CanSat 2016
Critical Design Review (CDR)
Outline
Version 1.0

#1274

TEAM ASTRAL

Presentation Outline

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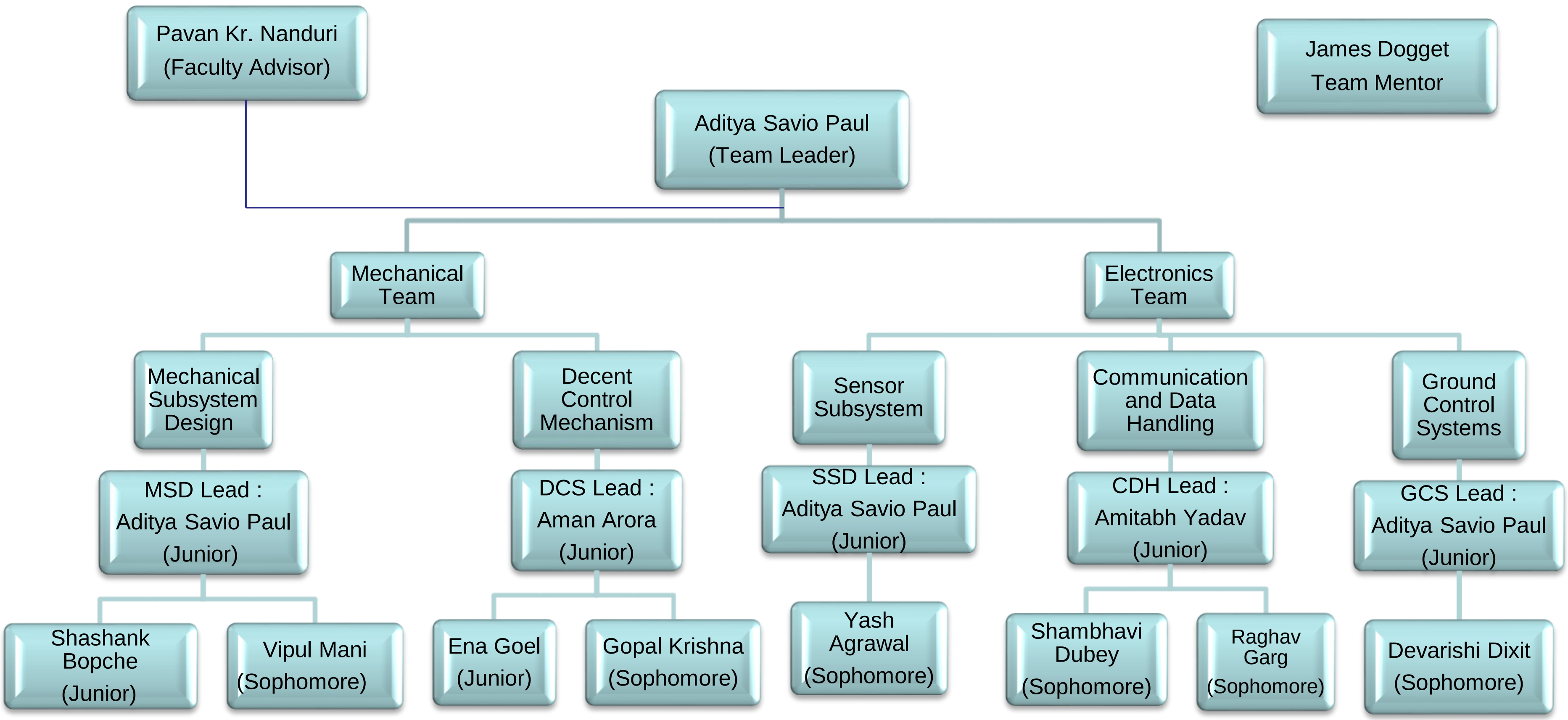
Team Organization



Acronyms

A	Analysis
ADC	Analog to Digital Converter
CDR	Critical Design Review
CMOS	Complementary Metal Oxide Semiconductor
CONOP	Concept of Operations
D	Demonstration
DCR	Decent control requirement
DCS	Descent Control System
FAT	File Allocation Table
FIFO	FIRST IN FIRST OUT
GCS	Ground Control Station
GUI	Graphical user interface
GS	Ground Station GPS –Global Positioning System
HW	Hardware
HWR	Hardware Review
I	Inspection
I/O	Input / Output
LCO	Launch Control Officer
LED	Light Emitting Diode
M	Minute

Acronyms

MB	Mega byte
MCU	Microcontroller Unit
MECH	Mechanism
MSR	Mechanical system requirement
m/s	Meters per Second
CDR	Preliminary Design Review
SOE	Sequence of Events
SPI	Serial Peripheral Interface
SSR	Sensor Subsystem Requirement
T	Test
TBD	To Be Determined
TBR	To Be Resolved
USART	Universal Asynchronous Receiver/ Transmitter
VM	Verification method
mA	Milli Ampere
µA	Micro ampere
dB	Decibel

System Overview

Aditya Savio Paul

- **Mission Objectives :**

  - To simulate a sensor Glider traveling through a planetary atmosphere sampling the atmospheric conditions during flight.

  - Deployment of Re-entry Container and Glider from Rocket and chronological separation to ensure proper Stabilization, Descent and landing.
  - Use of Glider Design to descend the Glider on covering a circular diameter of not more than 1000mts.
  - To attach a camera to the Glider and snap pictures on demand from the ground station.
  - To collect and Transmit the Telemetry Parameters at 1Hz Frequency transmission Rate.

- **Selectable Objective**

  - To transmit image to ground station after each picture is taken. Telemetry shall still be sent during image transmission at 1Hz rate using same x-bee radio.

    Rationale : Selected to avoid any haphazard arising due to extra mechanism for motion of camera that might disrupt the helical drop of the glider.

- **External Objective**

  - Determination of Glider Position by Flight Software States

Summary of Changes Since PDR

Mechanical System Changes:

Re-Entry Container:

- The **material of the DCS of re-entry container** has been changed from tarpaulin to nylon cloth.

Glider:

- **Angle of inclination of flaps** has been changed to 30 degrees in both wings.
- **The location of wings** have been changed to one-third the total length of glider.
- **Rudder** will be tilted at an angle of 45 degrees towards wing with low angle of attack.

Summary of Changes Since PDR

- **Electronic System Changes**

  -BMP-180 is used as the temperature sensor in place of LM35.

  - Using ‘,’ only instead of ‘<’ or ‘>’ in the Telemetry Format

System Requirement Summary (1 of 4)

ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-01	Total mass of the Cansat should not exceed 600gms.	Competition Requirement	HIGH	MSR-01		✓	✓	
SR-02	The container should fit within a container of 125mm x 310 mm	Competition Requirement	HIGH	MSR-02 DCS-01		✓		
SR-03	The container must descend with the aid of a parachute	Competition Requirement	HIGH	DCS -03 DCS-04 DCS-06	✓	✓		
SR-04	The container shall not have any sharp edges or protrusions	To Facilitate Deployment	HIGH	MSR-04	✓			
SR-05	Rocket airframe shall not be used to restrain any deployable parts or as part of CanSat operations.	Competition Requirement	HIGH	MSR-09	✓	✓		
SR-06	The Glider must be released from the container at 400 meters +/- 10 m	Competition Requirement	HIGH	MSR-07 DCS-05	✓	✓		

System Requirement Summary (2 of 4)

ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-07	The Glider must be fixed to glide in a preset circular pattern of no greater than 1000 meter diameter.	Competition Requirement	HIGH	DCS-09	✓	✓		
SR-08	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	For easy deployment from re-entry container	MEDIUM	MSR-05	✓	✓	✓	
SR-09	All structures shall be built to survive 30Gs of shock.	Competition requirement	HIGH	MSR-10	✓			
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	MSR-08	✓		✓	
SR-11	Mechanisms shall not use pyrotechnics or chemicals.	To avoid the risk of fire	HIGH	MSR-06 DCS-10				
SR-12	During descent, the Glider shall collect air pressure, outside air temperature and battery voltage once per second.	Competition Requirement	HIGH	FSW-02 EPS-07 CDH-01 to 06 SSD–01 to 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 at 1Hz per second	Competition Requirement	HIGH	FSW-03	✓	✓		
SR-14	The Glider shall have an imaging camera installed and pointing toward the ground.	Competition Requirement	HIGH	SSD-06	✓	✓		
SR-15	The Ground Station shall include a laptop, an antenna and a X-bee Radio for receiving	Setup for Receiving Telemetry	HIGH	GCS-01	✓		✓	
SR-16	All telemetry shall be displayed in real time and engineering units during descent.	Competition Requirement	HIGH	FSW-05	✓	✓		
SR-17	Cost of the CanSat shall be under $1000	Cost Effectiveness	HIGH		✓			
SR-18	Flight Software shall maintain the count of packets received.	For better monitoring of FSW states	HIGH	FSW-06	✓	✓	✓	

System Requirement Summary (4 of 4)

ID	Requirement	Rationale	Priority	Children	VM			
					A	I	T	D
SR-19	The Glider shall be a fixed wing Glider	Competition Requirement	HIGH	MSR-04	✓	✓		
SR-20	The Glide Duration should be 2 Minutes	Competition Requirement	HIGH	DCS-12	✓			
SR-21	The Glider must include a battery that is well secured to power the Glider.	Secured well so as to avoid toppling	HIGH	DCS-11	✓			
SR-22	The Glider shall receive a command to capture an image of the ground and store the image on board for later retrieval.	Competition Requirement	HIGH	FSW-07 GCS-06	✓	✓		
SR-23	The Glider vehicle shall incorporate a Pitot tube and measure the speed independent of GPS. The speed shall be compared with GPS speed.	Competition Requirement	HIGH	SSD-4	✓	✓		
SR-24	The Container should be of fluorescent color	To aid in locating the re-entry container	HIGH	MSR-12	✓			
SR-25	A buzzer must be included that turns on after landing	To Aid in Locating the Glider	MEDIUM	MSR-13	✓			✓

System Concept of Operations

Pre Launch

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

Launch

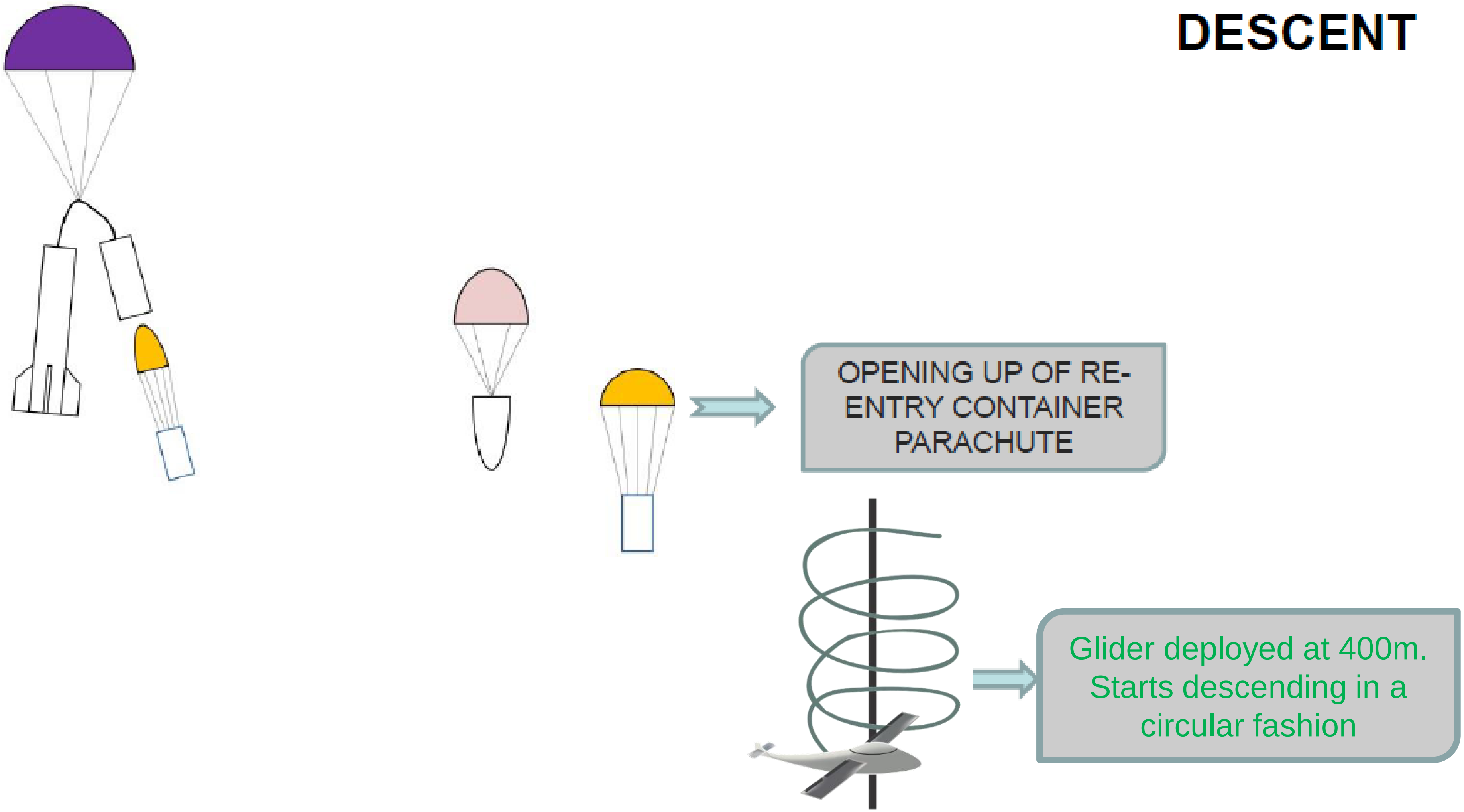
1. Placing Cansat into the Rocket
2. Rocket Launch
3. Near Apogee Deployment
4. Deployment of Glider from Container at 400m
5. Opening of Parachute for Re-Entry
6. Descent of Glider in helical fashion within 1000m Diameter
7. Receiving Sensory Data at Ground Station
8. Locating the Glider and the Re-Entry

