University of Petroleum and Energy Studies
CanSat 2017
Critical Design Review (CDR)
Version 2.0

#2232

Team Astral

March 29, 2017

Presentation Outline

Contents:

Presentation Outline

Presentation Outline

7. Communication & Data Handling (CDH) Subsystem Design

8. Electrical Power Subsystem (EPS) Design [112]

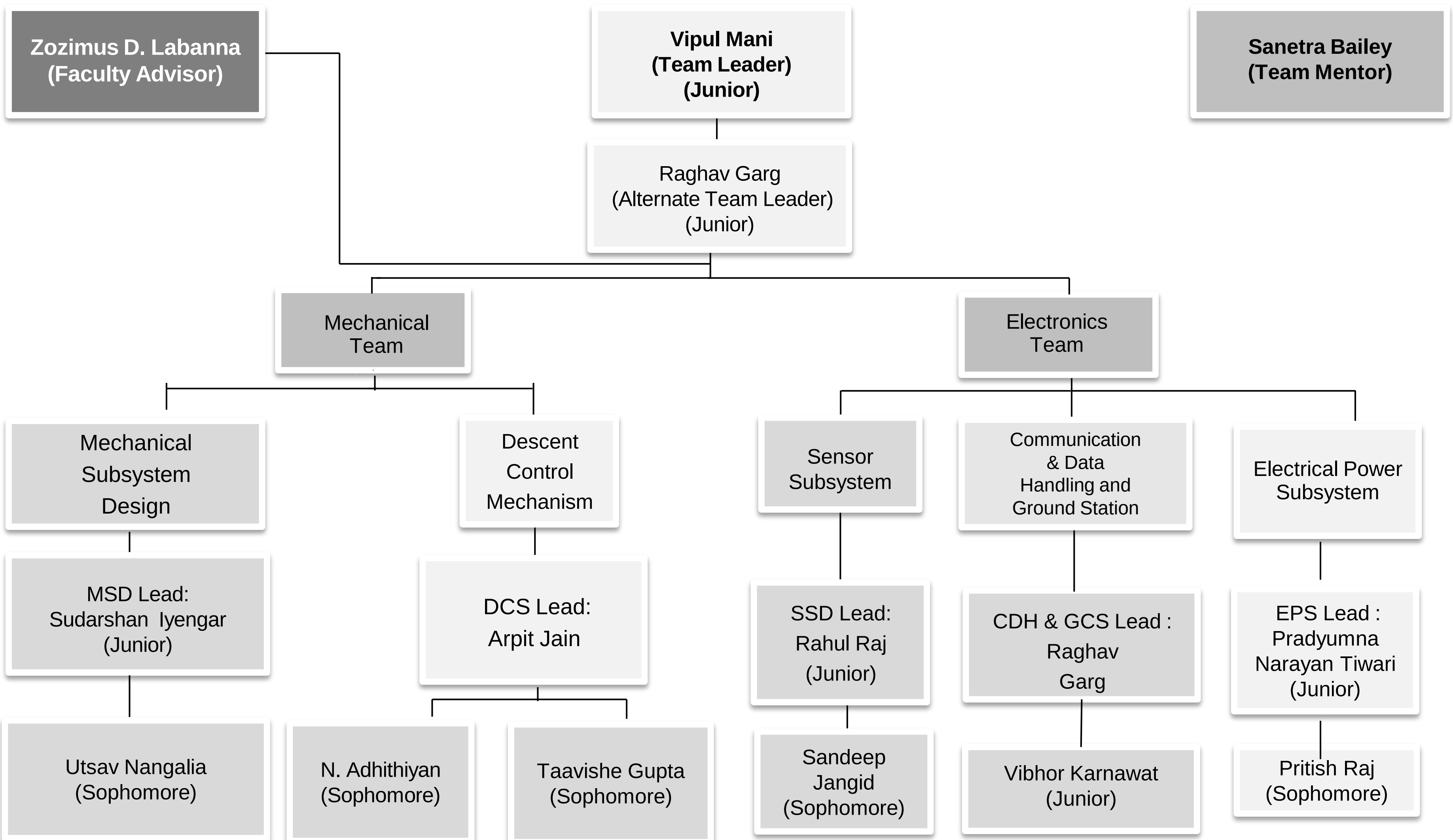
9. Flight Software (FSW) Design [124]

Presentation Outline

Presentation Outline

Section	Presenter
Systems Overview	Vipul Mani
Sensor Subsystem Design	Pritish Raj
Descent Control Design	Taavishe Gupta
Mechanical Subsystem Design	Sudharshan Iyengar
Communication and Data Handling Subsystem Design	Rahul Raj
Electrical Power Subsystem Design	Pradyumna Narayan Tiwari
Flight Software Design	Raghav Garg
Ground Control Systems Design	Vibhor Karnawat
CanSat Integration and Test	Utsav Nanglia and Sandeep Jangid
Mission Operation and Analysis	N. Adhithiyan
Requirements Compliance	Arpit Jain
Management	Anisha Absolom

Team Organization



Acronyms

A	Analysis
A/A	Air to Air
A-G	Air to Ground
AoA	Angle of Attack
ADC	Analog to Digital Converter
AR	Aspect Ratio
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
DC	Duracell Coppertop
DCS	Descent Control System
GCS	Ground Control System

Acronyms

GS	Ground Station
L/D	Lift to Drag Ratio
I	Inspection
ICT	Information And Communication Technology
MCU	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
R	Radius

Systems Overview

Vipul Mani

Mission Summary

MISSION OBJECTIVE

- **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 1Hz rate.
  - Safely release the glider from the re-entry container at 400 (+/- 10)m.
  - Glider shall glide in a circular pattern with diameter not more than 1000m.
  - 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.
  - Simple mechanical design, sufficient power availability and previous experience.

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.

Summary of Changes Since PDR

DESCENT CONTROL SYSTEM CHANGES

Container :

The Parachute material used for the descent of the container will be made of tarpaulin.

Glider:

The rudder angle is set to -10° after further testing and simulations. Previously, it was in full deflection in the direction of rotation as this setup was providing better helical path.

ELECTRONICS SYSTEM CHANGES

- Arduino Nano is replaced with MSP430G2553 because it has low power consumption.
- Magnetometer HMC5883L is being used in place of magnetometer LIS3MDL because of its ease of programming with MSP430G2553.
- Crystalline Solar Cells (flexible) are being used. The number of solar cells has increased from 3 to 5.

MECHANICAL SUBSYSTEM DESIGN CHANGES

- The material of the container changed to Poly Carbonate from Acrylic.
- The material of the fuselage of the glider changed to HIPS from Depron.

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 (+/-10)gm	Competition Requirement	HIGH	DCS01, MSR13	✓	✓		
SR-02	The container should fit in a container of 125mm x 310mm	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 (+/-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 1000m 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 XBee 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	✓	✓		

System Concept of Operations

PRE LAUNCH

Pre Flight Briefing → Mechanical Testings → Electronic Controls Turned On → Taking Cansat To Competition Launch Site

LAUNCH

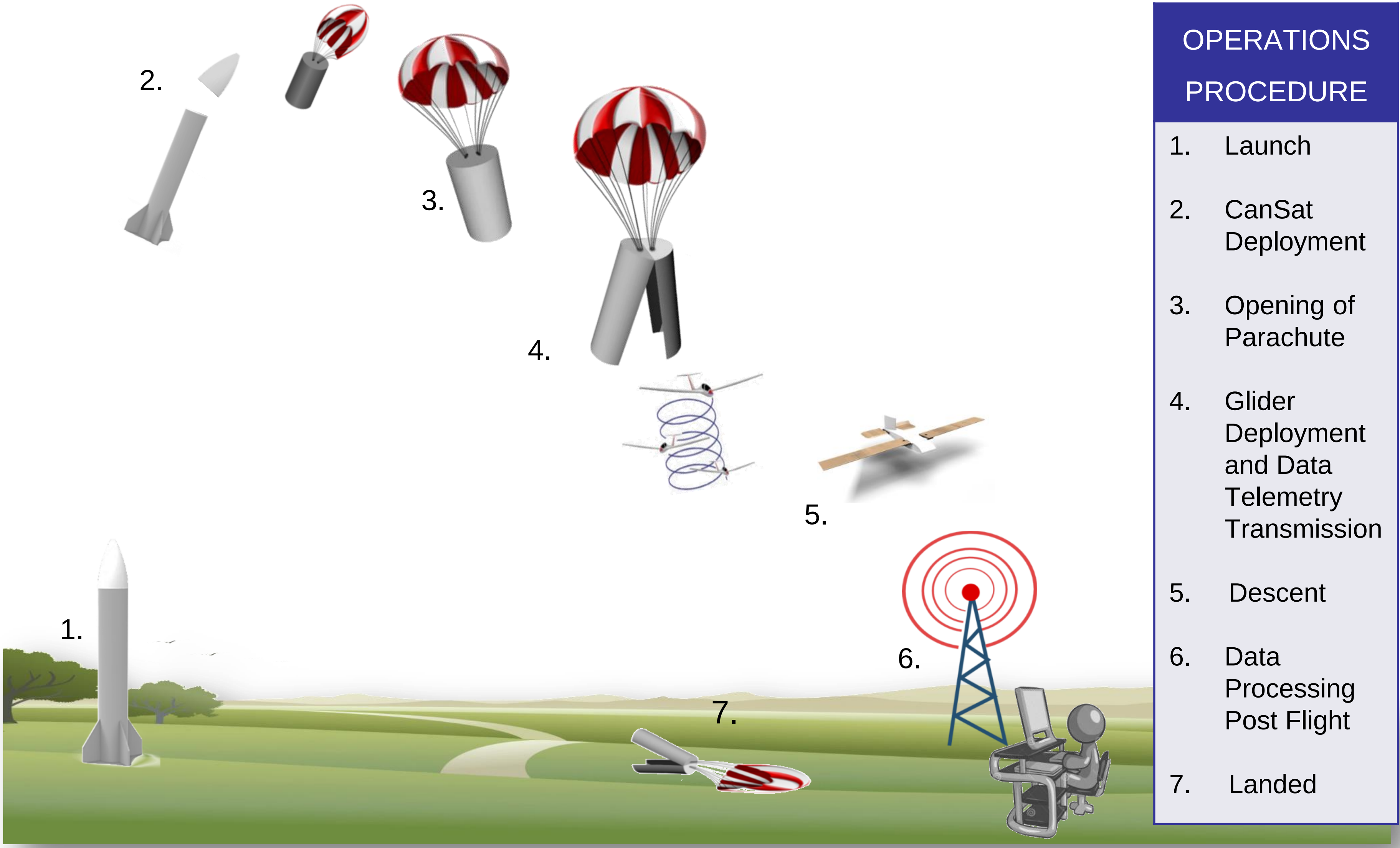
Placing Cansat into the Rocket → Rocket Launch → Container Data Telemetry Begins → Near Apogee Deployment → Deployment of Glider from Container at 400 (+/- 10)m

→ Glider Data Telemetry Begins → Container Data Telemetry Stops → Descent of Glider in helical fashion within 1000m Diameter → Receiving Sensory Data at Ground Station → Glider Telemetry stops Audio Beacons Activated. Locating the Glider and the Container

POST LAUNCH

Saving Data in required format in GCS → Retrieving Data Card from Glider → Analyzing procured Data → 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 Transmission
5. Descent
6. Data Processing Post Flight
7. Landed

Team Member Roles and Responsibilities

Crew — *The Crew will Prepare, Assemble and install the Cansat into the rocket*

Ground Station — *Communication between Cansat and Computer shall be Verified by the Ground Station Crew.*

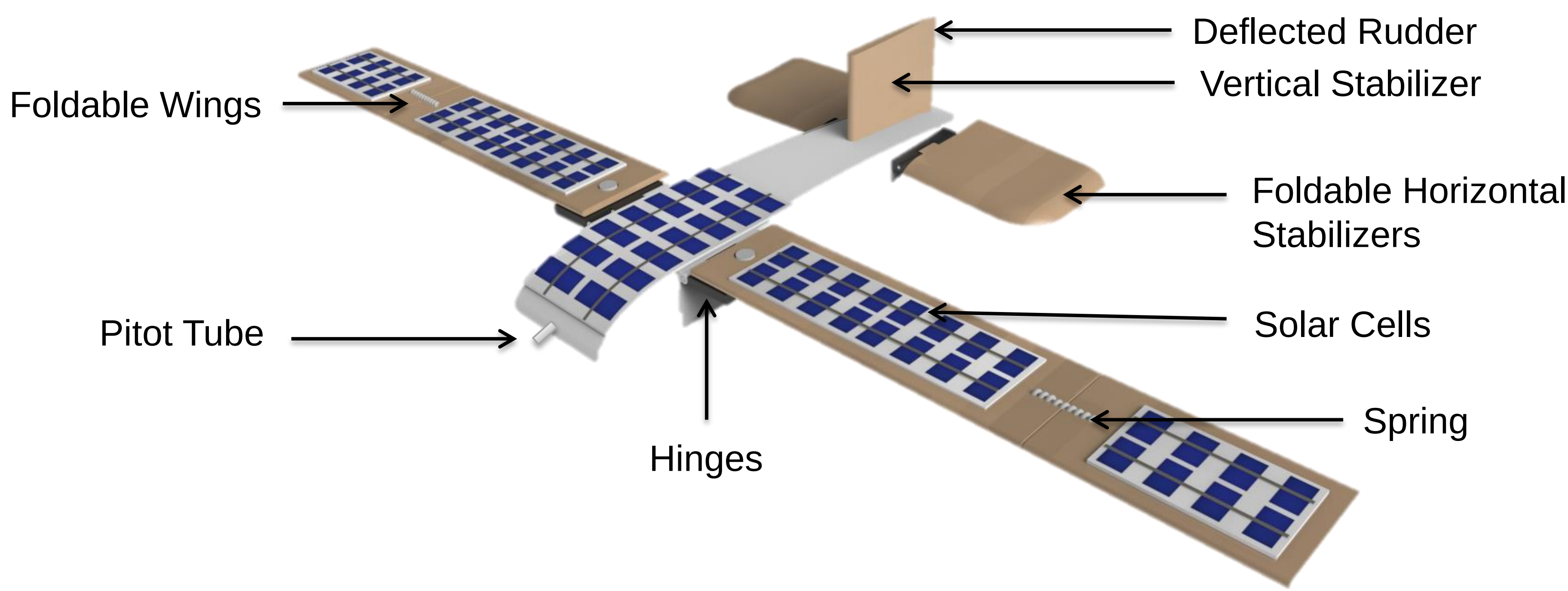
Mission Control Officer — *The Mission Control Officer shall be Informed about the readiness of the launch.*

Recovery Crew — *The Recovery Crew shall Locate and Retrieve the Cansat after Landing.*

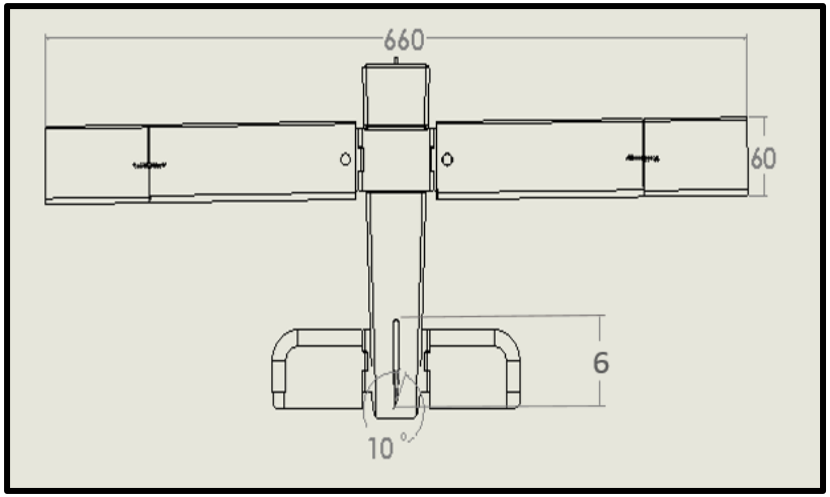
TEAM MEMBER	POST
Vipul Mani	CanSat Crew/ Recovery
Meenakshi Talwar	Ground Station Crew
Sandeep Jangid	Ground Station Crew
Anmol Agarwal	CanSat Crew/ Recovery
Pooja Dahiya	CanSat Crew
Kavitha Venugopalan	Mission Control Officer
Monika Sharma	Recovery
Devarrishi Dixit	Recovery

Payload Physical Layout

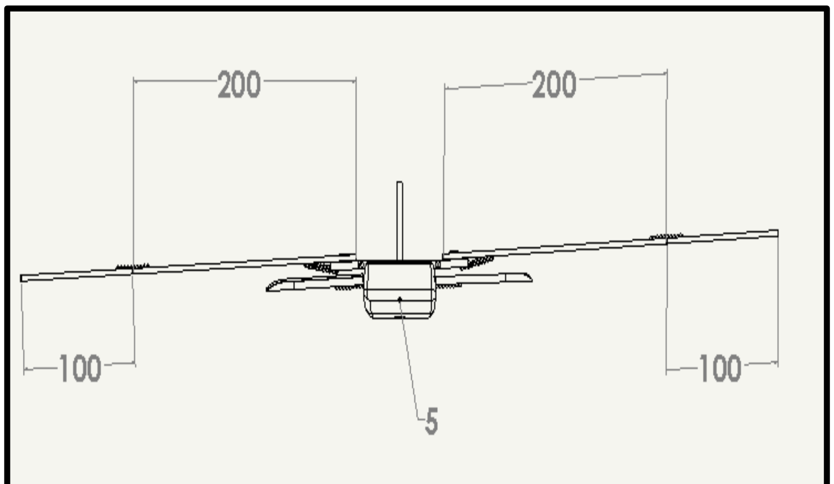
GLIDER LAYOUT



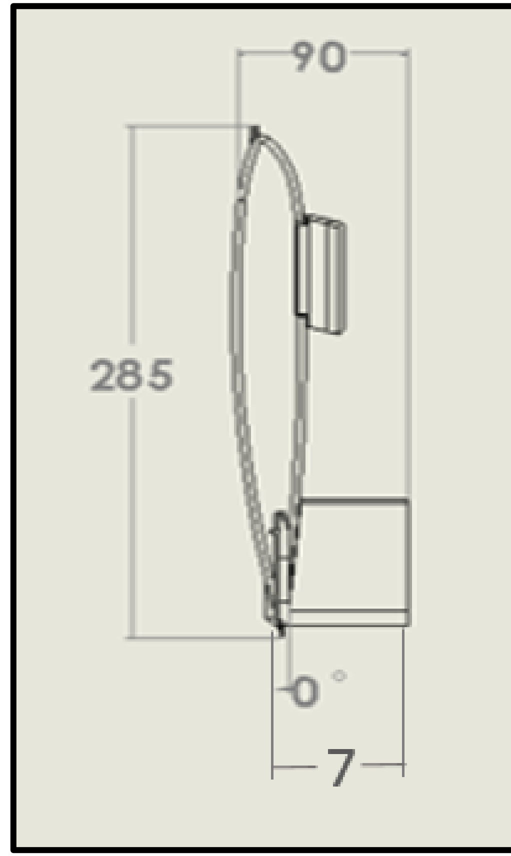
Payload Physical Layout



Top View



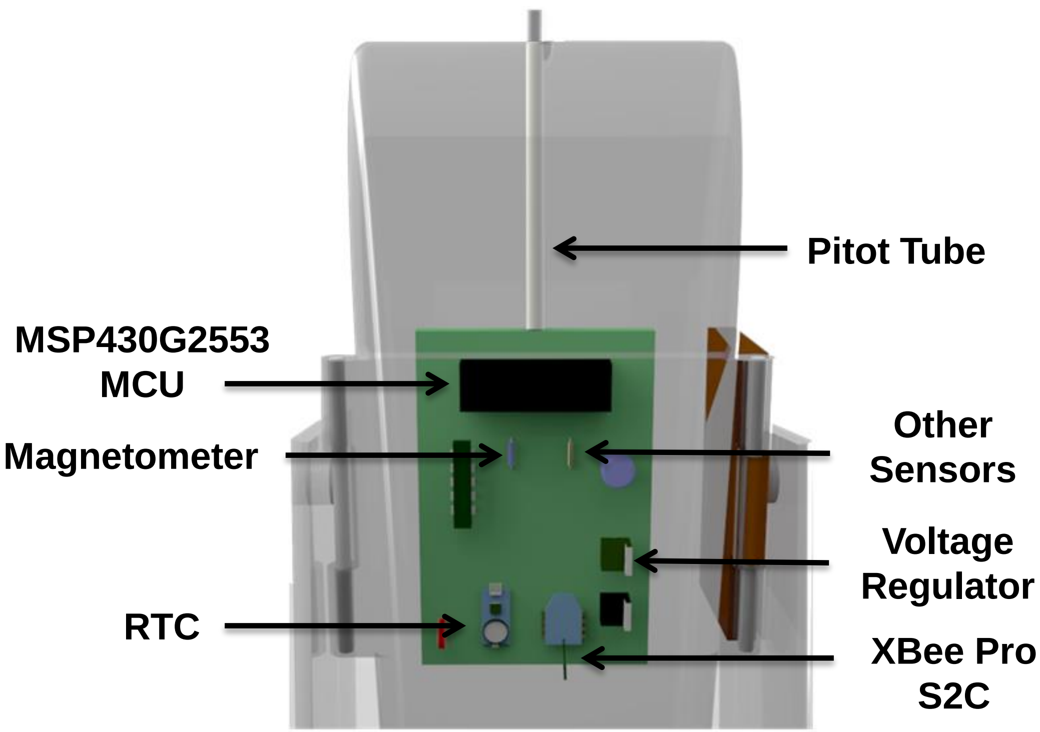
Front view

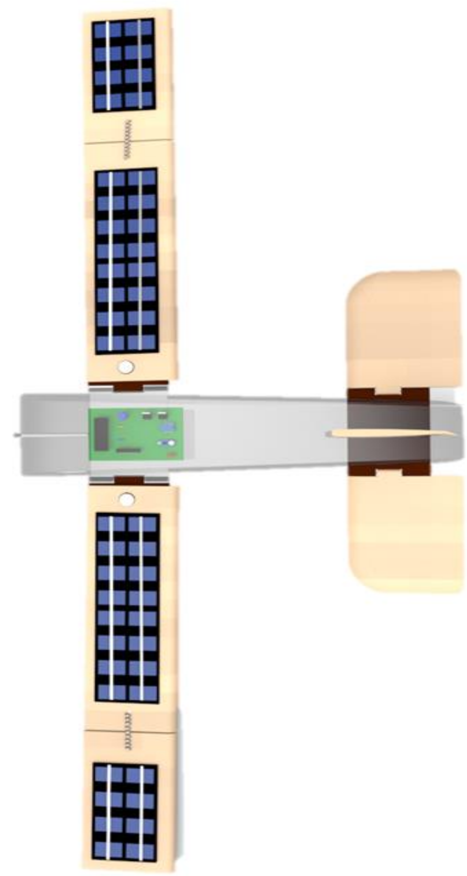


Side View

NOTE: All glider dimensions are in **mm**.

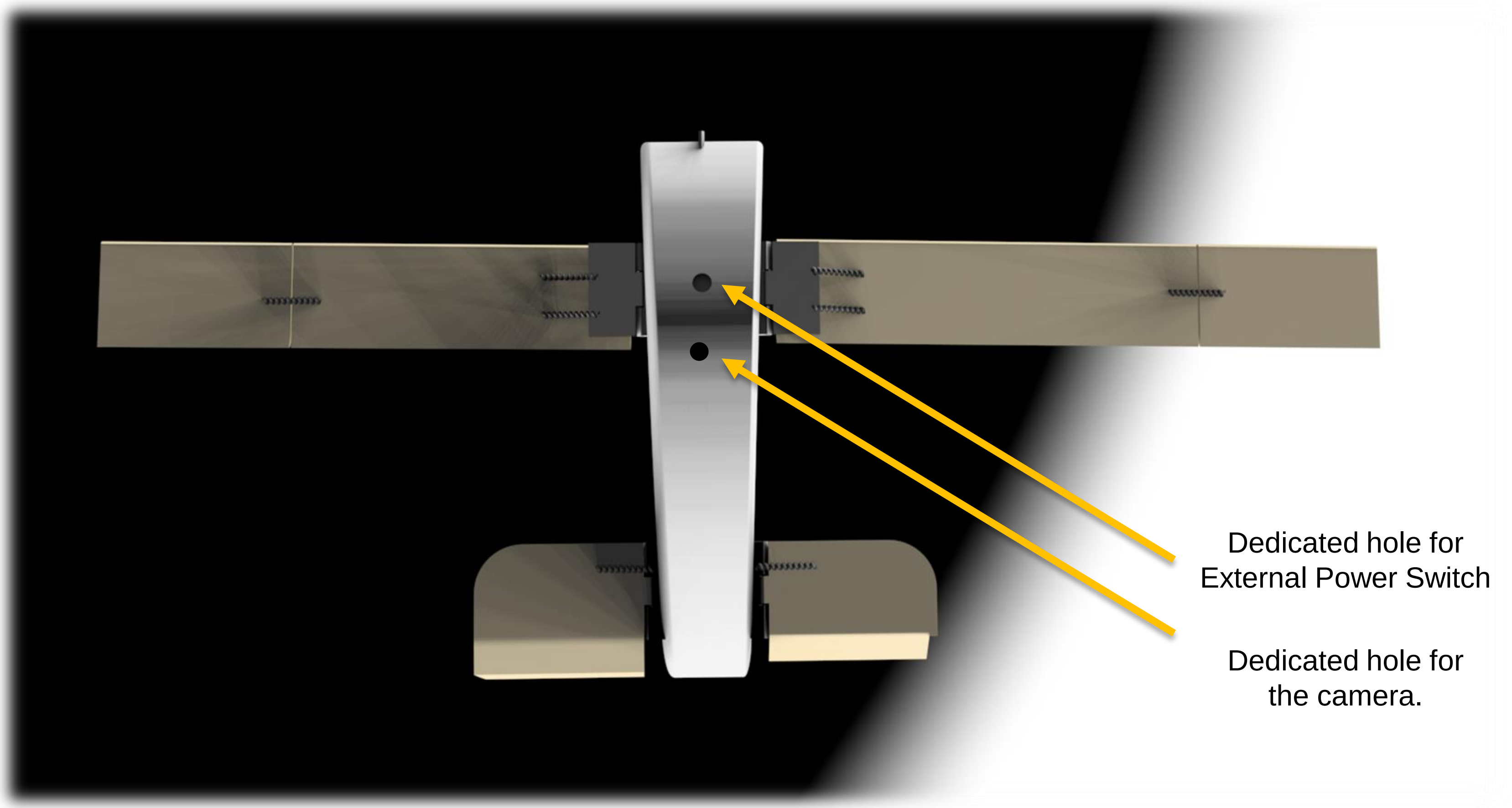
Placement of electronics inside the glider





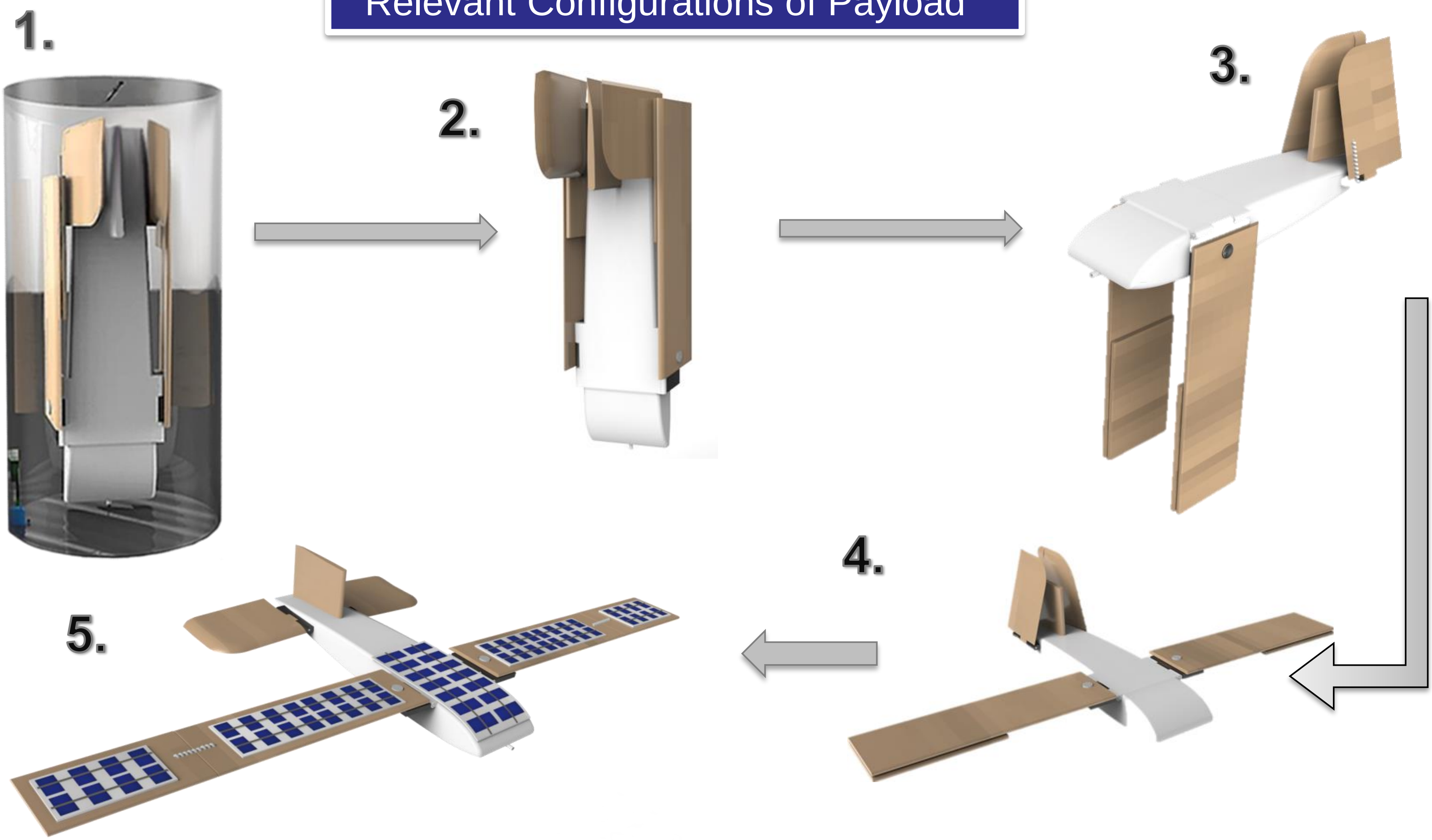
Payload Physical Layout

Placement of camera and external switch on the glider.

