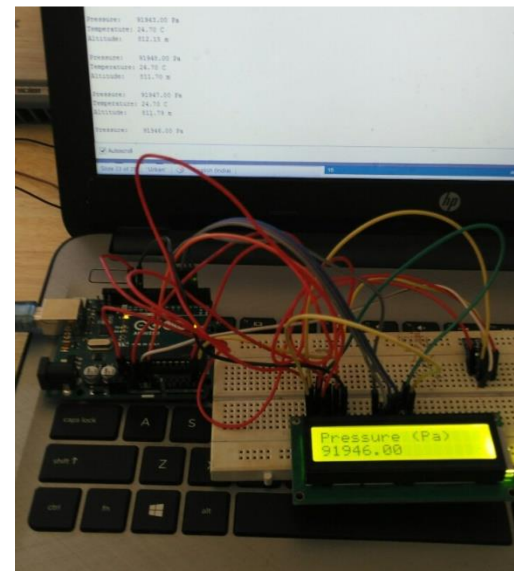
Subsystem Level Testing Plan

SENSOR SUBSYSTEM PLAN

- All the sensors shall be interfaced with the Arduino Nano according to their respective interfacing protocols (such as I2C, SPI, UART and ADC port). Once the interfacing is completed, the sensors will be tested and the readings shall be seen on the serial monitor.
- To attach a Camera module with the circuit and check for response when given click command from GS.



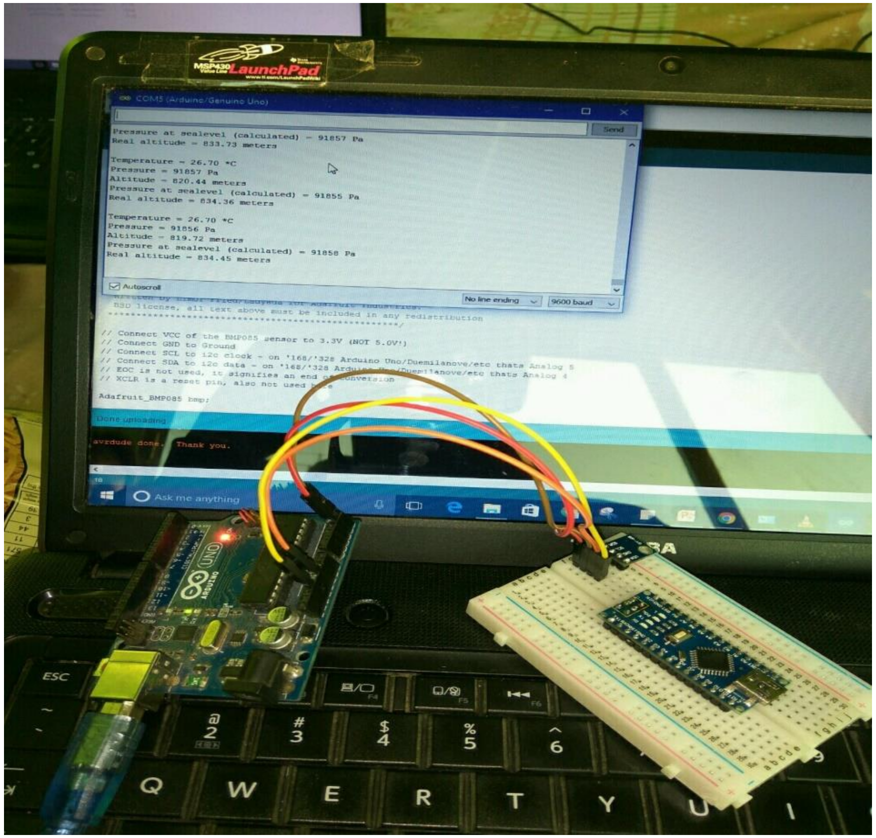




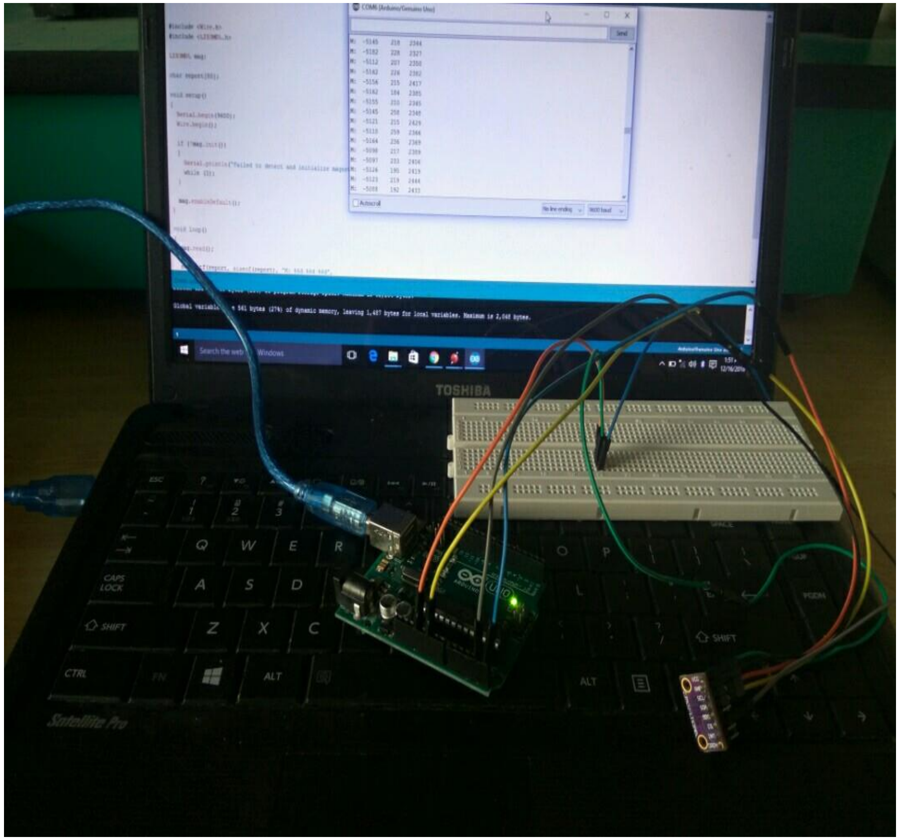
Above shows testing results of BMP180 on LCD display for Altitude, Temperature and Pressure .