Post Launch

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

System Concept of Operations

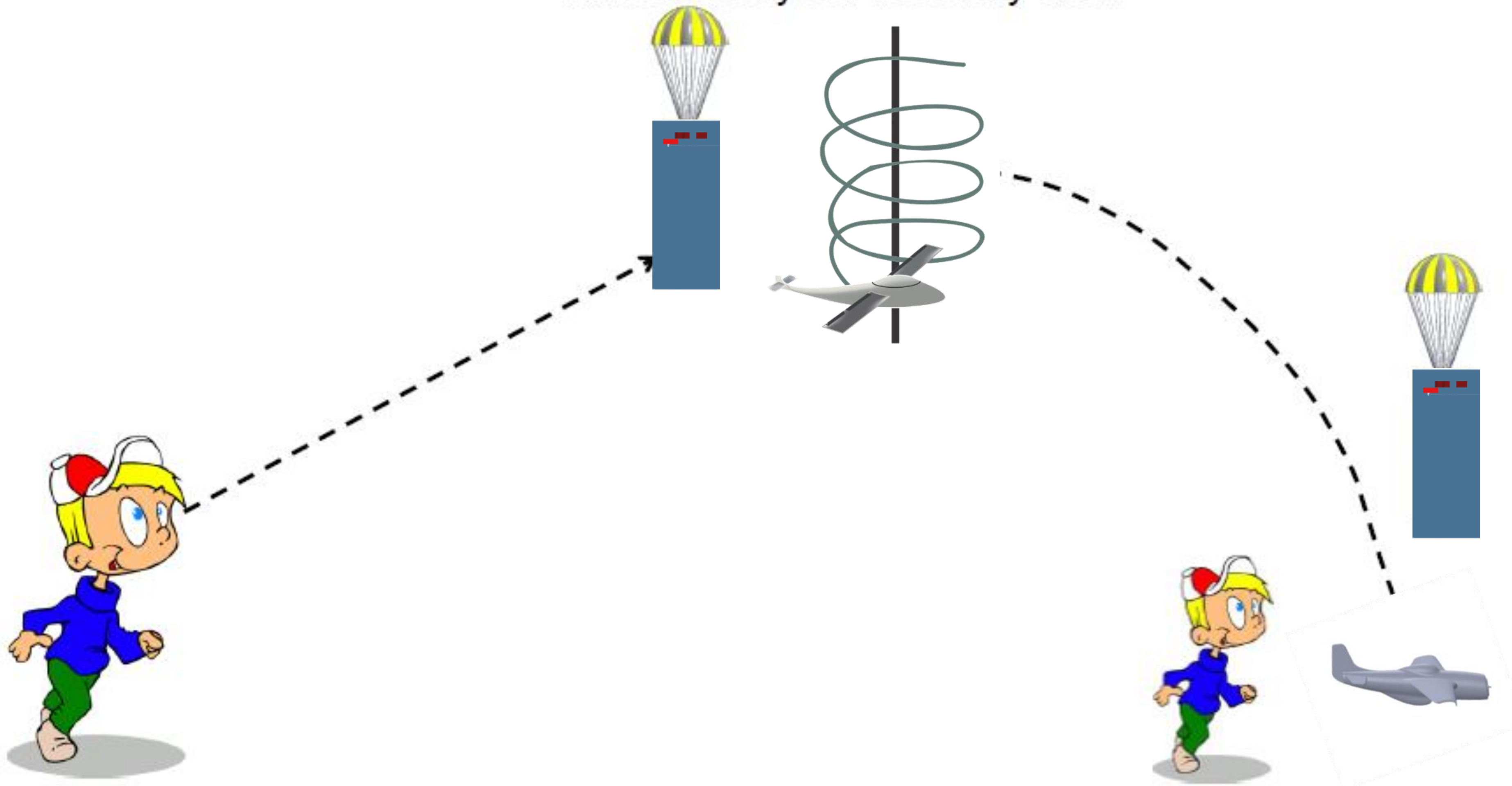
DESCENT



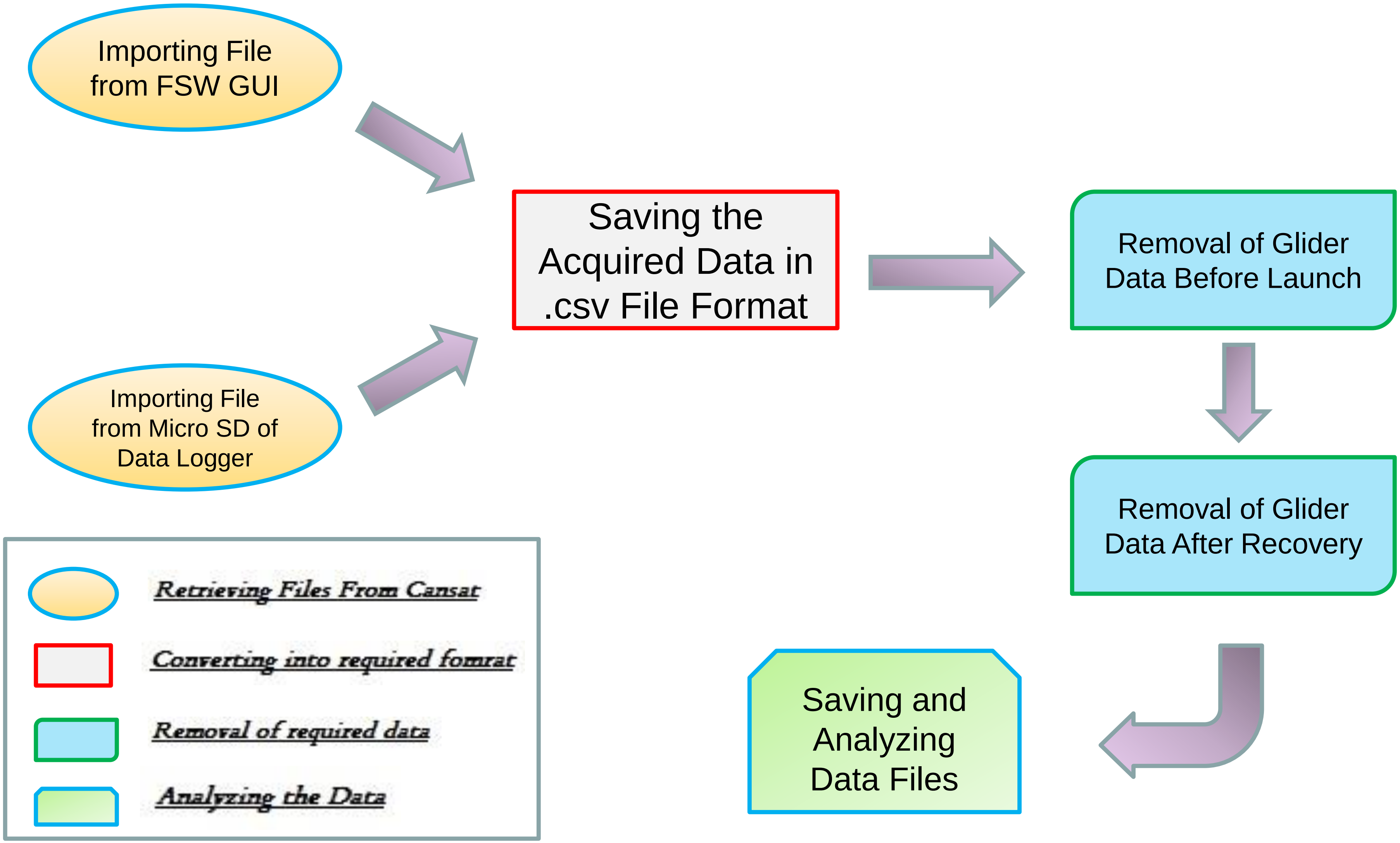
System Concept of Operations

Post-launch recovery

Post launch recovery will be done using binoculars by our recovery crew



System Concept of Operations

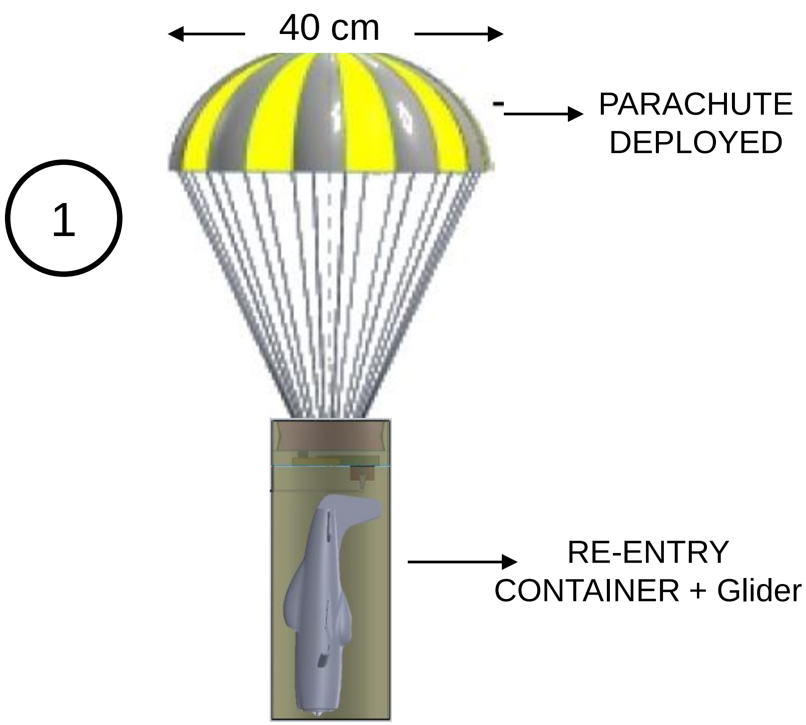


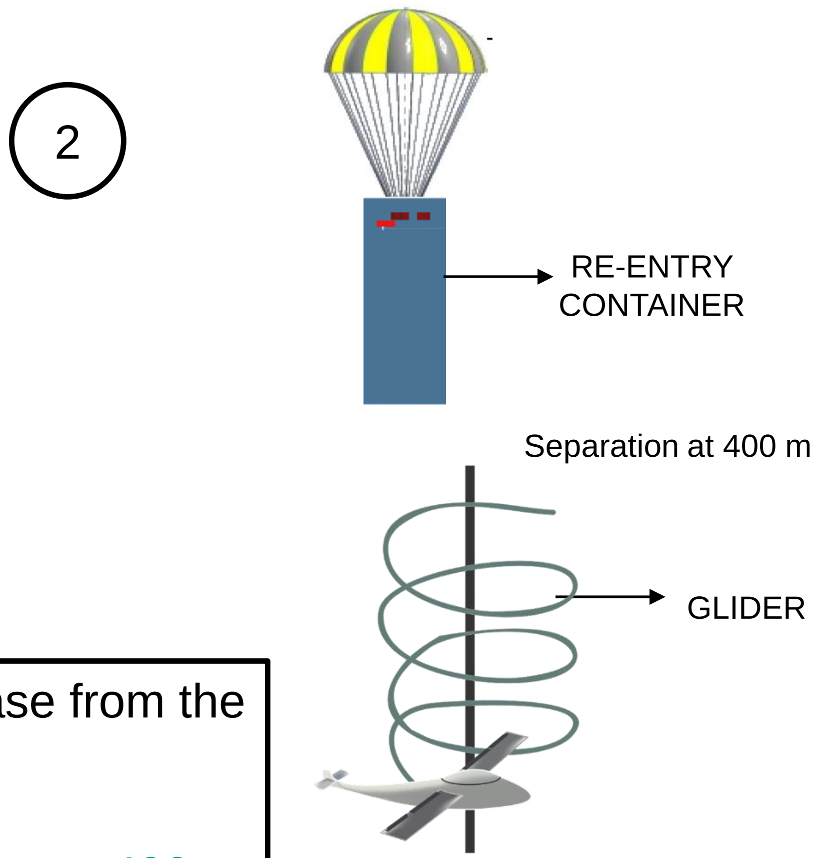
Team Member Roles and Responsibilities

- **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
Aditya Savio Paul	Ground Station Crew
Raghav Garg	Ground Station Crew
Vipul Mani	Cansat Crew/ Recovery
Devarrishi Dixit	Cansat Crew/ Recovery
Shambhavi Dubey	Cansat Crew
Aman Arora	Mission Control Officer