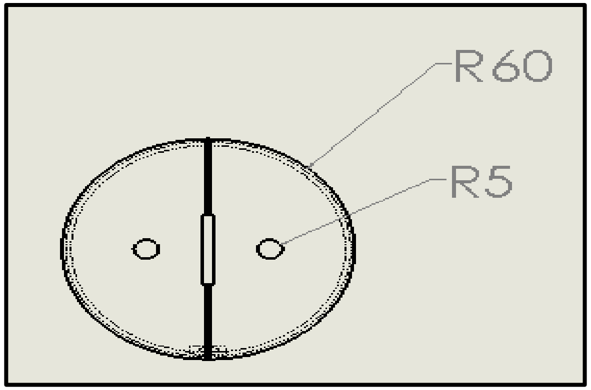


Payload Physical Layout

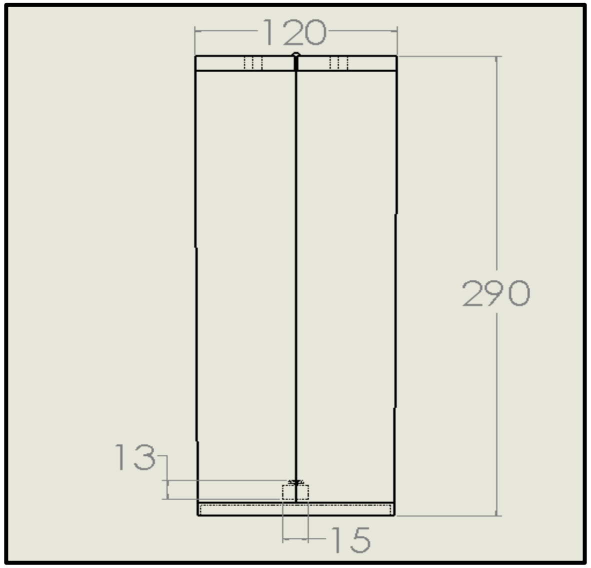
Relevant Configurations of Payload



CONTAINER DIMENSIONS



Top View



Front View

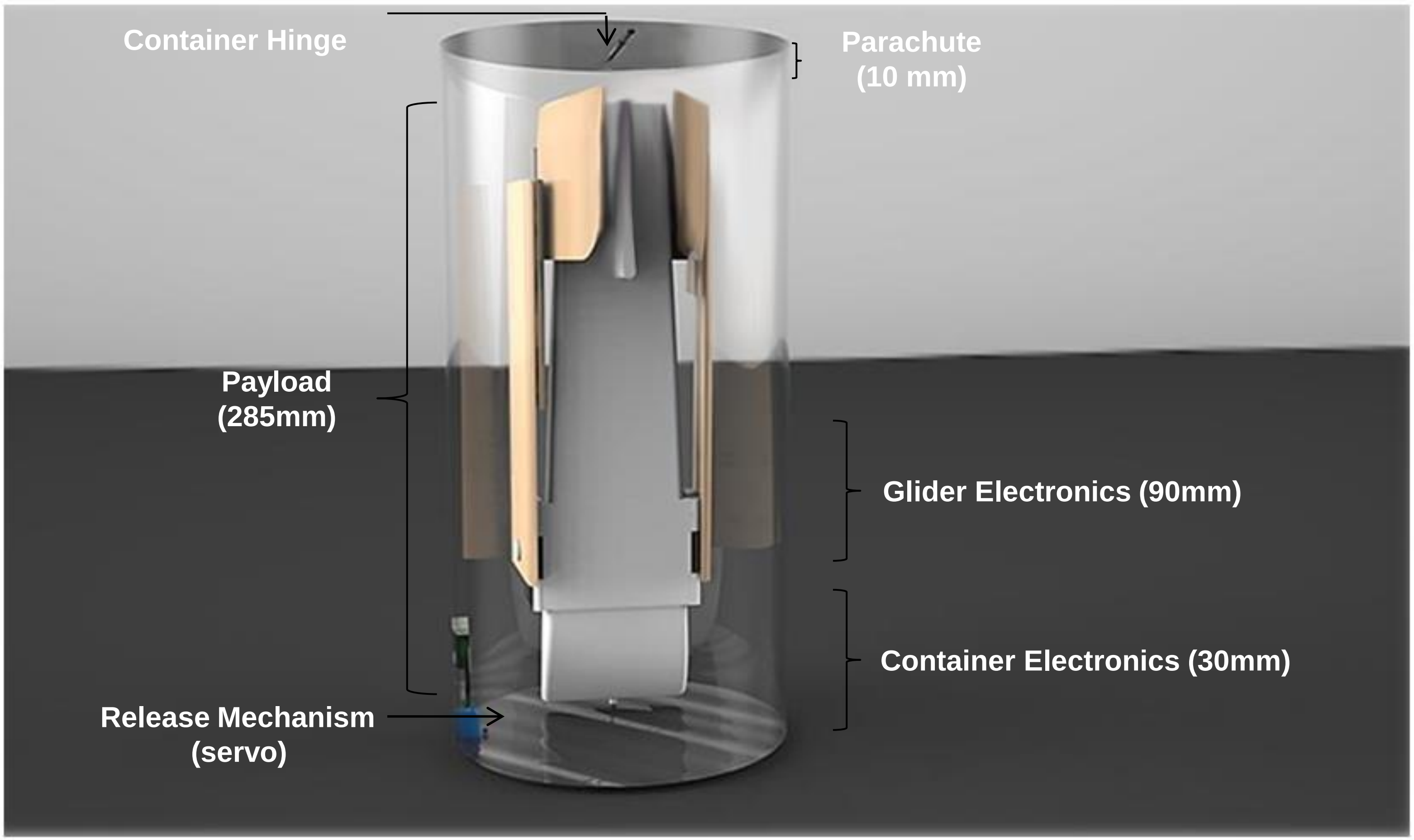
PRE-DEPLOYMENT

POST-DEPLOYMENT

NOTE: All container dimensions are in mm. (R is radius)

Container Physical Layout

CONTAINER DESIGN



GLIDER WITH NOSE DOWN ALIGNMENT IN THE CONTAINER

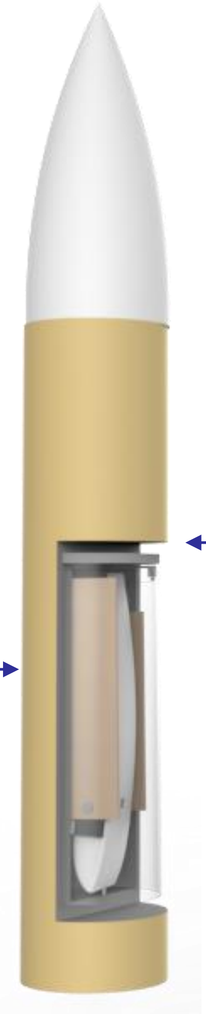
Launch Vehicle Compatibility

- The structure is designed in accordance with the CanSat parameters with safe tolerances.
- Container will be placed upside down in the rocket payload section.
- The dimensional compatibility of the CanSat is tested according to mission requirements and would also be verified a day before launch during Flight Readiness Review.
- No protruding components are allowed outside the container for smooth deployment.
- Clearance of 5mm and 10mm is given along the diameter and height of container respectively.

Sections	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



2.5mm clearance along the radius

10mm clearance at the top.

Clearance specifications of the CanSat in the rocket payload section.

Sensor Subsystem Design

Pritish Raj

Sensor Subsystem Overview

PAYLOAD

Air Pressure and Temperature Sensor (I2C → MCU)
Model: BMP180 (Digital), Provides **air pressure, temperature and altitude**

Real Time Clock (I2C → MCU)
Model: DS1307
Tracks and Records **Mission Time**

Magnetometer (I2C → MCU)
Model: HMC5883L (Digital)
Ultra low power, 3-Axis **Magnetometer**

MCU (MSP430G2553)

Solar Voltage Sensor (ADC → MCU)
Voltage Divider (Analog)
Solar voltage sensing using ADC of MCU

Camera (UART → MCU)
Model: TTL JPEG CAMERA(Serial)
Clicking photos (BONUS)

Pitot Tube (ADC → MCU)
Model: MPXV7002DP (Analog)
Senses **Air flow velocity**

Sensor Subsystem Overview

CONTAINER

Air Pressure and Temperature Sensor $\xrightarrow{\text{I2C}}$ MCU (Arduino Nano) $\xleftarrow{\text{ADC}}$ Battery Voltage Sensor

Real Time Clock $\xrightarrow{\text{I2C}}$ MCU (Arduino Nano)

Air Pressure and Temperature Sensor: Model: <u>BMP180</u> (Digital) barometer, Provides air **pressure, altitude and temperature**

Real Time Clock: Model: <u>DS1307</u> Tracks and Records **Mission Time**

Battery Voltage Sensor: <u>Voltage Divider</u> (Analog) **Battery voltage** measurement using ADC of MCU

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

Sensor Changes Since PDR

S No.	CHANGE	RATIONALE	EXPLAINATION
1.	Magnetometer: HMC5883L instead of LIS3MDL	• Lower current consumption • Smaller size • Lower cost • Easily available	• Lower current consumption, 100µA @ 3.3V (vs 270µA). Hence, lower power consumption. • Smaller, 3.0 x 3.0 x 0.9mm. • Compatible to MSP430G2553

- Both LIS3MDL and HMC5883L have been **tested** with MSP430G2553 and HMC5883L was found to be more appropriate.

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	✓		✓	

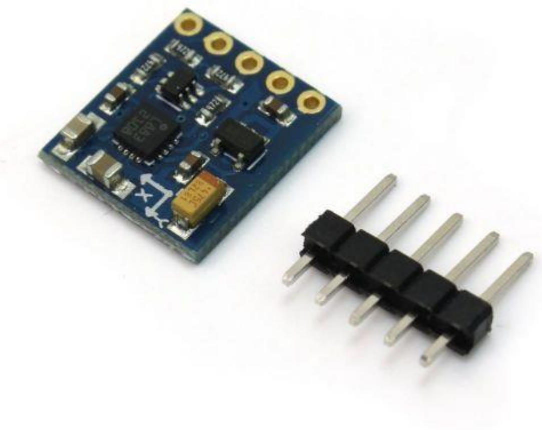
Magnetometer Sensor Summary

SELECTED: HMC5883L 3-Axis Magnetometer

Magnetometer is used to measure the heading direction of the payload.

DEVICE NAME	INTERFACE	OPERATING VOLTAGE	CURRENT CONSUMPTION	SIZE	WEIGHT
HMC5883L	I2C	2.16 to 3.6 V	100 µA	3 x 0.9 x 0.5 mm^3	0.18 g

- I2C digital output interface
- Smaller size compared to LIS3MDL.
- 1° to 2° Compass Heading Accuracy.
- **Lesser Current Consumption 100 µA in high resolution** (270µA compared to LIS3MDL)
- **12-Bit ADC coupled with Low Noise AMR Sensors achieves 2 milli-gauss Field Resolution in ±8 Gauss Fields.**
- **Compatible with MSP430G2553.**



Magnetometer Sensor Summary

Data Processing:

A compass heading can be determined by using just **the H_x and H_y component of the earth's magnetic field**, that is, the directions planar with the earth's surface.

The magnetic compass heading can be determined (in degrees) from the **magnetometer's x and y readings**. The flow chart shows the mechanism by which the heading is determined:

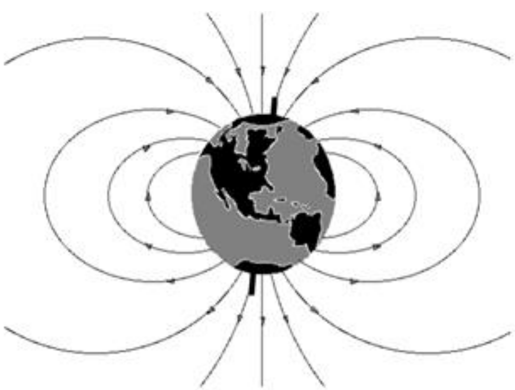
X and Y readings from magnetometer

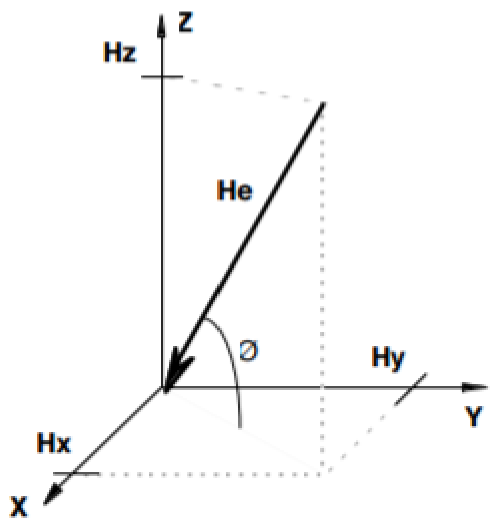
↓

Direction (y>0) = 90 - [arcTAN(x/y)]*180/π
Direction (y<0) = 270 - [arcTAN(x/y)]*180/π
Direction (y=0, x<0) = 180.0
Direction (y=0, x>0) = 0.0

↓

Plotted on LABVIEW





$$|He| = \sqrt{Hx^2 + Hy^2 + Hz^2}$$

Payload Air Pressure Sensor Summary

SELECTED: BMP180 Barometric Pressure Sensor

BMP180 is the upgraded version of BMP085 and has a large pressure sensing range.

DEVICE NAME	INTERFACE	OPERATING PRESSURE	SIZE	WEIGHT	ACCURACY	SUPPLY VOLTAGE
BMP180	I2C	300-1100 hPa	5 x 5 mm^2	1g	+/-2.5 hPa	1.8-3.6 V

The sampling rate can be increased to 128 samples per sec for dynamic measurements.

- Pressure sensing range: 300-1100 hPa
  (9000m to -500m above sea level)
- Resolution of 0.01 hPa
- This board/chip uses I2C 7-bit address 0x77
- **Low noise and very low current drawn (I_{peak} = 650μA)**
- Helps to determine the altitude readings and further the required FSW stat

The pressure and altitude is calculated by the equation given below:

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

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

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

Container Air Pressure Sensor Summary

SELECTED: BMP180 Barometric Pressure Sensor

BMP180 is the upgraded version of BMP085 and has a large pressure sensing range.

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

The sampling rate can be increased to 128 samples per sec for dynamic measurements.

- Pressure sensing range: 300-1100 hPa (9000m to -500m above sea level)
- Resolution of 0.01 hPa
- This board/chip uses I2C 7-bit address 0x77
- **Low noise and very low current drawn (I_{peak} = 650μA)**
- The sensor reading helps to measure altitude which is used to activate servo latch separation mechanism. It is also used to determine FSW states.

The pressure and altitude is calculated by the equation given below:

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

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

Payload Pitot Tube Summary

SELECTED: MPXV7002DP

The MPXV7002 is designed to measure positive and negative pressure. In addition, with an offset specifically at 2.5V instead of the conventional 0V, the new series allows to measure pressure upto 7kP a through each port for pressure sensing or vacuum sensing.

DEVICE NAME	SUPPLY VOLTAGE	PROTOCOL	WEIGHT	ACCURACY	COST
MPXV7002DP	4.75-5.25V	ADC	4g	+/-6.25kph	26.99$

- Cost effective and Easy interfacing
- Relatively light weight
- -2 to 2 kPa pressure range
- High accuracy of +/-6.25kph
- 10-60 °C operating temperature
- Maximum pressure of device is 75kPa with supply current of 10mA
- It is used to sense the air flow velocity around the Glider

Payload Air Temperature Sensor Summary

SELECTED: BMP180 Temperature Sensor

We are using BMP180 is used as the air temperature sensor which also works as the altitude and pressure.

DEVICE NAME	INTERFACE	OPERATING TEMPERATURE	SIZE	WEIGHT	ACCURACY	SUPPLY VOLTAGE	COST
BMP180	I2C	-40 to +85 °C	5x5 mm^2	1 g	±0.1 °C	1.8-3.6V	3.70 $

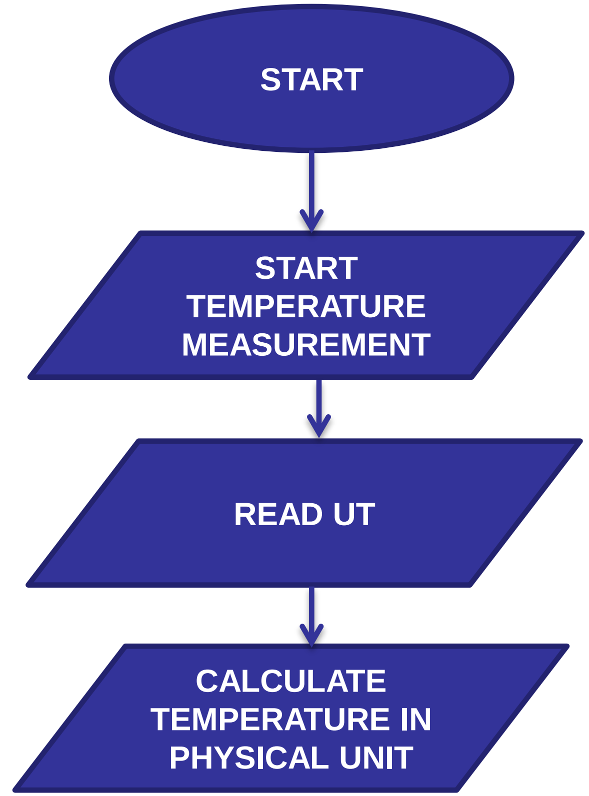
- V_{in}: 1.8-3.6 V DC
- I2C interface
- Pressure sensing range: 300-1100 hPa
- Resolution : 0.1°C
- -40 to +85°C operational range

- The sensor provides the 16 bit temperature data.
- The temperature is calculated in steps of 0.1º Celsius. Using some calibration data and the real time temperature data provided by the sensor.
- The sampling rate can be increased to 128 samples per sec for dynamic measurements.

Payload Air Temperature Sensor Summary

Formulas used in internal calculations for temperature values are based upon the reading of the BMP180

- U_T=MSB<<8+LSB(uncompressed temperature)
- $X_1 = \frac{(U_T - AC6) \times AC5}{2^{15}}$
- $X_2 = \frac{M_C \times 2^{11}}{X_1 + M_D}$
- $B_5 = X_1 + X_2$
- $T = \frac{(B_5 + 8)}{2^4}$



Source: Datasheet

Container Air Temperature Sensor Summary

SELECTED: BMP180 Temperature Sensor

We are using BMP180 is used as the air temperature sensor which also works as the altitude and pressure.

DEVICE NAME	INTERFACE	OPERATING TEMPERATURE	SIZE	WEIGHT	ACCURACY	SUPPLY VOLTAGE	COST
BMP180	I2C	-40 to +85 °C	5x5 mm^2	1g	±0.1 °C	1.8-3.6V	3.70 $

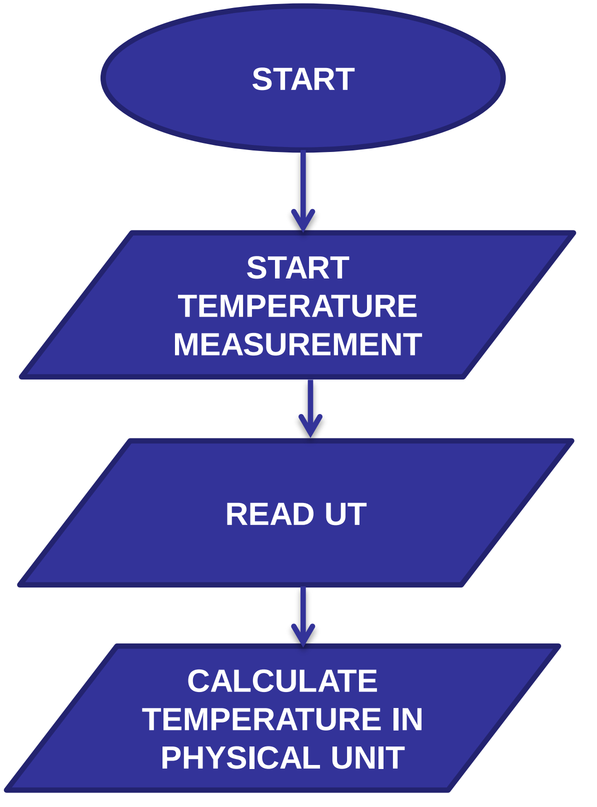
- V_{in}: 1.8-3.6 V DC
- I2C interface
- Pressure sensing range: 300-1100 hPa
- **Resolution : 0.1°C**
- -40 to +85°C operational range

- The sensor provides the 16 bit temperature data.
- The temperature is calculated in steps of 0.1 degree Celsius. Using some calibration data and the real time temperature data provided by the sensor.
- The sampling rate can be increased to 128 samples per sec for dynamic measurements.

Container Air Temperature Sensor Summary

Formulas used in internal calculations for temperature values are based upon the reading of the BMP180

- U_T=MSB<<8+LSB(uncompressed temperature)
- $X_1 = \frac{(U_T - AC6) \times AC5}{2^{15}}$
- $X_2 = \frac{M_C \times 2^{11}}{X_1 + M_D}$
- $B_5 = X_1 + X_2$
- $T = \frac{(B_5 + 8)}{2^4}$



Source: Datasheet

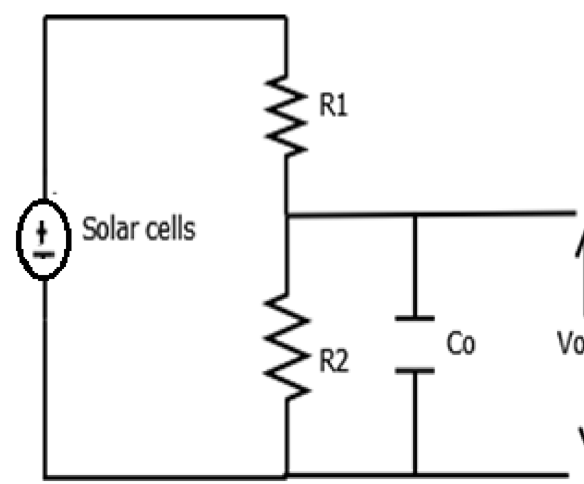
SELECTED: Voltage Divider Circuit.

Battery Voltage is measured using the ADC port through a voltage divider circuit.

SENSOR	INTERFACE	RESOLUTION	WEIGHT	SIZE	COST
Voltage Divider circuit	ADC Port	23.4 mV	N/A	Discrete Circuit	~$ 1.00

- Easy implementation
- No external hardware required
- It consists of two resistors in series which will divide the input voltage to bring it within the range of the analog inputs.
- The circuit with the particular values shown has an input impedance of 1MΩ + 1MΩ = 2MΩ and is suitable for measuring DC voltages up to about 50V.
- R1 = 1MΩ, R2 = 1MΩ
- Co = 100µF will increase the accuracy by 95%.
- Formula Used: **Voltage = SensorValue x (5.00 / 1023)**

$$Output\ Voltage = Input\ voltage \times \frac{R2}{R1 + R2}$$



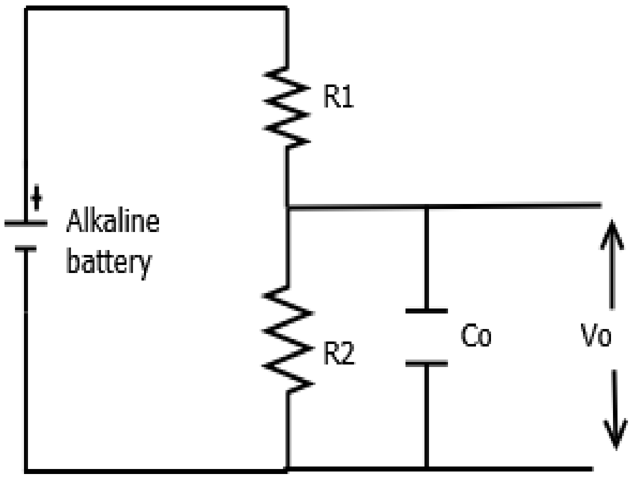
SELECTED: Voltage Divider Circuit.

Battery Voltage is measured using the ADC port through a voltage divider circuit.

SENSOR	INTERFACE	RESOLUTION	WEIGHT	SIZE	COST
Voltage Divider circuit	ADC Port	23.4 mV	N/A	Discrete Circuit	~$ 1.00

- Easy implementation
- No external hardware required
- It consists of two resistors in series which will divide the input voltage to bring it within the range of the analog inputs.
- The circuit with the particular values shown has an input impedance of 1MΩ + 1MΩ = 2MΩ and is suitable for measuring DC voltages up to about 50V.
- R1 = 1MΩ, R2 = 1MΩ
- Co = 100µF will increase the accuracy by 95%.
- Formula Used: **Voltage = SensorValue x (5.00 / 1023)**

$$Output\ Voltage = Input\ voltage \times \frac{R2}{R1 + R2}$$



Bonus Objective Camera Summary

SELECTED CAMERA: Adafruit Serial TTL JPEG Camera

It is used for capturing the image from the GLIDER when instructed from the ground station. Easy Interfacing and programming. Also meets resolution requirements of 640x480 in colour.

MODEL	SIZE	RESOLUTION	SCANNING FREQUENCY	OPERATING VOLTAGE
Serial TTL Camera VC0706	Medium	640x480	Progressive Scanning	5 V

- Size: 32mmx32mm
- Operating Voltage: 5 V
- Baud Rate: 38400
- Current Draw: 75 mA
- **Resolution: 640x480 pixels**
- Dynamic Range: 60DB
- Max analog gain: 16DB
- Frame speed: 640x480 30fps
- **Communication: 3.3V TTL(UART Protocol using Rx/Tx)**

Descent Control Design

Taavishe Gupta

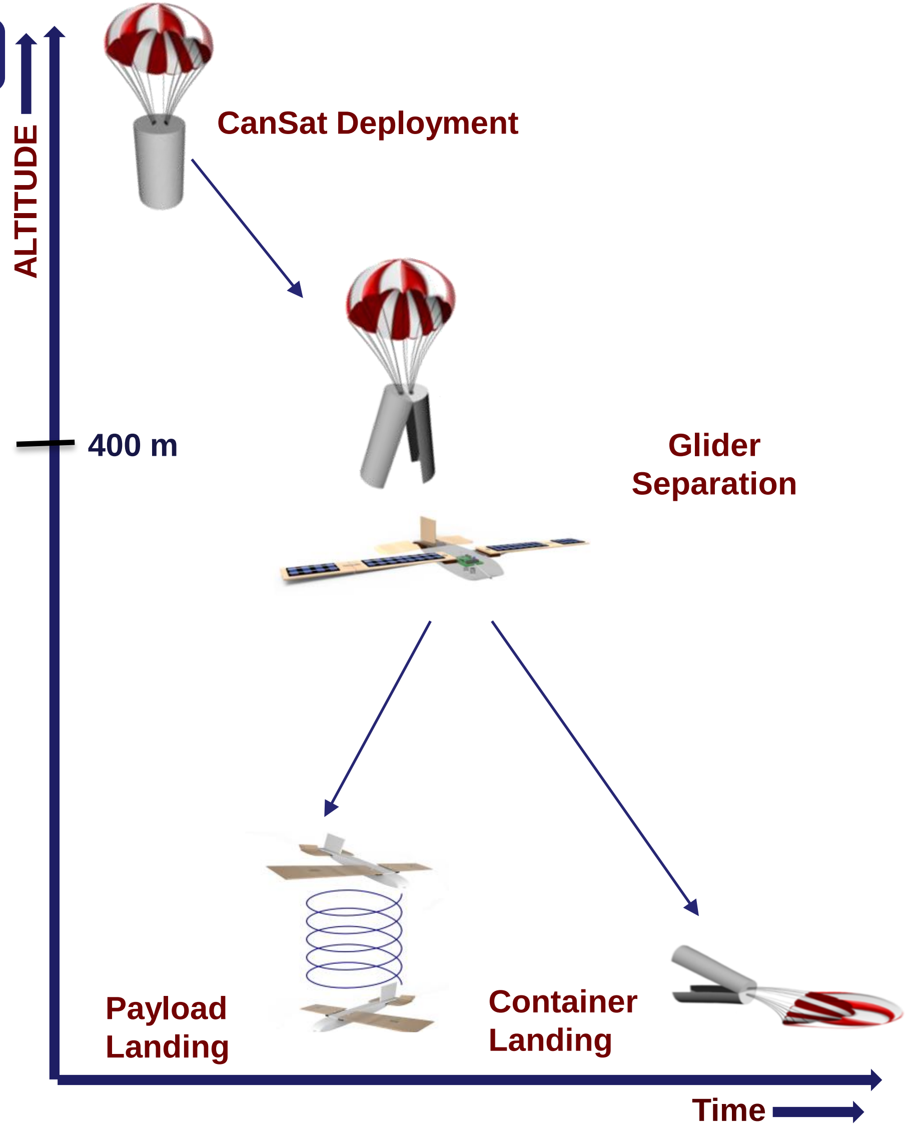
Descent Control Overview

Container Descent Control System

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

Glider Descent Control System

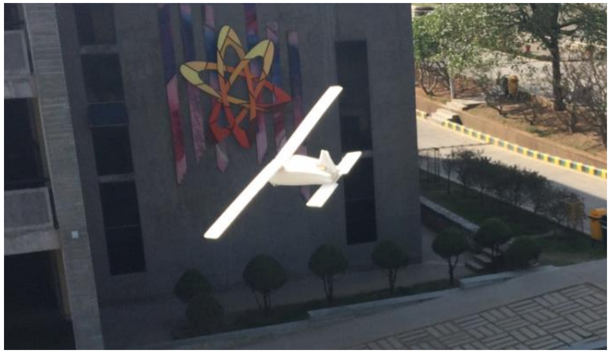
- Fixed wing glider configuration having equal wing area and elevators at zero deflection with rudder in direction of rotation.
- At approx. 400 (+/-10)m container lid is opened and glider is released.
- Post separation, glider shall automatically descent due to its weight and owing to its design, it 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 and MSP430G2553 respectively.



Descent Control Changes Since PDR

Components Changed	Requirement	Rationale
Material of Fuselage has been changed to HIPS.	The material of the fuselage should be strong enough to survive the shock force during deployment.	HIPS proves to be much stronger than Depron to resist the shock force.
Rudder deflection of glider has been changed to -10º.	Rudder deflection would create a yaw movement which defines the circular pattern	The Yaw movement of the glider depends on the deflection of rudder.
Zero deflection of elevators.	Deflection of elevators may lead to high pitching moment decreasing the stability of the glider	Pitching moment of the glider depends on the deflection of elevators.
Equal wing area for both wings.	Equal Lift from both the wings will add to the stability of the glider.	Banking of the glider depends on the difference in lift production from both the wings.