Note: Testing videos can be provided upon request

Subsystem Level Testing Plan



Testing results for BMP180 (Pressure, altitude and temperature sensor) on Serial Monitor.

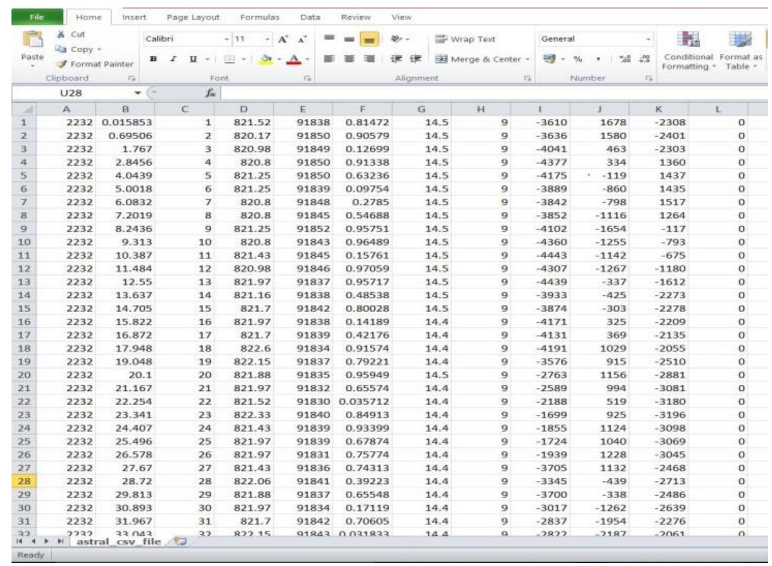


Testing results for LIS3MDL(magnetometer) on Serial Monitor.

CDH SUBSYSTEM PLAN

- Checks communication with every sensor and other devices.
- The data then shall be collected from all the sensors (Telemetry data) and sent using Radio Communication at 1Hz rate in the required format to the ground station, both through the payload and container when required.
- Antenna Range tests shall be performed, checking GS antenna with Payload Antenna and Container Antenna both under different ranges and positions.

XBee Pro S2C testing for radio communication.



	A	B	C	D	E	F	G	H	I	J	K	L
1	2232	0.015853	1	821.52	91838	0.81472	14.5	9	-3610	1678	-2308	0
2	2232	0.69506	2	820.17	91850	0.90579	14.5	9	-3636	1580	-2401	0
3	2232	1.767	3	820.98	91849	0.12699	14.5	9	-4041	463	-2303	0
4	2232	2.8456	4	820.8	91850	0.91338	14.5	9	-4377	334	1360	0
5	2232	4.0439	5	821.25	91850	0.63236	14.5	9	-4175	-119	1437	0
6	2232	5.0018	6	821.25	91839	0.09754	14.5	9	-3889	-860	1435	0
7	2232	6.0832	7	820.8	91848	0.2785	14.5	9	-3842	-798	1517	0
8	2232	7.2019	8	820.8	91845	0.54688	14.5	9	-3852	-1116	1264	0
9	2232	8.2436	9	821.25	91852	0.95751	14.5	9	-4102	-1654	-117	0
10	2232	9.313	10	820.8	91843	0.96489	14.5	9	-4360	-1255	-793	0
11	2232	10.387	11	821.43	91845	0.15761	14.5	9	-4443	-1142	-675	0
12	2232	11.484	12	820.98	91846	0.97059	14.5	9	-4307	-1267	-1180	0
13	2232	12.55	13	821.97	91837	0.95717	14.5	9	-4439	-337	-1612	0
14	2232	13.637	14	821.16	91838	0.48538	14.5	9	-3933	-425	-2273	0
15	2232	14.705	15	821.7	91842	0.80028	14.5	9	-3874	-303	-2278	0
16	2232	15.822	16	821.97	91838	0.14189	14.4	9	-4171	325	-2209	0
17	2232	16.872	17	821.7	91839	0.42176	14.4	9	-4131	369	-2135	0
18	2232	17.948	18	822.6	91834	0.91574	14.4	9	-4191	1029	-2055	0
19	2232	19.048	19	822.15	91837	0.79221	14.4	9	-3576	915	-2510	0
20	2232	20.1	20	821.88	91835	0.95949	14.5	9	-2763	1156	-2881	0
21	2232	21.167	21	821.97	91832	0.65574	14.4	9	-2589	994	-3081	0
22	2232	22.254	22	821.52	91830	0.035712	14.4	9	-2188	519	-3180	0
23	2232	23.341	23	822.33	91840	0.84913	14.4	9	-1699	925	-3196	0
24	2232	24.407	24	821.43	91839	0.93399	14.4	9	-1855	1124	-3098	0
25	2232	25.496	25	821.97	91839	0.67874	14.4	9	-1724	1040	-3069	0
26	2232	26.578	26	821.97	91831	0.75774	14.4	9	-1939	1228	-3045	0
27	2232	27.67	27	821.43	91836	0.74313	14.4	9	-3705	1132	-2468	0
28	2232	28.72	28	822.06	91841	0.39223	14.4	9	-3345	-439	-2713	0
29	2232	29.813	29	821.88	91837	0.65548	14.4	9	-3700	-338	-2486	0
30	2232	30.893	30	821.97	91834	0.17119	14.4	9	-3017	-1262	-2639	0
31	2232	31.967	31	821.7	91842	0.70605	14.4	9	-2837	-1954	-2276	0
32	2232	33.043	32	822.15	91843	0.031833	14.4	9	-2822	-2187	-2061	0