Physical Layout

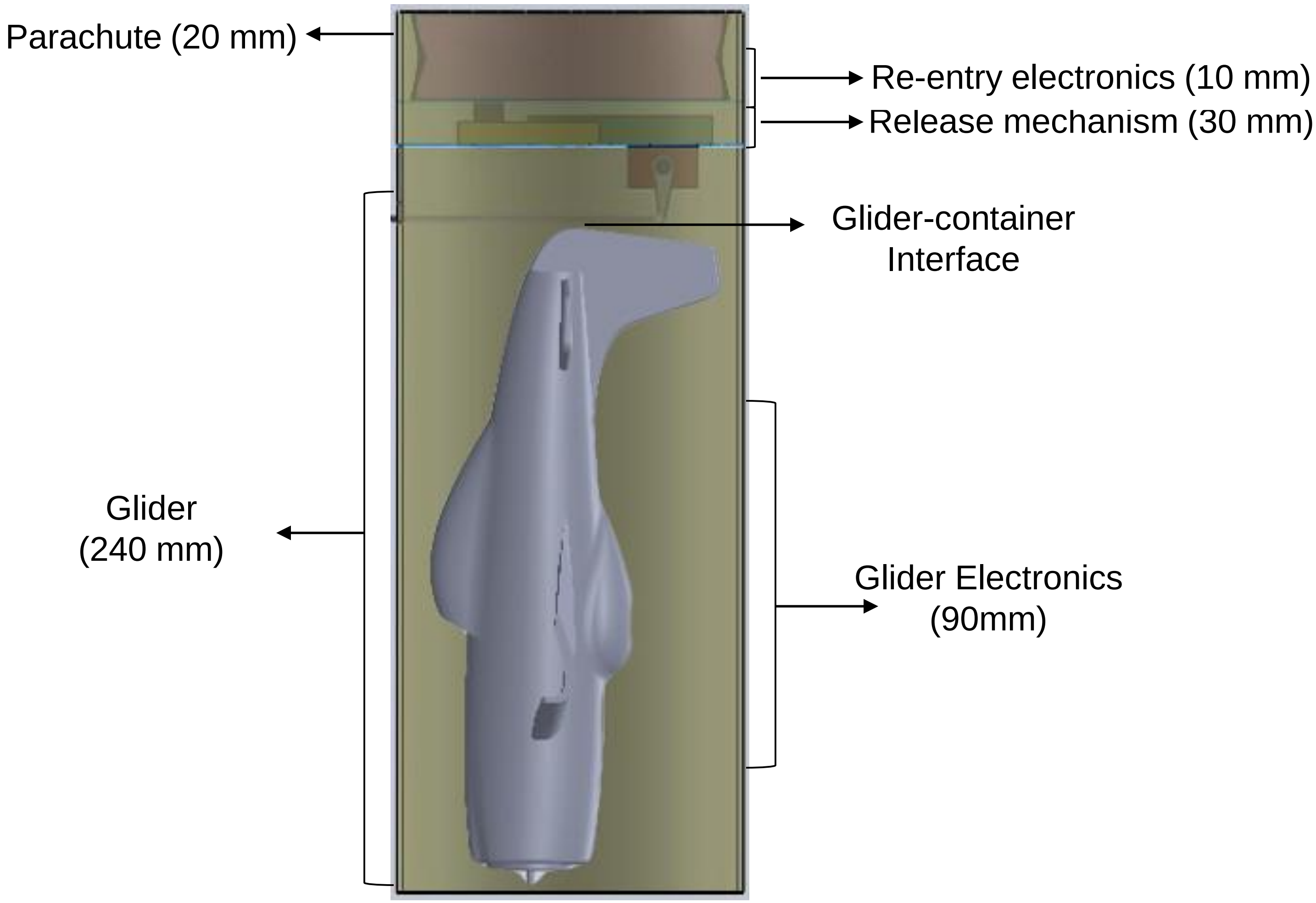




1. Re-entry container + Glider just after release from the rocket at 670 m.

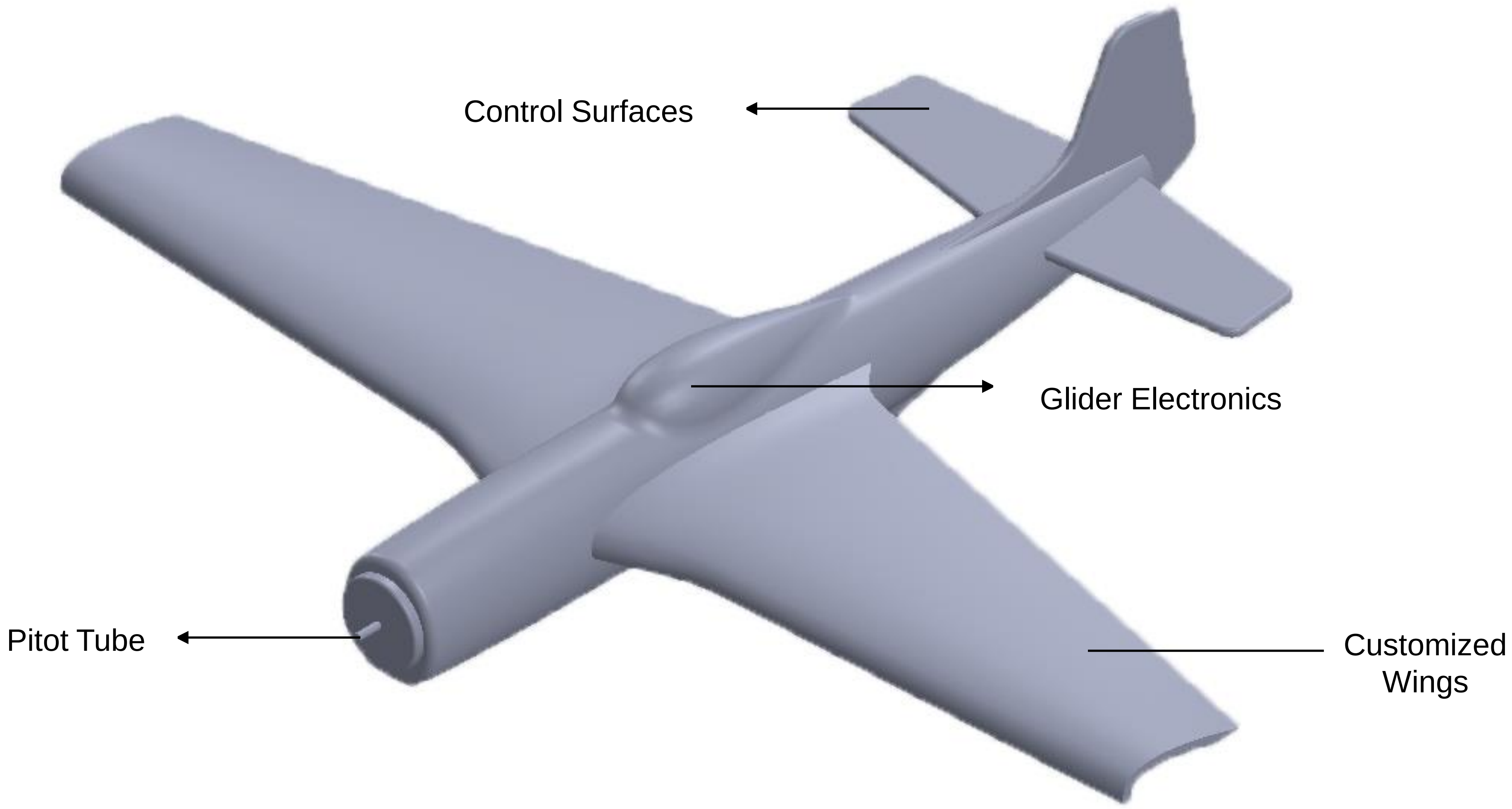
2. Glider separated from the re-entry container at 400 m to resume its operations.

Physical Layout

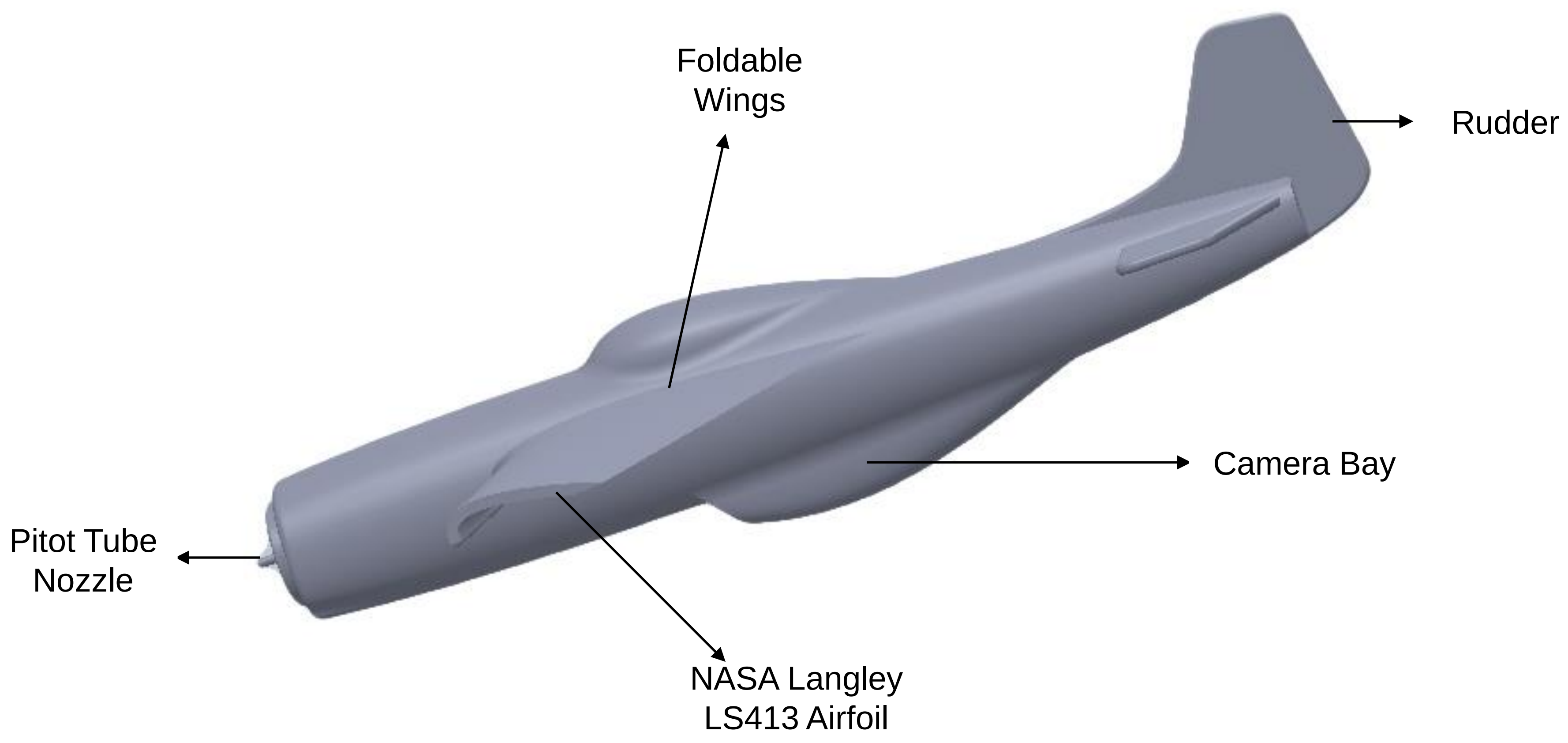


Note : Glider is Placed in the Container with NOSEDOWN Alignment

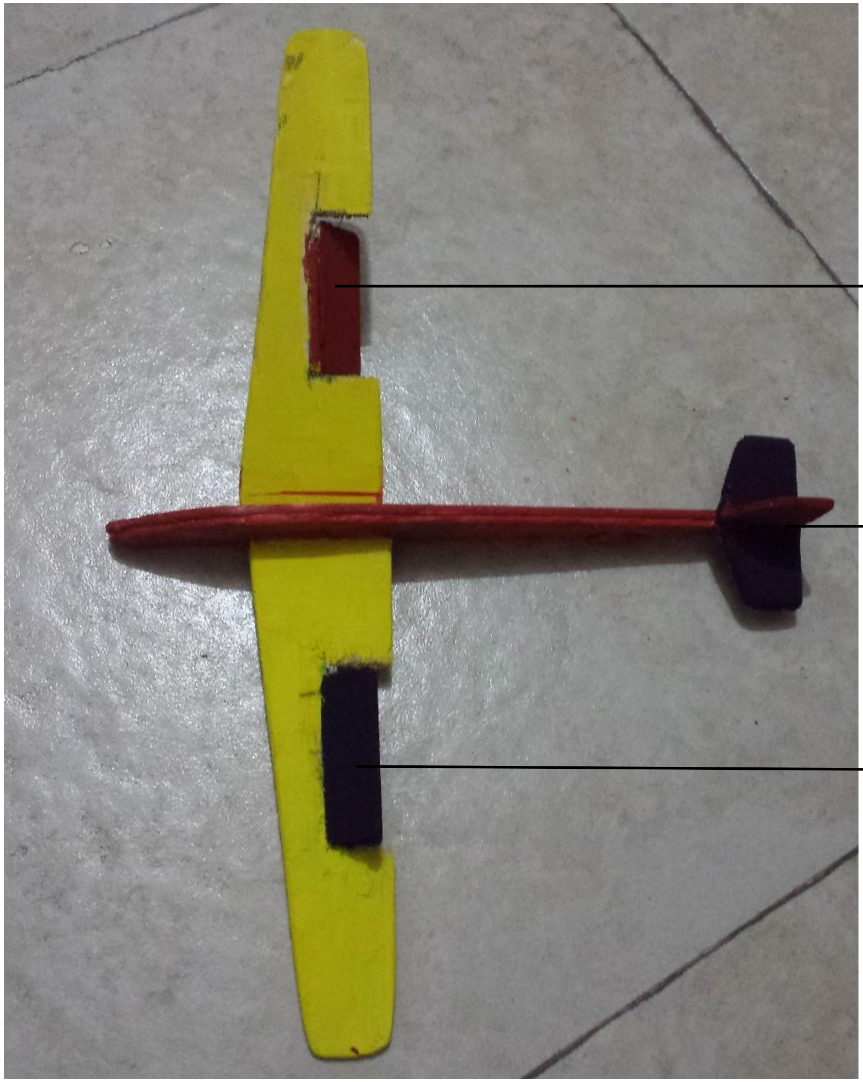
Physical Layout



Physical Layout



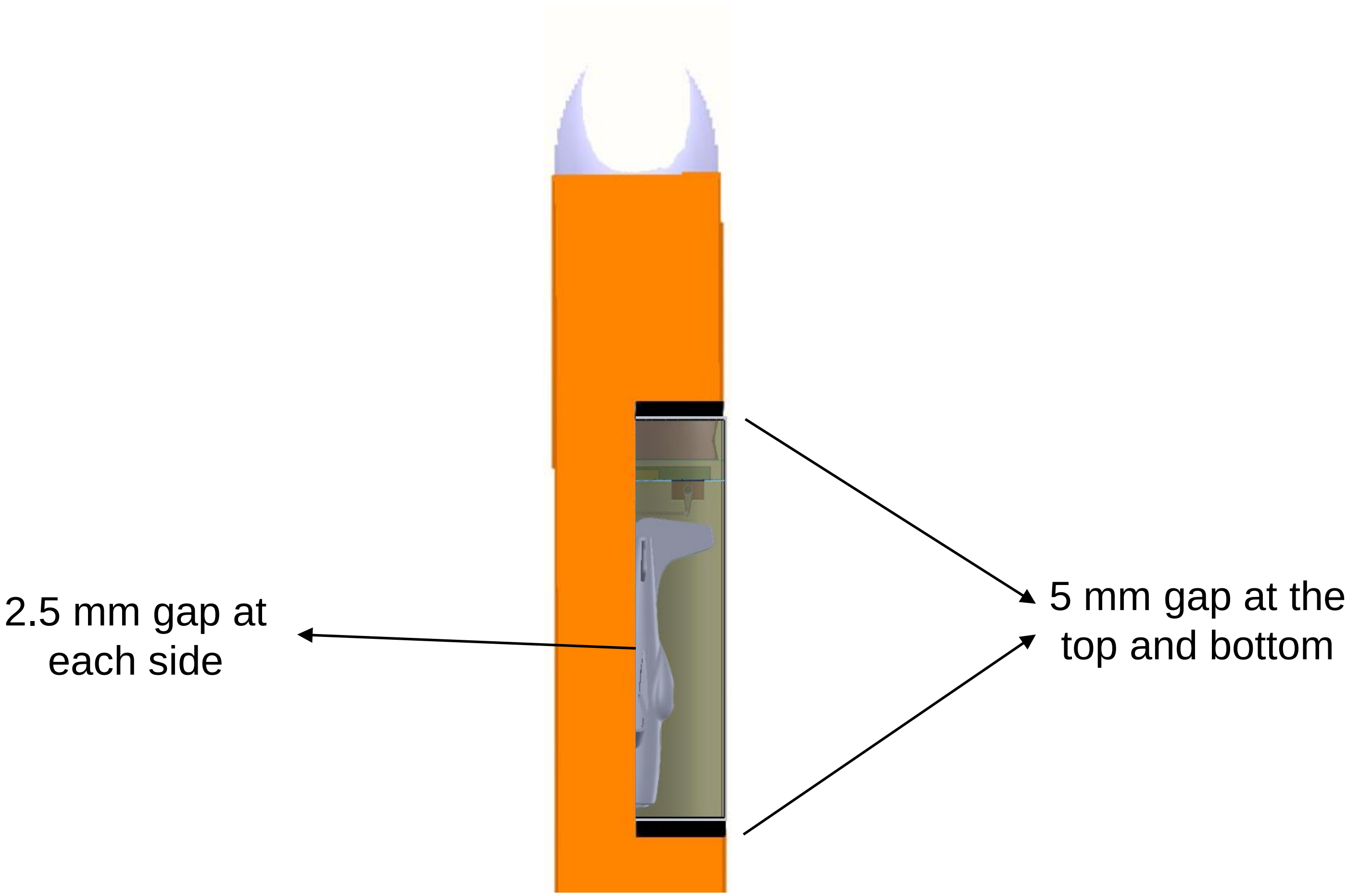
First Prototype for our Glider



Launch Vehicle Compatibility

- The structure is designed strictly keeping in mind, the size and weight restrictions.
- Re-entry container will be placed upside down in the rocket payload section.
- For verification of launch vehicle compatibility, we will test the dimensions, a day prior to the launch day by making sure that the re-entry container slides in a container of dimensions 310x125 mm.
- Max. diameter of re-entry container is 120 mm which is 5 mm less than the rocket's payload section and there are no components protruding outside the re-entry container which will facilitate smooth deployment.
- Height of the re-entry container is 300 mm. this is well under the given limit of 310 mm, ensuring that CanSat will not protrude out of the payload section.

Launch Vehicle Compatibility



Sensor Subsystem Design

Yash Agrawal

Sensor Subsystem Overview

GLIDER SENSORS:

- **Altitude and Pressure Sensor:** The sensor used here is BMP180 as it has a wide range of barometric pressure and altitude.
  With the measured pressure p and the pressure at the sea level p_0, the altitude in the meters can be calculated with the international barometric formula:

$$\boldsymbol{Altitude = 44330 \times \left[1 - \left(\frac{p}{p_o}\right)^{1/5.255}\right]}$$

- **Temperature Sensor:** BMP180 provides reading for the temperature.
  It has -40 to +85°C operational range, ± 2°C temperature accuracy.
- **Battery Voltage Sensor:** A voltage-divider circuit is used through the ADC port.
- **Pitot Tube Sensor:** It is used to sense the air flow velocity. MPXV7002-GC6U is used as the Pitot tube sensor. It provides a 0.5-4.5 V output.
- **GPS Sensor:** GPS sensor is used to get the co-ordinates, speed, altitude of the glider and track the no of the satellites. The GPS sensor used here is UBlox Neo6mv2.
- **Camera:** Serial TTL Camera VC0706 processor is used for image capturing. It is used for capturing the image in response of command send from ground station.