Glider Prototype Testing

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 (+/-10)gm.	Competition Requirement	HIGH	SR-01	✓	✓		
DCS-02	Container shall fit in a cylindrical envelope of 125mm x 310mm	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 whole should provide a descent rate of 13.2m/s to the CanSat before 400m	To provide an optimum velocity to Glider after getting deployed	HIGH	SR-03	✓			
DCS-06	The parachute shall not exceed a packing height of 10mm at the top of the re-entry container	Sufficient space allocated to rest of the systems.	MEDIUM	SR-12	✓	✓		
DCS-07	Both parachute and Glider must be reasonably light	Keep the weight budget from exceeding 500gm	MEDIUM	SR-01	✓	✓	✓	
DCS-08	The container and glider need to be separated at an altitude above 400m	Competition Requirement	HIGH	SR-06	✓			

Descent Control Requirements

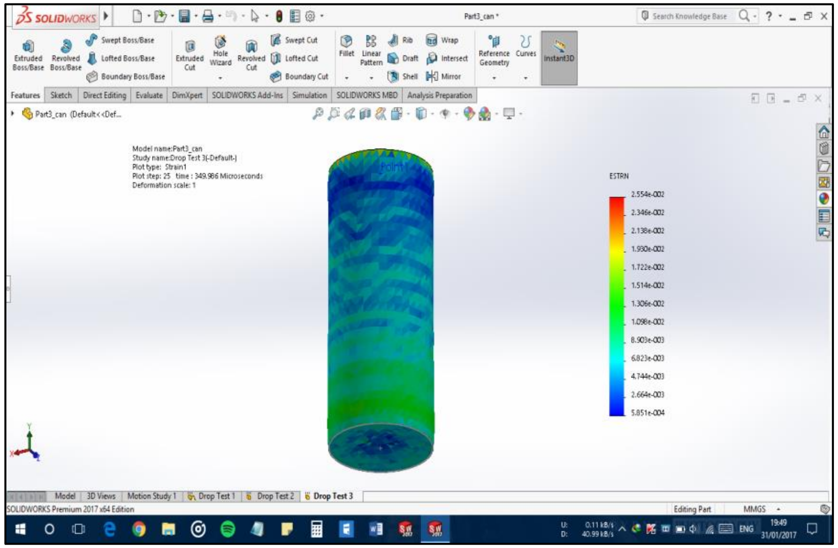
ID	Requirement	Rationale	Priority	Parent	VM			
					A	I	T	D
DCS-09	Glider must glide in a preset circular pattern of diameter not greater than 1000m	Competition Requirement	HIGH	SR-07	✓	✓	✓	✓
DCS-10	Glider shall be a fixed wing glider	Competition Requirement	HIGH	SR-19	✓	✓	✓	✓
DCS-11	The glide duration should be around 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	✓	✓	✓	

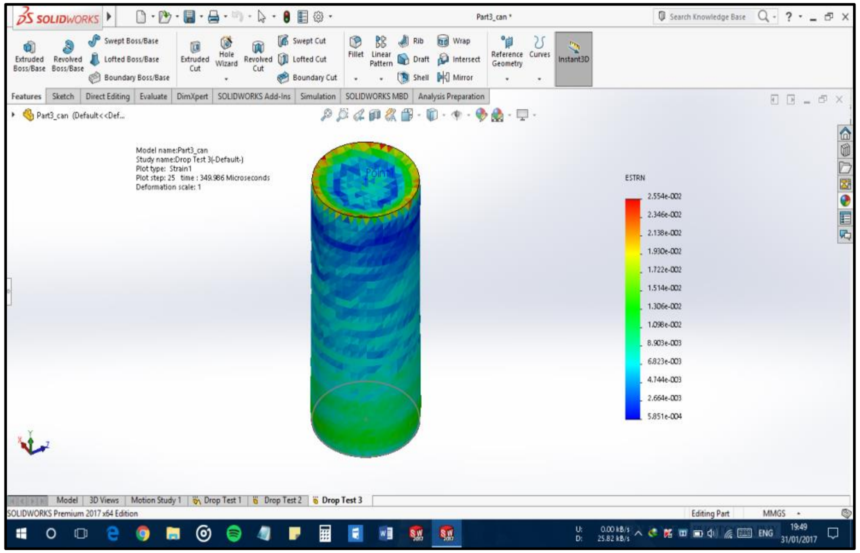
Summary of DCS component selection

Component	Material	Colour Selection	Size
Container	HIPS (High Impact Polystyrene)	Florescent Orange	Length: 290mm Diameter:120mm
Parachute	Tarpaulin	Blue	Base Diameter: 80cm Spill hole diameter: 4cm
Cords	Nylon cord	White	Length of cords: 120cm
Attachment	Swivel (prevent shroud lines from entangling)	No specific color	Length: 7cm

Shock Force Survivability

- Wind tunnel testing done on parachute and parachute material survived the free stream velocity of 30m/s.
- In case the parachute fails, the container is tested to survive 30Gs of shock. **(Simulation tests passed)**



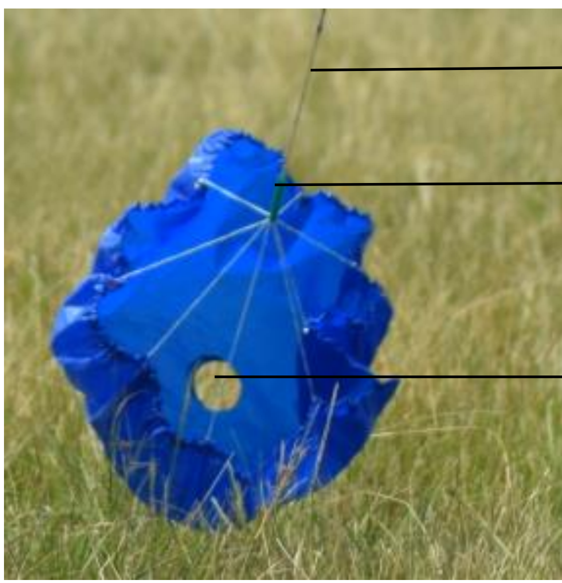


Pre-Flight Review Testability

- The CanSat would under go a pre-flight review testability a day prior to launch for the inspection of wings deployment and to verify whether the parachute deploys correctly.
- The CanSat has undergone fit-check, mass check and has no sharp protrusions.

Key Design Considerations

- The material of the parachute (Tarpaulin) is chosen such that it resists the shock/impact force.
- It is elastic i.e. will not deform permanently.
- It is resistant to wear and tear.
- It is lightweight, has high strength, good air blocking ability, that is non-porous and occupies little space.



Swivel

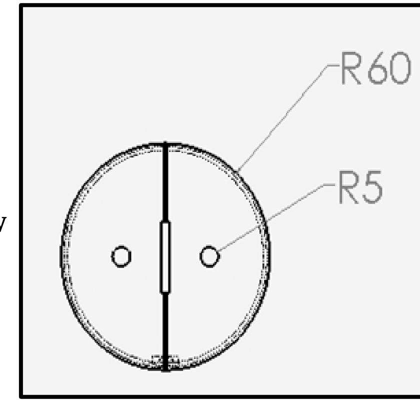
Shroud lines

Spill hole

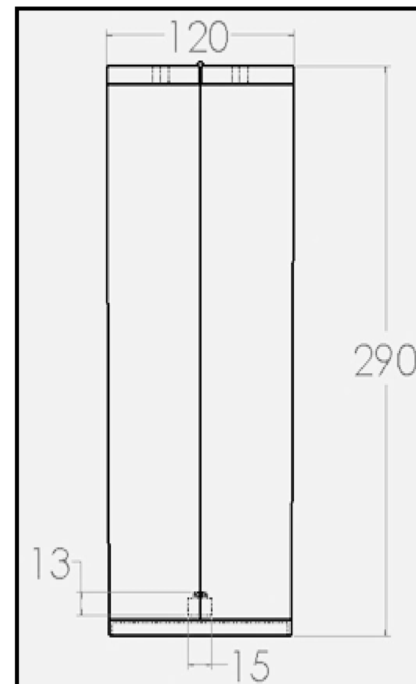
Color Selection

Blue color for the parachute and orange color for the container body is chosen to enhance visibility and ease in recovery.

Top View



Front View



Note: All container dimensions are in mm.

ACTIVE COMPONENTS

1. Air Pressure and Temperature Sensor (BMP180):

- **Sensor Accuracy:** The BMP180 has a high relative measuring accuracy of 0.01hPa combined with a low temperature coefficient of 0.01hPa/°C and low noise.
- **Data Format:** Data is received serially through SDA from the sensor using I2C interface (SDA and SCL).
- **Actuator Control:** Controls the Container opening mechanism at the appropriate height as per the competition guidelines. Stops the data telemetry when glider is separated. Triggers the audio beacon when container landed.
- **Command rates:** Less than 1Hz as the telemetry rate requirement is 1Hz.

2. Battery Voltage Sensor (Voltage Divider):

- **Sensor Accuracy:** The voltage divider circuit divides the input voltage by 2 to bring it within the range of analog pins of the microcontroller. Sensor accuracy depends upon the microcontroller used. The NANO used has 10 bits ADC thus the resolutions turns outs to be :

$$\frac{4.5}{2^{10}} = 0.0043988\ volts/step$$

- **Data Format:** Analog data (ADC)
- **Actuator Control:** N/A
- **Command rates:** Less than 1Hz as the telemetry rate requirement is 1Hz.

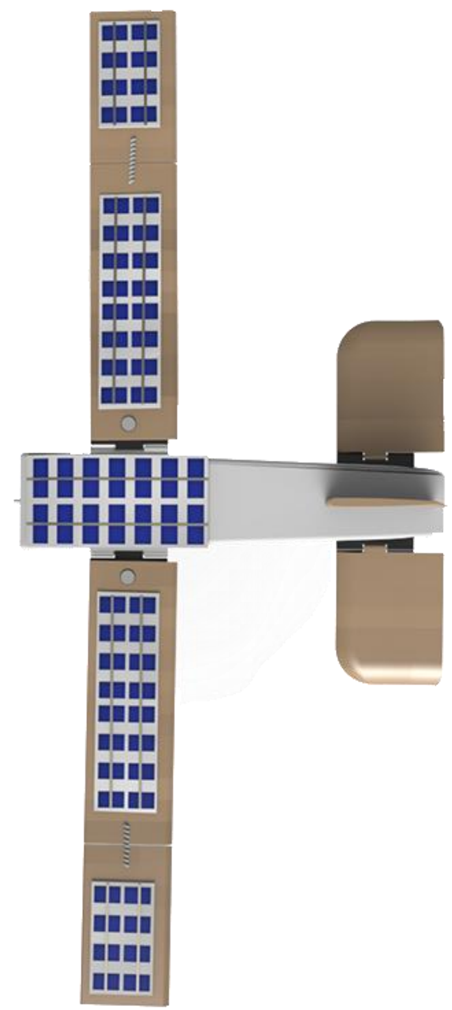
Payload Descent Control Hardware Summary

- The glider shall be placed inside the container in nose down configuration. No sensor is used in the deployment of wings of the glider.

- The wings are of equal area and the elevators are at zero deflection and rudder is at -10° deflection which shall provide the helical glide.

- Material used for the fuselage of the glider is HIPS and various tests and simulations have been done on it to ensure it's strength for the entire duration of the mission. **Glide Ratio: 1.2732**

- The release mechanism used for the deployment of the glider is servo latch which is completely on the container. The glider shall unfold it's wings with the help of the spring-hinge mechanism as soon as it is deployed and then get stabilized.



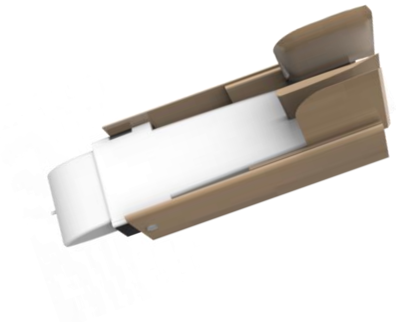
Preflight Review Testability

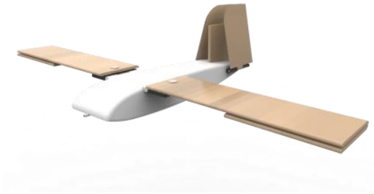
- A check on the position of the wings, elevators, parachute and also the folding mechanism of the wings and elevators.

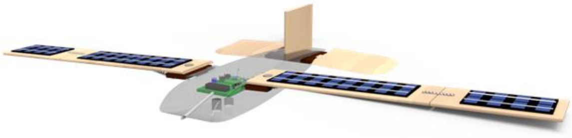
Deployment Trigger and Mechanism

BMP180 sensor triggers the container opening mechanism at the appropriate height as per the competition guidelines. With the help of its altitude readings, the servo latch mechanism gets activated at 400 ($\pm$10)m and opens the lid.

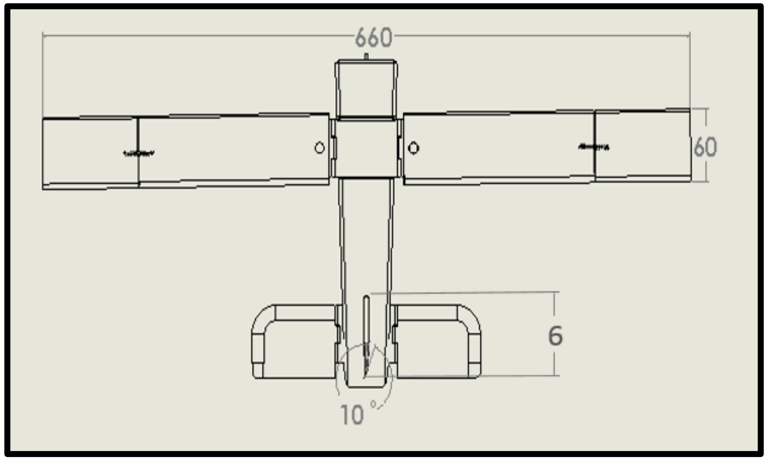
Alternate Release Mechanism: In case the servo latch mechanism fails, a hot wire technique would be employed to force the lid of the container open.



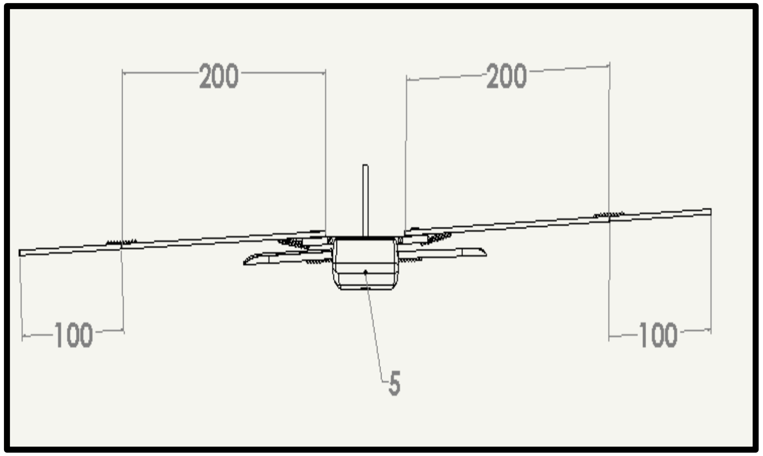




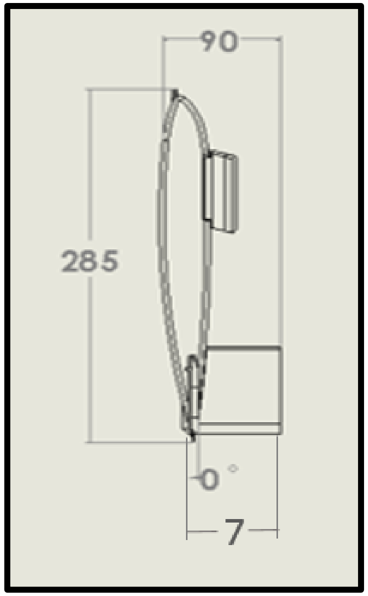
Component Sizing



Top View



Front view



Side view

Note: All glider dimensions are in mm.

Key Design Considerations

- Glider fuselage material is HIPS (High Impact Polystyrene), having high strength-to-weight ratio.
- With AR of 11, lift produced is optimum for a glide time of 2 minutes and experiencing lesser induced drag.
- Rudder is deflected at -10° to produce enough pressure difference over the vertical stabilizer and hence to create apt yaw moment for a helical glide.
- Wings are placed at one-third of the distance from the nose of the fuselage which will help to maintain the c.g. of the glider.

Color Selection

The fuselage of the glider will be fluorescent orange.

Payload Descent Control Hardware Summary

ACTIVE COMPONENTS

1. Air Pressure and Temperature Sensor (BMP180):

- **Sensor Accuracy:** The BMP180 has a high relative measuring accuracy of 0.01hPa combined with a low temperature coefficient of 0.01hPa/°C and low noise. The theoretical noise level at the BMP180's highest resolution is 0.25m/
- **Data Format**: Data is received serially through SDA from the sensor using I2C interface(SDA and SCL)
- **Actuator Control:** Triggers the audio beacon when glider is near to the ground and stops the Glider data telemetry.
- **Command rates:** Less than 1Hz as the telemetry rate requirement is 1Hz.

2. Solar Voltage Sensor (Voltage Divider):

- **Sensor Accuracy:** The voltage divider circuit divides the input voltage by 2 to bring it within the range of analog pins of the MCU. Sensor accuracy depends upon the microcontroller used. The MSP430G2553 used has 10 bits ADC thus the resolutions turns outs to be :

$$\frac{5}{2^{10}} = 0.004883\ volts/step$$

- **Data Format:** Analog data (ADC)
- **Actuator Control:** N/A
- **Command rates:** less than 1 Hz as the telemetry rate requirement is 1Hz.

Payload Descent Control Hardware Summary

3. 3-Axis Magnetometer (HMC58883L):

- **Sensor Accuracy:** Enables 1° to 2° Compass Heading accuracy also has 12-Bit ADC Coupled with Low Noise AMR, sensors achieves 2 milli-gauss Field Resolution in ±8 Gauss Fields
- **Data Format:** Data is received serially through SDA from the sensor using I2C interface (SDA and SCL)
- **Actuator Control:** N/A
- **Command rates:** Less than 1Hz as the telemetry rate requirement is 1 Hz.

4. Pitot Tube Sensor (MPXV7002DP):

- **Sensor Accuracy:** $\pm$6.25 % VFSS at 10 to 60 °C
- **Data Format:** Analog data (ADC)
- **Actuator Control:** N/A
- **Command rates:** Less than 1Hz as the telemetry rate requirement is 1 Hz.

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 Deployment Altitude (1.205 kg/m³)

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

v = Descent Velocity
s = 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)
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.

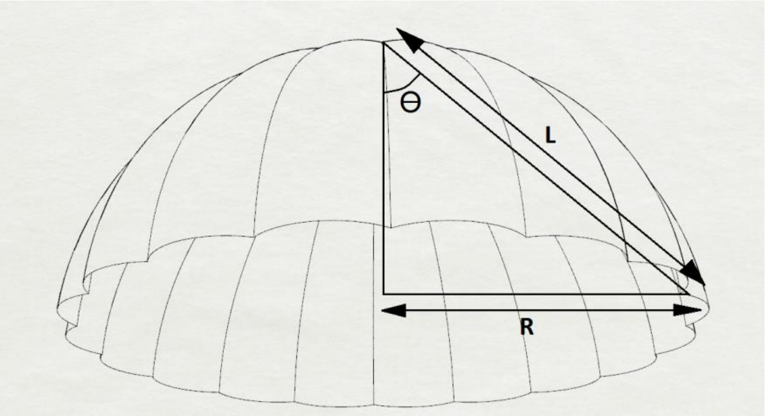
Conservation of Energy is used for finding velocity of container post glider separation.

Initial P.E + Initial K.E = Final P.E + Final K.E

Decent Rate Estimation of Container

- To govern the Decent Rate of the Re- Entry 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% diameter 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

For Glider

Decent Rate Estimation:

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

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 Weather Balloon.

- The Glider was taken up to a height of 200m which was measured using sextant.
- Its descent time was clocked at 65s.

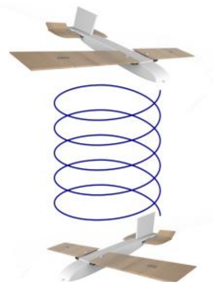
Note: For the height of 400±10m the glider shall take a descent time of around 130 s.

Descent Rate Estimates

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

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

v= 8.95 m/s



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

v= 4.82 m/s

Descent Rate of **Container** calculated using Conservation of Energy -

v= 6.9 m/s

Descent Rate Estimates Summary

Configuration	Mass (g)	Descent Rate Estimate (m/s)
Container With Glider	500	8.95
Container Only (With Parachute attached)	275	6.90
Glider Only	225	4.82

Mechanical Subsystem Design

Sudharshan Iyengar

Mechanical Subsystem Overview

The two major mechanical configurations of the CanSat includes the container and the glider with a total mass of 500 +/- 10 gm.

CONTAINER

Structure:

✓ Structure would be made of Poly-Carbonate with a thickness of 2 mm.

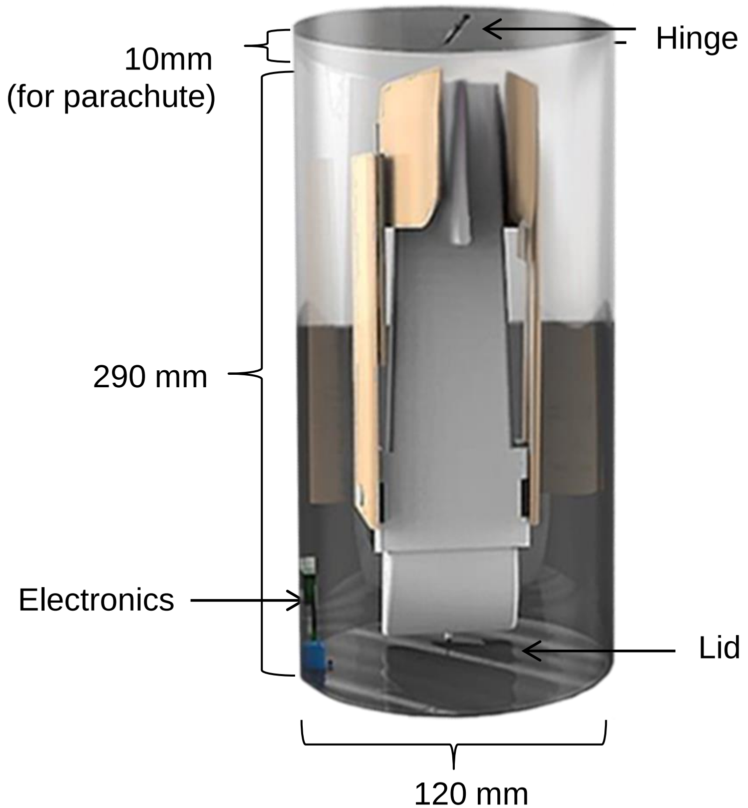
Mechanical Configuration:

✓ Consists of a hemispherical parachute of Tarpaulin with a spill hole to reduce swaying.

✓ A hinge on the top which will aid in the axial splitting of the container into two halves.

Electronics:

✓ Electronics in the container consists of a servo motor, Arduino Nano, BMP180, XBee Pro S2C, RTC (DS1307), Voltage divider circuit and an audio beacon.



The glider is placed freely inside the container with nose down configuration and the Parachute is attached through the two holes at the top lid of the container.

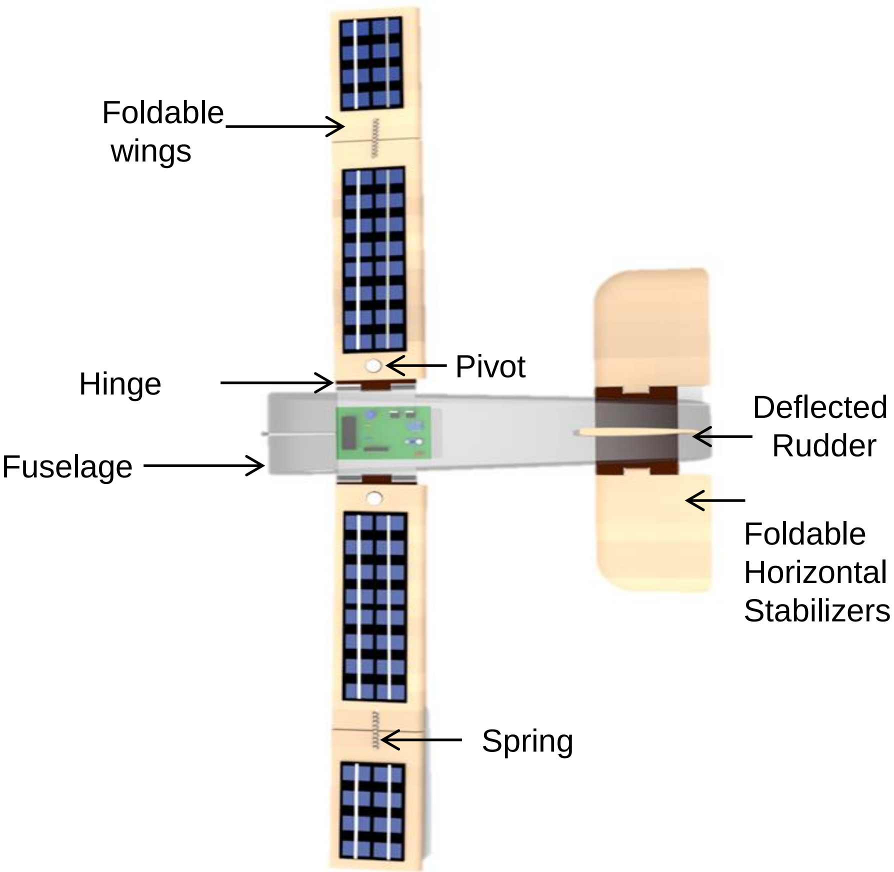
Mechanical Subsystem Overview

PAYLOAD

- **Structure :**
  - ✓ Fuselage material- High Impact Poly-Styrene
  - ✓ Wings and Stabilizers - made of Balsa wood.
  - ✓ Hinges - 3-D printed of ABS material.
  - ✓ Wings and stabilizers would unfold itself with restoring force of springs.
  - ✓ PCB bolted to fuselage.

- **Mechanical Configurations:**
  - ✓ For the folding mechanism of the wings and the stabilizers, hinges and springs are used.

- **Electronics:**
  - ✓ Solar cells are placed on top of the fuselage and wings.
  - ✓ It includes MSP, Pitot tube, XBee Pro S2C, BMP180, Camera, Magnetometer, RTC (DS1307), Audio Beacon and a Voltage Divider Circuit.