Telemetry Data in .csv files

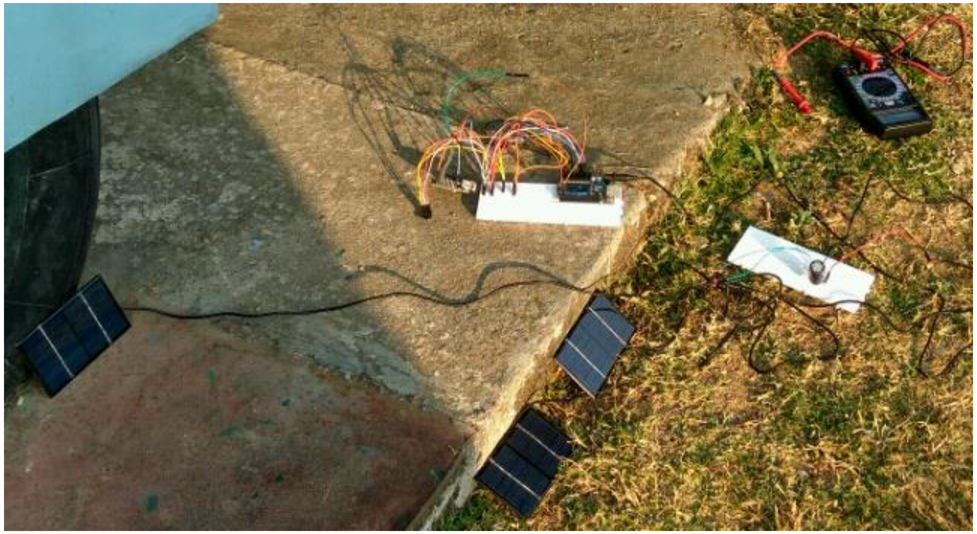
EPS SUBSYSTEM PLAN

PAYLOAD

- Calculation of power requirements of each of the components to be powered by solar cells.
- Selection of solar cells with power output equal to the required amount considering additional 25% loss.
- Selection of appropriate regulator.
- A circuit shall be designed and tested for sustained power supply.

CONTAINER

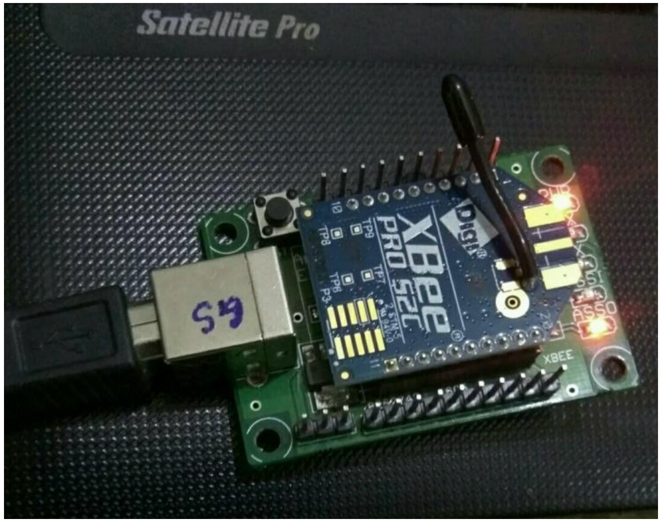
- Calculation of power requirement for the container and designing power circuitry accordingly.



Solar Panel Testing

RADIO COMMUNICATIONS PLAN

- The radio modules (for glider and ground station) being used, XBEE PRO S2C, is configured to work in full duplex mode for point-to-point communication.
- The two transmitting XBEEs is configured to work as AT router whereas the ground station XBEE as AT Co-ordinator.
- The destination address for each Router is set to the Coordinator's serial ID.
- After configuration, the radios will be tested by transmitting data through the router XBEEs to the Co-ordinator XBEE.

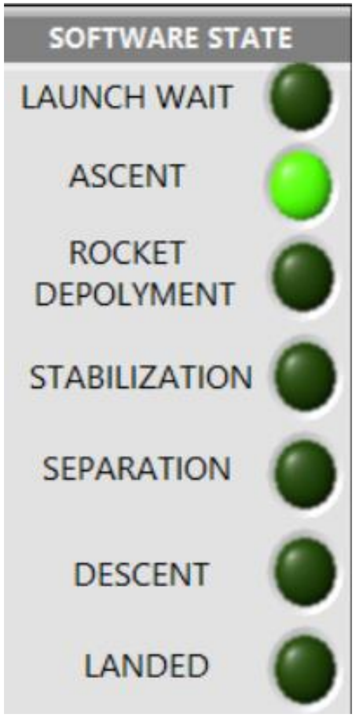


Radio Module: XBee Pro S2C

Subsystem Level Testing Plan

FSW PLAN

- Performing separate checks for different Flight software states.
- To check if FSW recovers properly after reset.
- To perform individual tests for payload separation system at different altitudes.
- Monitor software performance under various kinds of conditions.