Sensor Subsystem Overview

RE-ENTRY CONTAINER SENSORS:

- **Altitude Sensor:** BMP180 is used as the altitude sensor . As it has ultra low power consumption (5µA at 1 sample / sec). Based on the altitude readings of this sensor, the separation mechanism is activated.

- **Separation Mechanism:** As soon as separation mechanism is activated, Servo Motor is employed to implement the push-rod mechanism to separate the Glider from the Re-Entry Container.

Sensor Changes Since PDR

CHANGES IN PRESENTATION SLIDES:

- The trade and selection of Battery Voltage Sensor is added in the section, 'Battery Voltage Sensor Summary'.

CHANGES IN TEMPERATURE SENSOR OF THE GLIDER:

- Earlier, we planned to use **LM35** as the temperature sensor in the Glider as well as re-entry container . But now we prefer **BMP180.**
- **RATIONALE : BMP180** has inbuilt ability to calculate temperature as well as altitude that eliminates the need of the additional sensors thus helping us to save the space and reduce the weight of the Glider. The code for the same has been tested using a 16 x 2 LCD.

BMP180 is easily available.

PRODUCT	Operational Temperature	Accuracy	Power Limitations
LM35	-55 to 150 °C	-40 to +85°C	
BMP180 (CDR)	± 0.5 °C	±2°C	

Sensor Subsystem Requirements

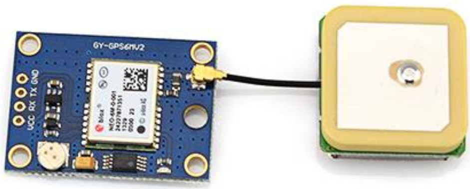
ID	REQUIREMENT	RATIONALE	PARENT	PRIORITY	VM			
					A	I	T	D
SSR-01	Altitude measurement (Glider as well as Re-Entry)	Competition Requirement	SR-06	High	✓	✓	✓	
SSR-02	Temperature measurement of Glider surroundings	Competition Requirement	SR-12	High	✓	✓	✓	
SSR-03	Battery voltage measurement of Glider	Competition Requirement	SR-12	High	✓	✓		
SSR-04	Air velocity measurement through pitot tube on Glider	Competition Requirement	SR-22	High	✓			

Sensor Subsystem Requirements

ID	REQUIREMENT	RATIONALE	PARENT	PRIORITY	VM			
					A	I	T	D
SSR-05	GPS measurement of required parameters of Glider	Competition Requirement	SR-12	High	✓	✓	✓	
SSR-06	Camera for Image capturing	Competition Requirement	SR-14	High	✓		✓	
SSR-07	Servo motor for separation of Glider from Re-Entry container	Competition Requirement	SR-06	High	✓	✓	✓	

GPS Receiver chosen: Ublox Neo6mv2

- Occupies less space and less power consumption.
- EEPROM for saving data when powered off.
- Accurate up to 2.5m
- It will be used to measure the required parameters of the Glider-Latitude, Longitude, Speed, Altitude and Number of Tracked Satellites.



Manufacturer	Model	Dimensions/ Weight	Operating Voltage	Accuracy	Interfacing	Power Consumption
Ublox	Neo6mv 2	L=25mm B=35mm W=18g	3.3V	2.5m	Serial UART	33mW

Source: Datasheet

- GPS will use NMEA 0183 Protocol with the baud rate of 9600.
- The data received will be stored and the required values are extracted.
- The data received from module will be:

$GPGGA,456719,9007.038,N,01131.000,E,1,08,0.9,545.4,M,46.9,M,,*47
$GPGSA,A,3,04,05,,09,12,,,24,,,,,2.5,1.3,2.1*39
$GPGSV,2,1,08,01,40,083,46,02,17,308,41,12,07,344,39,14,22,228,45*75
$GPRMC,456719,A,9007.038,N,01131.000,E,022.4,084.4,230394,003.1,W*6A

Air Pressure Sensor Summary

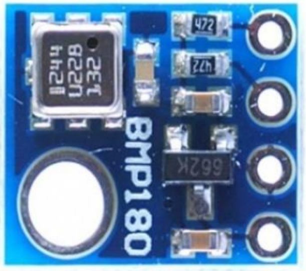
GLIDER: Pressure Sensor Chosen: BMP180

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

Device Name	Weight	Interfacing	Serial Data Clock (f_{SCL})	Size	Sample Rate
BOSCH BMP180	1g	I2C	3.4 MHz	5x5 mm	Up to 128 Hz

Source: Datasheet

The sensor provides the 16 bit temperature data. The sampling rate can be increased to 128 samples per sec for dynamic measurements.



- Logic: 3 to 5V compliant
- Pressure sensing range: 300-1100 hPa (9000m to -500m above sea level)
- Up to 0.03hPa / 0.25m resolution
- This board/chip uses I2C 7-bit address 0x77.
- Upgraded version of BMP180
- Ultra-low power consumption
- Low noise
- It will be used to measure altitude and pressure in the Glider and to activate the separation mechanism in the Re-Entry.

Air Pressure Sensor Summary

RE-ENTRY CONTAINER: Chosen Sensor: BMP180

The BMP180 sensor is used in the re-entry container to measure the altitude. This reading is then used to activate the push rod mechanism for the separation of glider from the Re-Entry Container.

Device Name	Weight	Interfacing	Serial Data Clock (f_{SCL})	Size	Sample Rate
BOSCH BMP180	1g	I2C	3.4 MHz	5x5 mm	Up to 128 Hz

Source: Datasheet

- Pressure sensing range: 300-1100 hPa (9000m to -500m above sea level)
- Up to 0.03hPa / 0.25m resolution
- It will be used to measure altitude and pressure in the Glider and to activate the separation mechanism in the Re-Entry.

Pitot Tube Summary

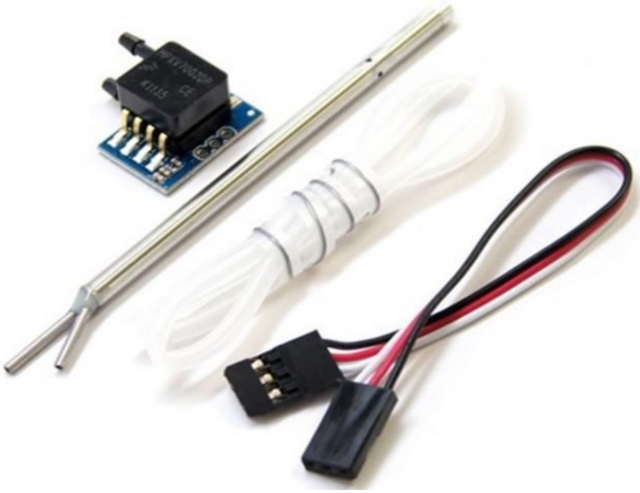
Pitot Tube Sensor Chosen: MPXV7002-GC6U

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 up to 7kPa through each port for pressure sensing or vacuum sensing.

Device Name	Weight	Protocol	Supply Voltage	Cost
MPXV7002-GC6U	4 g	ADC	4.75-5.5 V	$ 24.95

Source: Datasheet

- Accuracy : ±6.25 %V_{FSS}
- Relatively lighter
- Easy Interfacing
- Cost effective
- -2 to 2 kPa pressure range
- 10-60°C operating temperature
- It is used to sense the air flow velocity around the Glider.



Air Temperature Sensor Summary

Air Temperature Sensor Selected: BOSCH BMP180
We are using BMP180 as the air temperature sensor which also works as the altitude and pressure sensor for the Glider as well as Re-entry Container.

Product	Interfacing	Operational range	Operational Voltage	Accuracy
BMP180	I2C Protocol	-40 to 85 °C	4.25V	± 2 °C

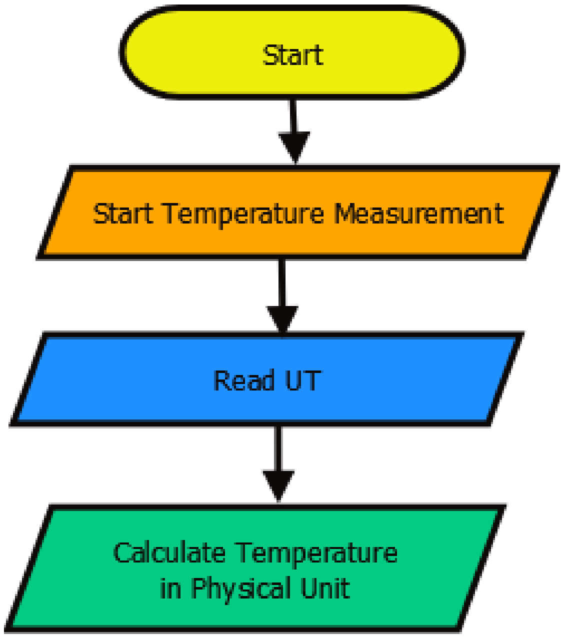
Source: Datasheet

- 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.

ANNUAL CANSAT COMPETITION

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

- UT=MSB<<8+LSB (uncompressed temperature)
- X1= (UT- AC6)*AC5/2^15
- X2= MC*2^11/(X1+MD)
- B5= X1+X2
- T= (B5+8)/2^4



Battery Voltage Sensor Summary

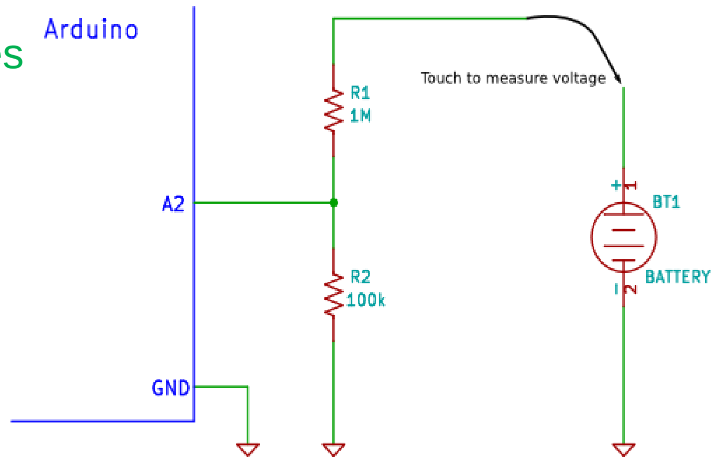
Selection Trade Study (Added to meet up with clause mentioned in the PDR)

Product	Type	Operating Range	Current Consumption
FrSky Battery Voltage Sensor	Analog	0 to 19.8V	25mA
RB-Phi-86	Analog	-30V to 30V	3.6mA
Voltage Divider	Analog	Any Range	Negligible

Source: Datasheet

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

- A voltage divider circuit consisting of two resistors in series will divide the input voltage to bring it within the range of the Arduino analog inputs.
- <u>Formula Used for Arduino coding:</u>
  Voltage = SensorValue * (5.00 / 1023.00) * 2
- The circuit shown will divide the input voltage by 11 (from the battery as the input voltage being measured).
- The circuit with the particular values shown has an input impedance of 1MΩ + 100kΩ = 1.1MΩ and is suitable for measuring DC voltages up to about 50V.



Chosen Camera: Serial TTL Camera VC0706 Processor

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	Operating Temperature	Scanning Frequency	Operating Voltage
Serial TTL Camera VC0706 Processor	Medium	640x480	-40 to 85 °C	Progressive Scanning	5 V

Source: Datasheet

- Image sensor: CMOS 1/4 inch, Standard JPEG
- SNR: 45DB
- Dynamic Range: 60DB
- Max analog gain: 16DB
- Frame speed: 640*480 30fps
- Image size: VGA（640*480 pixels)
- Baud rate: Default 38400, Maximum 115200
- Current draw: 75mA; DC +5V
- Communication: 3.3V TTL

Descent Control Design

Ena Goel

Descent Control Overview

- Descent control system will consist of a parachute of radius 20 cm for re-entry container with a spill hole of 6.5 cm to provide stability. For the Glider, wings will be fixed at different angle of attack and full rudder in direction of rotation.

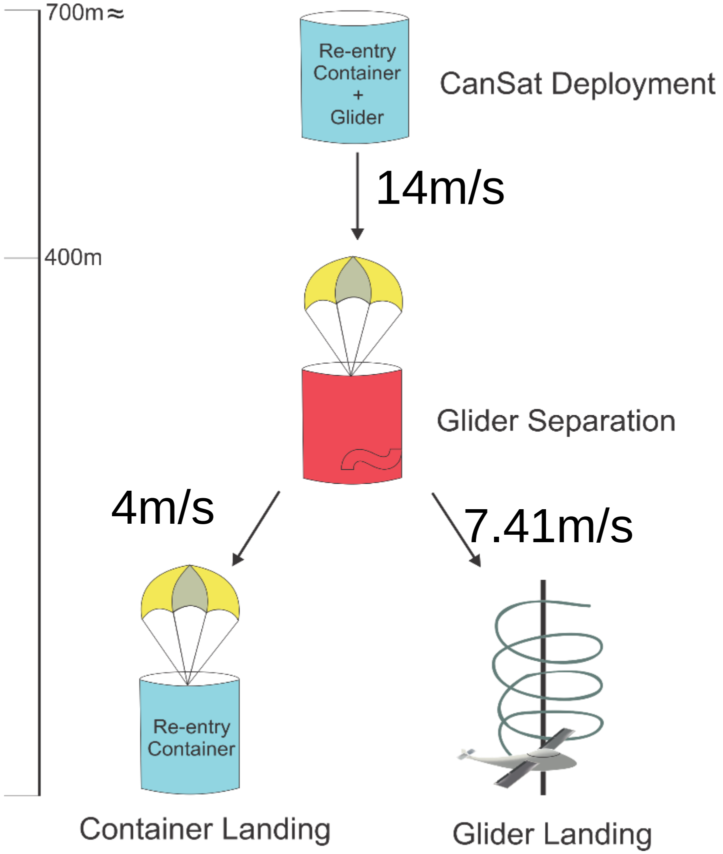
- As glider shall not be remotely steered or autonomously steered so proper design and right choice of material is important.

- Parachute will be folded such that it will occupy not more than 1.5 cm of space above the re-entry container.

- At the time of separation, Glider will release automatically and due to design of the glider, it will start to glide in a circular pattern. A customized NASA Langley LS413 Airfoil is used to ensure that it glides in a preset circular pattern.

- At approx. 400m, a servo motor will be used to separate Glider from re-entry container.

- The whole system will be controlled by Arduino Uno microcontroller.



Descent Control Changes Since PDR

Components Changed	Requirements	Rationale
Angle of inclination of flaps has been changed to 30 degrees in both wings.	The Angle is increased so as to get more pressure difference on both wings.	Greater the angle of attack, greater is the lift.
The location of wings have been changed to one-third the total length of glider.	The wings are placed such that the center of gravity moves backward and the glider configuration is stable.	Location of center of pressure and center of gravity defines the stability of the glider.
The material of the DCS of re-entry container (Parachute) has been changed from tarpaulin to nylon cloth.	The material of DCS of re-entry container should be strong enough take the loads from air while descending.	Nylon cloth proves to be much stronger and air resistant than the tarpaulin.
Rudder will be tilted at an angle of 45 degrees towards wing with low angle of attack.	Yaw movement of the glider depends on the rotation of rudder.	The yaw movement defines the diameter of the helical path.