Mechanical Subsystem Changes Since PDR

Changes	Requirements	Rationale
The material of the container has been changed from Acrylic to Poly-Carbonate.	Due to its higher strength to weight ratio.	Resilient
Material of glider has been changed to High Impact Polystyrene	Greater ease of fabrication and high strength to weight ratio.	Low density

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 125mm x 310mm	Competition Requirement	HIGH	SR-02		✓	✓	
MSR-03	The glider must be released from the container at 400 (+/- 10)m	Competition Requirement	HIGH	SR-06	✓		✓	
MSR-04	The glider shall not be remotely 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 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 must be solar powered	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(+/- 10)gm	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	✓	✓		

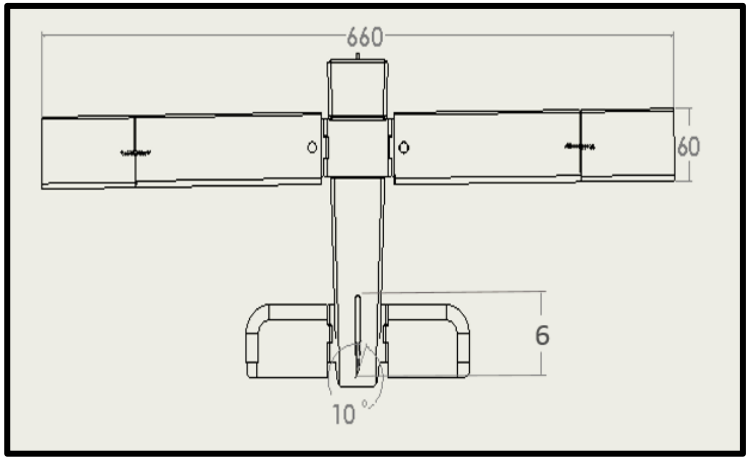
Mechanical Sub-System Requirements

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	✓		✓	

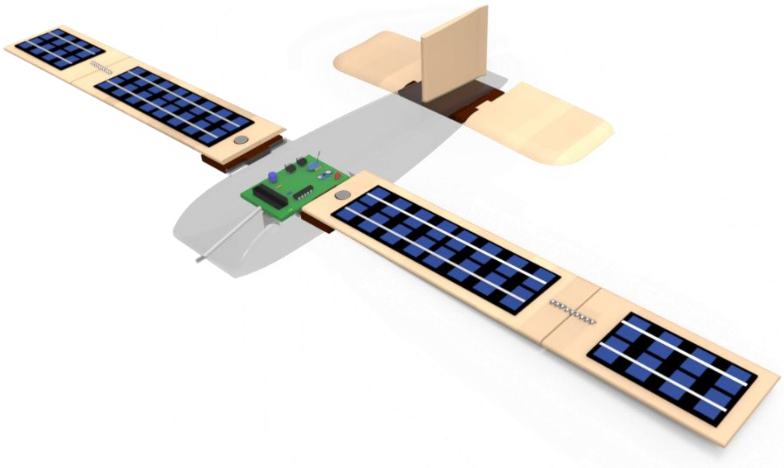
Mechanical Sub-System Requirements

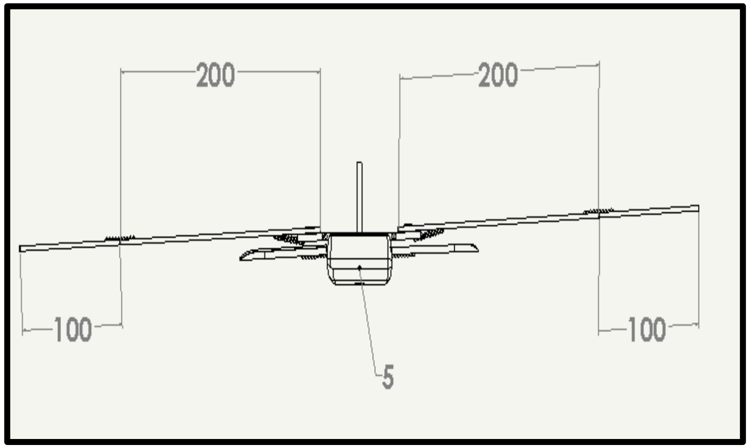
ID	Requirement (Container)	Rationale	Priority	Parent	VM			
					A	I	T	D
MSR-25	Mechanisms that use heat shall not be exposed to the outside environment	Competition Requirement	HIGH	SR-09	✓		✓	
MSR-26	The CanSat container shall have a payload release override command	Competition Requirement	HIGH	SR-13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

Payload Mechanical Layout of Components

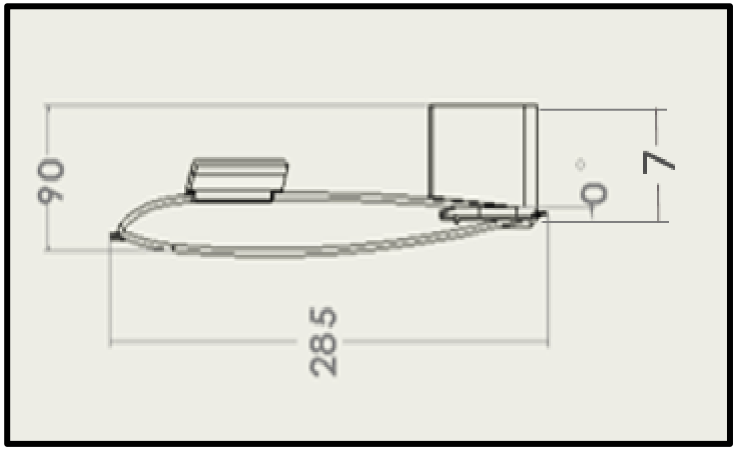


Top View





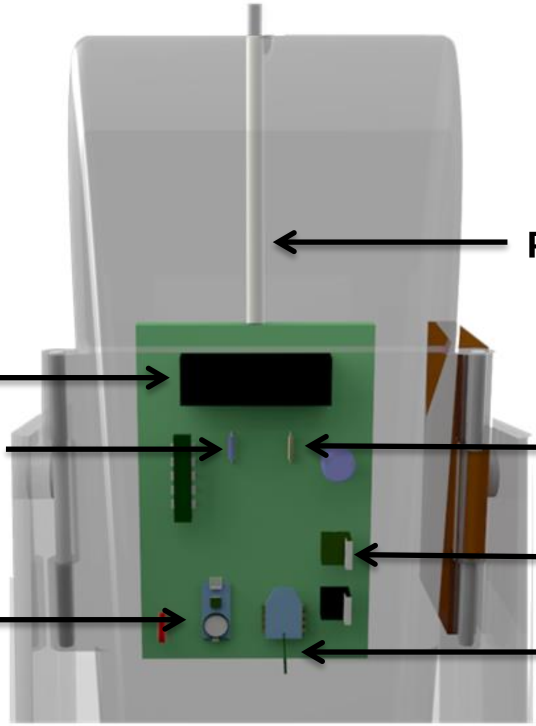
Front view

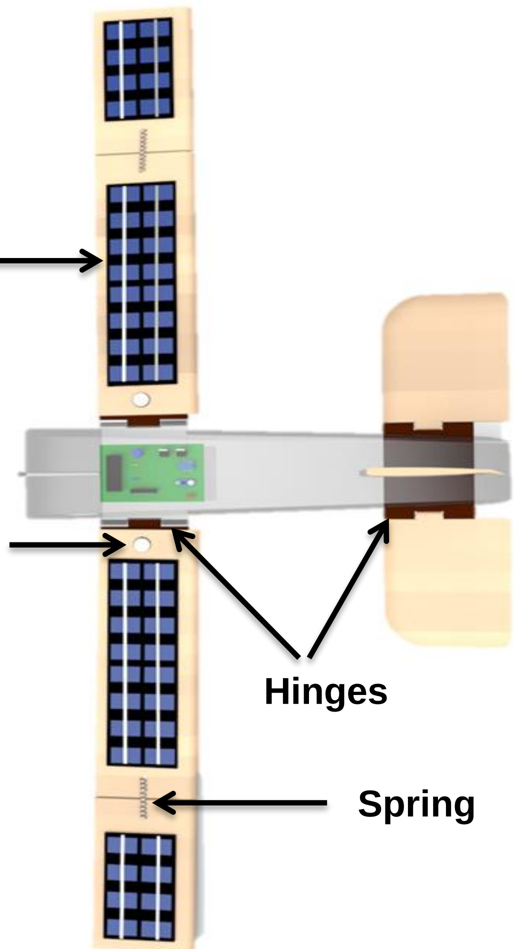


Side View

Note: All Glider dimensions are in mm.

Payload Mechanical Layout of Components



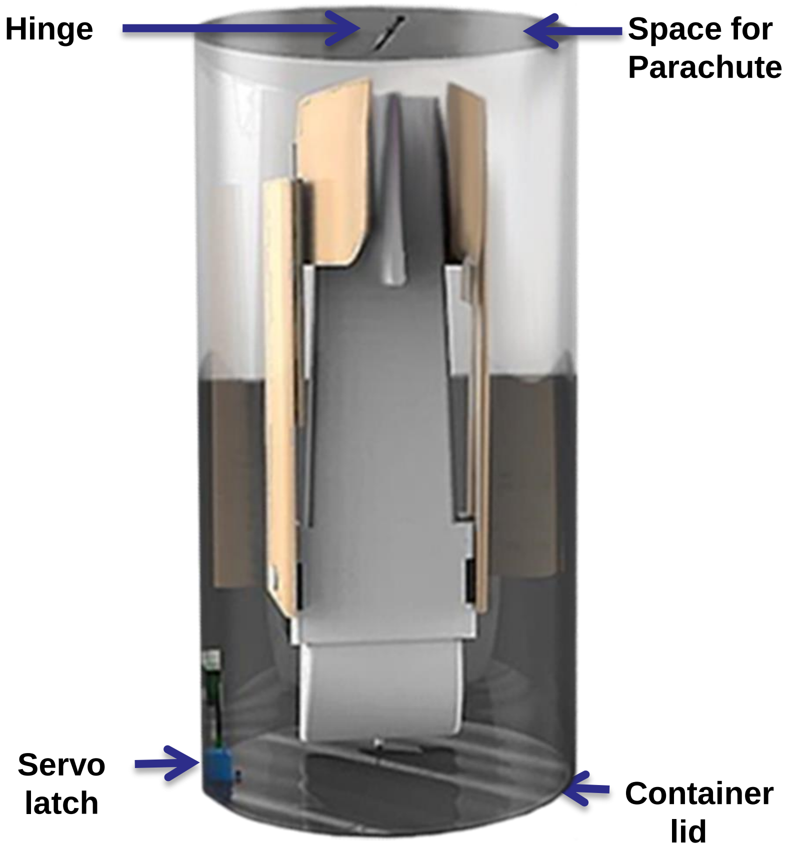


- Solar Cells are placed on the wings of the glider.
- The electronics are enclosed inside the fuselage of the payload with opening at the bottom part to place the camera and the external switch.
- The Pitot Tube is placed on the nose of the glider.

Payload Mechanical Layout of Components

Container attachment points:

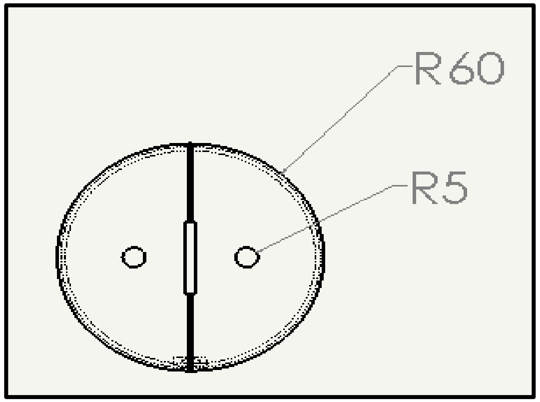
- Glider will be supported by the bottom lid of the container made of HIPS material of desired thickness.
- Initially the lid is being locked by the servo motor placed at the bottom of the container.
- The altitude sensor on the container will sense the altitude at 400 (+/-10) m and command the servo to rotate and open the lid.



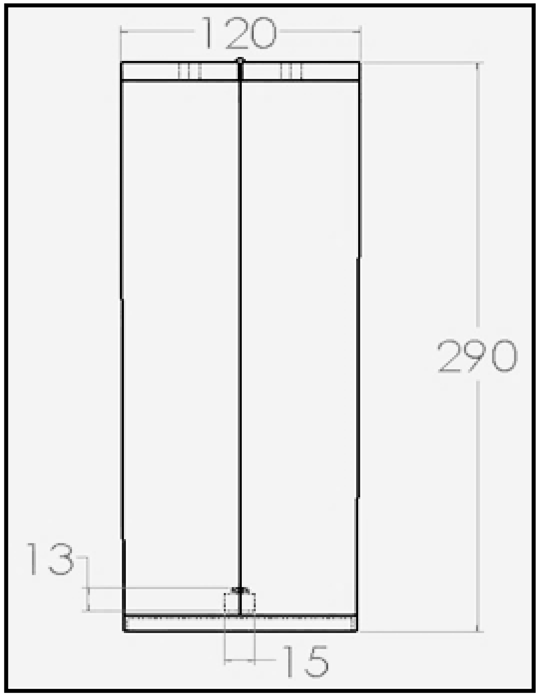
Payload Mechanical Layout of Components

COMPONENT	MATERIALS	COST	DENSITY	TENSILE STRENGTH	PROS	CONS
Fuselage	High Impact Polystyrene	$4 per 1m × 1m × 1mm	1.08 g/cm³	42 MPa	• Can be Easily molded • High strength to weight ratio • Easy machining	• Limited to certain adhesive
Wings and Stabilizers	Balsa Wood	$1.5/ sheet	163 kg/m³	19.9 MPa	• Easy machining • Vibration absorbent property • Light weight	• Poor toughness • Low resistance to shear forces
Hinges	ABS	$3/kg	1.060 g/cm³	40 MPa	• Impact resistance	• Becomes brittle under UV rays.

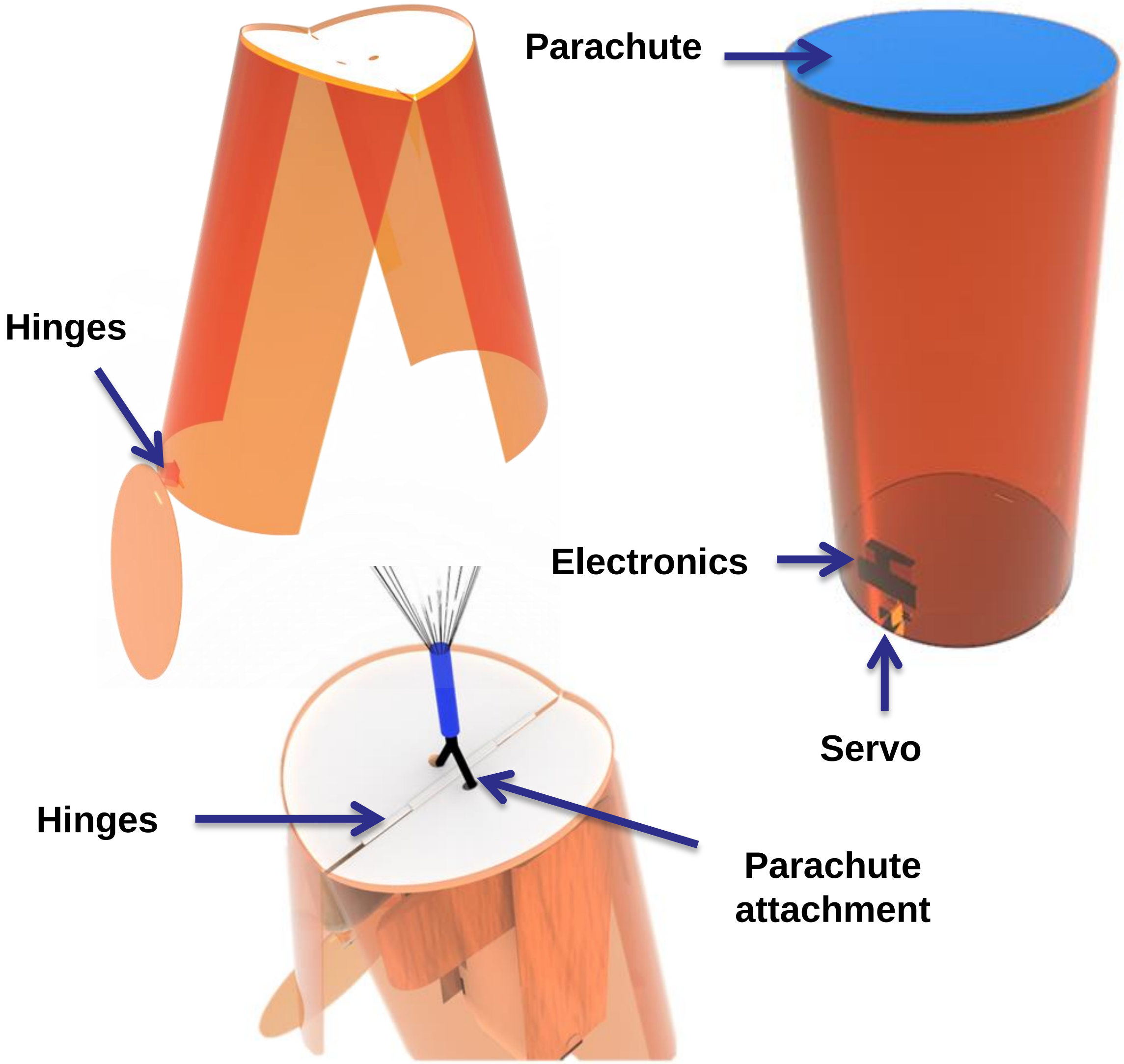
Container Mechanical Layout of Components



Top View



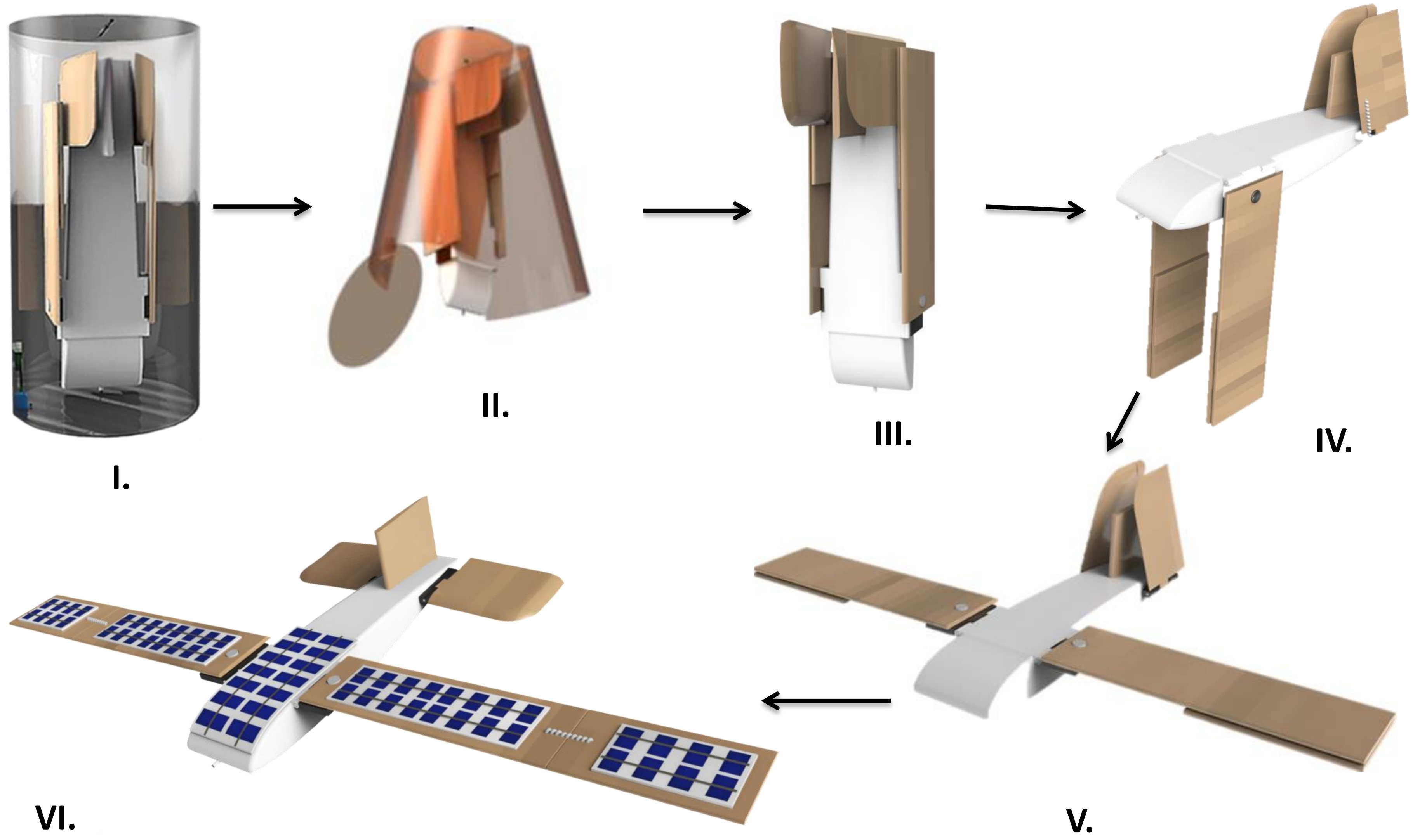
Front View



Container Mechanical Layout of Components

Following materials were considered for container:

COMPONENTS	MATERIALS	COST	DENSITY	TENSILE STRENGTH	PROS	CONS
Container Body	Poly Carbonate	$1 per sq. ft.	1.2 g/cm³	70 MPa	• Virtually unbreakable • Heat resistant	• Non-resistant to scratching
Hinges	ABS	$3 per kg	1.060 g/cm³	40 MPa	• Impact resistance	• Becomes brittle under UV rays.



I.
II.
III.
IV.
V.
VI.

Payload Release Mechanism

The container shall release the glider at an altitude of 400 (+/-10) m.

Stage 1	The container makes use of BMP180 readings to detect accurate altitudes and activates the servo latch to open the lid, hence releasing the payload.
Stage 2	The glider shall free fall due to the force of gravity acting on it downwards.
Stage 3	The container shall open axially into two halves.
Stage 4	The glider shall release itself and deploy as soon as the container opens itself.
Stage 5	The wings of the glider shall unfold as soon as the glider comes out of the container with the help of springs on the wings of the glider.
Stage 6	The glider shall take the preset circular path.

Structural Survivability

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 popping tape.
Descent control Attachments	• Usage of nylon chord for attaching parachute with the container. • The glider is placed in its stowed configuration inside the container with closed bottom lid using a servo latch.
Test	• Scale model was tested using SolidWorks and the result showed no deformation. • Drop test observation for Container.

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

(Experimental)
Drop Test Observation Glider using Quadcopter

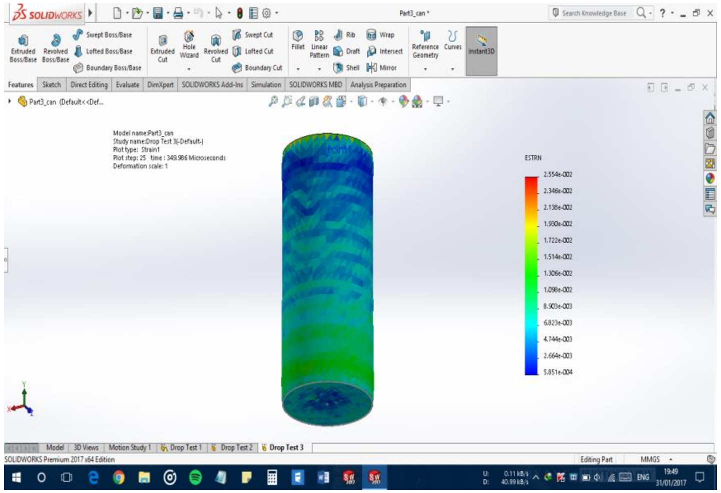
- Quadcopter drone carried the Glider and dropped it from a height of 200m.
- Glider descended traversing a helical path.
- Telemetry parameters were transmitted and collected.
- No visible damage was observed to the Glider during the drop test.

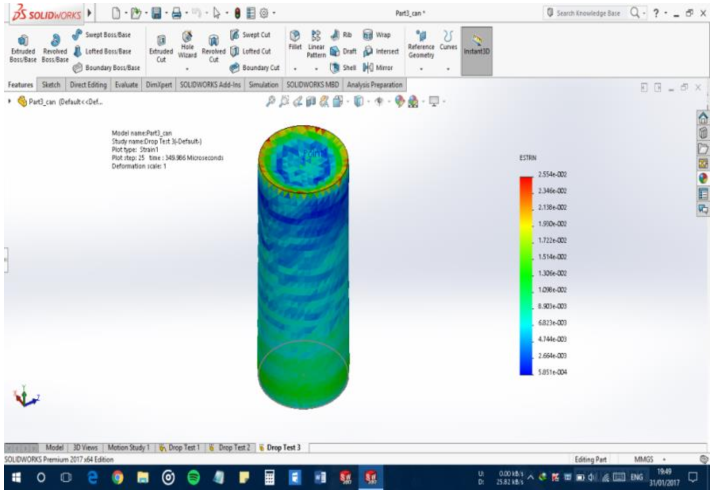
(Experimental)
Drop Test Observation Glider using
Weather Balloon

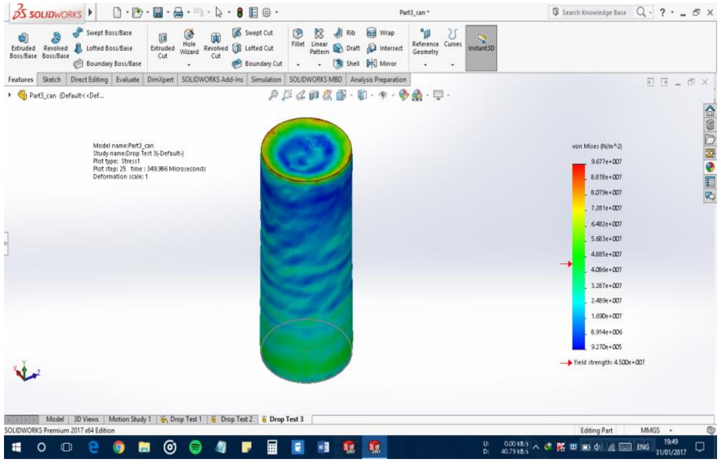
- Weather Balloon carried the Glider and dropped it from a height of 250 m.
- Glider descended along a helical path.
- Solar cells placed on the glider provided ample electricity to power the glider electronics.
- Telemetry Parameters were successfully transmitted and collected.
- No visible damage to the Glider during the drop test.

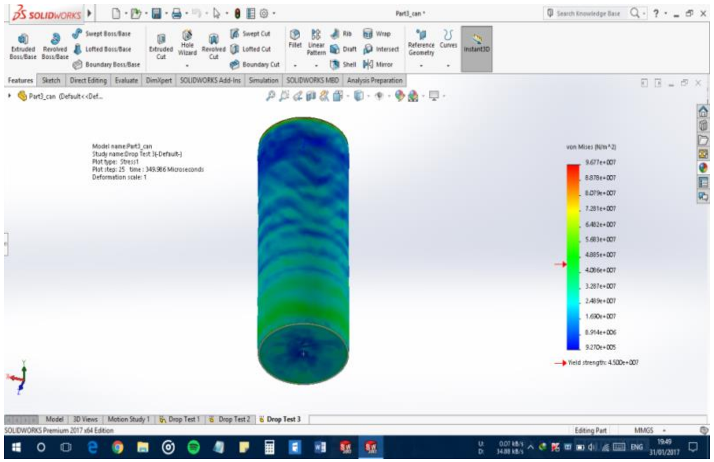
Structural Survivability

Container Drop Test Simulation for Stress, Displacement and Strain variation throughout the Glider



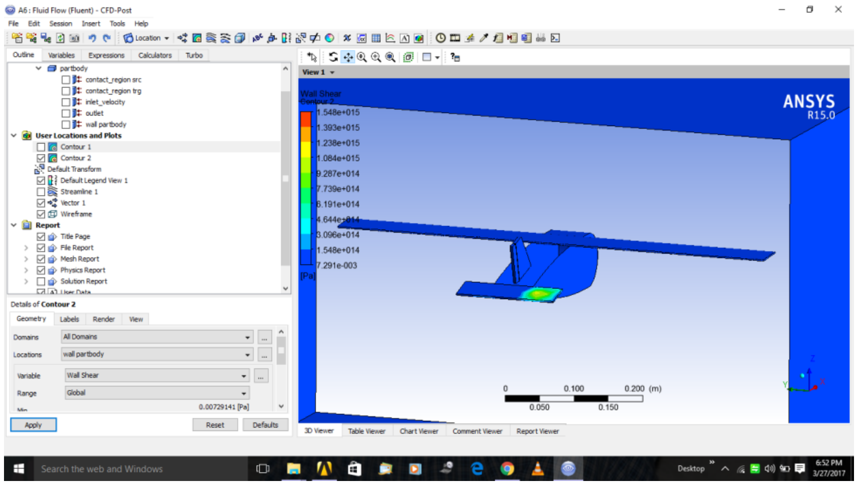


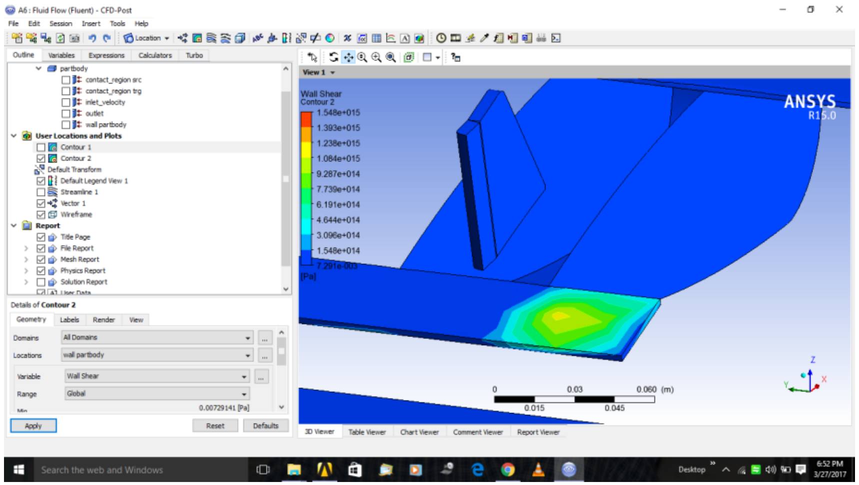


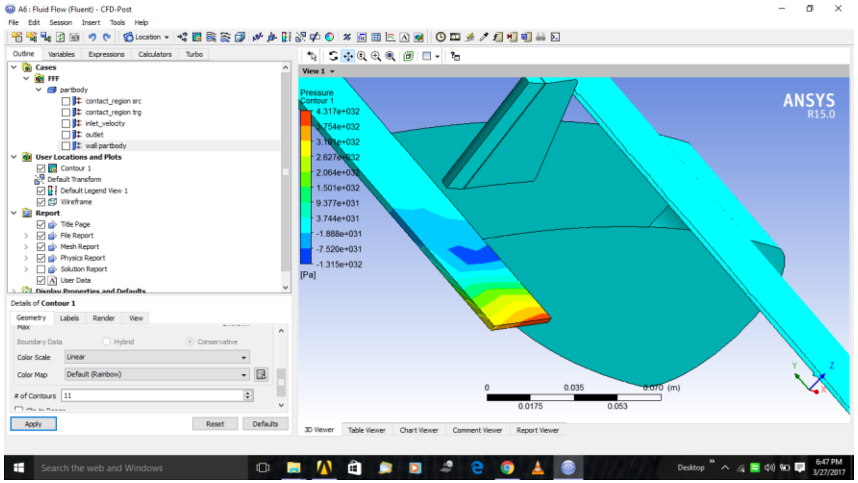


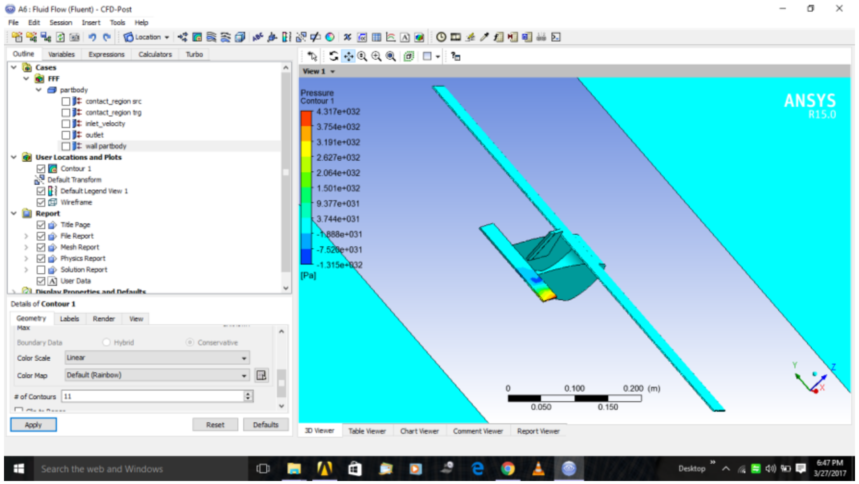
Structural Survivability

Flow simulations done on ANSYS and the results are as below:







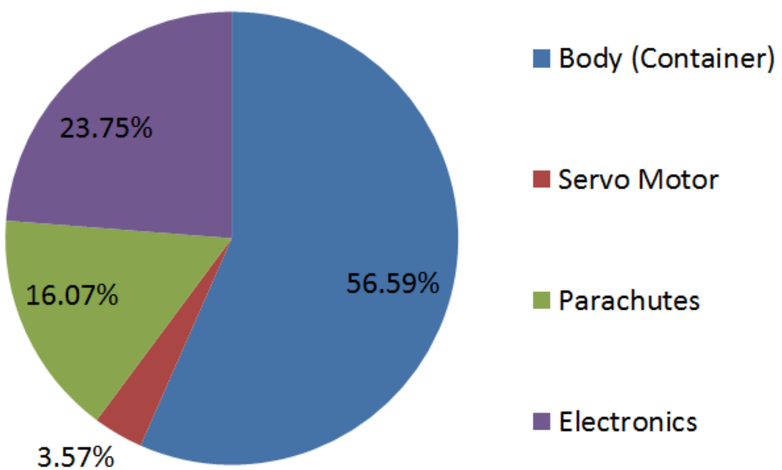


Mass Budget

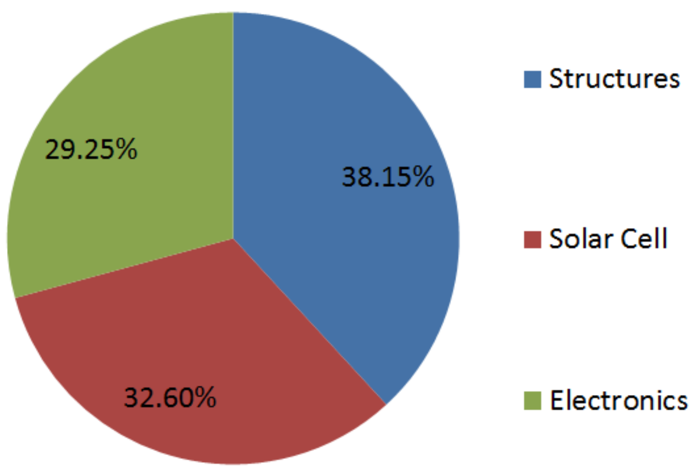
SYSTEM	SUBSYSTEM	SUBSYSTEM MASS (g) ± Error	PERCENT	VM
Container	Body	155 ± 03	56.59	Estimate
	Servo Motor	10 ± 00	03.57	Actual
	Parachute	45 ± 00	16.07	Actual
	Electronics	65 ± 02	23.77	Estimate
	TOTAL	275 ± 05	100	
Glider	Structures	85 ± 03	38.15	Estimate
	Solar cells	75 ± 00	32.60	Actual
	Electronics	65 ± 02	29.25	Estimate
	TOTAL	225 ± 05	100	