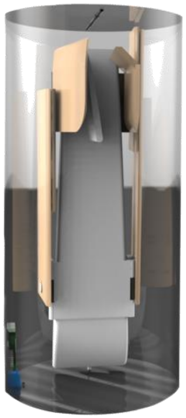


Flight Software States

Subsystem Level Testing Plan

MECHANICAL SUBSYSTEM PLAN

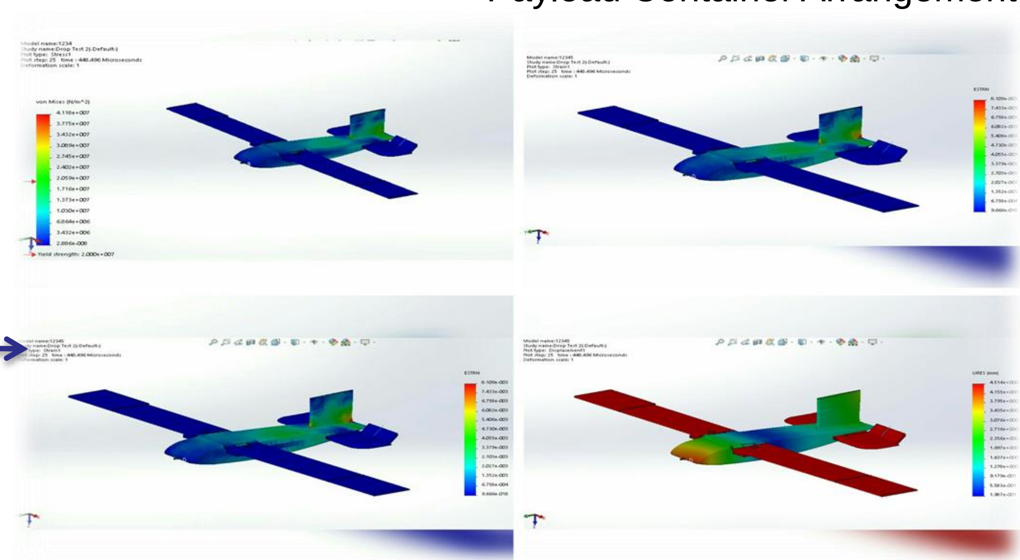
- To perform weight checks if total mass is within range [490,510] grams .
- To perform checks whether glider is completely fitted into the container and there are no sharp edges in the container.
- To check whether our CanSat survives successful drop tests and structure survivability tests.



Payload Container Arrangement

A simulation of Stress, Displacement and Strain variation throughout the proposed Glider was done in solid works

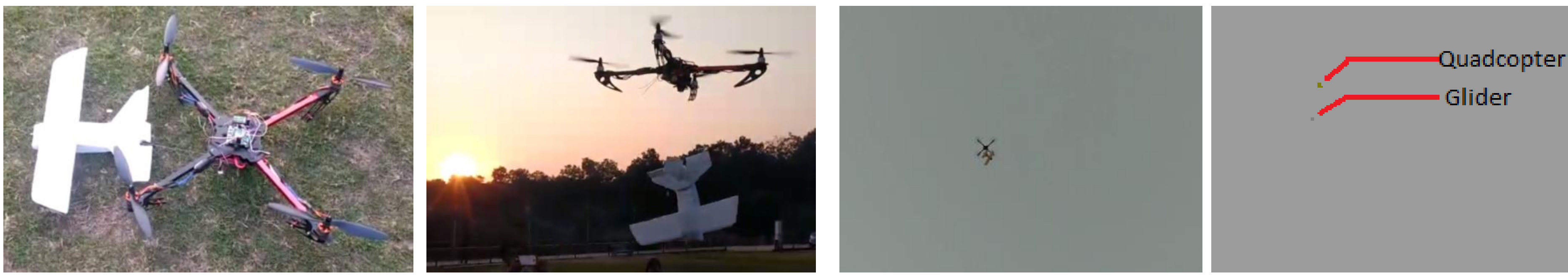
RESULT



Subsystem Level Testing Plan

DESCENT CONTROL SYSTEM PLAN

- The parachute has been tested along with the CanSat (Glider) by dropping it with the help of a Quad-copter from a height of about 150-180m.
- The complete CanSat system along with the sensor subsystem electronics will be tested using a Helium Weather Balloon and perform Descent Test from heights up to 400-500m.
- The total time of flight, descent rate and vibration and survivability test of the payload and the container shall be performed practically and recorded.



Quad Copter Descent Control Testing

Integrated Level Functional Test Plan

GLIDER TESTING

- The glider is tested from different heights in various configurations such as nose down, nose up, nose inclination at possible angle of attack during deployment and ensuring the glider achieves the required helical glide in all the different configurations of deployment.

Glider Flight Testing

Integrated Level Functional Test Plan

COMMUNICATIONS

The respective electronics is integrated on a PCB so as to reduce the size as well as the weight of the glider and container electronics, which will then be inserted in the glider as well as the re-entry container and on a whole shall be tested including the data from the sensors sent using XBEE modules.

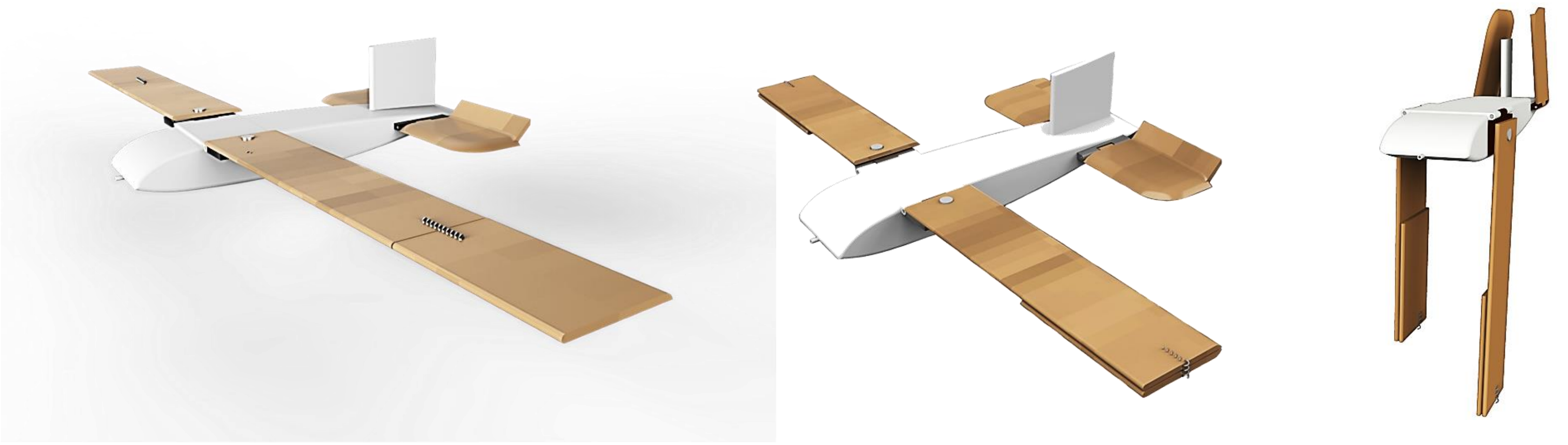
Radio module: XBee Pro S2C Testing

Telemetry Data on X-CTU

Note: Testing videos can be provided upon request

MECHANISMS

The wing folding/un-folding mechanism is done with the help of hinges which is custom made by 3D printing. This will ensure that the wing shall unfold itself as soon as it is released from the re-entry container. For this the gilder is dropped from the quadcopter from a height of 150+/-10m in pre-deployment configuration and result is observed. At final stage a glider drop test shall be done with a weather balloon from a height of 500+/-10m.