Prototype Testing:

Balloon Test:

- This test was done to check the descent control of the system from two different altitude.
- The Glider was sent up with the help of a weather balloon. It was tied with the balloon with the help of a thread.
- A servo motor was programmed to cut that thread after 15 minutes, at an approximate altitude of 250 m.
- Again it was tied and sent and now the programming was done for 150 m.

Observations:

- After falling, it took some time to get stabilized and start falling in a helical fashion. The landing site was found to be under 500m.

Descent Control Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
DCS-01	Container shall fit in a cylindrical envelope of 125 mm diameter x 310 mm length	Competition requirement	HIGH	SR-02		✓		
DCS-02	The parachute shall not exceed a packing depth of 10 mm at the top of the re-entry container.	Allow for sufficient space allocated to the rest of the systems.	MEDIUM	SR-03		✓		
DCS-03	Both parachute and Glider must be reasonably light	Keep the weight budget from exceeding 500 g	MEDIUM	SR-01		✓		
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-05				✓
DCS-05	The re-entry container and glider need to be separated at an altitude above 400m.	Competition requirement	HIGH	SR-06	✓			
DCS-06	The container shall use a passive descent control system.	Competition requirement	MEDIUM	SR-19			✓	✓

Descent Control Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
DCS-07	Parachute should provide a descent rate of 14 m/s to the CanSat before 400m.	To provide an optimum velocity to Glider after getting deployed	HIGH	MSR-04	✓			
DCS-08	Materials used to be light and flexible	To minimize mass and volume requirements.	MEDIUM	SR-01	✓			✓
DCS-09	The Glider must be fixed to glide in a preset circular pattern of no greater than 1000 meter diameter.	Competition requirement	HIGH	SR-07	✓		✓	
DCS-10	Decent Control System (DCS) shall not use flammable or pyrotechnic devices	Competition requirement	HIGH	SR-11	✓			✓
DCS-11	Glider shall be a fixed wing glider.	Competition requirement	HIGH	SR-19	✓	✓		
DCS-12	The glide duration should be 2 minutes .	Competition requirement	HIGH	SR-20		✓		

Container Descent Control Hardware Summary

- For descent control of container no sensors or actuators will be used but the mechanical structure is made in such a way that the parachute will deploy automatically due to up thrust when the container is released from the rocket at 670 m.

- The descent control hardware for the container consists of a nylon parachute of radius 20cm with a spill hole of 6.5cm which deploys automatically at 670 m on coming out of the rocket.

- It is easy to design and fabricate/easily available according to the required descent rate. The design and size of the parachute has been chosen to obtain a descent rate of 14m/s.

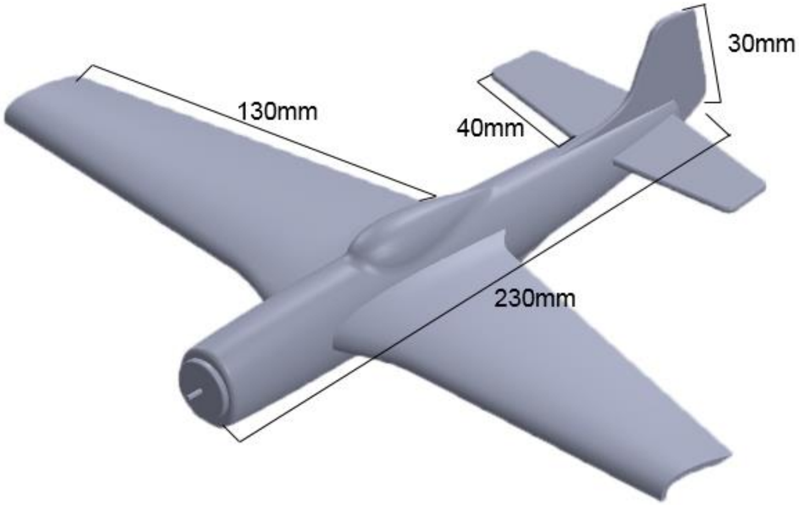
- The color of the parachute is bright (red) and flashy so that visual contact can be maintained with the container while it is descending.

- Shock resistance tests have been done to check the amount of shock force that can be resisted by the parachute. It survived 50 Gees of shock force.

- The material of the parachute (Nylon) 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, has good air blocking ability, that is non-porous and occupies small space.

Payload Descent Control Hardware Summary

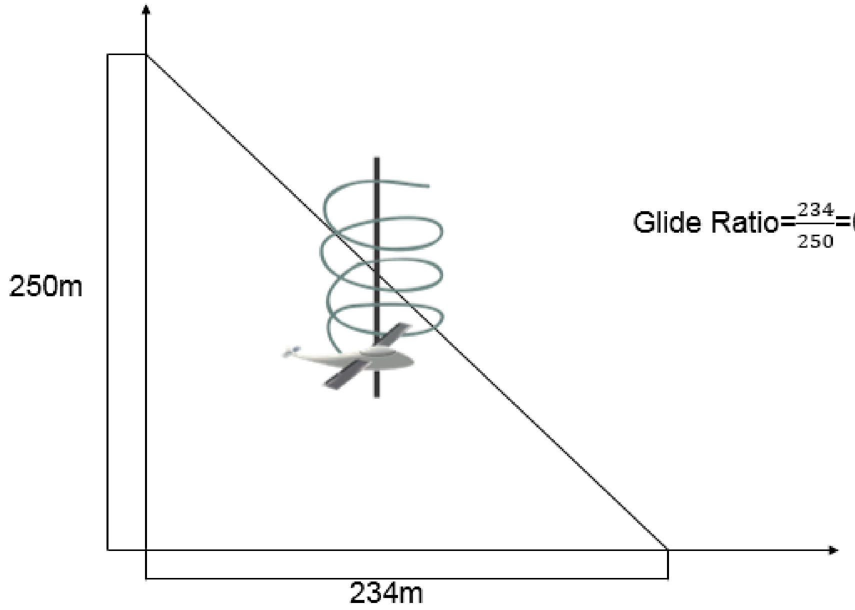
- For descent control of Glider no sensors or actuators will be used but the glider is made in such a way that it will start descending in a helical fashion.
- **The descent control system of the Glider are flaps at different inclination. The pressure difference provides glider with the required centrifugal force.**
- The material is chosen such that it resists shock / impact force, it is elastic i.e., will not deform permanently, it is lightweight, has high strength.
- The wings of the glider are attached at one-third the total length of the fuselage, which will help us to maintain the center of gravity of the glider.



Note:- The length of wings are taken to be 130mm. The dimensions taken ensures that the glider generates enough lift and the wings can be easily folded along length of the glider.

- In order to prevent the Glider from toppling, proper dimensions of the wings and the Glider body were used keeping in mind the helical path.
- The release of the Glider from the container will be governed by the release mechanism in which a pressure sensor will be used to determine the altitude. At an altitude above 400m the Glider will be released and will start descending in helical path.

Note:- Weather balloon Testing was carried out for the glider and glide ratio was found to be 0.936

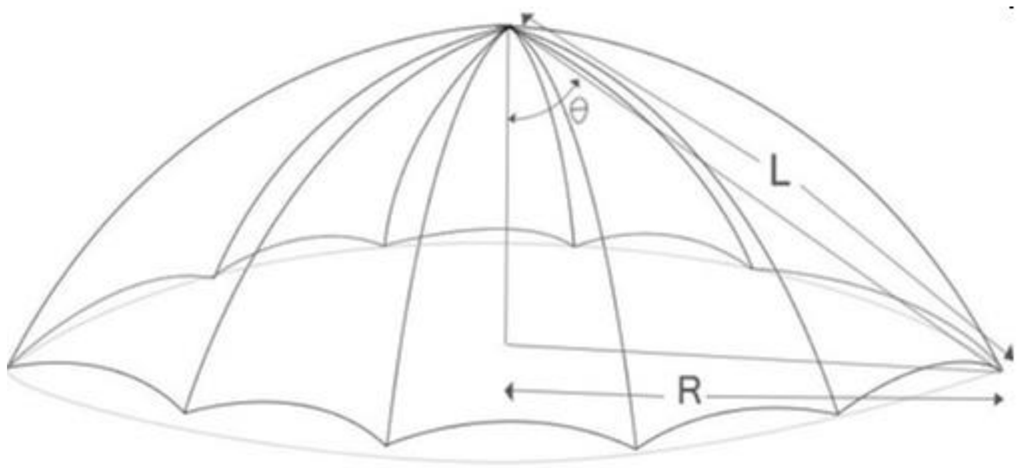


Glide Ratio=$\frac{234}{250}$=0.936

Glide Ratio = 0.936

Note: The color of glider was chosen to be Neon Orange.

Descent Rate Estimation of Re-Entry Container :



R = radius of hemispherical umbrella
L = length of the spoke
θ = angle b/w the axis and spoke

Descent Rate Estimates

- A parachute will be used to control the descent rate of the re-entry container
- To get the required drag and vertical velocity, radius of the parachute can be calculated as follows :

$$R = \sqrt{(2F_{Drag}/\ \pi\rho V^2 C_d)}$$

Where,

- Π = 3.14159265359
- Ρ = 1.15605 Kg/m^3 (b/w 700 m and 450 m)
- C_d = *0.4547 (drag coefficient of a hemisphere chute with a spill hole)*
- R = Radius of the chute = 20 cm (spill hole dia. = 6.5cm)
- F_{drag} = Drag Force = 6.543 Newton (Recovering from 22m/s)

Descent Rate Estimates

Calculation for descent rate of re-entry container

After rearranging the equation and finding the velocity:

$$\mathbf{20} = \sqrt{(2} \times 6.543)/(3.14 \times 1.15605 \times V\hat{\ }2 \times 0.4547)$$

So the Descent rate of the re-entry container comes out to be 14 m/s

Descent Rate Estimation for Glider

After looking at many airfoils for our glider we came at the conclusion of using **NASA Langley LS413** airfoil which would best suit our requirement to glide in a preset circular pattern.

A Test Model of The Glider was made and was taken to a height using a Weather Balloon.

The Height was measured using Sextant and came out to be 250m.
The Glider was released using Cutting Mechanism.

The Descent of the glider was noticed and time taken by Glider to land was recorded to be 34 seconds.

Descent Rate Estimates

- **By Applying Basic laws of kinematics**

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

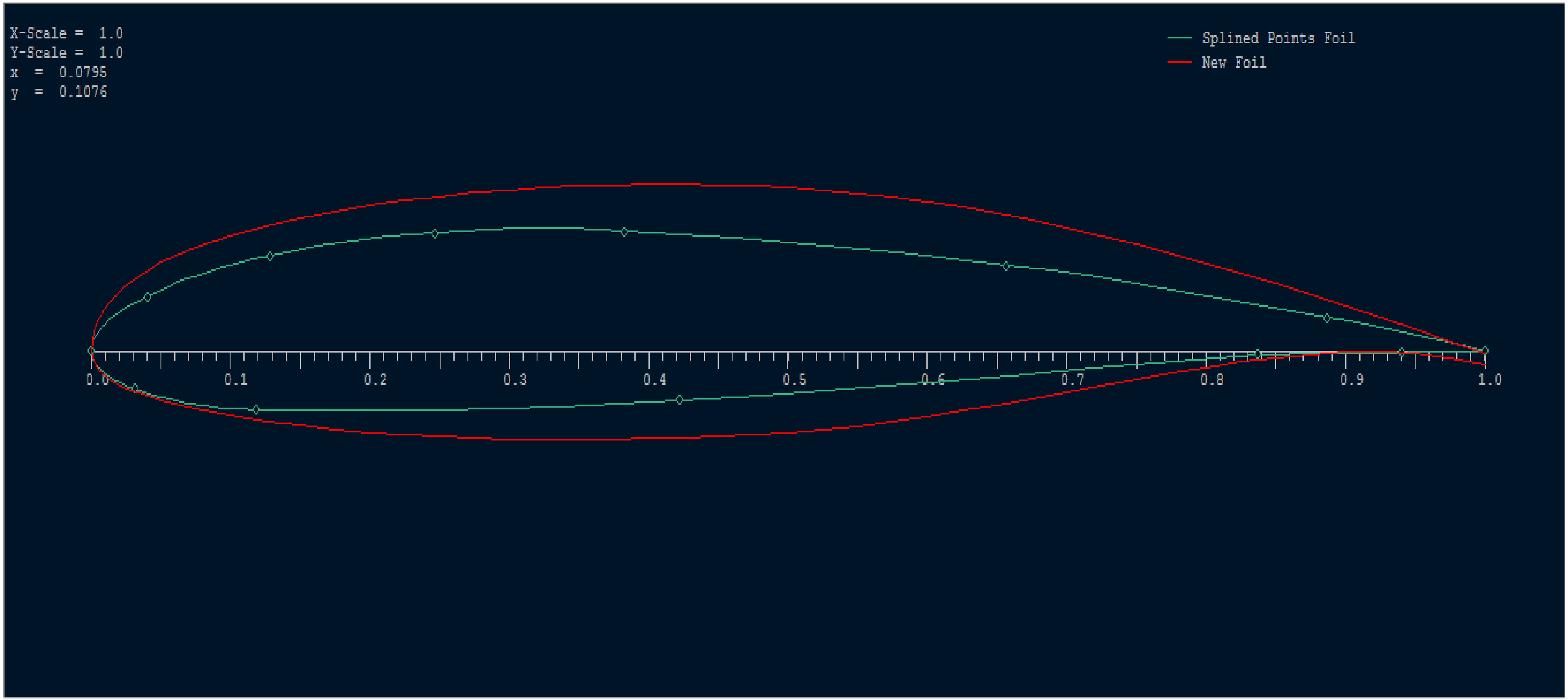
Where s=250m and t=34s

we get velocity of glider=7.41m/s

The distance of the location where glider landed was measured from the launch site and was determined to be 234m.

The above lies well within the range of 1000m diameter requirement.