Mass Budget

COMPONENT	MASS (g)
Container	275 ± 05
Glider	225 ± 05
Total	**500 ± 10**



Container

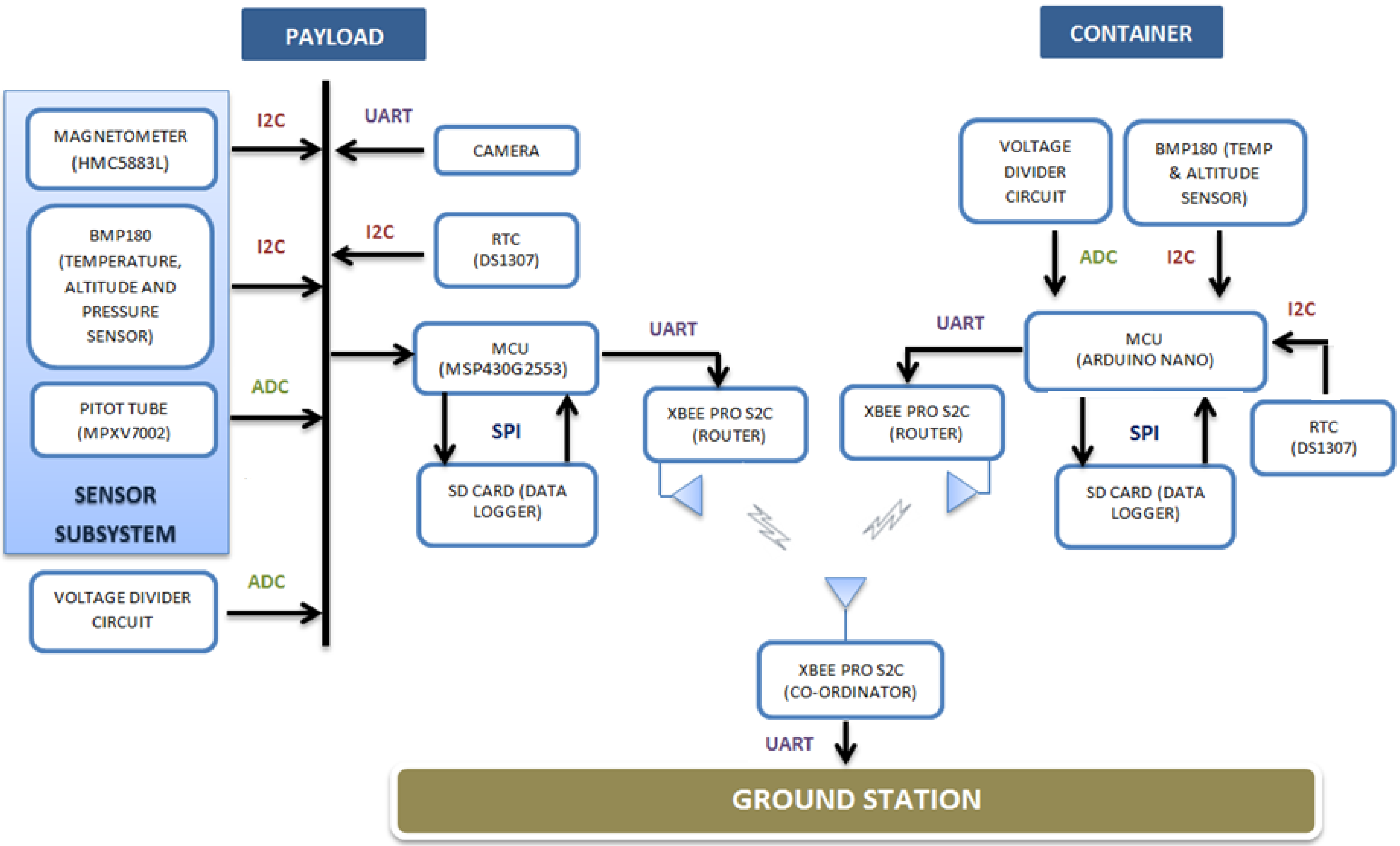


Glider

Communication and Data Handling Subsystem Design

Rahul Raj

CDH Overview



CDH Overview

S. No.	Component	Model	Function
01	Magnetometer	HMC5883L	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	Microcontroller	MSP430G2553	Control Unit
06	XBee Radio Modules	XBee Pro S2C	Communication
07	Camera	Serial TTL JPEG Camera	Capturing Images
08	Voltage Divider Circuit	Discrete Circuit consisting of two resistors and a capacitor	Measuring input voltage

CDH Changes Since PDR

- Payload Processor has been changed from Arduino Nano to MSP430G2553 due to its low power requirement.

MCU	VOLTAGE	CURRENT	
		IDEAL	ACTIVE
MSP430G2553	3.3V	0.5 µA	230 µA
Arduino Nano	5V	0.75×10^{-3} mA	28 mA

- Container Processor remains the same as Arduino Nano.

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 (1Hz rate)	SR-21	HIGH	✓	✓	✓	
CDH-02	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(1Hz 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 Selection

DEVICE NAME (MCU)	OPERATING VOLTAGE	CLOCK FREQUENCY	POWER REQUIREMENT		FLASH MEMORY	POWER DOWN
			IDEAL	ACTIVE		
MSP430G2553	3.3V	UPTO 16 MHz	0.5 µA	230 µA	16 KB	<0.1 µA

Final Selection of Processor : MSP430G2553

- Programmed using Energia.
- **Low power consumption** in both ideal and active modes.
- Smaller size, light weight
- Clock speed: Upto 16 MHz

INTERFACES	NUMBER
I2C	1
UART	1
ADC	8- 10 channels
SPI	2

Note: Three sensors (BMP180, HMC5883L and DS1307) are connected to the single I2C bus.

Payload Processor & Memory Selection

MODEL	SIZE	INTERFACING	PROGRAMMING
Mini TF Card Reader	Small	SPI	Ease of Programming

Selected: **Mini TF Card Reader**

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

MODEL	SIZE	CAPACITY	SPEED
Samsung Evo Plus	Small	16GB	48 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 Selection

DEVICE NAME (MCU)	OPERATING VOLTAGE	CLOCK FREQUENCY	POWER REQUIREMENT		EEPROM	FLASH MEMORY	POWER DOWN
			IDLE	ACTIVE			
ARDUINO NANO	5 V	UPTO 16 MHz	0.75×10^{-3} mA	28 mA	1 KB	32 KB	<0.1 µA

Final Selection of Processor : Arduino Nano

- Ease of Programming (Arduino IDE)
- **Low power consumption** in idle mode
- Flash memory-32 KB of which 2 KB used by bootloader.
- EEPROM- 1 KB

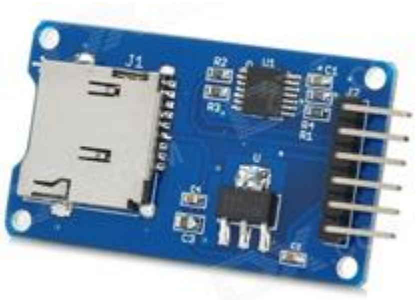
INTERFACES	NUMBER
I2C	2
UART	1
ADC	1

Container Processor & Memory Selection

MODEL	SIZE	INTERFACING	PROGRAMMING
Mini TF Card Reader	Small	SPI	Ease of Programming

Selected: Mini TF Card Reader

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



MODEL	SIZE	CAPACITY	SPEED
Samsung Evo Plus	Small	16GB	48 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

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	-

Selected RTC Type: Hardware

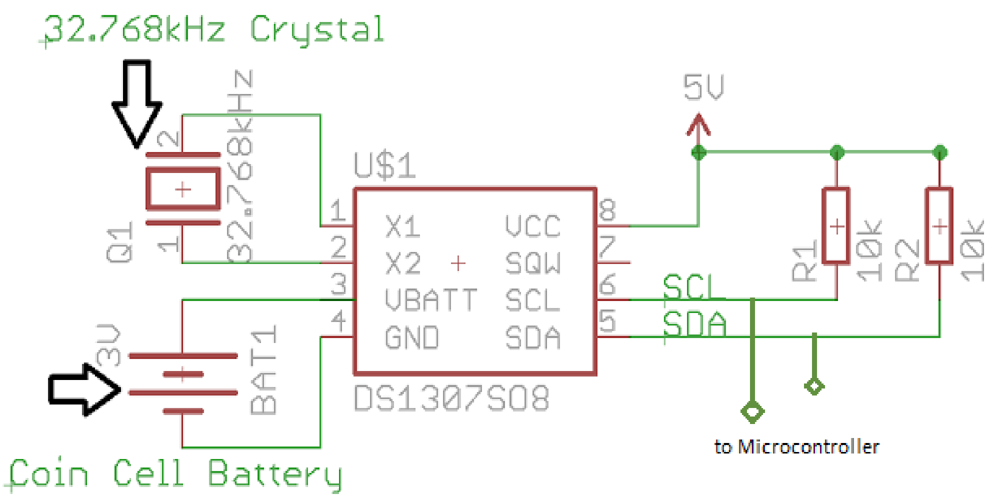
- Faster Initialization
- I2C Bus Interfacing

Payload Real-Time Clock

Real Time Clock	Operating Voltage	Clock Frequency	Power Requirement (Active)
DS1307	4.5 - 5.5V	UPTO 16MHz	<1µA

Final Selection of RTC: DS1307

- I2C Bus Interfacing
- Low Power Consumption
- Highly Accurate
- Tolerance Level is 100ppm



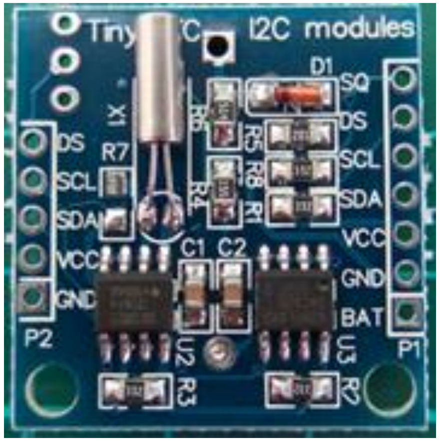
REAL TIME CLOCK (RTC) :

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 Type: Hardware

- Faster Initialization
- I2C Bus Interfacing

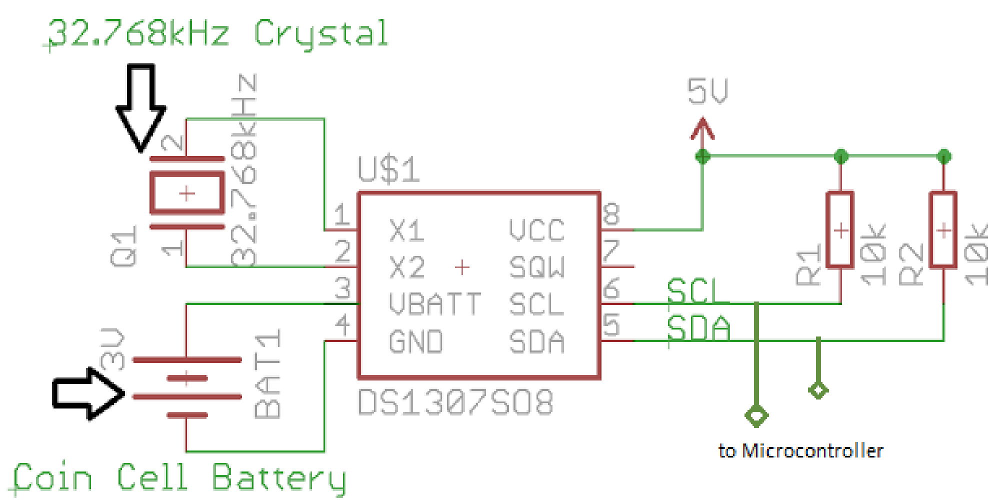


Container Real-Time Clock

Real Time Clock	Operating Voltage	Clock Frequency	Power REQUIREMENT (Active)
DS1307	4.5 - 5.5V	UPTO 16MHz	<1µA

Final Selection of RTC: DS1307

- I2C Bus Interfacing
- Low Power Consumption
- Highly Accurate
- Tolerance Level is 100ppm



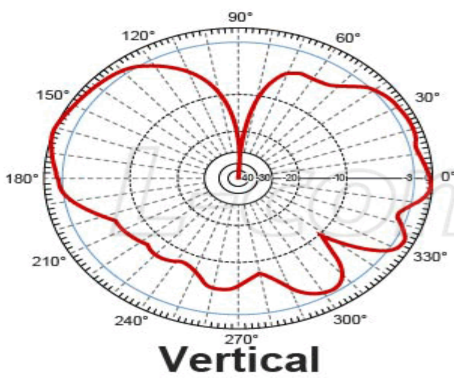
Payload Antenna Selection

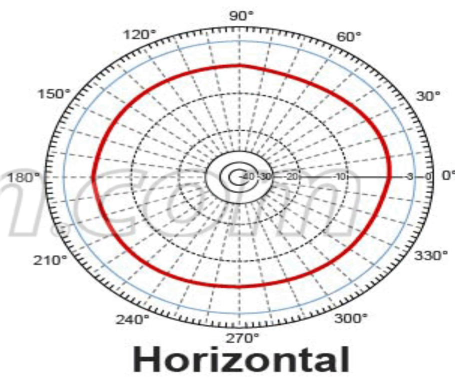
S No.	Model	Type(and connector)	Peak Gain	Dimensions	Radiation Pattern	VSWR/Eff.	Frequency Range
01	**Rubber Duck L-com Hg2402rd-rsf**	Patch antenna (SMA plug Connector)	2.2 dBi	100 mm(length) 10 mm (Diameter)	Omni directional	< 2.0	2.4GHz ISM Band

Source:- Datasheet

Final Selection: Rubber Duck L-com Hg2402rd-rsf

- Omnidirectional
- Broad Coverage and High Gain(2.2dBi)
- High Range Antenna
- Frequency- 2400-2500 MHz
- Compact size
- Tilt and Swivel design
- Mass - 15 gm.
- Diameter -10 mm





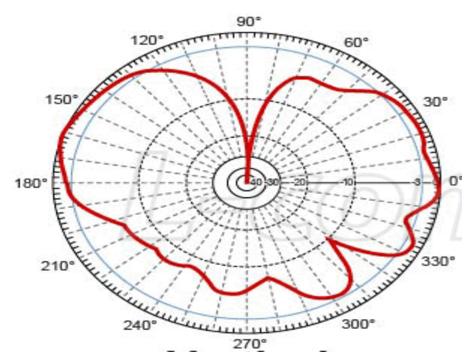
Container Antenna Selection

S No.	Model	Type(and connector)	Peak Gain	Dimensions	Radiation Pattern	VSWR/Eff.	Frequency Range
01	**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

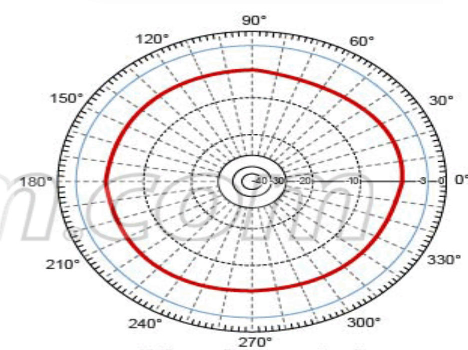
Source:- **Datasheet**

Final Selection: Rubber Duck L-com Hg2402rd-rsf

- Omnidirectional
- Broad Coverage and High Gain(2.2dBi)
- High Range Antenna
- Frequency- 2400-2500 MHz
- Compact size
- Tilt and Swivel design
- Mass- 15 gm.
- Diameter -10 mm



Vertical



Horizontal

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	120 mA	31 mA	ISM 2.4 GHz	250 Kbps	3.1 mW (+5 dBm)	4000 ft. (1200 m)

Source:- Datasheet

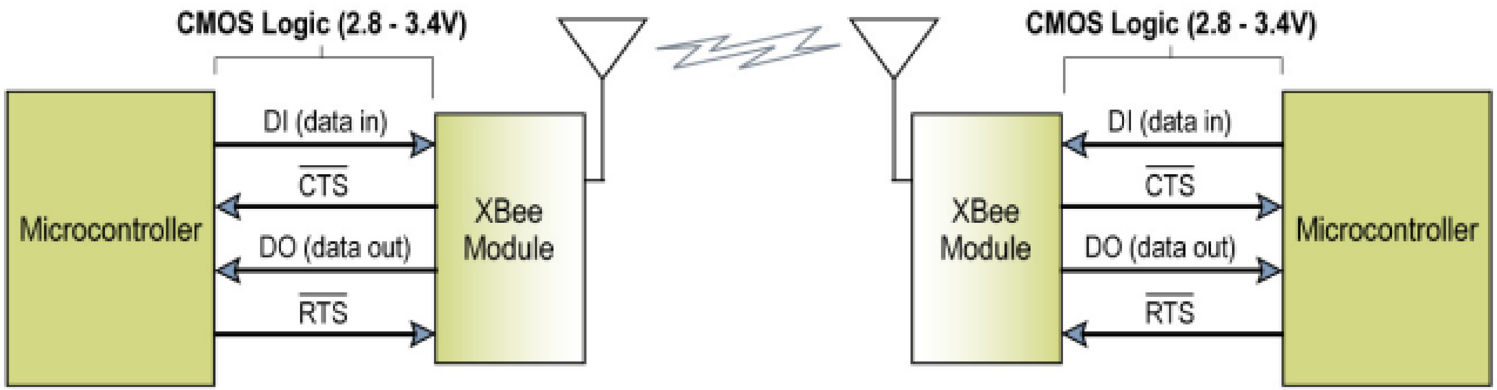
Final Selection of XBee: XBee PRO S2C

- Good Range and Low Operating Current.
- **XBee Radio Module** is interfaced to the MCU through UART Communication Protocol.
- NETID/PANID 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 XBee 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



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	120 mA	31 mA	ISM 2.4 GHz	250 Kbps	3.1 mW (+5 dBm)	4000 ft. (1200 m)

Source:- Datasheet

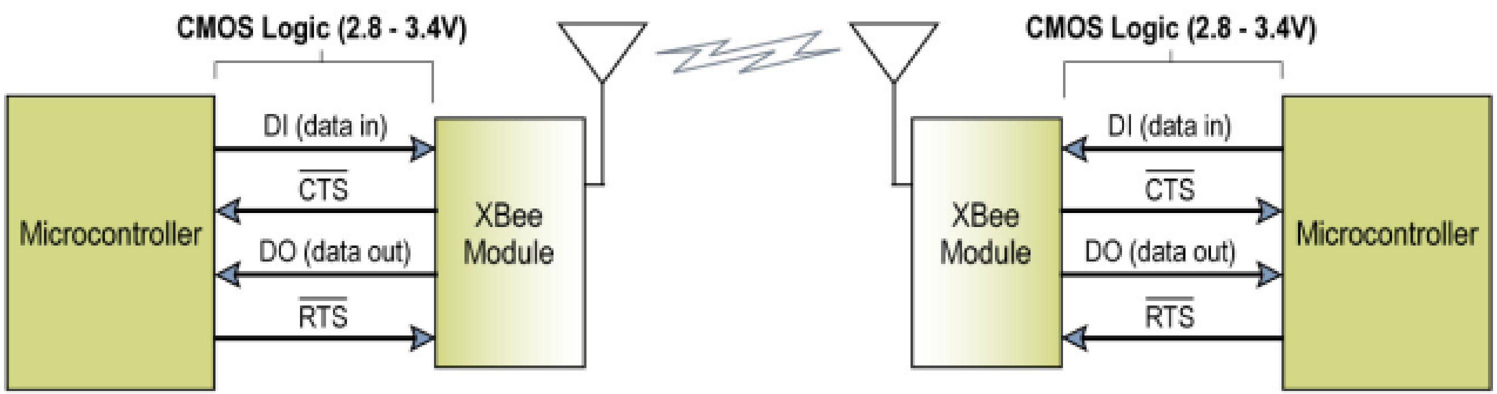
Final Selection of XBee: XBee PRO S2C

- Good Range and Low Operating Current.
- **XBee Radio Module** is interfaced to the MCU through USART Communication Protocol.
- NETID/PANID 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 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 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>,<SOFTWARE 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>,<4204>,<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 (,)

Telemetry Format:

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

Example :

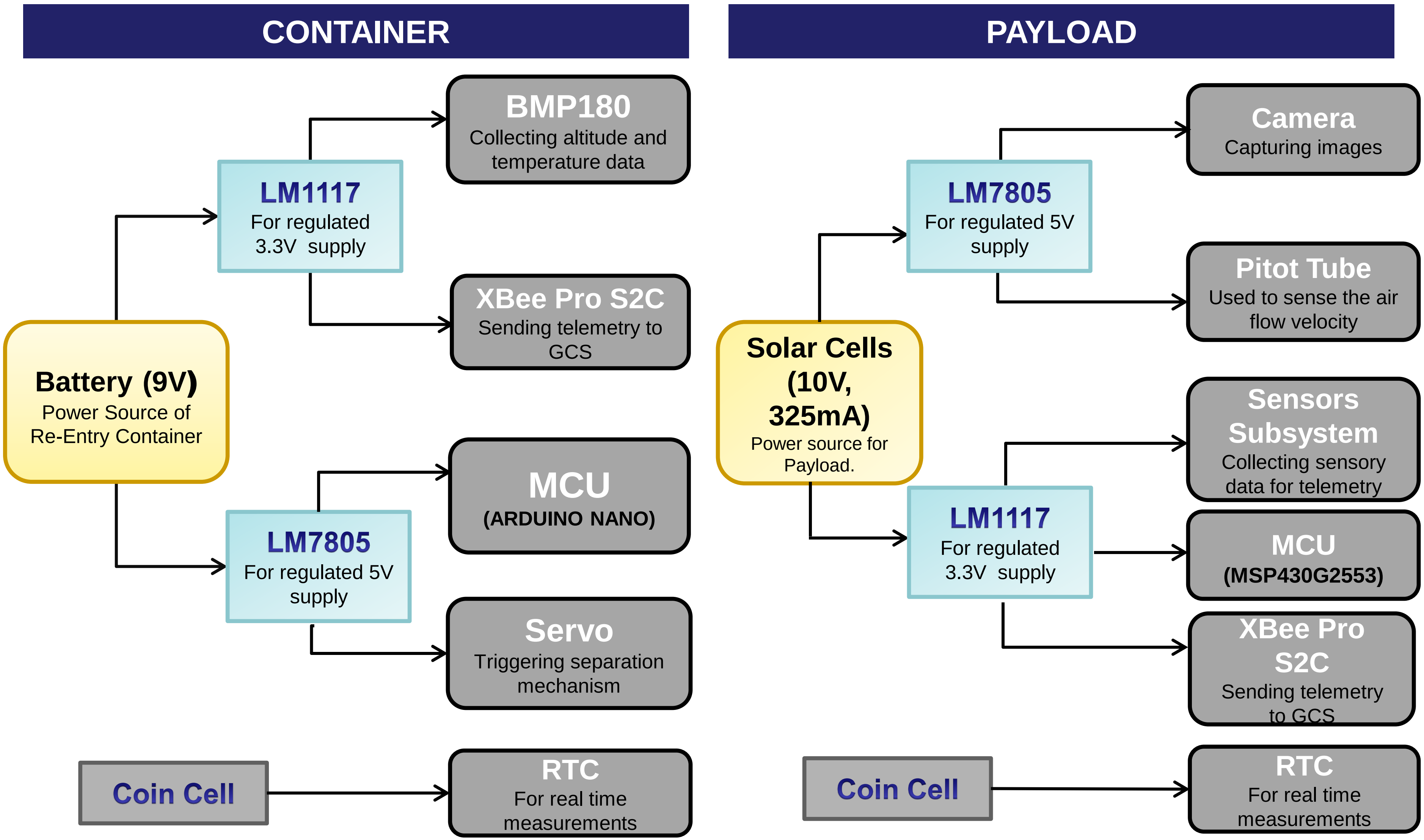
<2232>,CONTAINER,<2>,<44>,<810.1234>,<101325>,<5.523>,<30.123>,<5.23>,<4204>,<3>,

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

Electrical Power Subsystem Design

Pradyumna Narayan Tiwari

EPS Overview



EPS Changes Since PDR

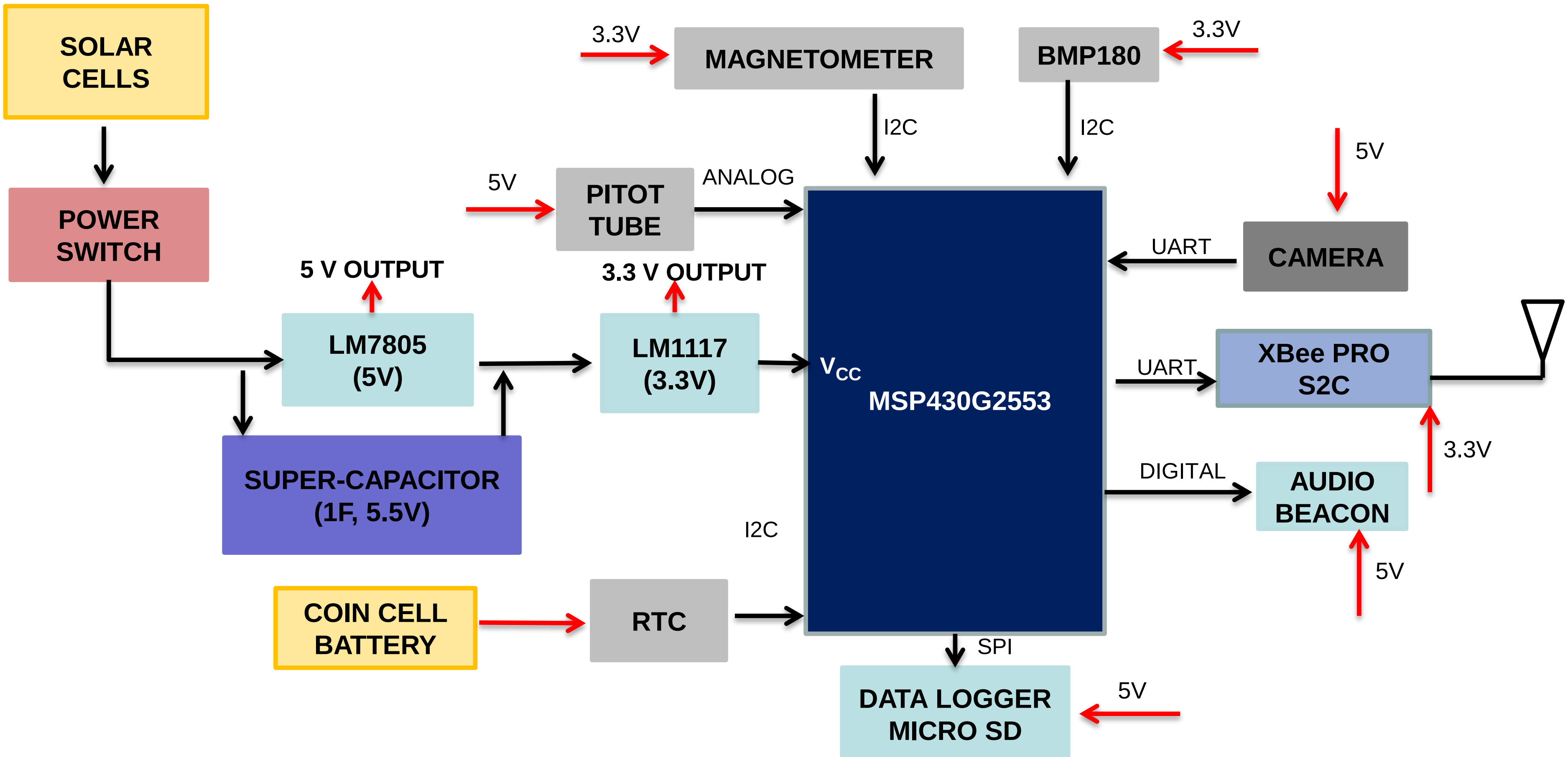
Solar PV Modules changed to **Flexible Crystalline Solar Cells.**

Specifications:

- Efficiency of solar cells being used = 17%
- Addition of solar cells to wings (two cells) and fuselage (one cell).
- Dimensions of the solar modules have been changed.
- Voltage provided by solar modules = 10V
- Current provided by solar modules = 325mA