Wing Folding Mechanism

Integrated Level Functional Test Plan

DEPLOYMENT

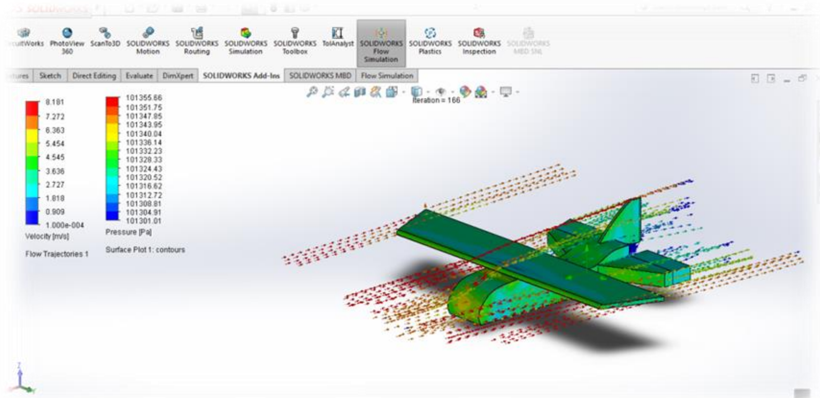
With the help of altitude sensor, as soon as the re-entry container reaches an altitude of 400+/-10 m, the servo latch gets activated, the lid of re-entry container opens and the glider is deployed. This testing is to be done with the help of Weather balloon and Quadcoptor.

Glider Deployment

WIND TUNNEL TESTING

To practically observe and verify the amount of lift and drag produced by the glider. A simulation of the CAD model was run in Solidworks Software

SolidWorks Simulation



Environmental Test Plan

Drop Test Procedure

1. Secure the cord to the ceiling or structure eye-bolt.
2. Secure the other end of the cord to the parachute attachment point of the container.
3. Raise the CanSat up 80 cm in line with the cord.
4. Release the CanSat and let it drop.
5. Observe the results of the drop test. Did the parachute attachment point fail? Did the glider release from the container.
6. Remove the glider from the container and inspect for any damage.
7. If there was no damage, turn on the glider and perform a functional test.

Thermal Test Procedure

1. Place CanSat into the hot oven.
2. Turn on the CanSat.
3. Close the hot oven.
4. Monitor the temperature and turn off the oven when the internal temperature reaches 60ºC
5. Maintain the temperature for 10 minutes.
6. Turn off the oven and perform visual inspection and any functional tests to verify the CanSat survived the thermal exposure and can operate as expected.

7. With the CanSat still hot, test any mechanisms and structures to make sure the integrity has not been compromised.
8. Verify epoxy joints and composite materials still maintain their strengths.

Vibration Test Procedure

1. Perform a functional test of the CanSat.
2. Mount the glider on the vibration fixture and secure it in place.
3. If included, start the accelerometer data collection.
4. Over a 1 minute period, turn the sander on. Let it power up to full speed, wait 2 seconds and turn off. As soon as the sander stops moving, repeat until one minute is complete.
5. Remove CanSat from test fixture and inspect it for any damage.
6. Perform a functional test.
7. Review accelerometer data to determine the intensity of the vibrations.

Mission Operations & Analysis

Monika Sharma

Overview of Mission Sequence of Events

Mission Sequence will proceed as follows:

Arrival

- Weight check of the CanSat
- Verification of communication between CanSat and Ground Control Station
- Final Check for Sensors

Ground Station Setup

- Antenna Assembly and Ground Station Settings

GROUND STATION CREW

CanSat Assembly

- Check for Mechanical Damage in the CanSat structure
- Unfolding Mechanism Check
- CanSat Assembly

GROUND STATION AND CANSAT CREW

Flight Preparations

- Power On re-entry container electronics
- Integration of CanSat into Rocket Payload
- Launch

CANSAT CREW

Overview of Mission Sequence of Events

Mission

- **Telemetry transmission from re-entry container to the ground station**
- **Deployment of container from Rocket at apogee**
- **Parachute opens right after deployment**
- **Re-entry container and Glider separation at 400m**
- **Transmission of data from Glider begins and**
- **Audio Beacon Activation when Glider lands**
- **Telemetry Transmission from glider stops**

Recovery

- **Recovery Crew to enter the field and search for CanSat**
- **Localization of the Field Judge and delivering of score card**
- **Retrieval of re-entry container and the CanSat**
- **Submission of the telemetry data file for inspection**

RECOVERY CREW

Analysis

- **Collection of data acquired by camera**
- **Analysis of obtained data**
- **Mission assessment and preparation of the post flight review**
- **Delivery of the presentation on the next day**

WHOLE TEAM

The Development Process

This includes various checklist for initial ground setup, launch preparation and recovery of payload. It also includes safety guidelines and troubleshooting mechanism.

Manual major components

Pre-launch Checklist	**Structural tests** - Unfolding mechanism test - Glider release mechanism - Final visual checkup of parachute **Electronics test** - Check all PCB connections - Check working of all sensors - Check camera trigger
CanSat and GCS setup checklist	✓ Initial Startup of the program ✓ Configure the GCS and begin data receiving
CanSat assembly test	✓ Installation of the glider inside the container
Integration	✓ Integrate the CanSat into rocket and mount it on the stand
Recovery	✓ Recovery crew will be ready to retrieve the CanSat

CanSat Location and Recovery

- The recovery crew will be split into two teams, one in search for the glider and other for the container:

Container recovery

- The container will be visually spotted during its descent by parachute.
- Both re-entry container and parachute will be painted fluorescent orange to increase the visibility.
- The audio beacon will aid in locating the container.