Descent Rate Estimates



NASA LANGLEY LS413 AIRFOIL

Descent Rate Estimates

NASA LANGLEY LS413 AIRFOIL DATA

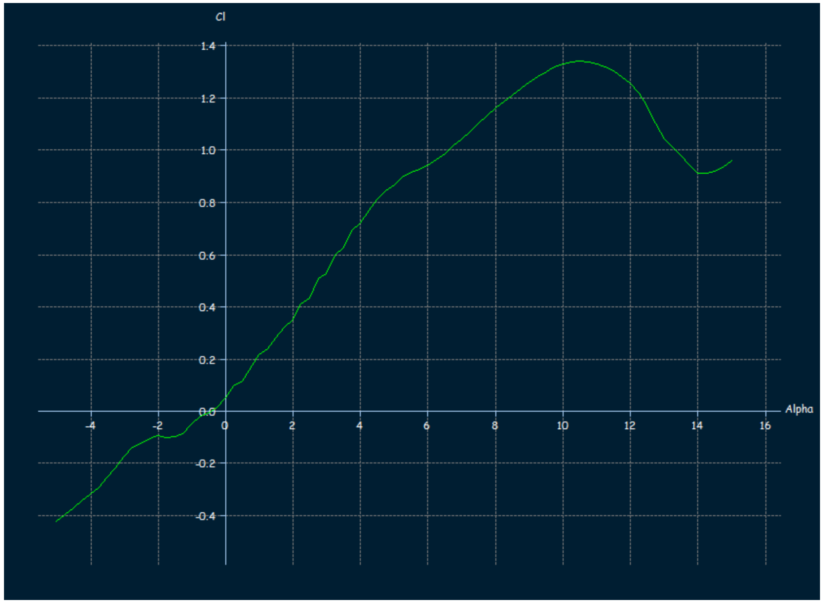
x	y	z	x	y	z	x	y	z
1.0000	-.00160	0	.25000	.07860	0	.30000	-.04480	0
.97500	.00480	0	.22500	.07650	0	.32500	-.04510	0
.95000	.01100	0	.20000	.07400	0	.35000	-.04520	0
.92500	.01690	0	.17500	.07100	0	.37500	-.04500	0
.90000	.02270	0	.15000	.06750	0	.40000	-.04470	0
.87500	.02840	0	.12500	.06350	0	.42500	-.04420	0
.85000	.03400	0	.10000	.05860	0	.45000	-.04350	0
.82500	.03930	0	.07500	.05260	0	.47500	-.04260	0
.80000	.04450	0	.05000	.04480	0	.50000	-.04140	0
.77500	.04950	0	.03750	.03970	0	.52500	-.03990	0
.75000	.05420	0	.02500	.03320	0	.55000	-.03810	0
.72500	.05870	0	.01250	.02420	0	.57500	-.03590	0
.70000	.06290	0	.00500	.01590	0	.60000	-.03330	0
.67500	.06670	0	.00200	.01040	0	.62500	-.03050	0
.65000	.07020	0	0.0000	0.0000	0	.65000	-.02740	0
.62500	.07330	0	.00200	-.00500	0	.67500	-.02420	0
.60000	.07610	0	.00500	-.00940	0	.70000	-.02100	0
.57500	.07830	0	.01250	-.01450	0	.72500	-.01770	0
.55000	.08020	0	.02500	-.01910	0	.75000	-.01440	0
.52500	.08170	0	.03750	-.02230	0	.77500	-.01130	0
.50000	.08290	0	.05000	-.02500	0	.80000	-.00830	0
.47500	.08380	0	.07500	-.02940	0	.82500	-.00570	0
.45000	.08440	0	.10000	-.03280	0	.85000	-.00350	0
.42500	.08460	0	.12500	-.03560	0	.87500	-.00180	0
.40000	.08460	0	.15000	-.03790	0	.90000	-.00080	0
.37500	.08430	0	.17500	-.03980	0	.92500	-.00060	0
.35000	.08380	0	.20000	-.04140	0	.95000	-.00130	0
.32500	.08300	0	.22500	-.04270	0	.97500	-.00340	0
.30000	.08180	0	.25000	-.04370	0	1.00000	-.00710	0
.27500	.08030	0	.27500	-.04430	0			

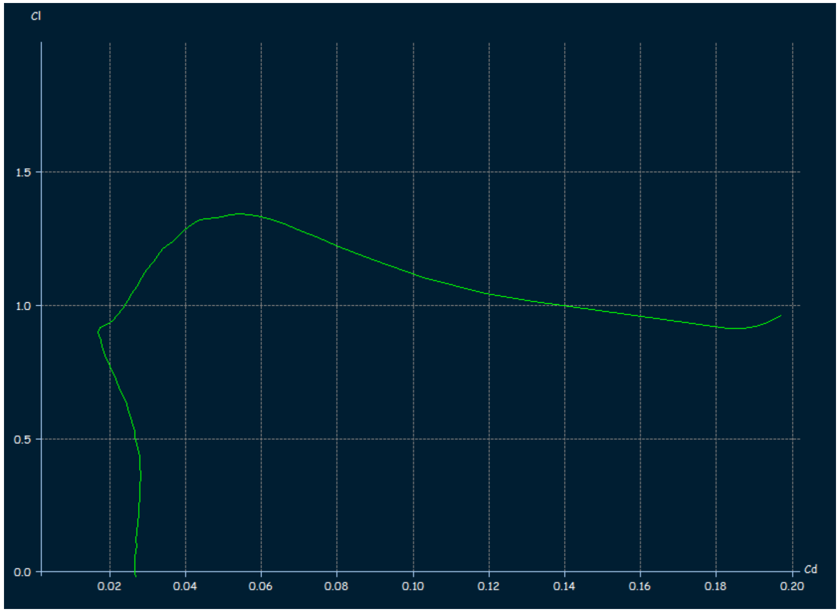
Descent Rate Estimates

- **The airfoil was analysed using XFLR5 software and following data was noted:-**

Specification	Value
Airfoil	NASA LANGLEY LS413
Chamber	2.14%
Chamber position	61.90%
Maximum Thickness	12.93%
Maximum Thickness position	37.50%
C_L	0.9170
C_D	0.1904
C_m	-0.098
L/D	4.82
Angle of Attack (Stall)	10.9 deg

Descent Rate Estimates





C_L Vs α graph for NASA Langley LS413

C_L Vs C_D graph for NASA Langley LS413

Descent Rate Estimates

DESCENT RATE ESTIMATES SUMMARY

CONFIGURATION	MASS (gm)	DESCENT RATE ESTIMATES (m/s)
Container with Glider	500	14
Container only (parachute)	150	4
Glider Only	350	7.41

Mechanical Subsystem Design

Aman Arora

Mechanical Subsystem Overview

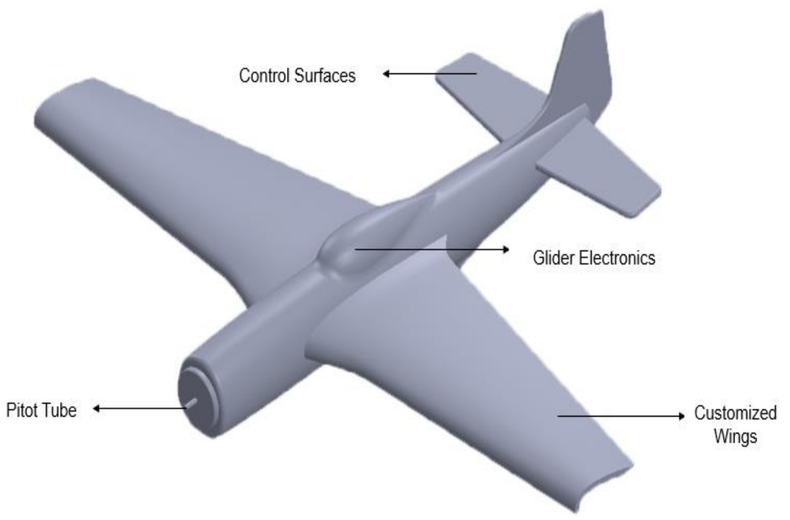
Major structural components of the CanSat include the re-entry container and the glider.
The total mass would be 500 gm.

Re-entry container:

- **Structure** is to be made of Carbon Fiber which will provide strength and will be lighter in weight.
- **Descent Control Mechanism:** Consists of a hemispherical parachute of radius 20 cm with a spill hole at its center so the velocity above 450 m will become less than 14 m/s.
- **Electronics:** Electronics in the re-entry container include a BMP180, and a servo motor for the release mechanism.
- **The glider system is connected to the re-entry container with a rod controlled by a servo motor**.

Glider:

- **Structure** consists of a Glider is made of Nylon using 3-D printing technique. The electronics are enclosed in a inside the fuselage of the glider with opening at the bottom part to place the camera. The pitot tube is placed in the nose of the glider. Foldable Wings are used in the glider to save space.
- **Descent Control Mechanism:** Consists of wings designed using NASA Langley LS413 Airfoil and fixed at different angle of attack. The rudder is fully deflected in direction of rotation which provides us the required circular preset. The descent is maintained to get a Erect spin.
- **Electronics:** Electronics in the glider include BMP180, voltage monitor, Pitot tube, GPS, Camera and XBEE radio.



Mechanical Subsystem Changes Since PDR

Changes	Requirements	Rationale
The position of Centre of Gravity has been shifted towards the tail of the Glider.	The further aft the center of gravity, the flatter the spin.	Less stall speed will help glider for less reliable recovery.
The location of batteries were changed from wings to the fuselage.	. The center of gravity is made to lie on the axis of symmetry.	Moving center of gravity backward increases stability of the glider.
The material of the DCS of re-entry container (Parachute) has been changed from tarpaulin to nylon cloth.	The material of DCS of re-entry container should be strong enough take the loads from air while descending.	Nylon cloth proves to be much stronger and air resistant than the tarpaulin.

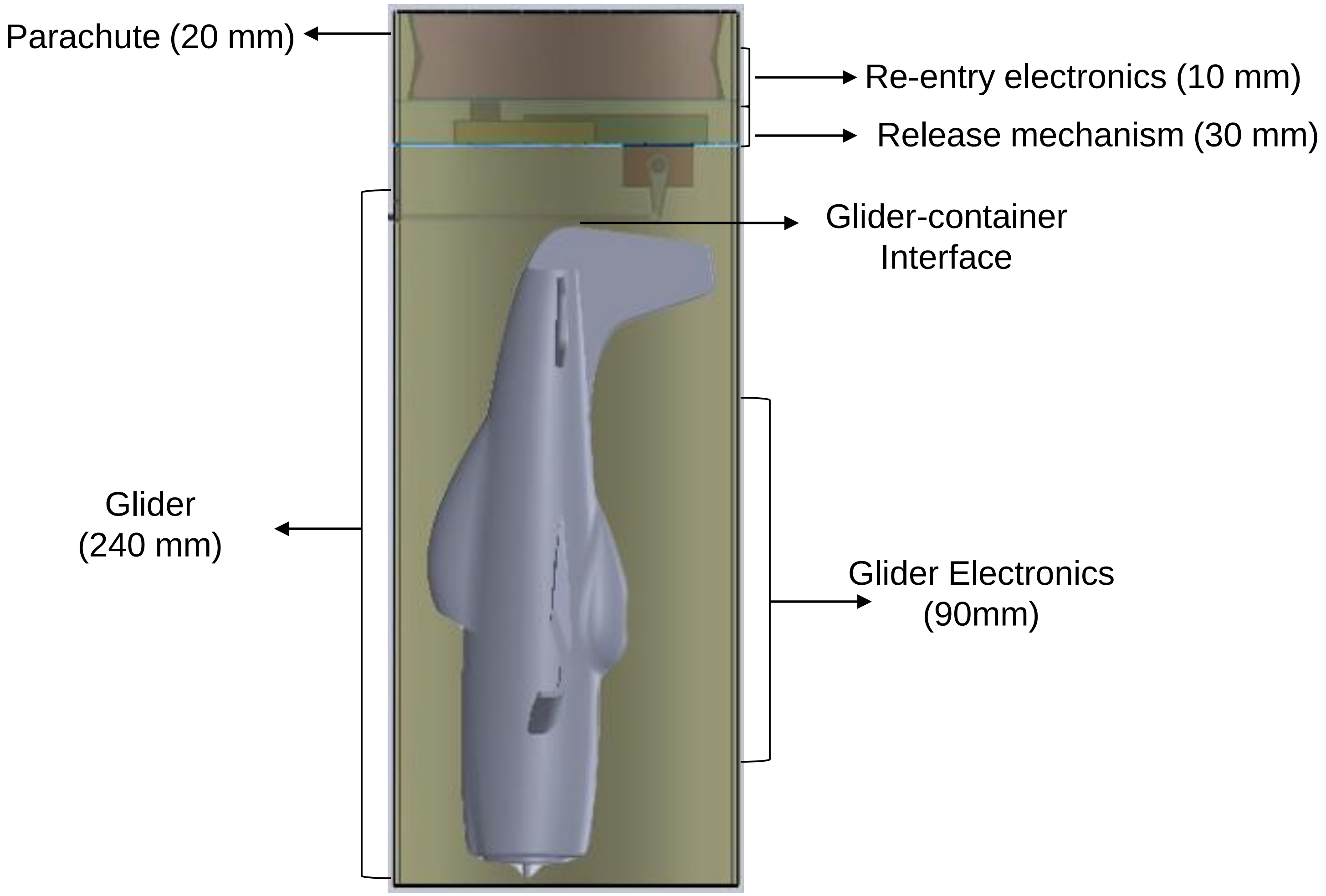
Mechanical Sub-System Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
MSR-01	Total mass of the CanSat shall not exceed 500 gm.	Competition Requirement	HIGH	SR-01	✓	✓		
MSR-02	Container shall fit in the envelope of 125 mm x 310 mm	Competition Requirement	HIGH	SR-02	✓		✓	
MSR-03	The glider shall not be remotely steered or autonomously steered.	Competition Requirement	HIGH	SR-07	✓			
MSR-04	The Glider Should be a Fixed Wing Glider	Competition Requirement	HIGH	SR-19				
MSR-05	The container shall not have any sharp edges protruding.	To facilitate leaving the rocket	HIGH	SR-04		✓	✓	
MSR-06	Proper placement of GPS, antenna and other sensors	To ensure safe landing of glider on surface	HIGH	SR-08	✓			
MSR-07	CanSat shall not use any flammable or pyrotechnic devices.	To prevent the CanSat from burning and causing a fire.	HIGH	SR-11	✓		✓	
MSR-08	The Glider shall release at an altitude above 400m from the container.	Competition Requirement	HIGH	SR-06	✓	✓		

Mechanical Sub-System Requirements

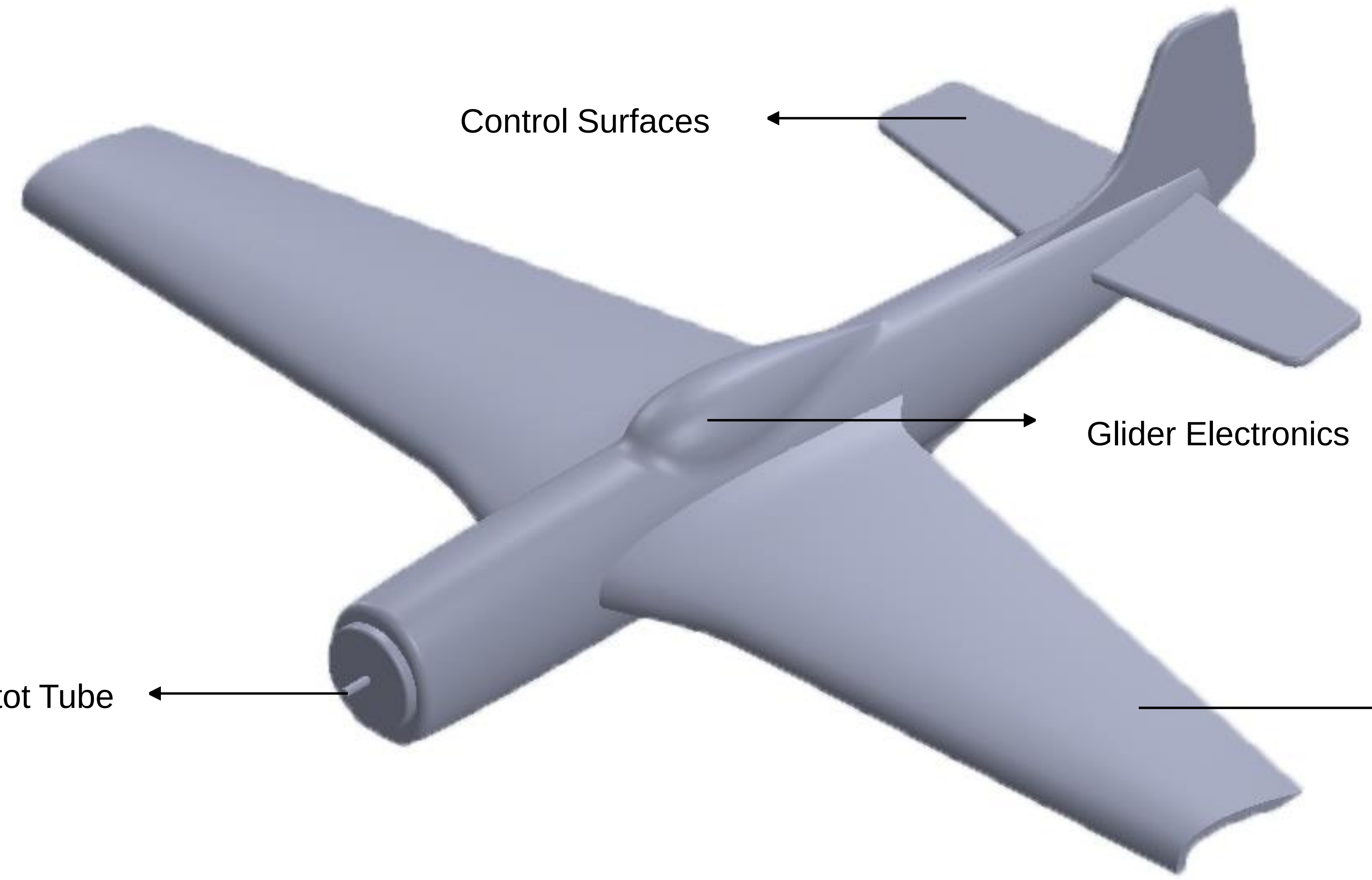
ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
MSR-09	All electronics shall be hard mounted.	To prevent them from getting displaced during descent.	HIGH	SR-10	✓			
MSR-10	The Glider shall not have any active control surfaces.	Competition Requirement	HIGH	SR-05	✓	✓		
MSR-11	All devices and attachments shall survive 30 Gs of shock and 15Gs of acceleration.	Competition Requirement	HIGH	SR-09		✓		
MSR-12	Container shall be of a fluorescent color.	Competition Requirement	MEDIUM	SR-24	✓		✓	
MSR-13	Audio beacon shall be installed to the Glider.	Competition Requirement	MEDIUM	SR-25	✓	✓		