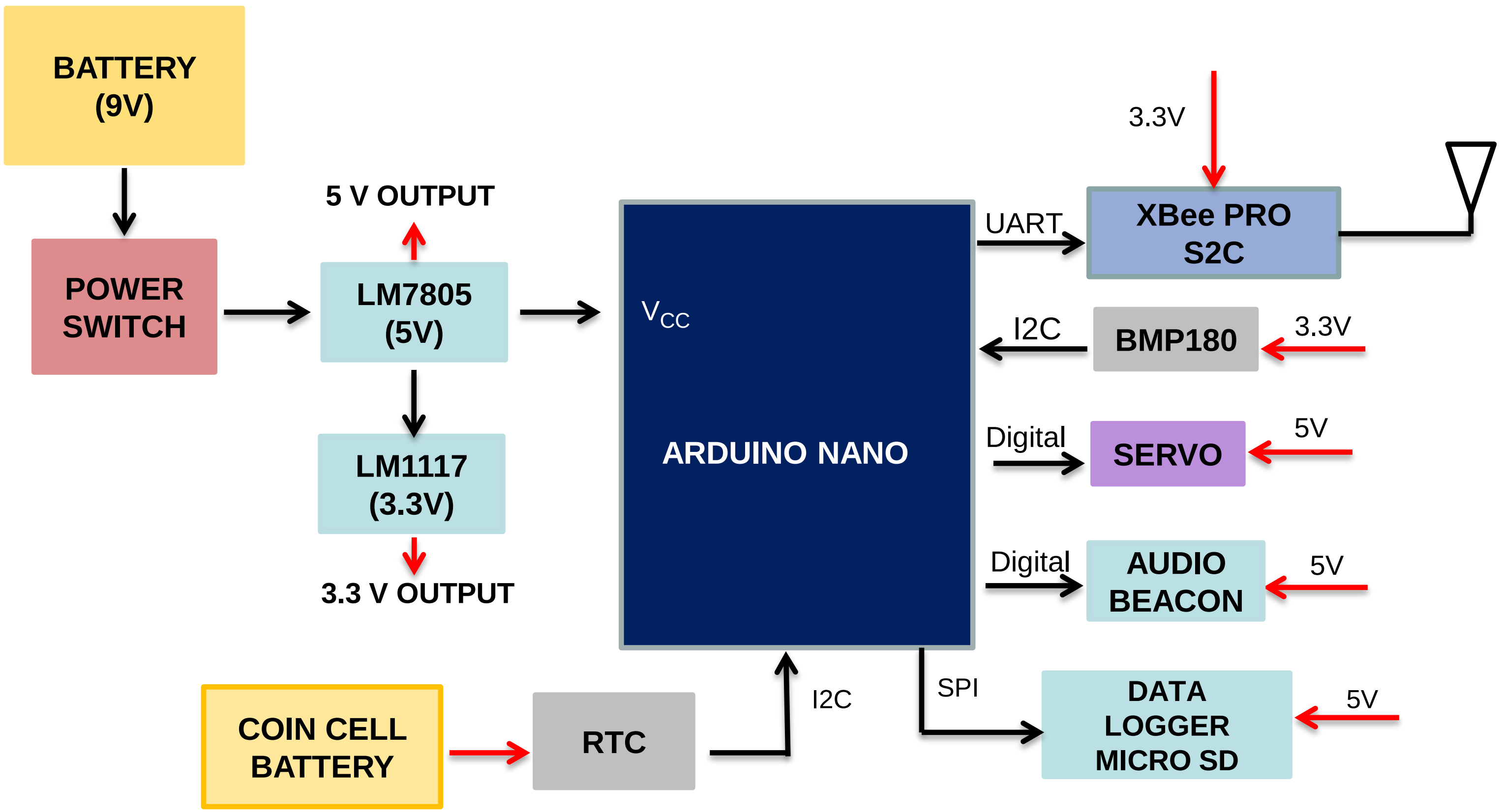
EPS Requirements

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	✓	✓	✓	



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



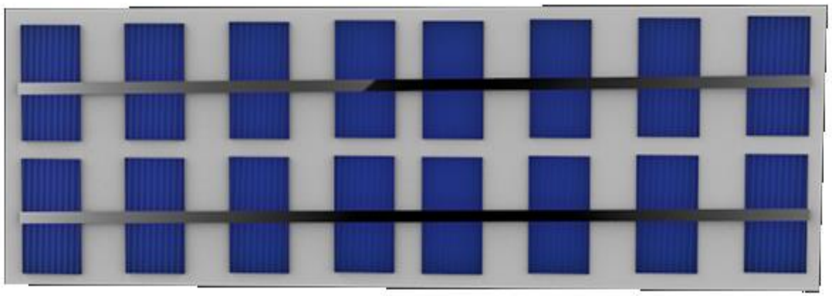
External verification of power : Voltage divider on MCU
External switch : Push-Button DPDT Switch
Umbilical Power source : USB Power and Power Supply (Full Wave Rectifier) Circuit

Payload Solar Power Design

SELECTED: Flexible Solar Modules

S.NO.	EMBEDDED ON	NUMBER	SIZE	V_{oc} (V)	I_{sc} (mA)	V_{mp} (V)	I_{mp} (mA)
1.	Wings	2	(19cm×4cm)	12.4	100	10	92
2.	Fuselage	1	(12cm×6cm)	12.4	94	10	86
3.	Extended wings	2	(7cm×4cm)	6.2	29.5	10	26.5

- **Voltage By Solar Cells** = 10V
- **Current By Solar Cells** = 325mA
- **Conversion Efficency** = 17%
- **Material** = Crystalline Silicon



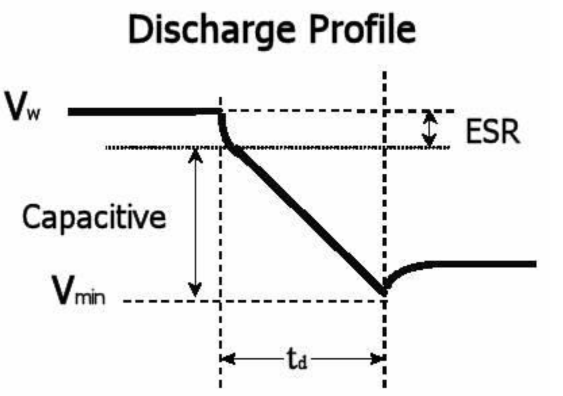
Payload Solar Power Design

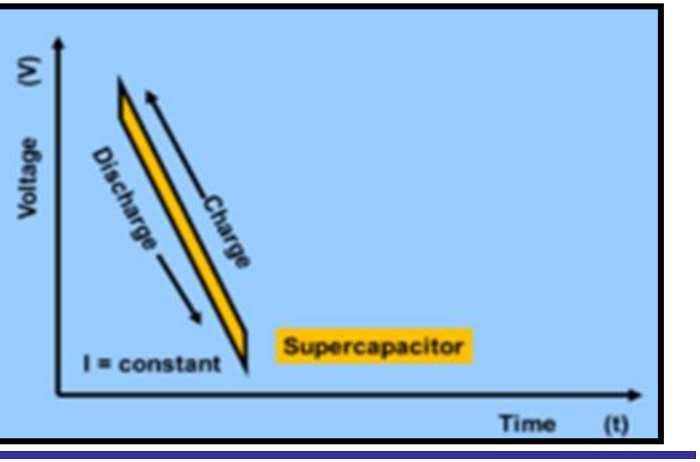
ENERGY STORAGE

- **DEVICE –** Super Capacitor

- **SPECIFICATIONS OF SUPER CAPACITOR**
  - Storage capacity = 1F
  - Maximum bearable voltage = 5.5V
  - Current capacity= 1.6A

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





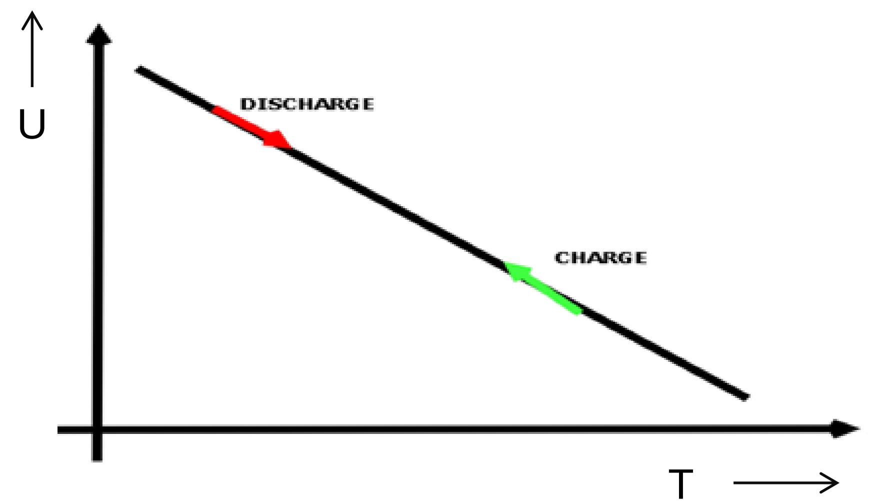
Payload Solar Power Design

POWER PROFILE

- Time of flight = **2 min**
- Power required by system = **25.91 mWh**
- Power Capacity of super capacitor over time of flight = **266.66 mWh**
- Hence from above values it can be seen clearly that energy storage device super capacitor is capable enough to tackle any emergency condition i.e. shade on PV modules

$$Q = (U * I)/(\mathrm{dU}/\mathrm{dT})$$

Where: Q = Charge
U = Energy
I = Source Current
T = Time



SELECTED: 9V Alkaline Battery

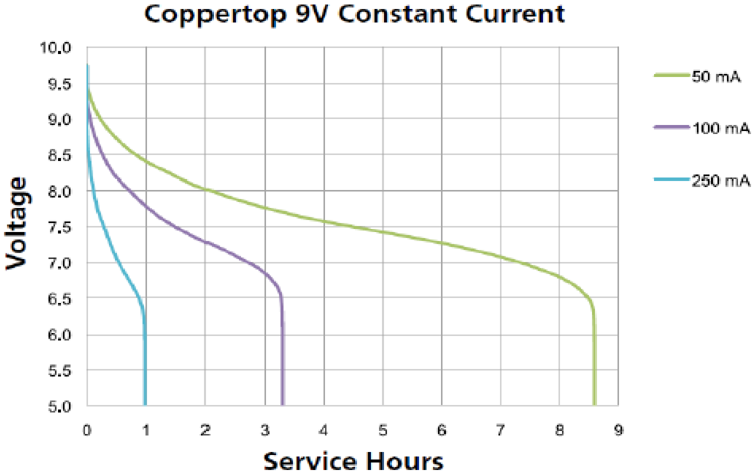
Capacity: 9V, 500 mAh

The battery life (hrs) was estimated by dividing the capacity by the actual load current. Our container circuit draws ~398.012mA, powered by a 9 volt alkaline battery will operate about 1.25 hours:

500 mAh / 398.012 mA = 1.25 hours

Sustained battery current capability: 398.012 mA (on a sustained basis of 1.25 hours).

Nominal voltage	9 V
Impedance	1,700 m-ohm @ 1 kHz
Typical weight	45 g (1.6 oz)
Typical volume	22.8 cm³ (1.4 in³)
Terminals	Miniature snap
Storage temperature range	5°C to 30°C (41°F to 86°F)
Operating temperature range	-20°C to 54°C (-4°F to 130°F)
Designation	ANSI: 1604A IEC: 6LR61



Payload Power Budget

S. No	Power Source	Device	Voltage (V)	Current (mA)	Power Required (W)	Duty Cycle
1.	5 Modules of Solar Cells	MSP430G2553	3.3	0.280	0.000924	100%
2.		BMP180	3.3	0.012	0.0000396	100%
3.		XBee Pro S2C	3.3	120	0.396	100%
4.		Pitot Tube	5	10	0.05	100%
5.		Camera	5	75	0.000375	25%
6.		Magnetometer	3.3	0.1	0.33	100%

Source: Datasheet

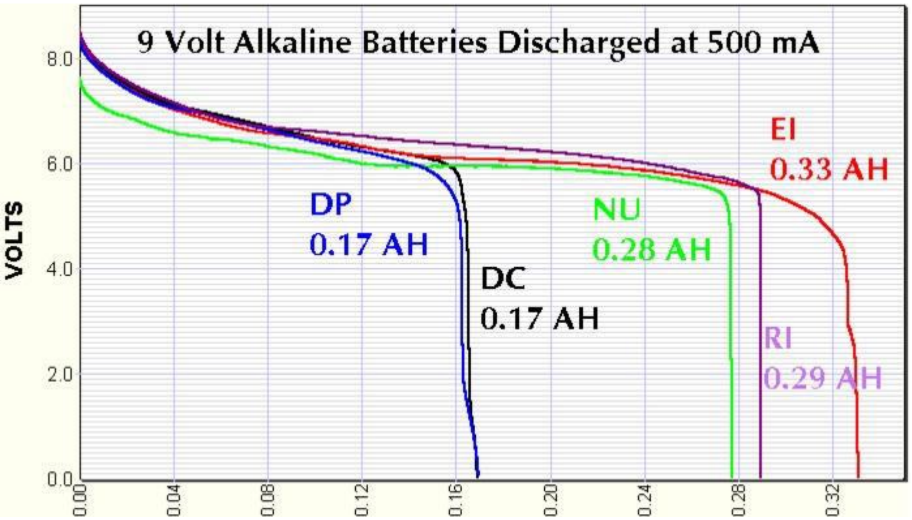
Power Available	3.25 W
Total Power Required /Consumed	25.91 mWh
Margin	2.472 W

Container Power Budget

DEVICE	VOLTAGE (V)	CURRENT (MA)	POWER (W)	DUTY CYCLE	SOURCE
Servo	5	250	1.250	25%	**Datasheet**
BMP180	3.3	0.012	0.0000396	100 %	**Datasheet**
Arduino Nano	5	28	0.14	100%	**Datasheet**
XBee Pro S2C	3.3	120	0.396	100%	**Datasheet**

POWER SOURCE	ALKALINE BATTERY
Power Available	4500.00 mWh
Total Power Consumed	2143.24 mWh
Margins	2356.75 mWh

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



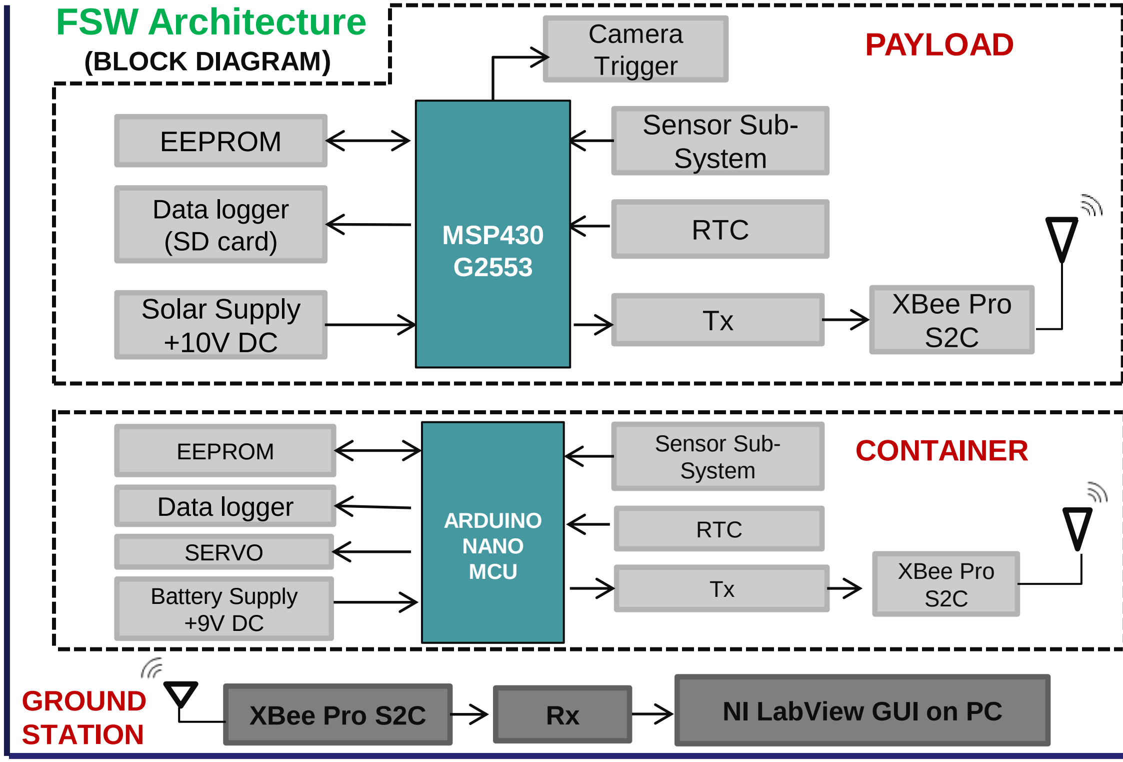
Flight Software (FSW) Design

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++
  - MSP Programming(ENERGIA)
- **Development environments**
  - Arduino IDE
  - ENERGIA
- **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.
- ✓ Detection and activation of states.
- ✓ 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 Changes Since PDR

- FSW overview has been modified with its Programming Language and Development Environments.
- Payload FSW State diagram has been modified in terms of logic.
- An operational pseudo-code has been included with point by point depiction to the State Flow Diagrams.
- Phase II of the plan is effectively finished and presently working on Phase III.

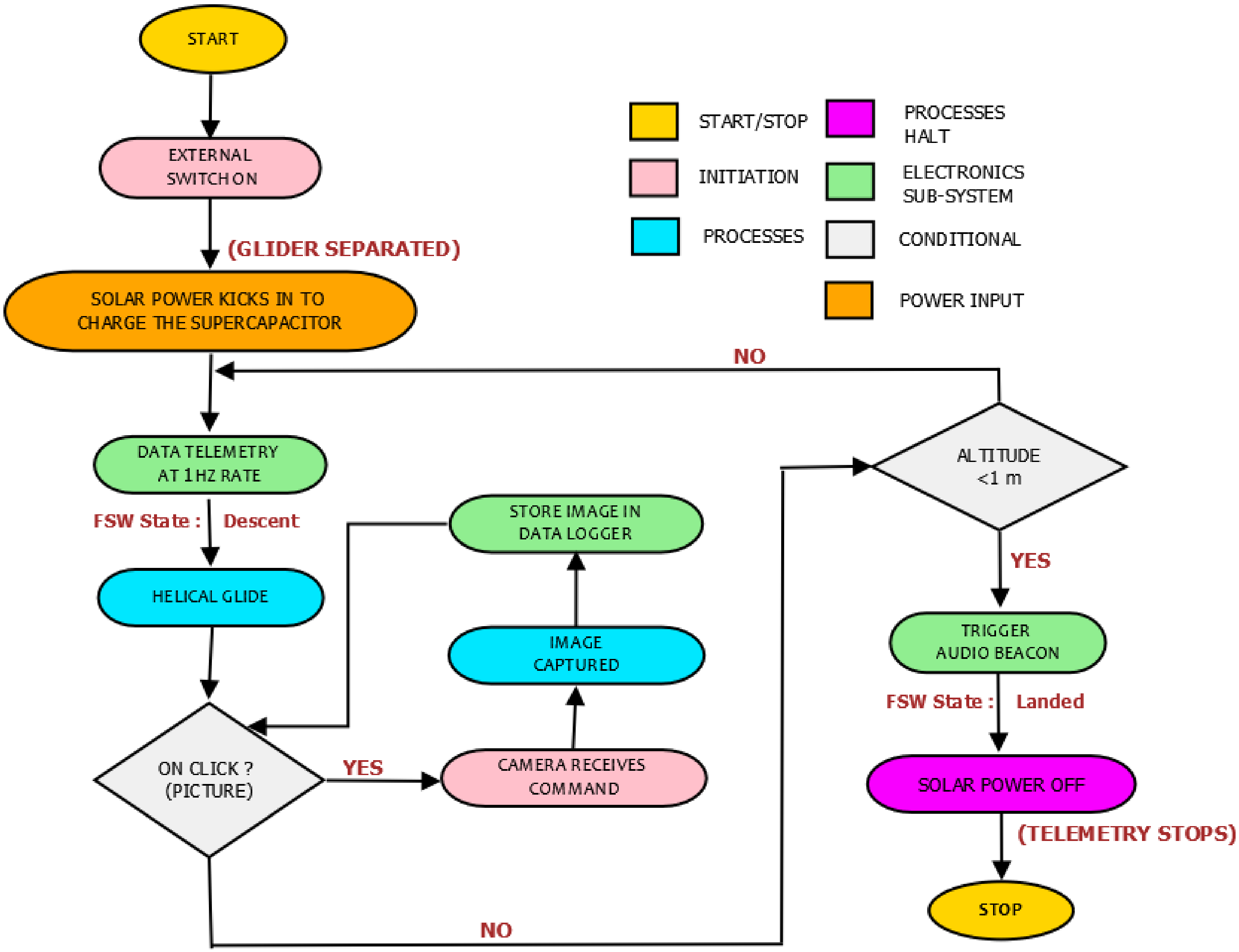
FSW Requirements

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 CanSat 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

Payload CanSat FSW State Diagram

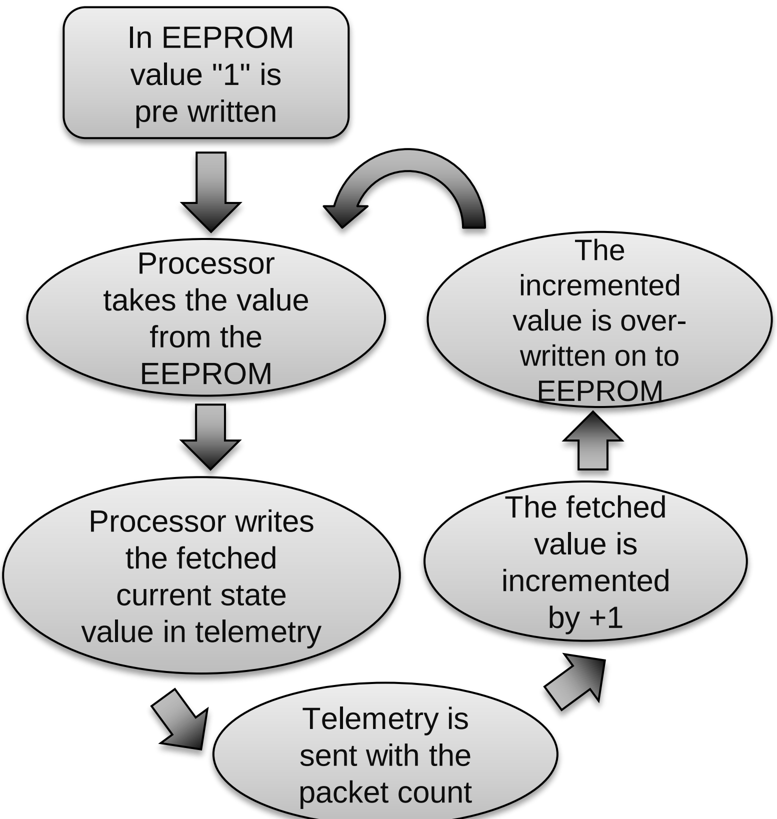
PSEUDO - CODE

```
Start // External Switch ON
Start_RTC();
preAlt=Initial_Ground_Reading
If(FSW_state()==4) //recovery to
correct state after reset
{
While (1)
{
FSW_State=4;
readSensorData();
WriteSensorData();
TransmitSensorData();
//Write Sensor Data, & FSW_state
If(alt_reading<=prealt+400)
{
FSW_State=5; // "Descent"
WriteFSW_State();
FScount1=1;
}
If(FSW_State==5)
{
while (1)
{
readSensorData();
WriteSensorData();
if(alt_reading<1m && FSW_State==5 &&
FScount5==0)
{
FSW_State=6; //"Glider landed"
WriteFSW_StateToMemory();
FScount5=1;
while(1)
{
readSensorData();
WriteSensorData_toSdCard_CSV();
Activate_BUZZER();
}
}
}
}
```

Payload CanSat FSW State Diagram

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.*



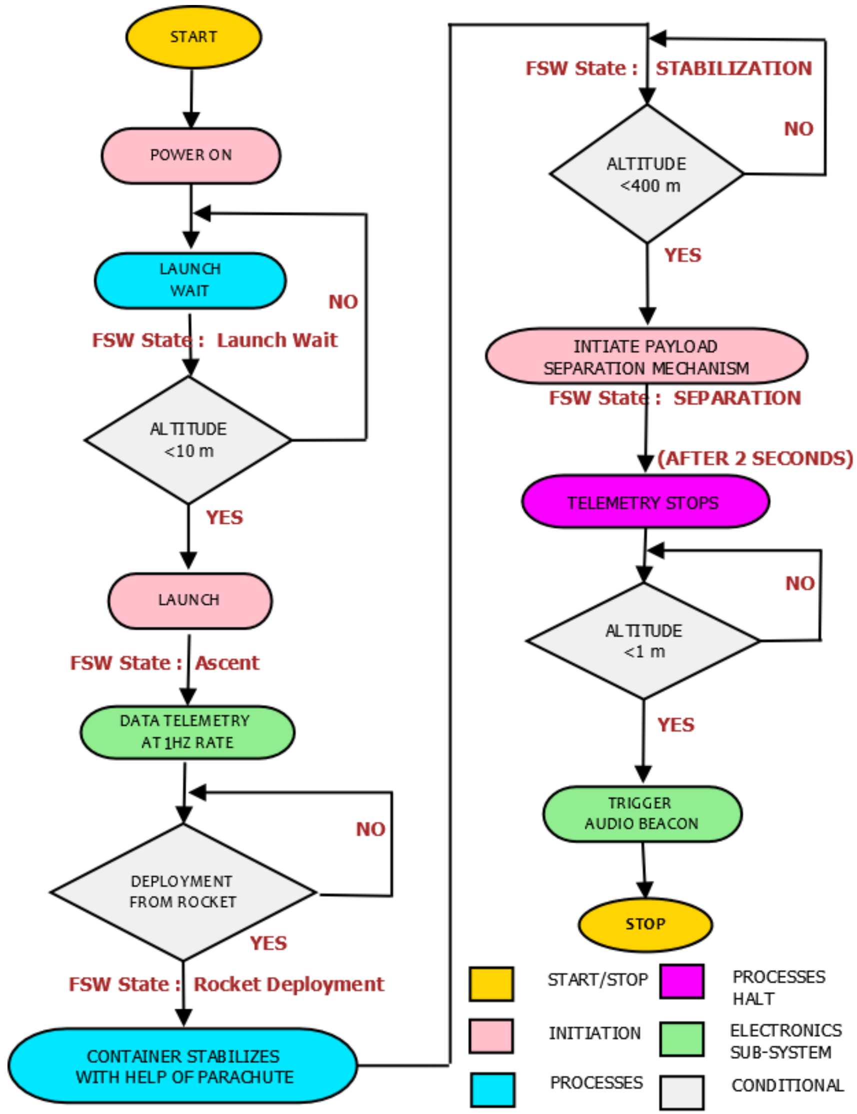
EEPROM (inside the Arduino Nano) will be controlling the irregular pattern of the telemetry count

(Selected)

Alternative solution :

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

Container Cansat 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 CanSat FSW State Diagram

ANNUAL CANSAT COMPETITION

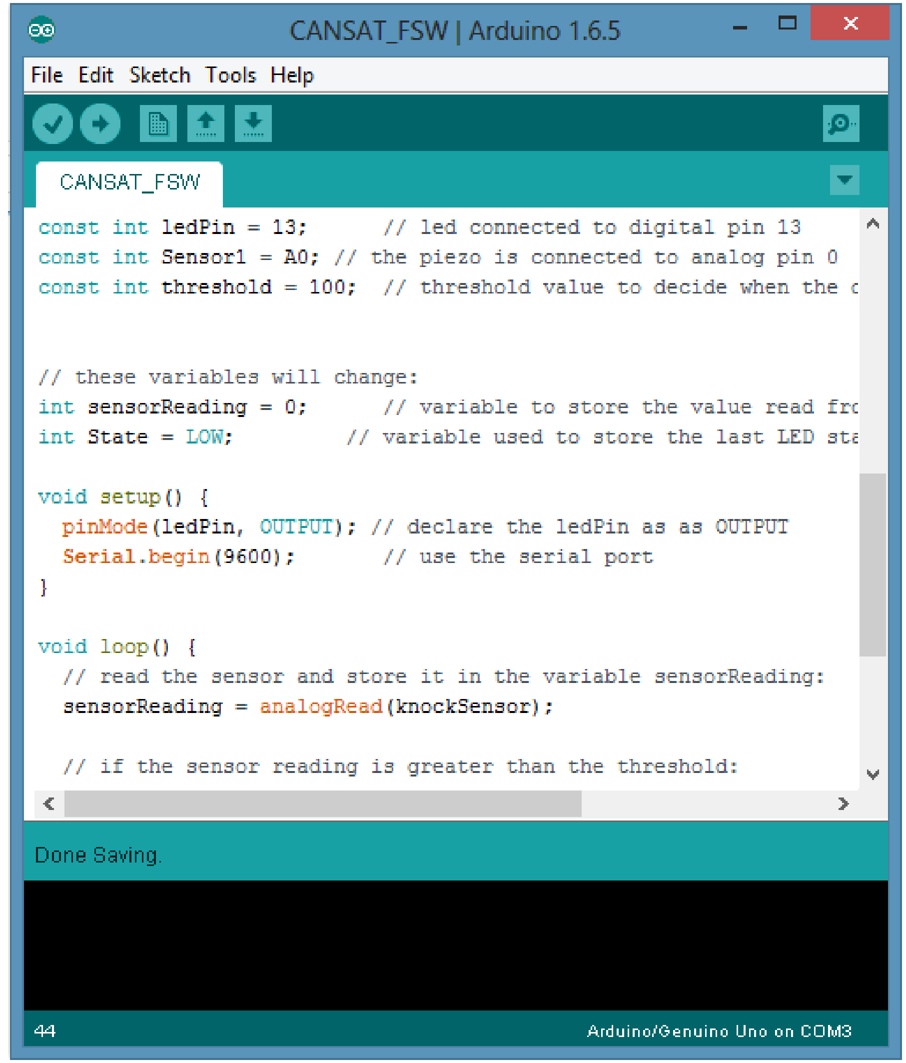
PSEUDO - CODE

```
Start //Power ON the system
Start_RTC();
If(FSW_state()==0) //recovery to
correct state after reset
{
While (1)
{
FSW_State=1; //"Launch Wait"
readSensorData();
WriteSensorData();
//Write Sensor Data, RTC& FSW_state
TransmitSensorData(); // Perform Pre-
flight test
If(Launch_Button==HIGH && FScount1==0)
{
FSW_State=2; //"Ascent"
WriteFSW_StateToMemory();
FScount1=1;
}
If(FSW_State==2)
{
while (1)
{
readSensorData();
WriteSensorData_toSdCard_CSV();
preAlt=Fetch_Previous_Altitude_Reading();
if(preAlt>AltNow&& FScount2==0)
//Previous Altitude > AltitudeNow
{
FSW_State=3; //"Rocket Deployment"
WriteFSW_StateToMemory();
FScount2=1;
}
if(Stabilization Condition && FSW_State==3 &&
FScount3==0)
//Previous Altitude > Altitude Now
{
FSW_State=4; //"Stabilization"
WriteFSW_StateToMemory();
FScount3=1;
}
if(alt_reading<=450 && FSW_State==3 &&cnt==0))
{
FSW_State=4;
WriteFSW_StateToMemory();
cnt=1;
}
```

Pseudo Code Contd….