Payload recovery

- Payload will be painted fluorescent orange to increase the visibility.
- The audio beacon will aid in locating the glider on landing.

- The Glider and the re-entry container will possess the following information written on them to aid identification:

Team Leader Name
Team Number
Contact Details
Email Address

Requirements Compliance

Kavitha Venugopalan

Requirements Compliance Overview

- **The following designs comply to the required :**
  - Mechanical Subsystem
    - Glider meets all dimensional requirements.
    - Cansat meets mass requirements.
    - Glider meets flight pattern requirements.
    - Container meets specifications and launch verification requirements.
  - Electronics Subsystem
    - GCS meets communication requirements.
    - Most sensors collect data at required sampling rate.
    - Flight software has been analyzed.

- **Not Comply**
  - Electronics Subsystem

    Final Integration of the camera (as a Bonus Objective) is yet to be integrated with the complete system and tested practically to meet the power budget targets.

Requirements Compliance (1 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Base requirements	--	--	--
2	Total mass of CanSat, container, and all descent control devices shall be 500 grams. Mass shall not vary more than +/- 10 grams.	**Comply**	**12,47,70,66,35,159**	
3	The CanSat must be installed in a container to protect it from deployment out of the rocket.	**Comply**	12,13,17,2729,31,47,52	
4	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length	**Comply**	12,27,47	
5	The container must use a descent control system. It cannot free fall.	**Comply**	12,26,29,46,50	
6	The container shall not have any sharp edges that could cause it to get stuck in the rocket payload section.	**Comply**	31,46,75,77	
7	The container must be a florescent color, pink or orange.	**Comply**	171	

Requirements Compliance (2 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
8	The Container cannot free fall. A parachute is allowed and highly recommended. Include a spill hole to reduce swaying.	Comply	50,51	
9	The container shall not have any sharp edges that could cause it to get stuck in the rocket Glider section.	Comply	12,27,31,52,66	
10	No protrusions beyond the envelope defined are allowed while stowed in the rocket.	Comply	31,66,75,77	
11	The rocket airframe cannot be used to restrain any deployable parts of the CanSat. The rocket airframe cannot be used to restrain any deployable parts of the CanSat.	Comply	17,27,31	
12	The rocket airframe and Glider section shall not be used as part of the CanSat operations.	Comply	31,12	
13	The CanSat shall deploy from the rocket Glider section.	Comply	31,164	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
14	The CanSat shall comply with the required descent and recovery requirements.	Comply	12,26	
15	The descent control system shall not use any flammable or pyrotechnic devices.	Comply	12,13	
16	The Container and Glider shall include electronics and mechanisms to determine the best conditions to release the Glider at altitude of 400m ± 10m	Comply	13,46,163,160,164	
17	The Glider must glide in a preset circular pattern of no greater than 1000 meter diameter.	Comply	13,25	
18	Total glide duration must be close to 2 minutes.	Partial	49	Testing yet to be done
19	Glider must be a fixed wing Glider.	Comply	17,21,25,56	

Requirements Compliance (4 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
20	All descent control device attachments must survive 30 Gs of shock.	Comply	13,69,71	
21	All descent control devices must survive 15 Gs of shock.	Comply	68,71	
22	The CanSat shall comply with the following communications requirements	Comply	14,109	
23	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are also allowed.	Comply	24,109,118	
24	The XBEE radios shall have their NETID/PANID set to the team number.	Comply	99,109,111	
25	The XBEE radio shall not use the broadcast mode.	Comply	99	

Requirements Compliance (5 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
26	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand held or table top antenna.	Comply	133,144,148	
27	The XBEE radio can operate in any mode as long as it does not interfere with other XBEE radios.	Comply	97,99,109,111	
28	The telemetry is displayed in engineering units in real time	Comply	113,114,145	
29	The CanSat shall comply with the following power requirements:	Comply	25	
30	The CanSat shall have an external power control such as a power switch and some indication of being turned on or off.	Comply	25,120,121	
31	Lithium polymer cells are not allowed due to being a fire hazard. Alkaline, Ni-MH, lithium ion built with a metal case, and Ni-Cad cells are allowed.	Comply	77,116,118,121	
32	The glider electronics shall be solar powered.	Comply	15,21,69,117,120	

Requirements Compliance (6 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
33	The CanSat shall comply with the following flight software requirements.	Comply	134,135	
34	The CanSat flight software shall maintain and telemetry a variable indicating its operating state. In the case of processor reset, the flight software shall re-initialize to the correct state either by analyzing sensor data and/or reading stored state data from non-volatile memory. The states are to be defined by each team.	Comply	133-142	
35	The cost of the CanSat flight hardware shall be under $1000 (USD). Ground support and analysis tools are excluded.	Comply	14,188	
36	Each team shall develop and use their own ground station. All telemetry shall be displayed in real-time during launch and descent. All telemetry shall be displayed in engineering units (meters, meters per second, Celsius, etc.). Teams shall plot data in real-time during flight.	Comply	28,29	
37	Structure Requirements	--		
38	All electronics shall be enclosed and shielded from the environment. No electronics can be exposed except for sensors. There must be a structural enclosure.	Comply	13	

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
39	The structure must support 15 Gs acceleration.	Comply	68	
40	The structure must survive 30 Gs shock force.	Comply	69	
41	Electronic circuit boards must be hard mounted using proper mounts such as standoffs and screws. High performance adhesives are acceptable.	Comply	88	
42	Both the container and Glider shall be labeled with team contact information including email address	Comply	171	
43	Mechanisms Requirements	--		
44	Mechanisms must be capable of maintaining their configuration or states under all forces such as acceleration and shock forces.	Comply	13,51,68,69,71	