Mechanical Layout of Components

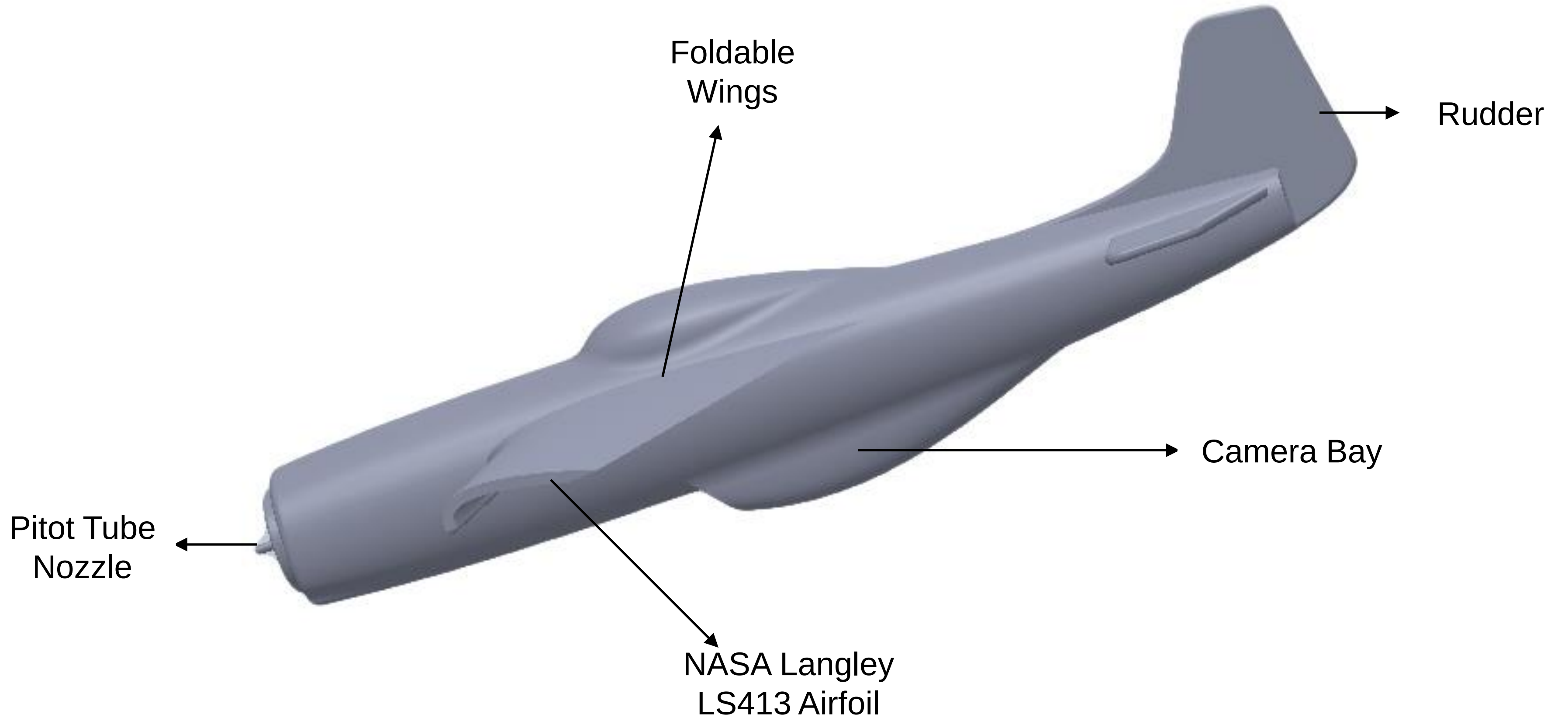


Note:- Glider is placed in the container with Nose down alignment.

Mechanical Layout of Components



Mechanical Layout of Components



Material Selections

Criteria for selection

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

For the glider system body, following materials were considered-

MATERIALS	COST	DENSITY (g/cc)	TENSILE STRENGTH (MPa)	PROS	CONS
Carbon Fiber	$12 per pound	1.74	3500	Very Light	Expensive, tough to use
Nylon	$1.6 per pound	1.15	75	High Specific Strength	Slightly Heavier
High Density Polyethylene	$0.25 per pound	0.95	27	Good specific strength, cheap, easily available.	Melts easily under high temperature

Material Selections

Re-entry container:

To be made of High density Carbon Fiber as it is strong, lightweight, cheap and easily available, easy to fabricate

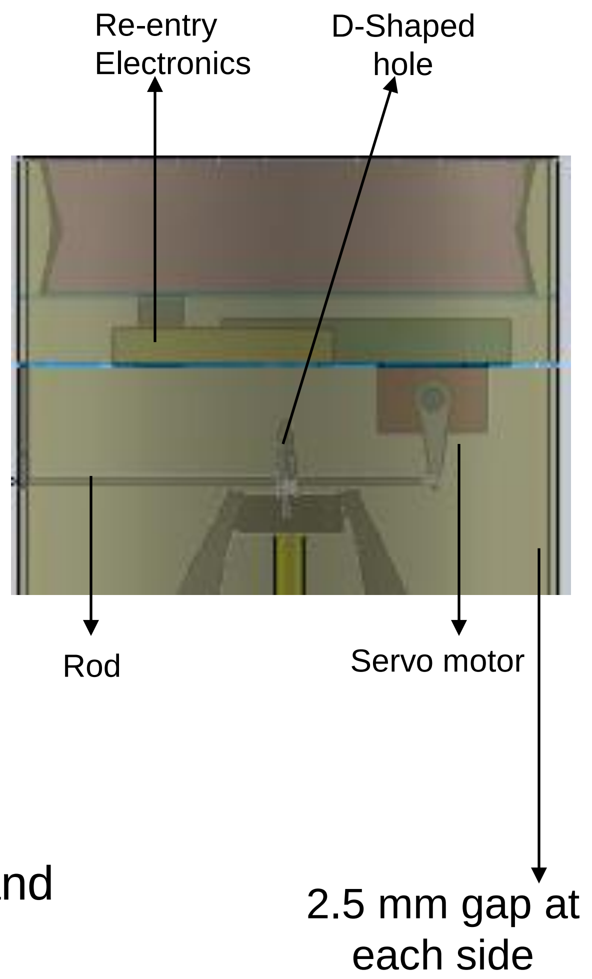
Glider System:

The structure would be made out of Nylon due to the following reasons:

- -Economical
- -Easy to fabricate
- -Easily Available
- -Lightweight
- -Sufficient strength

Container - Payload Interface

- The container and glider system are interfaced with a rod mechanism which is controlled by servo motor.
- The rod is attached to the glider through a D shaped hole and one end is connected to the servo motor.
- At an altitude above 400m the servo motor will rotate and pull the rod out of the glider.
- Due to its weight and the effect of gravity, the glider will be released.
- After separation the wings will unfold and it will start gliding in a circular preset pattern.



Note:- Clearance of 2.5mm is provided between glider and the container to ensure smooth separation of glider.

Structure Survivability

- **Mounting Method:** All electronic components are hard mounted with the Glider frame using screws, hot glue and standoffs. No electronics are exposed to the outside atmosphere except for the sensors.
- **Enclosures:** A removable structural coating made of high quality sponge is being used to protect the electronic components during impact. A thin film of polythene covers the electronic circuits and sensors.
- **Connections:** All electrical connections are verified and secured using insulation tapes.
- The glider structure and electronics will support 15 g acceleration and will survive 30 g shock force.
- The skeleton is made using truss type structure to increase the strength.
- A scale model was tested using solidworks and results showed no deformation.

Structure Survivability

STRUCTURE MADE OF	WEIGHT	STRENGTH	EASE OF MANUACTURING	DROP TEST RESULT (Solidworks)
Carbon Fiber	8	7	4	No Deformation
Nylon	7	7	9	Very Less Deformation
High Density Polyethylene	4	5	6	Cracked Body

Grading (0-10):
0-4 Least
5-7 Moderate
8-10 High

We chose Nylon because of its ease of manufacturing and less weight.

- The Drop Test as suggested by the Environmental Testing Guide was performed and the results are shown in the following slides:

Drop Test Observations for Re-entry Container (Experimental)

- The parachute attachment point didn’t fail and was in a good shape.
- the Glider remained well attached with the container.
- No visible damage to the Glider during the drop test, which gives us surety about the reliability of our mechanisms.
- The visual proof of the Drop Test has been provided in the CanSat Integration and Test slides.

Re-entry container containing the Glider post Drop test. The parachute attachment did not break and also, the Glider did not fall out under the force.

Drop Test Observations for Glider (Experimental)

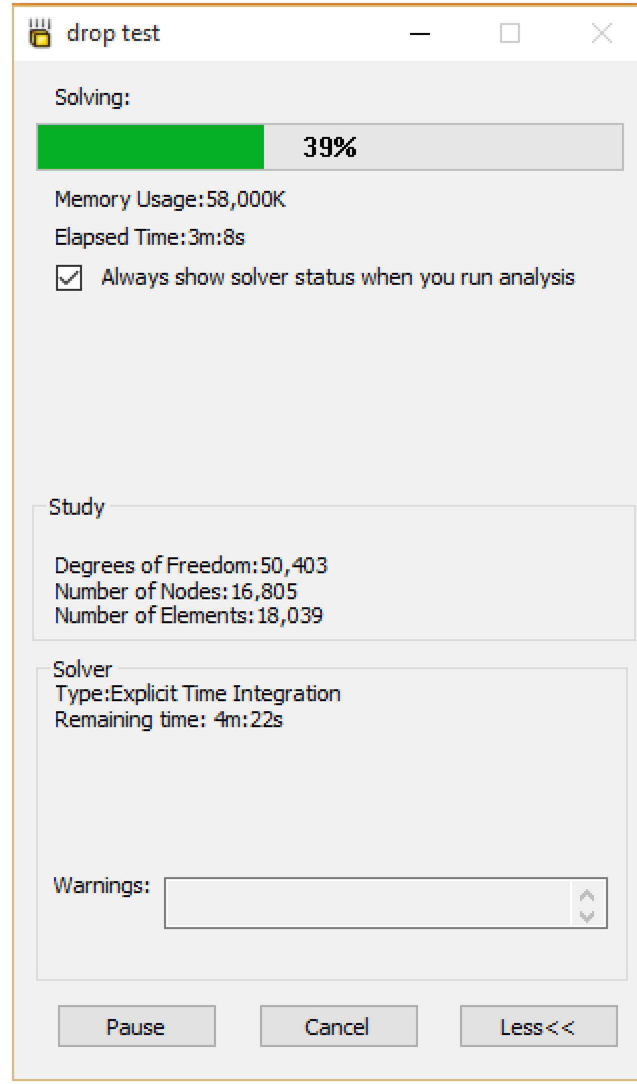
- A scale model of glider was prepared using balsa wood.
- The glider was dropped from a height of 20m.
- The results were noted and showed the motion of glider in a helical fashion.
- The screenshots of the video are shown in the image below.
- The Glider sustained shock force of 30Gs.

Structure Survivability

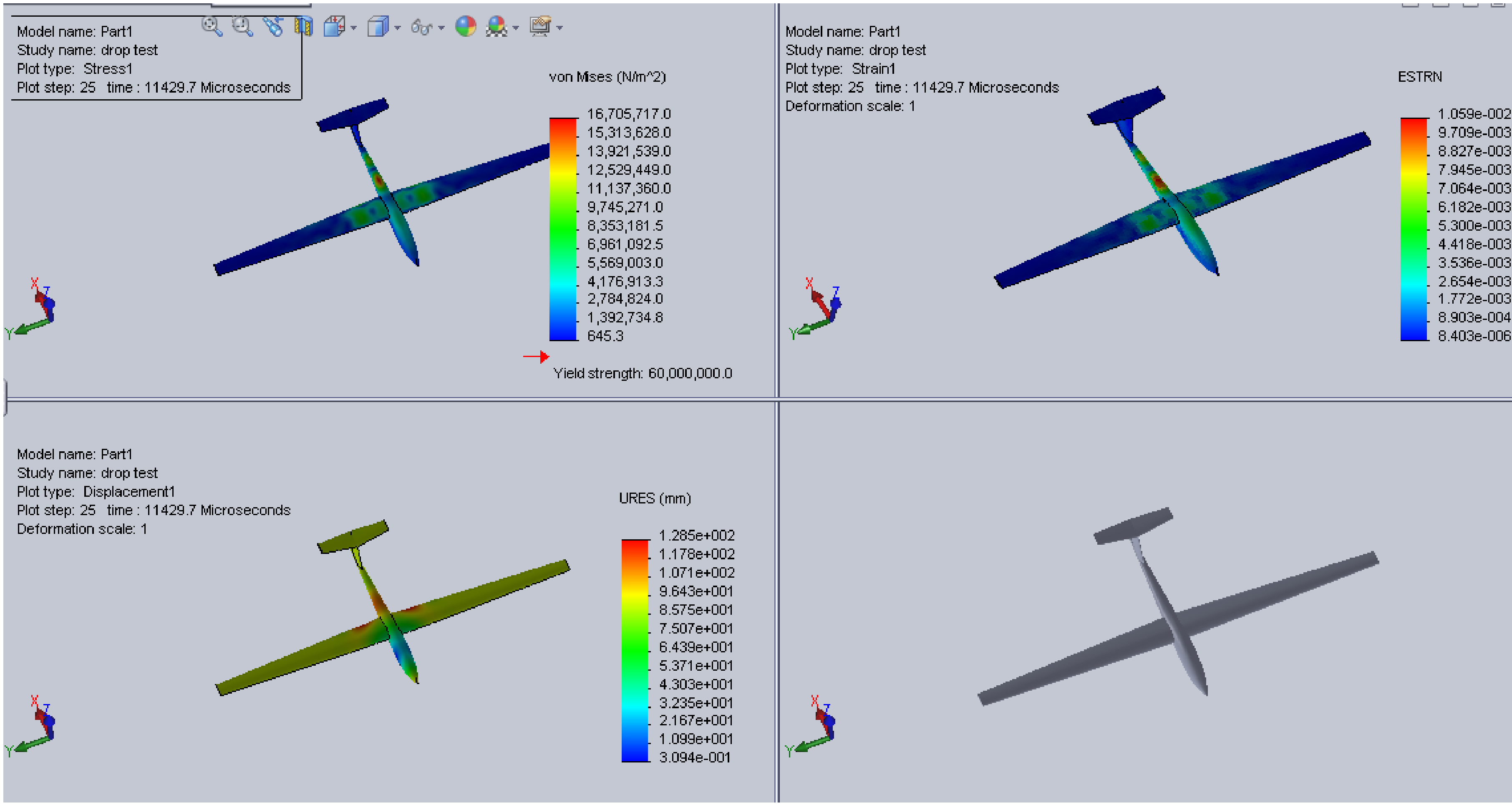
Structure Survivability

Drop Test Observations for Glider (Using Solidworks)

- A scale model of glider was prepared in solidworks.
- Material selected was Nylon.
- 30Gs of shock and 15Gs of acceleration was applied.
- The results were noted and showed no sign of deformation or any permanent damage.
- The results are tabulated in the next slide.