Container CanSat FSW State Diagram

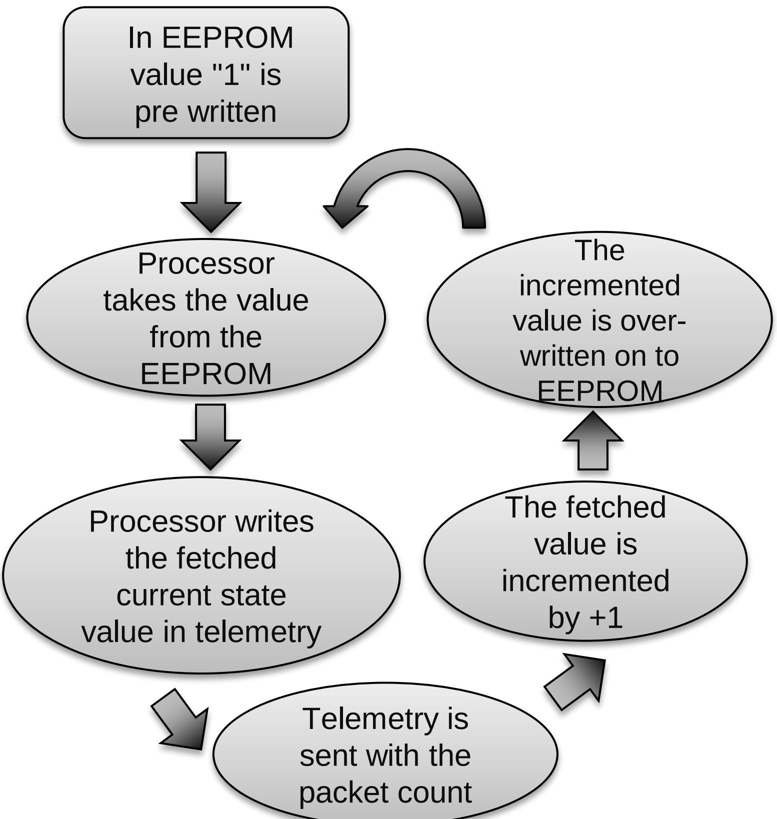
```
If(alt_reading<=400 && (FSW_State==4 ||
FSW_State==3) && FScount4==0){)
{
ActivateSeparationMechanism();
FSW_State=5; //"Glider Separated"
WriteFSW_StateToMemory();
FScount4=1;
while (1)
{
readSensorData();
WriteSensorData();
if(alt_reading<1m && FSW_State==5 &&
FScount5==0)
{
FSW_State=6; //"Glider landed"
WriteFSW_StateToMemory();
FScount5=1;
while(1)
{
readSensorData();
WriteSensorData_toSdCard_CSV();
Activate_BUZZER();
} } } } } } } }}
```



Container Cansat 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 Serial monitors (both for Arduino and Energia) 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	PHASE 2	PHASE 3
Completed	Completed	In Progress

Software Development Plan

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

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

- **Progress Since PDR**

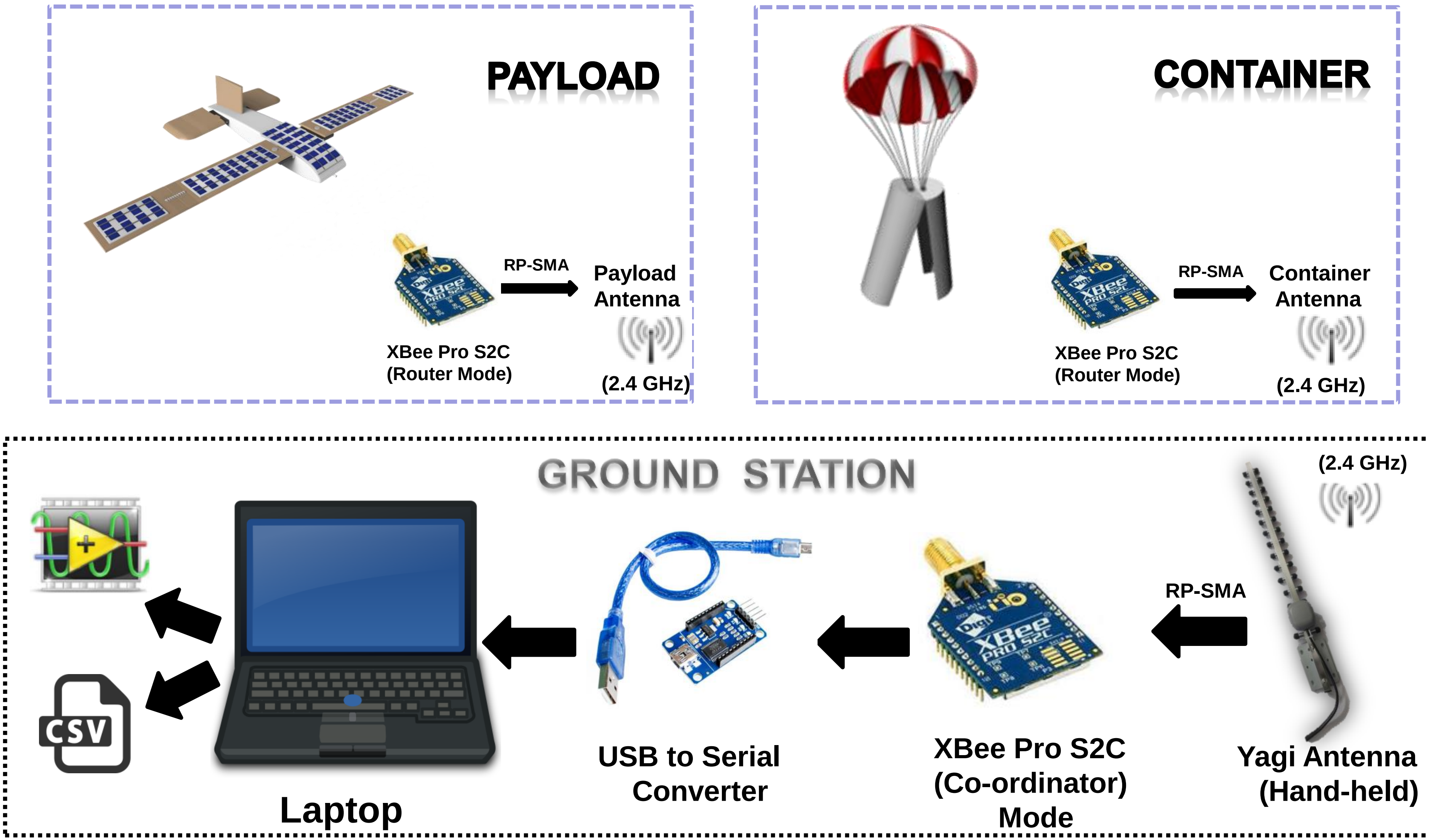
PHASE II is complete

- Algorithm development and integration with hardware procedure is finished.
- The PCB design is completed.
- Information and data exchange between sensors and microcontrollers has been tested and checked since PDR.

Ground Control System (GCS) Design

Vibhor Karnawat

GCS Overview



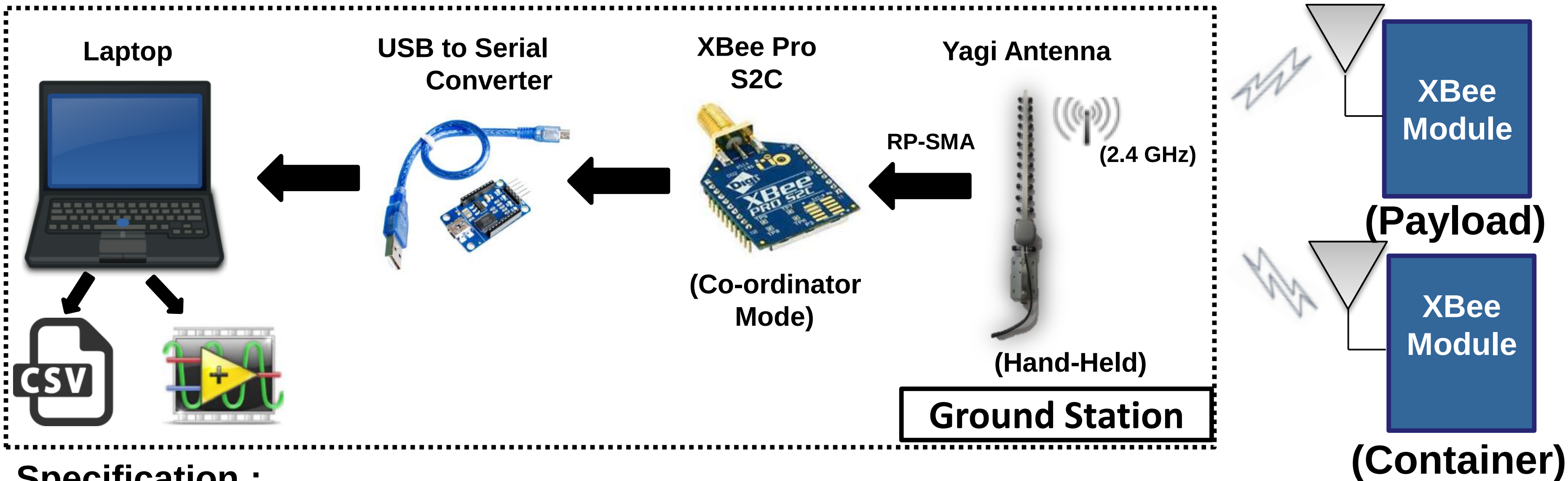
GCS Changes Since PDR

- No major changes to Ground Control Station.
- Screen Shot of telemetry data has been included.
- All details mentioned are as per stated in the PDR and are being tested in real time conditions and processing.

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



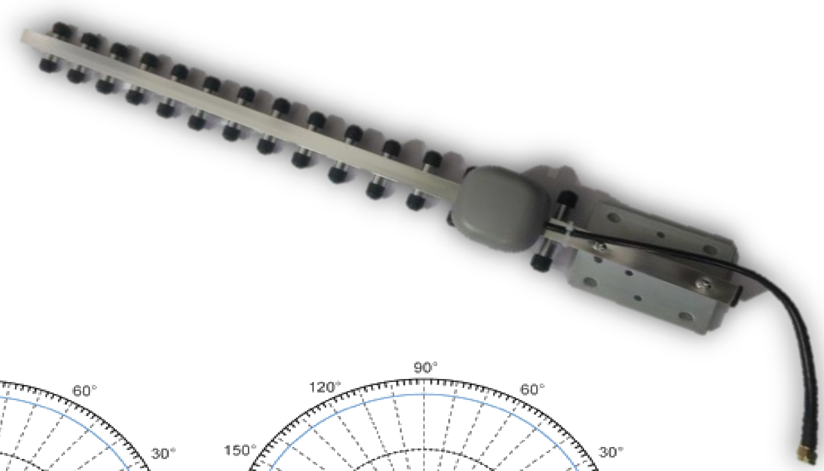
Specification :

- GCS must have **atleast 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.

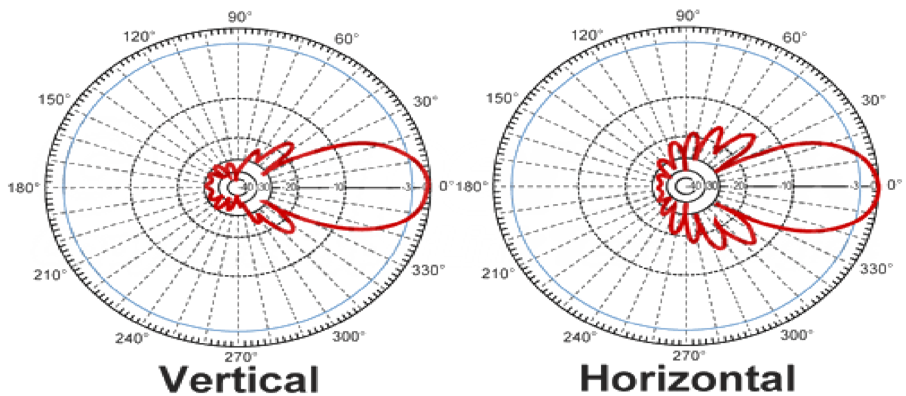
GCS Antenna

ID	ANTENNA TYPE	GAIN	DIRECTIVITY	FREQUENCY	POLARIZATION
GCS-01	YAGI UDA	13 dBi	Unidirectional	2.4 GHz	Vertical or Horizontal Polarity

Final Selection of Antenna: Yagi Uda



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



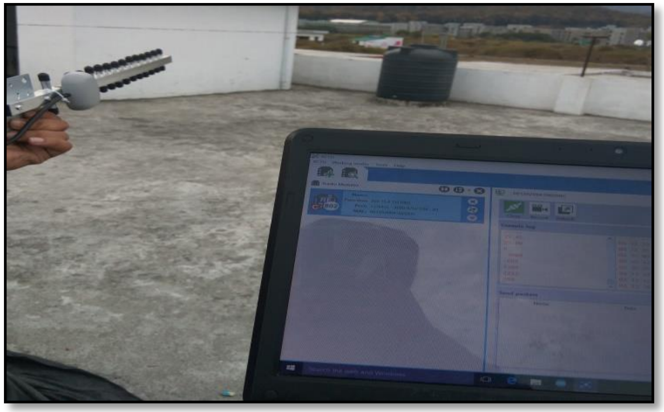
Yagi Radiation Pattern

GCS Antenna

Antenna Construction:
- Antenna is pre-built, so only additional assembly is screwing onto stand.
- Antenna has been purchased and tested.

Antenna Portability:
- Antenna is **hand-held** by a member of GS crew with the help of antenna holder.
- Antenna holder is composed of PVC pipes.
- Antenna is easy to hold and lightweight.

Antenna Coverage:
- Antenna is excepted to work in a defined range of approx. 3 km.
- It has given positive results on testing upto 1.5 km range with line of sight.



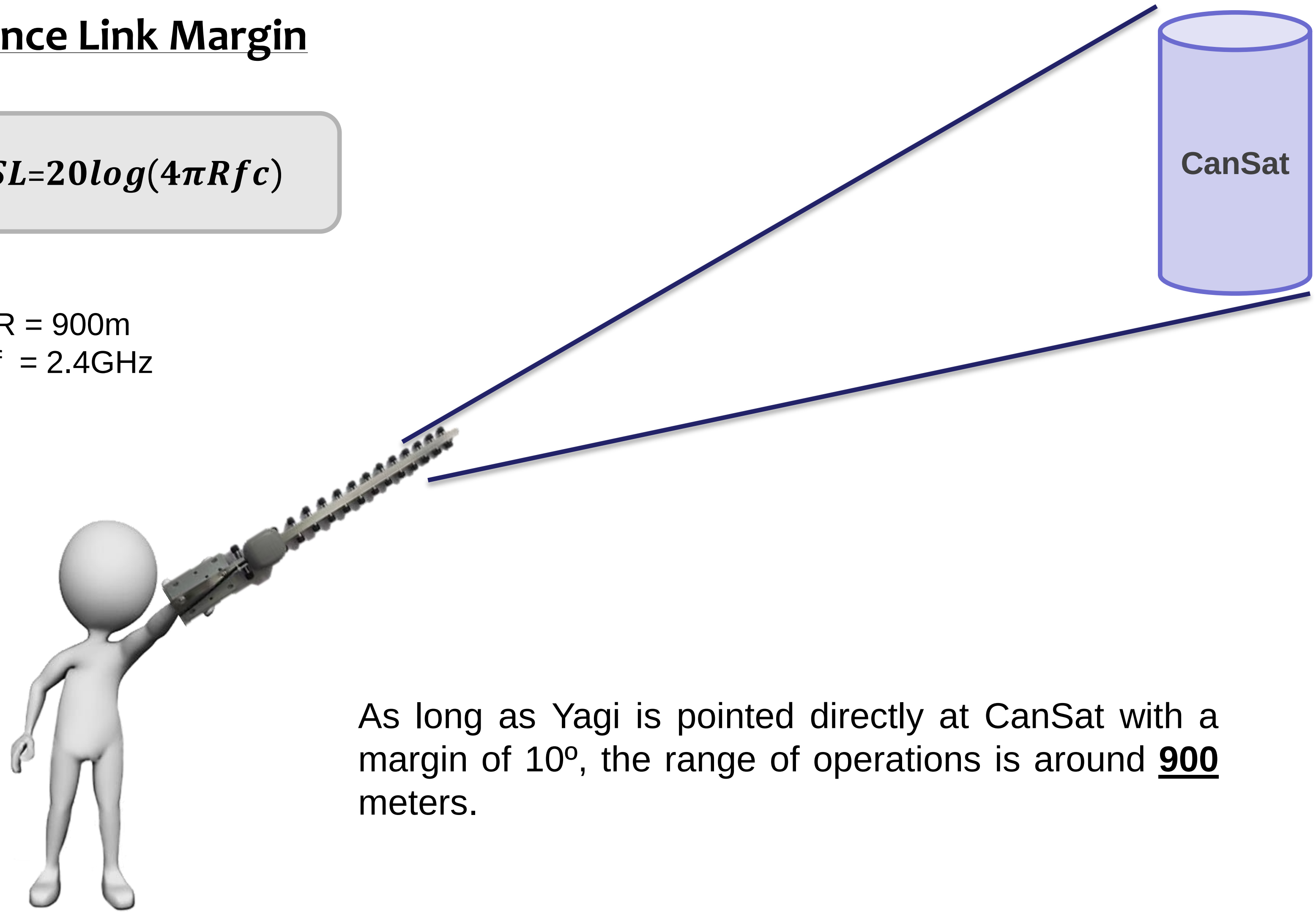
GCS Antenna

Distance Link Margin

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

Where:

R = 900m
f = 2.4GHz

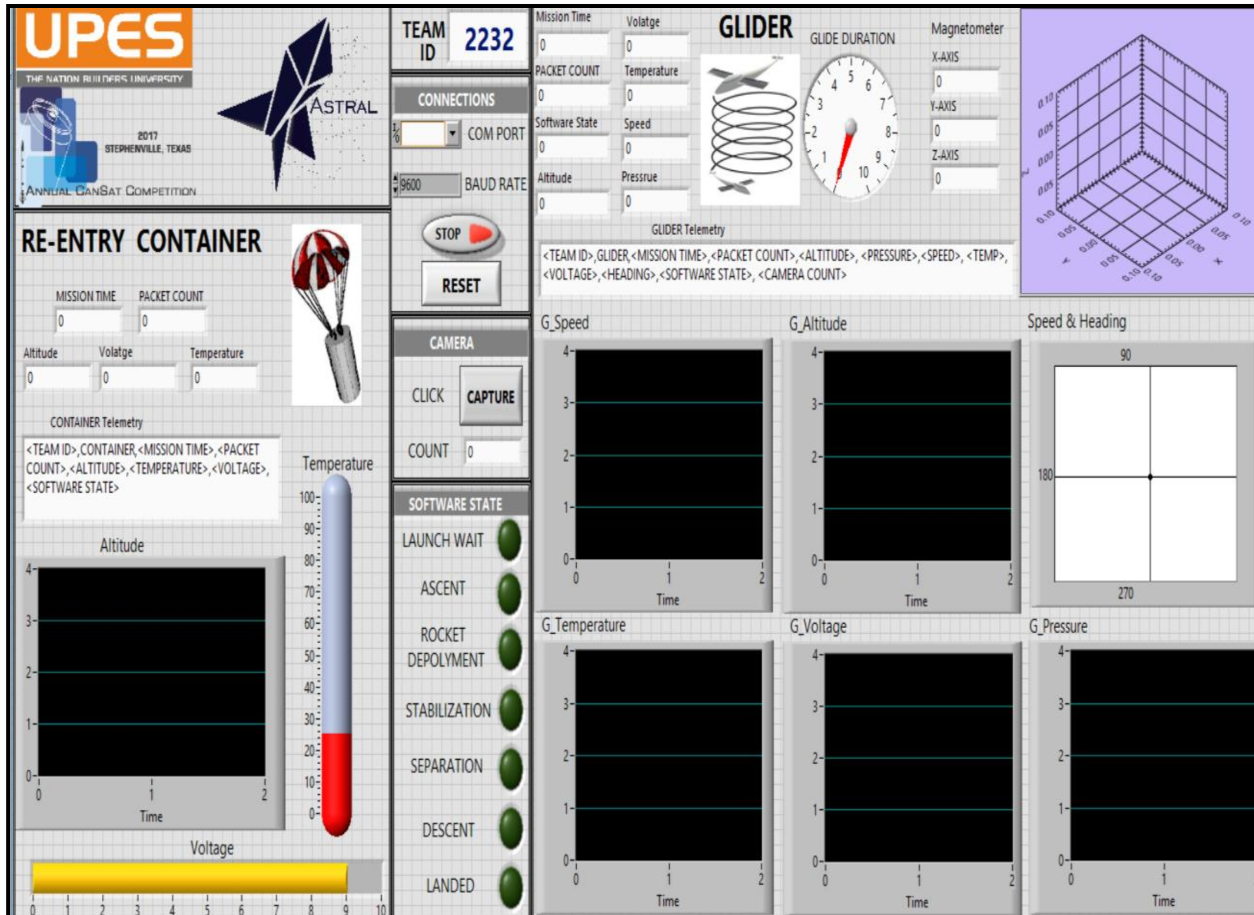


As long as Yagi is pointed directly at CanSat with a margin of 10º, the range of operations is around **900** meters.

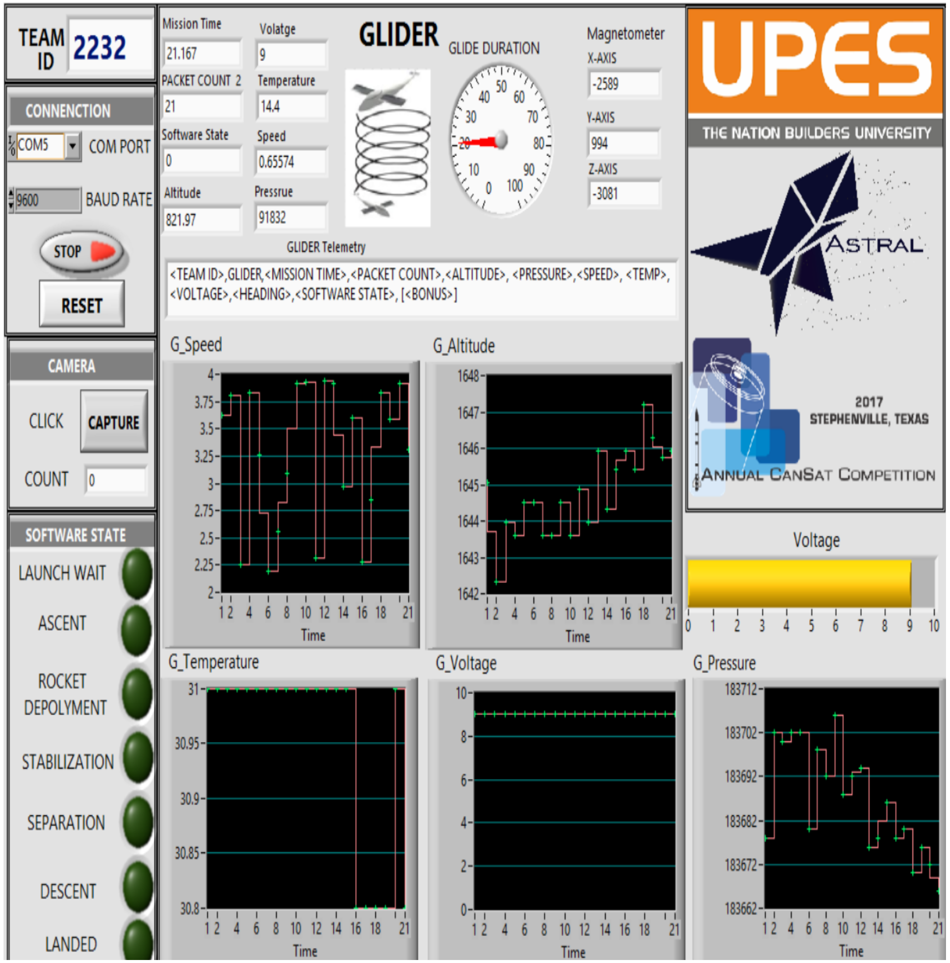
GCS Software

- 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".



Screenshot of Telemetry Data : Including the software as well as .CSV file



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

astral_csv_file

GCS Software

X-CTU- software is being used to obtain values from data ports during sensor testing.

Data Archiving and Retrieval :

- The Data is received individually from each sensor and plotted onto the GUI.
- The sensor readings are then converted to a string data type and concatenated according to the. telemetry format and displayed
- The data is stored in a .csv file by creating writing frames to the file at the end of every frame carriage return symbol is added which enable easy access to the data.

Progress Since PDR :

- The GCS software is ready and underway for use.
- A Few debugging issues are to be catered to, to reduce complexity.
- Algorithm has been designed and tested to separate readings from Container and Glider and storing them in .csv file separately.
- Working on Bonus Objective that is 3-D graphs and simulation.

NOTE: Testing of the Electronics and Receiving Data on GUI is in process and ceaseless advancement is going on.

CanSat Integration and Test

Utsav Nangalia
Sandeep Jangid

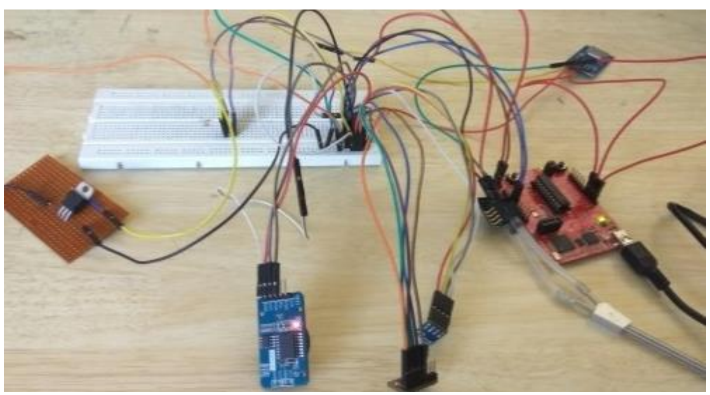
CanSat Integration and Test Overview

SUBSYSTEM LEVEL TESTING

SENSORS
- To verify the smooth functionality of all the sensors on the respective MCUs using breadboard

CDH
- To verify the communication between the interfaced devices and MCU
- To verify the transmission of the fetched data (telemetry) via XBee

EPS
- To obtain desired voltage from 10V solar panels connected in parallel



SUBSYSTEM LEVEL TESTING

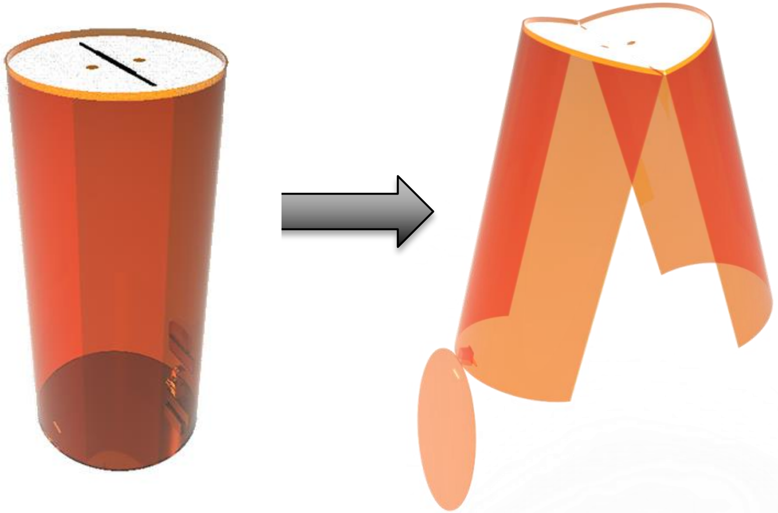
COMMUNIC-ATION

- To test the range of radio modules (XBee Pro S2C) communicating and the extent of data transmission

MECHANIS-MS

- This test is performed to verify the release mechanism of glider from container

Antenna Range Testing



Separation mechanism

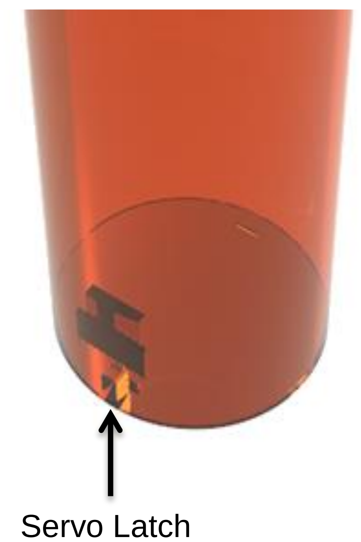
INTEGRATED FUNCTIONAL LEVEL TESTING

1. Release Glider from Container

RELEASE TRIGGER
- To verify the altitude trigger mechanism using BMP180

MECHANISMS
- To verify the servo latch mechanism

GLIDER UNFOLDING WHEN RELEASED
- To test the spring and hinge mechanism to unfold the glider wings



INTEGRATED FUNCTIONAL LEVEL TESTING

2. Glider Functional

DOES IT GLIDE AS REQUIRED

- To verify whether the glider meets the competition requirement of traversing a circular path

GLIDER SLOPE VERIFICATION

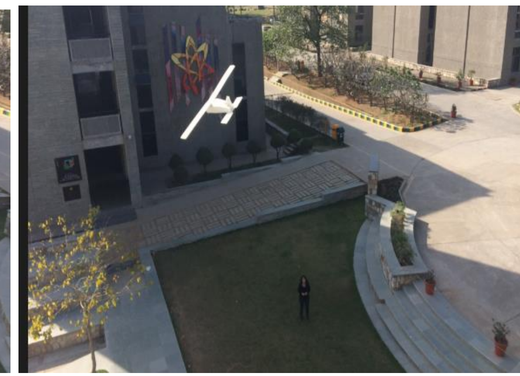
- To verify whether glider takes specified slope to get desired helical path.

INTEGRATED FUNCTIONAL LEVEL TESTING

2. Glider Functional

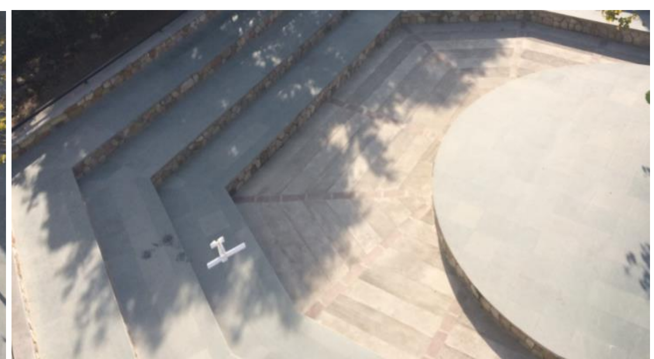
III.

II.



I.

IV.