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
45	Mechanisms must not use pyrotechnics or chemicals.	**Comply**	**12,13,78**	
46	Mechanisms that use heat (e.g. nichrome wire) must not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	**Comply**	12,13	
47	The Container or Glider shall include electronics and mechanisms to determine the best conditions to release the Glider based on stability and pointing.	**Comply**	66,67,77	
48	The Glider shall incorporate a Pitot tube and measure independent air speed.	**Comply**	33,39	
49	The Glider shall incorporate a camera which should receive a command to capture and image of the ground and store the image on board for later retrieval.	**Comply**	44,102	
50	During descent, the Glider shall transmit the following telemetry data once every one second.	**Comply**	97-114,147,148,149	

Requirements Compliance (9 of 9)

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
51	Pressure in Pascal. Altitude in meters above sea level Air temperature. Battery voltage in volts.	Comply	33-44,60,125	
52	The external power connection shall be a sturdy connector that is easily accessible when the Glider is stored in the container.	Comply	23,24,25,74,75, 77,152	
53	Flight software maintained mission time and real time plots of data.	Comply	149,154,155,162	
54	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission.	Comply	11,14,133,134,136,138,145	
55	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission.	Comply	12,47,70,66,95,159,173	

Management

Kavitha Venugopalan
Vipul Mani

CanSat Budget – Hardware

ELECTRONICS HARDWARE					
Component		**Model**	**Quantity**	**Cost**	**Determination**
Micro Controller		Arduino Nano	2	$ 27.99	Actual
Communication Module		Xbee Pro S2C	3	$ 154.95	Actual
Sensors	Temperature Pressure Altitude	BMP 180	2	$ 12.50	Actual
	Magnetometer	LIS3MDL	1	$ 5.55	Actual
	Pitot Tube	Freescale MPXV7002	1	$ 24.95	Actual
Camera		VC0706 Serial TTL	1	$ 56.03	Actual
Audio Beacon		Miniature Buzzer	1	$1.05	Actual
Super Capacitor		Panasonic Kam Cap (Coin Type)	1	$ 3.42	Actual

CanSat Budget – Hardware

ELECTRONICS HARDWARE				
Component	**Model**	**Quantity**	**Cost**	**Determination**
Antenna	Rubber-duck L-COM	2	$ 88.20	Estimated
Circuit Base Boards	PCB	1	$ 10.00	Actual
Miscellaneous			$ 20.00	
SUBTOTAL			**$ 404.64**	

CanSat Budget – Hardware

MECHANICAL HARDWARE				
Category	**Model**	**Quantity**	**Cost**	**Determination**
Glider Material	Polypropylene and Balsa Wood	-	$ 35.00	Estimated
Re-Entry Container Material	Acrylic	4 meter square	$ 100.00	Estimated
Parachute	Rip-Stop Nylon	1	$ 31.95	Actual
Fabrication of Glider	-	-	$ 80.00	Estimated
Servo Motor	RKI-1129	1	$ 17.00	Actual
SUBTOTAL			**$ 263.95**	

CanSat Budget – Other Costs

GROUND CONTROL COST

Component	Model	Quantity	Cost	Determination
Antenna	Yagi Antenna	1	$ 80.88	Estimate
Micro Controller	Arduino Nano	1	$ 35.00	Actual
Communication Module	Xbee Pro S2C	1	$ 70.00	Actual
Others			$ 20.00	
SUBTOTAL			**$ 205.88**	

CanSat Budget – Other Costs

OVERALL COST

Category	Costs
Mechanical Hardware	$ 263.95
Electronics Hardware	$ 404.64
Ground Costs	$ 205.88
TOTAL	**$ 874.47**

Note : The Total Cost of the CanSat adds to $ 874.47 which lies well within the Competition Guidelines of $ 1000.

CanSat Budget – Other Costs

Component	Quantity	Cost	Determination
Prototyping		$ 5,500	Estimate
Travel	10	$ 15,000	Estimate
Accommodation/ Hotel Room	2	$ 900	Estimate
Transport	10	$ 500	Budgeted
Food	10	$ 700	Budgeted
SUBTOTAL		**$ 22,600**	

Sources of Funds:

Our Management Team is in constant seek of Sponsors that would aid in the funding of the project. Till date it is self funded.

Program Schedule

- Competition started in **September'16** with formation of team by selecting students who could best contribute to the Team Requirement. The focus was then converged onto the mission statement, probing the ideas which could complete the task in the most efficient and effective way.

- In **October '16**, different designs for Gliders were discussed and research on sensors complying to the competition requirements started.

- In **November '16,** different designs were discussed and an apt design was chosen to work upon and around **November 15th 2016**, work on **PDR** started and it was divided among different team members.

- In **December '16**, the Team was registered following which we began with the **End Semester exams** during which 4 prototypes underwent full flight test.

- The PDR was compiled by the **25th January 2017**, and was mailed on the **1st February 2017**.

Program Schedule

- In **February '17**, small scale fabrication of the Glider shall begin along with building of the electronic circuits. By the mid of February, we intend to start testing our model by drop tests and on the basis of the test results we shall decide the further modus operandi.

- By **March '17**, our **Mid semester exams** will begin. Mid of March shall witness us start work on **CDR** and intend to compile it until 25th March 2017 for final reviewing.

- CDR will be submitted on **29th March '17**. Also Team Members who do not hold U.S. VISA, will apply for their VISA application.

- In **March '17**, we will start full scale fabrication of the Glider; UAV Drop Tests and Weather Balloon Testing from a height of ~300m will be done to ensure proper working.

- Any failures, would lead us to make more improvements in our model and thus bring us closer to our success. The required changes will be incorporated immediately to the model and will be retested.