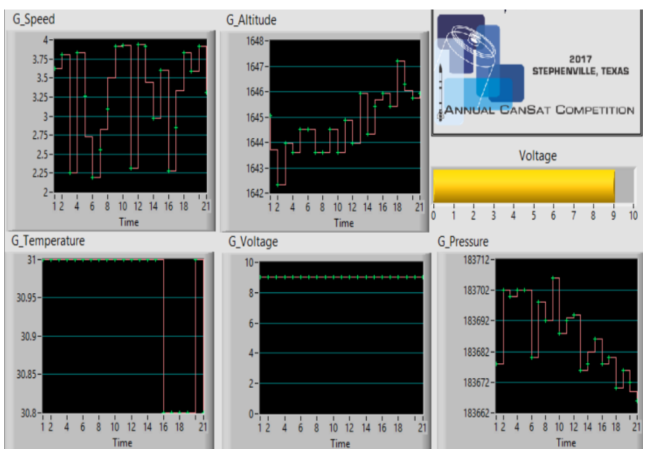
V.

VI.

INTEGRATED FUNCTIONAL LEVEL TESTING

3. Communications

GROUND STATION SOFTWARE	• To verify the real time plotting of telemetry data
TELEMETRY	• To verify the transmission and reception of data collected from all the sensors to the ground station
ANTENNA	• To verify communication using antenna at different ranges within line of sight.



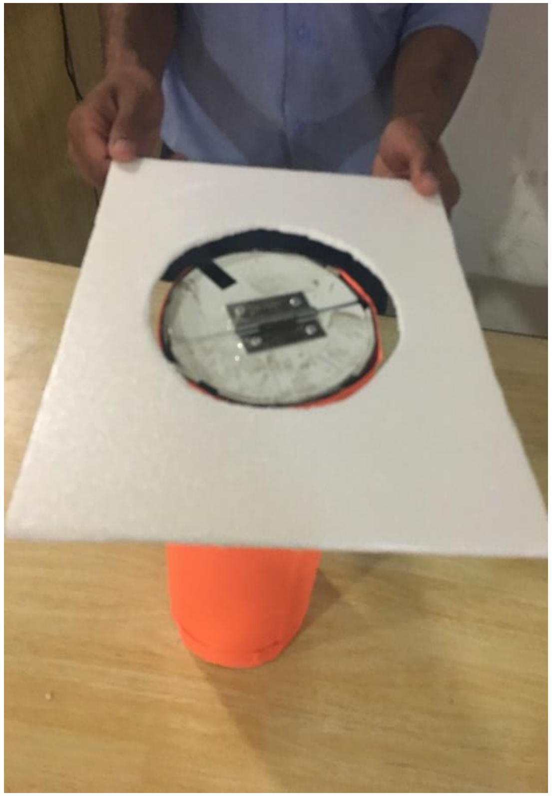
Real time Graph Plotting

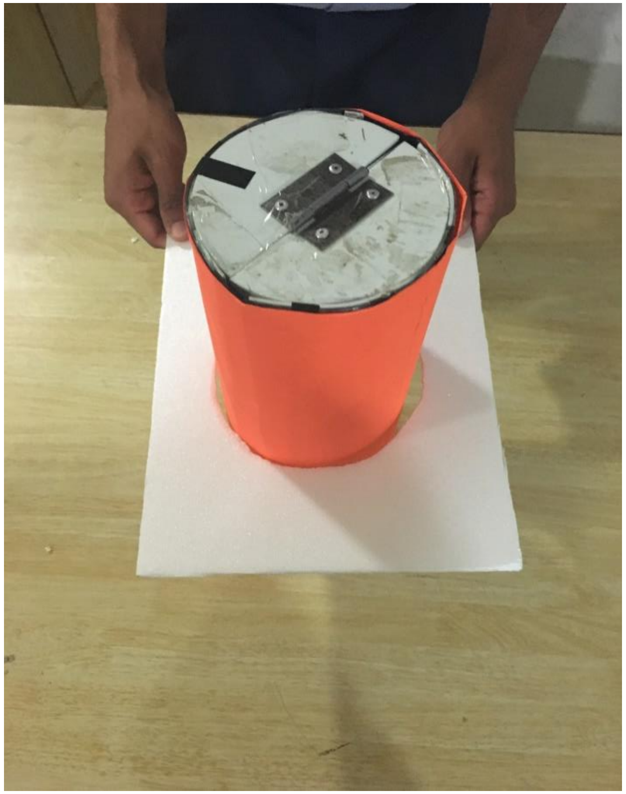
Antenna Range testing

Environmental Testing

VIBRATION	• To verify the mounting integrity of all the components, electronics and battery connections.
THERMAL	• To verify that CanSat and container can operate in a hot environment.
DROP TEST	• To verify that the container - parachute attachment point will survive the deployment.
DIMENSIONS VERFICATION	• To verify CanSat will properly fit in the rocket and slide out at deployment time.

Environmental Testing





Thermal Test at temp. 54º C

Fit check for container was performed to verify the CanSat will properly fits in the rocket payload section

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
1.	**SENSOR SUBSYSTEM LEVEL TESTING** **Task:** To verify the smooth functionality of all the sensors on the respective MCUs using breadboard. **Constraints:** • Packet loss • Constant power supply for optimal operations. **Procedure:** • Pressure, temperature and altitude and Pitot sensors have been tested for elevated temperature conditions. • HMC5883L magnetometer sensor has been tested using MSP430G2553 and I2C ports. • Servo motor has been tested using BMP180 as altitude sensor.	10,14,17,21,27, 36,38,39,40,44	PASS
2.	**SENSOR SUBSYSTEM LEVEL TESTING** **Task:** To ensure that the servo motor attached to the lid will rotate, separating the glider from container. **Constraints:** • Motor would rotate only when the command received by it **Procedure:** • We have manually sent a value of 250m to the microcontroller which compares the value, resulting in the opening the lid. • Servo motor is allowed to rotate through 180°	39	PASS

Test Procedures Descriptions

<table>
<tr><th>Test Procedure</th><th>Test Description</th><th>Requirements</th><th>Pass/Fail Criteria</th></tr>
<tr><td>3.</td><td>COMMUNICATION AND DATA HANDLING TESTING
Task: To verify the transmission of the fetched data (telemetry) via XBee.
Constraints:
• XBee Pro S2C has a range of 2800m but maintaining proper line of sight is difficult for efficient data transmission and reception.
Procedure:
• Transmitter was attached with the helium filled weather balloon. Receiver was at ground and Weather balloon was raised to the altitude of 250m.
• Data was displayed on 16x2 LCD and also on GUI developed in LabVIEW and pictures are shown in FSW testing section.</td><td>22,23,24,25,26, 29,30,31,32,33, 44,46,47,48</td><td>PASS</td></tr>
<tr><td>4.</td><td>ELECTRICAL POWER SYSTEM TESTING
Task:To obtain desired voltage from 10V solar panels connected in parallel as well as for power saving of CanSat.
Constraints:
• Any naked wire left unattended would result in short circuiting.
• All connections should be rendered tight.
Procedure:
• After installation of all circuits, short circuit tests were conducted to check any wrong connections.
• LED is used as power indicator to check power supply in all electronic components
• ADC port were used; results were obtained with an error of 5%..</td><td>14,17,27,38,40 44,49,50</td><td>PASS</td></tr>
</table>

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
5.	**GROUND CONTROL STATION TESTING** **Task:** This test is to verify that combined data is being received successfully on the ground station and to display the data with respective graphs. **Constraints:** • Constant Power supply is required for efficient working of the development board. **Procedure:** • Serial interfacing between microcontroller and laptop by using MAX-232 IC . • Receiving and Transmitting Data through Rx and Tx Ports. • Data to be Provided in real time to the Ground System. Sorting, Logging and Plotting of data simultaneously in the Ground System.	22,23,24,25,26, 29,30,31,32,33, 34,44,46,47,48	PASS
6.	**FLIGHT SOFTWARE TESTING** **Task:** To verify that data acquisition takes place, then transmit data to the ground station and plot the acquired data in real time. **Constraints:** • The complexity of the program of the FSW determines the proper functioning of the MCU. • Too much complexity may result in lagging of data transmission and/or processor hanging. **Procedure:** • The data acquisition was programmed using a function based approach. • Auto-restore mechanism to correct FSW State has been performed using state parameters, HIGH and LOW, with correct readings on X-CTU.	32,36	PASS

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
7.	**RELEASE MECHANISM LEVEL TESTING** **Task:** This is to test the structure survivability or the strength of the glider**.** **Constraints**: • Crosswinds may drift the weather balloon. • Strong winds may affect the descent rate of the glider. **Procedure:** • The glider was dropped from 250m and 200m with the help of weather balloon . • Then it was recovered and checked for any damages to glider or electronics.	3,12,13,15,16	PASS
8.	**RELEASE MECHANISM LEVEL TESTING** **Task:** This is to test the release trigger mechanism of the CanSat. **Constraints:** • Any opening around container may affect BMP180 data. **Procedure:** • CanSat was taken airborne to 250m with the help of weather balloon. • A default value of 250m was set to activate the release trigger mechanism. • As the weather balloon reached 250m, glider was released from the container and helical glide was obtained.	2,3,4,10,11,12,13 15,16,18,19,20 39	PASS

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
9.	**RELEASE MECHANISM LEVEL TESTING** **Task:** To Verify experimentally the unfolding of Glider when released from container. **Constraints:** • Cross wind may drift the balloon disrupting position of Glider within container. **Procedure:** • CanSat was taken airborne to 250m with the help of weather balloon. • At 250m, the release mechanism was activated which allowed the glider to fall freely with which the unfolding of wings was achieved.	2,3,4,10,11,12,13 15,16,18,19,20 39	PASS
10.	**GLIDER FUNCTION LEVEL TESTING** **Task:** To Verify experimentally the Lift and Drag produced by the Glider. **Constraints:** • The Wind Tunnel Should be completely Compact and no External Air Should go inside. • Electric fluctuations can disrupt the flow of air in the wind. **Procedure:** • Glider was mounted on the mount and placed inside the wind tunnel. • The Fan Blade of the wind tunnel were allowed to rotate. • It was calculated whether the Wings produced lift or not.	2,10,11,21,41,43	PASS

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
11.	**GLIDER FUNCTION LEVEL TESTING** **Task:** This test was aimed to verify the Descent Rate Estimates. **Constraints:** • Due to Cross-Winds there are chances of balloon getting drifted. **Procedure**: • CanSat was tied to weather balloon filled with He Gas. • A servo Mechanism is used to rotate the lid and then the glider will free fall. • Height of the balloon is measured using sextant. • Team Members replicated the exact operations as in the real competition.	1,4,10,11,12,13, 41	PASS
12.	**GLIDER FUNCTION LEVEL TESTING** **Task**: This test was performed to check whether the glider is descending in helical path and to calculate glide ratio. **Constraints:** • Cross winds may disrupt the motion of the glider. **Procedure:** • Instead of electronics equivalent weight of dead mass was added. • Glider was allowed to free fall from building about 50m tall. • The drop flight was recorded and analysed. • Glider's horizontal descent distance to vertical distance covered was measured and Glide ratio of 0.775 was obtained.	2,10,11,21,41,43	PASS

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
13.	**COMMUNICATION LEVEL TESTING** **Task**: To verify container altitude by the data of BMP180. **Constraints:** Any opening around container may affect BMP 80 data **Procedure:** GUI will display telemetry readings according to mission requirements.	10,21,48	PASS
14.	**COMMUNICATION LEVEL TESTING** **Task**: To verify Glider sensor reading in required format **Constraints:** Constant power supply for optimal operations **Procedure:** GUI will show the real time status of power available	22,23,24,25,26, 29,30,31,32,33, 34,36,44,46,47, 48	PASS

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
15.	**ENVIRONMENTAL VIBRATION TESTING** **Task**: This test was done to verify the mounting integrity of all the components, electronics and battery connections. **Equipment Used:** Orbit sander, benchtop-Wise, duct tape. **Procedure:** • Secure the CanSat on the sander and Mount the Glider on the vibration fixture • Over a 1 minute period, turn the sander on. Let it power up to full speed, wait 2 seconds and turn off. • Repeat until one minute is complete. • Remove CanSat from test fixture and inspect it for any damage.	14,17,18	PASS
16.	**ENVIRONMENTAL THERMAL LEVEL TESTING** **Task:** This test was done to verify that CanSat and container can operate in a hot environment. **Equipment's Used:** Oven. **Procedure:** • The Glider was placed inside the oven and its electronics was turned on. • The temperature inside the oven was maintained between 35°C and 45°C by monitoring it and switching the heat source off when it reached 50°C.It was followed for next two hours. • Heat source was turned off and visual inspection and other functional tests were performed.	18,19,20	PASS

Test Procedures Descriptions

Test Procedure	Test Description	Requirements	Pass/Fail Criteria
17.	**ENVIRONMENTAL DROP TESTING** **Task:** This test was done to verify that the container - parachute attachment point will survive the deployment from the rocket payload section which can be very violent. **Equipments used:** Non-stretching Kevlar cord, Floor mat, Ceiling. **Procedure:** • Secure the cord to the ceiling and the other end of the cord to the parachute attachment point of the container. • Raise the CanSat up 80 cm in line with the cord and then release the CanSat and let it drop. • Observe the results of effect at attachment point. • Remove the glider from the container and inspect for any damage.	2,3,4,5,12,13,15 16,18,20	PASS
18.	**ENVIRONMENTAL DIMENSION VERIFICATION TESTING** **Task:** This test is to verify the CanSat will properly fits in the rocket payload section and slide out at deployment time. **Equipments used:** Aluminium Sheet, container. **Procedure:** • Cut a hole in the sheet with a diameter of 120.0mm. • Slide the CanSat container through the hole to verify it is within the required envelope.	3,5,7,8,9	PASS

Mission Operations & Analysis

N Adhithiyan

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
- Wing 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 container to the ground station begins**
- **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**
- **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 CanSat (container and payload)**
- **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 the next day**

WHOLE TEAM

Overview of Mission Sequence of Events

- Each Team Member will be assigned a specific task(s) on the competition day based on level of expertise in his/her respective field and will be responsible for the successful completion of the assigned task and whether any task needs reviewing or troubleshooting.
- The Team Members shall be divided under the following categories : Cansat Crew, Recovery Crew, Ground Station Crew, Mission Control Officer.

Team Member	Post
Vipul Mani	CanSat Crew /Recovery
Kavitha Venugopalan	Mission Control Officer
Anmol Agarwal	CanSat Crew/ Recovery
Raghav Garg	Ground Station Crew
Sandeep Jangid	Ground Station Crew
Meenakshi Talwar	Ground Station Crew
Aakash Verma	Cansat Crew /Recovery
Pooja Dahiya	Cansat Crew /Recovery
Devarrishi Dixit	Recovery
Monika Sharma	Recovery

Field Safety Rules Compliance

ANNUAL CANSAT COMPETITION

- **The Development Process:**

  Development of operations manual is almost done and includes the basic checklist for all the components of the CanSat systems and the GS, including troubleshooting guide and preparations and procedures prior to launch and after touchdown.

- Three ring binder copies will be made out of which one will be provided to flight coordinator and two will be provided for flight readiness review.

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.
- Container will be painted fluorescent orange and parachute color is fluorescent blue to increase the visibility.
- The audio beacon will aid in locating the container.

Payload recovery

- Payload will be painted with bright and shiny colors 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

Rehearsal Activities

1. **Ground Station Radio Link Check Procedures**

   Verified the communication procedures by using XBee-PRO S2C, MAX-232 and DATALOGGER . The data was transmitted from XBee and was received on the ground successfully.

2. **Loading Glider into Re-entry Container**

   Test Run verified smooth loading and deployment of glider from re-entry container and desired fall was achieved.

3. **Powering ON/OFF the CanSat**

   Analysis has been made by two procedures:

   - by powering the whole circuit by on/off switch
   - by sending the $ sign to start the telemetry transmission

Mission Rehearsal Activities

4. Launch Configuration Preparation

CanSat was assembled before the balloon test and all the appendages were checked by pulling the parachute.

5. Loading The Cansat In The Launch Vehicle

Tested that CanSat will fit into the payload section of rocket by using a Can of similar dimension.

6. Telemetry Processing, Archiving, And Analysis

Data received on the two sensors was converted to .csv format and plotted in graphs. This was analyzed and displayed accurate altitude and temperature values.

7. Recovery

Observations made by recovering the CanSat after drop tests from 250m and 150m. Florescent blue color is chosen as the color of parachute to increase the visibility.

Requirements Compliance

Arpit Jain

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 No.	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	13,49,68,73,90	
3	The CanSat must be installed in a container to protect it from deployment out of the rocket.	Comply	13,14,16,25,26, 27,49,51,68	
4	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length	Comply	25,26,27,49,51	
5	The container must use a descent control system. It cannot free fall.	Comply	62,63,64	
6	The container shall not have any sharp edges that could cause it to get stuck in the rocket payload section.	Comply	13,52,73	
7	The container must be a florescent color, pink or orange.	Comply	51,53,73,173,175	

Requirements Compliance (2 of 9)

Rqmt No.	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**	**53,61,62,80,84**	
9	The container shall not have any sharp edges that could cause it to get stuck in the rocket Glider section.	**Comply**	13,52,73	
10	No protrusions beyond the envelope defined are allowed while stowed in the rocket.	**Comply**	13,52	
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**	13,28,173,175	
12	The rocket airframe and Glider section shall not be used as part of the CanSat operations.	**Comply**	28,173,175	
13	The CanSat shall deploy from the rocket Glider section.	**Comply**	19,36,48,55,82	

Requirements Compliance (3 of 9)

Rqmt No.	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**	**19,62-64,170-173,**	
15	The descent control system shall not use any flammable or pyrotechnic devices.	**Comply**	14,18,26,47,50, 62,74	
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**	13,17,47,56,64	
17	The Glider must glide in a preset circular pattern of no greater than 1000 meter diameter.	**Comply**	11,14,50	
18	Total glide duration must be close to 2 minutes.	**Partial**	16,50,55	Testing yet to be done
19	Glider must be a fixed wing Glider.	**Comply**	21-24,55-57	

Rqmt No.	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	**72,74**	
21	All descent control devices must survive 15 Gs of shock.	Comply	71,72	
22	The CanSat shall comply with the following communications requirements	Comply		
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	86,95,104,105,108,140	
24	The XBEE radios shall have their NETID/PANID set to the team number.	Comply	95,106,108	
25	The XBEE radio shall not use the broadcast mode.	Comply	95,140,143	

Requirements Compliance (5 of 9)

Rqmt No.	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	142,147,161	
27	The XBEE radio can operate in any mode as long as it does not interfere with other XBEE radios.	Comply	15,68,69,95,106, 108	
28	The telemetry is displayed in engineering units in real time	Comply	15, ,147,148	
29	The CanSat shall comply with the following power requirements:	Comply		
30	The CanSat shall have an external power control such as a power switch and some indication of being turned on or off.	Comply	23,116,117,118	
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	16,115,121	
32	The glider electronics shall be solar powered.	Comply	20,22,77,86,113, 114,117,118	

Requirements Compliance (6 of 9)

Rqmt No.	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		
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	128,131,132,135,	
35	The cost of the CanSat flight hardware shall be under $1000 (USD). Ground support and analysis tools are excluded.	Comply	15,193	
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	15,134,147,148	
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	14,22,26,33,71,77,78	

Requirements Compliance (7 of 9)

Rqmt No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
39	The structure must support 15 Gs acceleration.	Comply	71,72	
40	The structure must survive 30 Gs shock force.	Comply	72,74	
41	Electronic circuit boards must be hard mounted using proper mounts such as standoffs and screws. High performance adhesives are acceptable.	Comply	14,71-74,76,77	
42	Both the container and Glider shall be labeled with team contact information including email address	Comply	72,173	
43	Mechanisms Requirements	--		
44	Mechanisms must be capable of maintaining their configuration or states under all forces such as acceleration and shock forces.	Comply	71,7,73,74	

Requirements Compliance (8 of 9)

Rqmt No.	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
45	Mechanisms must not use pyrotechnics or chemicals.	**Comply**	**14,74**	
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**	14,75	
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**	13,17,47,56,64	
48	The Glider shall incorporate a Pitot tube and measure independent air speed.	**Comply**	11,38,60,77	
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**	11,15,110	
50	During descent, the Glider shall transmit the following telemetry data once every one second.	**Comply**	11,15,59,95,125, 127,142	

Rqmt No.	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	14,30,31,33,36,3, 38,54,58,59,189	
52	The external power connection shall be a sturdy connector that is easily accessible when the Glider is stored in the container.	Comply	14,71,72,76,77	
53	Flight software maintained mission time and real time plots of data.	Comply	100,127,147,148	
54	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission.	Comply	15,107,125,127,1 47,148	

Management

Anisha Absolom
Vipul Mani

Status of Procurements

Component	Quantity	Order Date (Mm/Dd/Yy)	Expected Arrival	Status
Flight Hardware				
Solar cells	8	03/01/2017	-	Received
PCB	2	01/10/2017	-	Received
Transistor	2	10/01/2016	-	Received
Programmer	1	10/15/2016	-	Received
Data logger	1	10/30/2016	-	Received
Regulator	5	11/05/2016	-	Received
Sensors	3	11/05/2016	-	Received
Camera	2	02/25/2017	03/30/2017	Ordered
GCS Hardware				
Antenna	2	01/05/2017	-	Received
XBee	3	02/17/2017	-	Received
OTHERS			-	Received

CanSat Budget – Hardware

ELECTRONICS HARDWARE					
Component		Model	Quantity	Cost	Determination
Micro Controller		Arduino Nano	1	$7.58	Actual
		MSP430G2553	1	$9.99	Actual
Communication Module		Xbee Pro S2C	3	$154.95	Actual
Sensors	Temperature Pressure Altitude	BMP 180	2	$12.50	Actual
	Magnetometer	HMC5883L	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

CanSat Budget – Hardware

ELECTRONICS HARDWARE				
Component	**Model**	**Quantity**	**Cost**	**Determination**
Super Capacitor	Panasonic Kam Cap (Coin Type)	1	$3.42	Actual
Antenna	Rubber-duck L-COM	2	$88.20	Estimated
Circuit Base Boards	PCB	1	$10.00	Actual
Miscellaneous			$20.00	
SUBTOTAL			**$ 394.22**	

CanSat Budget – Hardware

MECHANICAL HARDWARE				
Category	**Model**	**Quantity**	**Cost**	**Determination**
Glider Material	HIPS and Balsa Wood	-	$35.00	Estimated
Re-Entry Container Material	Poly Carbonate	4 meter square	$100.00	Estimated
Parachute	Rip-Stop Nylon	1	$31.95	Actual
Fabrication of Glider	-	-	$80.00	Estimated
Servo Motor	SG90 Tower Pro	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	$7.58	Actual
Communication Module	Xbee Pro S2C	1	$70.00	Actual
Others			$20.00	
SUBTOTAL			**$ 178.46**	

CanSat Budget – Other Costs

OVERALL COST	
Category	**Costs**
Mechanical Hardware	$263.95
Electronics Hardware	$394.22
Ground Costs	$178.46
TOTAL	**$836.63**

Note : The Total Cost of the CanSat adds to $ 836.63 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:

- **The Solar Cells have been sponsored by Central Electronics Limited, New Delhi.**
- Our management team is still in constant seek of sponsors that would aid in the funding of the project.

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 that were made earlier in **October '16** were examined 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** and within that span 4 prototypes underwent full flight test.
- The major hardware components were ordered and received before **20th Jan'17**.
- The PDR was compiled by the **25th January 2017,** and was mailed on the **31st January 2017**.
- In **February'17,** small scale fabrication of the Glider began along with designing of the electronic circuits. By the mid of February, we started testing our model by drop tests and on the basis of the test results we decided the further modus operandi.

Program Schedule

- In **March'17,** our **Mid semester exams** began. Mid of March witnessed us working on **CDR** and intending to compile it until 25^{th} March 2017 for final reviewing.

- CDR was submitted on **29^{th} March'17**. Team members who do not hold U.S. VISA, have applied for their VISA application.

- In **March'17,** we started with the full scale fabrication of the Glider; UAV drop tests and weather balloon testing from a height of ~250m was done to ensure proper working.

- In **April'17,** The complete testing is to be done of the CanSat including the remaining environmental tests. Any failures, would lead us to make more improvements in our model. The required changes will be incorporated immediately to the model and will be retested.

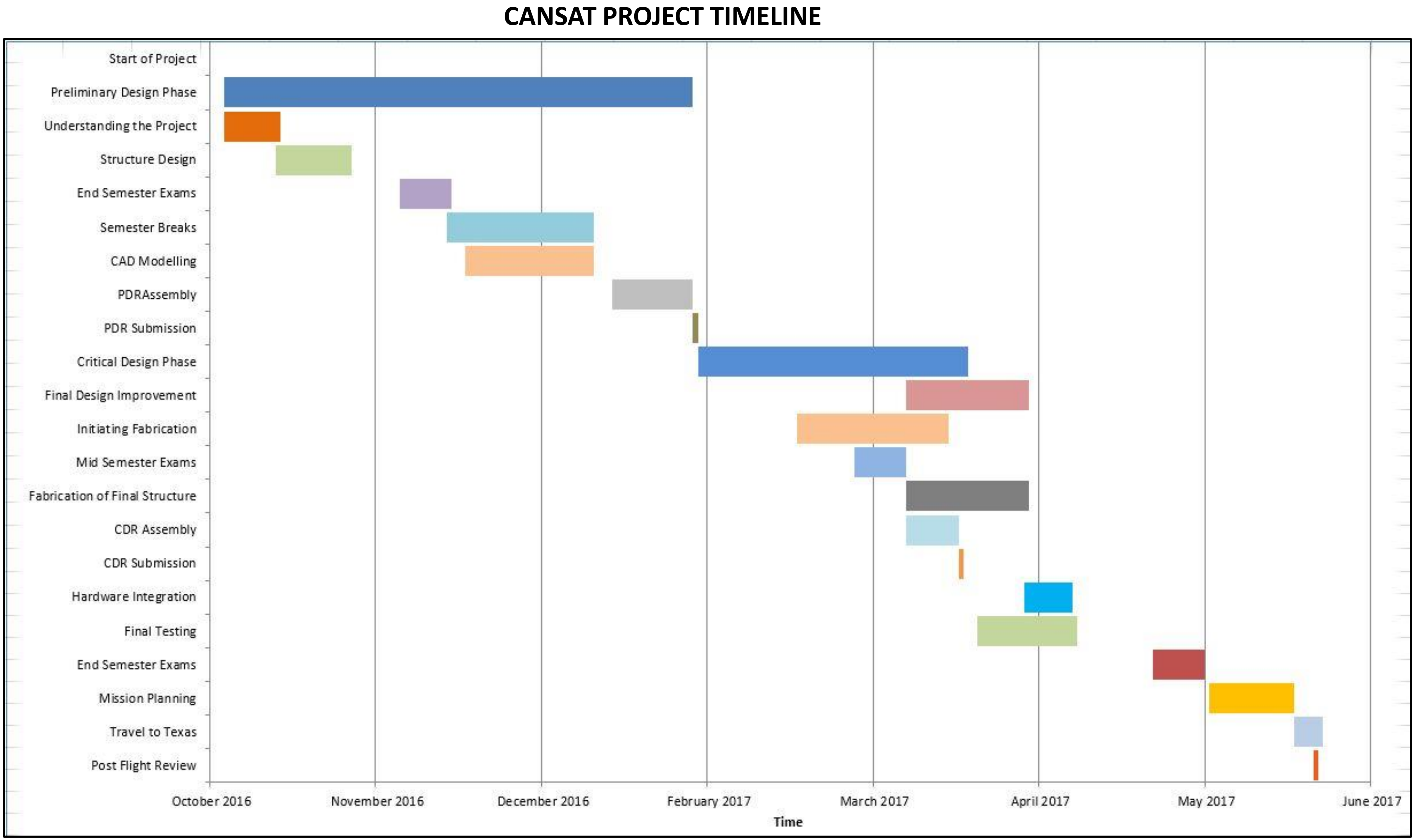
- By **May'17,** our **End semester exams** will start. Our final model for the CanSat Competition 2017 will be fabricated with precision by the end of May 2017.

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

Program Schedule

Task	Start Date	Duration	End Date
Start of Project	25-Oct-16	0	-
Understanding the Project	25-Oct-16	12	5-Nov-16
Preliminary Design Phase	25-Oct-16	99	31-Jan-17
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
PDR Assembly	15-Jan-17	14	28-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	5-May-17	10	15-May-17
Mission Planning	21-May-17	18	7-Jun-17
Travel to Texas	8-Jun-17	6	13-Jun-17
Post Flight Review	11-Jun-17	1	11-Jun-17

Program Schedule



Shipping and Transportation

<u>Plans For Shipping / Transporting The CanSat Hardware</u>:

- We are planning to transport the CanSat hardware by air with us in June.

- We have decided to first disassemble everything into smaller subsystems and then pack each subsystem carefully, so that possibility of damage is minimized. At the launch site, all the subsystems will be reassembled.

- A request will be made to the airlines travelling to the States before booking our tickets about making special arrangements for our team since we will be carrying a lot of delicate components and quite a lot of electronics which might not be allowed under normal circumstances. We will prepare/show necessary documents if required.

- We will hire a mini-van for transporting our hardware from the airport to the hotel and from the hotel to the launch site. More than one van might be required.

- **<u>Other Shipping Options</u>: Water Transportation** - It's a relatively better and inexpensive mode of transportation also less complicated but generally takes a lot of time. We will use this as our back-up option and consider shipping by water only when air shipping is not possible.

Shipping and Transportation

Carry-on restrictions:

- ✓ There is a weight limit to the check in baggage in airlines. Materials exceeding the weight limit might not be allowed or extra fee may be required (depending on the airlines).
- ✓ Materials having large volumes might also not be allowed, so we are planning to disassemble the CanSat hardware into smaller subsystems for shipping.
- ✓ Transportation of sophisticated electronic components may not be allowed. We might need to obtain special permission from airline companies for carrying electronic components and other large parts.

Shipping of tools and equipments:

- ✓ Parts like antenna mast will be disassembled into smaller parts. All tools and equipment which might come in handy during reassembly will be carried. Special security permission might be needed for carrying some tools and equipment.
- ✓ All inquires will be made and all decisions regarding the mode of shipping will be finalized beforehand.

Conclusions

A Comprehensive Study of the Competition Requirements for CanSat 2017 has been done and all potential solutions have been identified and mentioned. The Critical Design Phase is complete and now we are ready to begin with the final fabrication. All major decision points have been accomplished and a detailed list of the finished and unfinished tasks is given below:

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.
- ✓ Antenna testing's have given positive results.

MAJOR UNFINISHED WORK

- ✓ Camera is yet to be procured and tested.
- ✓ Alternative separation mechanism has to be finalized and tested.

TESTING TO BE DONE

- ✓ Environmental Tests are yet to be conducted.

FLIGHT SOFTWARE STATUS

- ✓ The ground station GUI has been developed and various flight softwares states have been tested and verified. 3D simulation of telemetry (external objective) is under process.

Conclusions

Questions?