Program Schedule

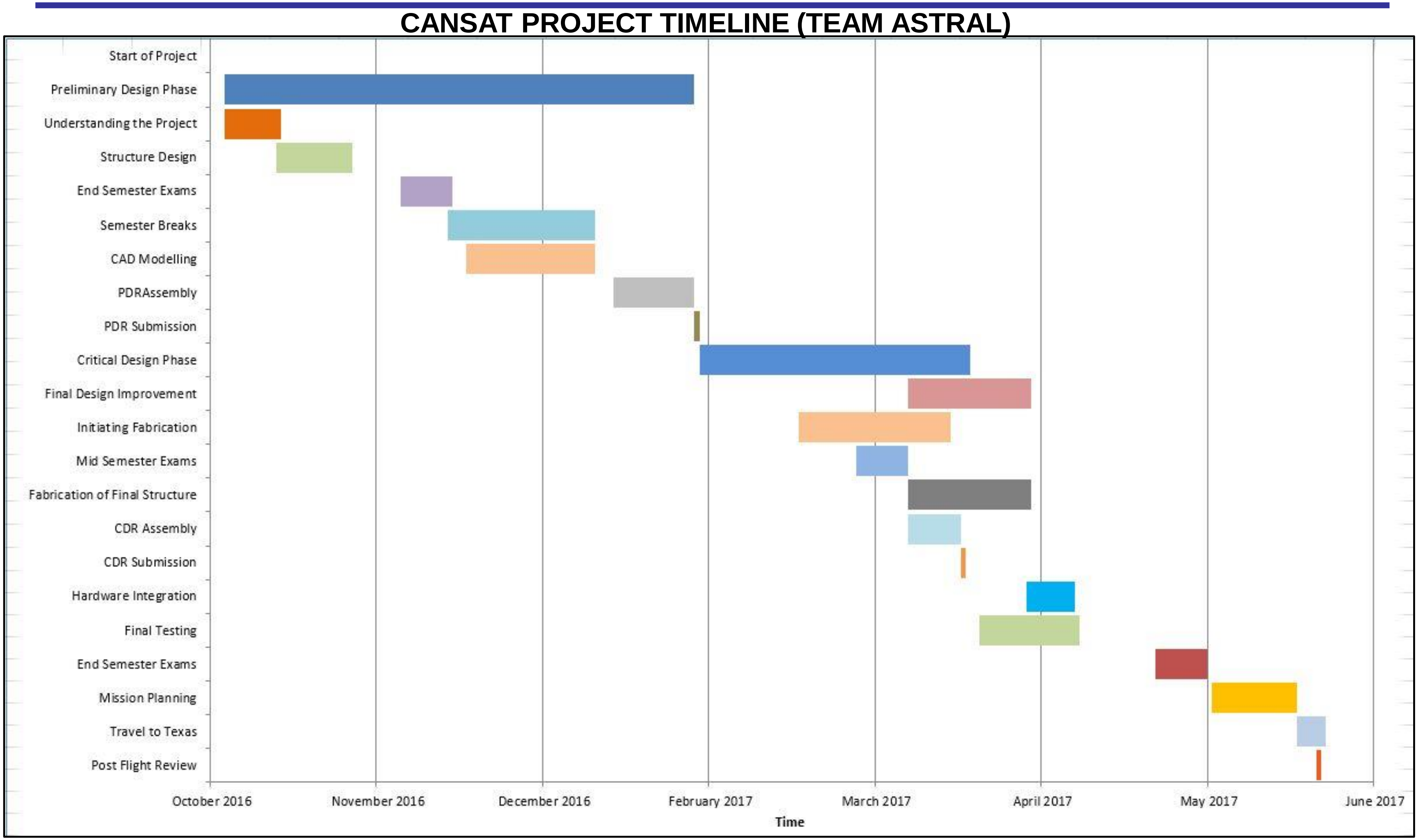
- By **May '17**, our **End semester exams** will start. Our final model for the CanSat Competition 2017 will be fabricated with precision by the end of May 2017.

- In **June '17**, miscellaneous errands like team merchandise and proper packaging of the CanSat will be done. And finally, on 6th June, our team will depart for participating in the competition.

CanSat Project Timeline

Task	Start date	Duration	End date
Preliminary Design Phase	25-Oct-16	99	31-Jan-17
Start of Project	25-Oct-16	0	25-Oct-16
Preliminary Design Phase	25-Oct-16	99	31-Jan-17
Understanding the Project	25-Oct-16	12	5-Nov-16
Structure Design	5-Nov-16	16	20-Nov-16
End Semester Exams	1-Dec-16	11	10-Dec-16
Semester Breaks	11-Dec-16	31	10-Jan-17
CAD Modelling	15-Dec-16	27	10-Jan-17
PDRAssembly	15-Jan-17	17	3-Jan-17
PDR Submission	1-Feb-17	1	1-Feb-17
Critical Design Phase	2-Feb-17	57	29-Mar-17
Final Design Improvement	18-Mar-17	26	12-Apr-17
Initiating Fabrication	23-Feb-17	32	25-Mar-17
Mid Semester Exams	7-Mar-17	11	17-Mar-17
Fabrication of Final Structure	18-Mar-17	26	12-Apr-17
CDR Assembly	18-Mar-17	11	28-Mar-17
CDR Submission	29-Mar-17	1	29-Mar-17
Hardware Integration	12-Apr-17	10	21-Apr-17
Final Testing	2-Apr-17	21	22-Apr-17
End Semester Exams	9-May-17	11	29-May-17
Mission Planning	21-May-17	18	7-Jun-17
Travel to Texas	8-Jun-17	6	13-Jun-17
Post Flight Review	12-Jun-17	1	6-Jun-17

Program Schedule



Conclusions

A Comprehensive Study of the Competition Requirements for Cansat 2017 has been done and all potential solutions have been identified and mentioned. The Preliminary Design Review aims to present all preliminary accomplishments and progress made during Phase 2 (out of 5) of the competition.

Accomplishments

- ✓ 3D models have been developed to ensure all components will fit after fabrication.
- ✓ Multiple wing configurations designed and prototyped.
- ✓ Successfully tested a glider prototype for helical glide, with onboard electronics.
- ✓ Flight Software real-time telemetry test runs have given positive results.
- ✓ Electronics board for the Glider is finalized conceptually and interfacing is underway.

Unfinished Work

- ✓ The antenna has been ordered but yet to be received.
- ✓ Communication System test has to be performed after procurement of XBee Antennas.
- ✓ Environmental Tests are yet to be conducted.

The Preliminary Design Phase is complete for Mechanical and Electronics setup. Design and hardware, both are finalized and we are ready to move to the next phase i.e. the Critical Design Phase.

Conclusions

Questions?