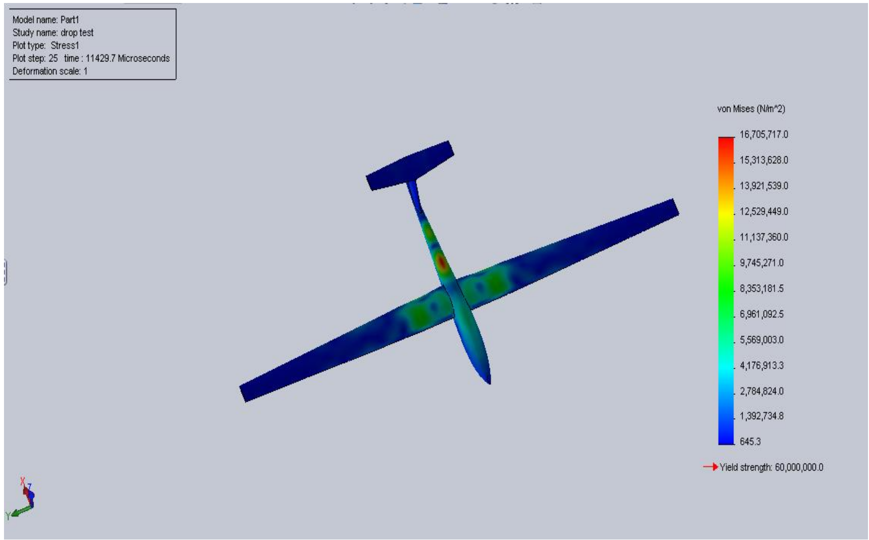


DROP TEST SIMULATION OF THE GLIDER

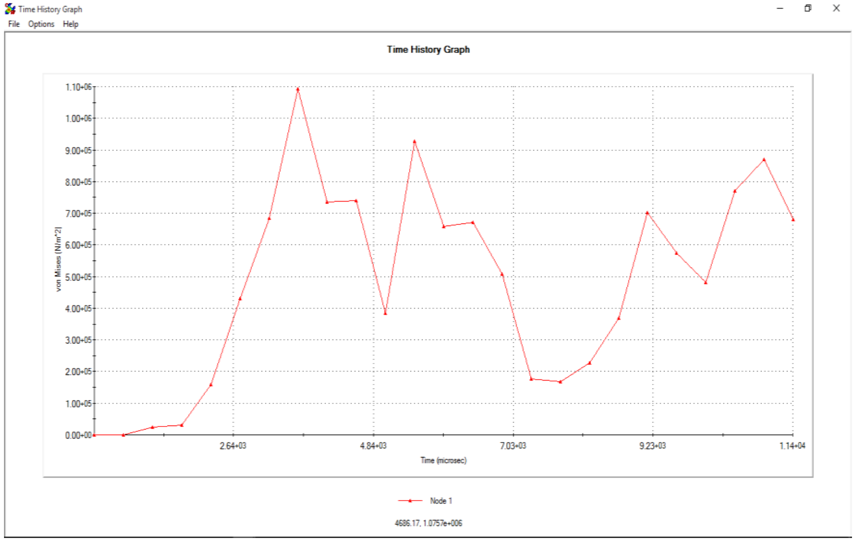


Stress, Displacement and Strain variation throughout the Glider

Structure Survivability



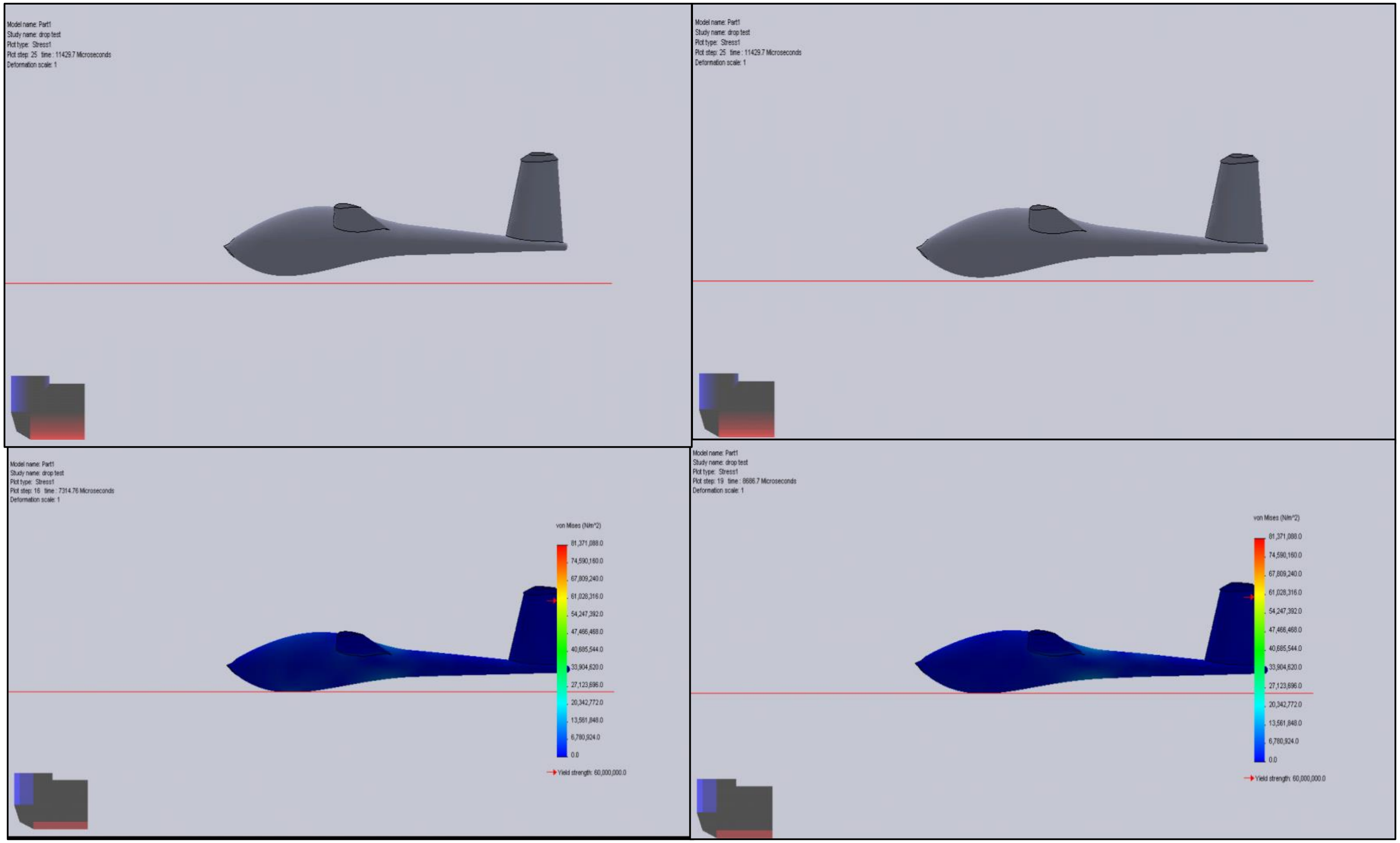
Stress Distribution



Time History Graph

Structure Survivability

Simulation shows no deformation occurs at 30gs of shock and 15gs of acceleration.



Note:- Simulation video can presented upon request.

Mass Budget

RE-ENTRY CONTAINER

SYSTEM	SUBSYSTEM	SUBSYSTEM MASS(gm.)	PERCENT (%)	VM
Re-Entry Container	Body	50	10	Estimate
	Servo motor	30	6	Exact
	Batteries	30	6	Exact
	Parachute	10	2	Estimate
	Electronics	30	6	Estimate
	TOTAL	150 gm		

Mass Budget

GLIDER

SYSTEM	SUBSYSTEM	SUBSYSTEM MASS(gm.)	PERCENT (%)	VM
Glider	Structure	150	30	Estimate
	Electronics	190	38	Estimate
	Margin	10	2	Estimate
	TOTAL	340-360 gms		

TOTAL

SYSTEM	SUBSYSTEM	SUBSYSTEM MASS(gm.)	PERCENT (%)	VM
Re-Entry Container + Glider	Re-entry Container	150	30	Exact
	Glider	340-360	66-70	Estimate
	TOTAL	490-510 gms		

Communication and Data Handling Subsystem Design

Amitabh Yadav

CDH Overview

MICRO-CONTROLLER(S) UTILIZED :

- **Re-Entry Container** : Arduino Nano
- **Glider** : Arduino Uno

Interfacing of sensors to the Arduino Uno (based on ATmega328P) and Arduino Nano (based on ATmega328) with higher data processing speed would enable faster transmitting of data through telemetry.

INTERFACED DEVICES:

- **Pressure and Altitude Sensor:** BMP180 sensor would enable simultaneous recording and analysis of pressure and altitude measurements.

- **Temperature Sensor:** LM35 is easy to interface using ADC port and easy to program sensor with wide range of temperature (-55 C to 150 C) sensing.

CDH Overview

- **Voltage Measurement:** Voltage-Divider Circuit is employed to measure the battery voltage via the ADC port.
- **Pitot tube:** Pitot Tube MPXV7002 sensor uses the ADC port
- **GPS Device:** UbloxNeo6-MV2
- **Camera:** Serial TTL Camera VC0706 processor

CDH Changes Since PDR

The only change made in the CDH since PDR is in the Telemetry Format section.

- **Using ‘,’ only instead of ‘<’ or ‘>’.**

The listed change has been made to the section Telemetry Format so as to make it easier to pass the data by dropping symbols such as ‘<’ or ‘>’ and separating the telemetry data sent only by a comma(,).

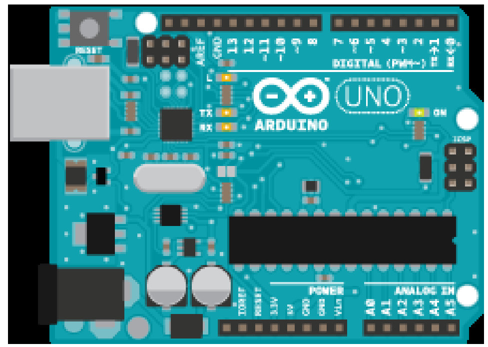
LM35 Temperature sensor has been replaced with BMP180 Sensor to record Temperature Readings.

CDH Requirements

ID	REQUIREMENT	RATIONALE	PARENT	PRIORITY	VM			
					A	I	T	D
CDH-01	Receive Data Stream	Descent Telemetry Package (at 1Hz rate)	SR-13	HIGH	✓	✓		
CDH-02	Transmit Altitude in Meters	Descent Telemetry Package (at 1Hz rate)	SR-12	HIGH	✓	✓	✓	
CDH-03	Transmit Pressure in Pa	Descent Telemetry Package (at 1Hz rate)	SR-12	HIGH	✓	✓	✓	
CDH-04	Transmit Temperature in Degree Celsius	Descent Telemetry Package (at 1Hz rate)	SR-12	HIGH	✓	✓	✓	
CDH-05	Transmit Battery Voltage in Volts	Descent Telemetry Package (at 1Hz rate)	SR-12	HIGH	✓			✓
CDH-06	Transmit speed in m/s	Descent Telemetry Package (at 1Hz rate)	SR-12	HIGH	✓			
CDH-07	Terminate Telemetry	Terminate at Landing	SR-12	MEDIUM	✓	✓		✓

Processor & Memory Selection

Arduino Uno has been selected (based on ATmega 328P) for the Glider.



<u>Selection Criteria</u> :

- Flash Memory of 32 KB (ATmega328P)
  of which 0.5 KB used by bootloader
- SRAM- 2 KB (ATmega328P) and EEPROM- 1 KB (ATmega328P)
- Provides UART TTL (5V) serial communication, SPI and I2C (TWI) communication.
- Ease of programming(Arduino IDE)
- Lesser weight and dimensions (by using the mounted AtMega328 only)
- Lower Power Consumption (in both, Active and Idle Mode)
- 6 analog inputs

Arduino Nano has been selected (based on ATmega 328) for the Re-entry container.

<u>Selection Criteria</u> :

- Flash memory- 32 KB (ATmega328) of which 2 KB used by bootloader.
- SRAM- 2 KB (ATmega328) and EEPROM- 1 KB (ATmega328)
- Provides UART TTL (5V) serial communication, SPI and I2C (TWI) communication.
- Ease of programming(Arduino IDE)
- Weight- 5g
- Lower Power Consumption (in both, Active and Idle Mode)
- 8 analog inputs, each of which provide 10 bits of resolution (i.e. 1024 different values).

Sony 4GB Memory Card is selected for Data and Picture storing from Camera

Selection Criteria :

- Medium size
- Ease of Programming Software
- Easy Retrieving of Data
- Supports all Format Data

Processor & Memory Selection

Memory Card Reader Trade Study (Data and Picture Storing on Glider)

Memory Card Reader is used to physically utilize the acquired data saved on the memory card onto a computer software.

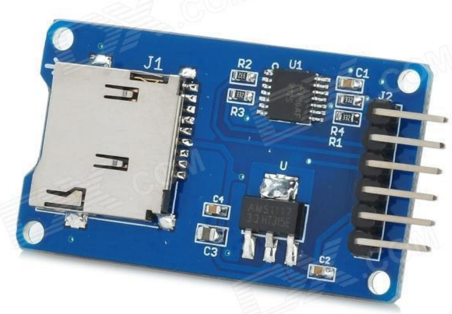
For Arduino, IDE built-in SD card library is used to complete the card initialization, read and write.

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

Mini TF Card Reader Module is Selected.

Selection Criteria :

- Light Weight (5g)
- Small Size (42 * 24 * 12mm)
- No adapter required
- Ease of Programming
- Good Response in previous year CanSat



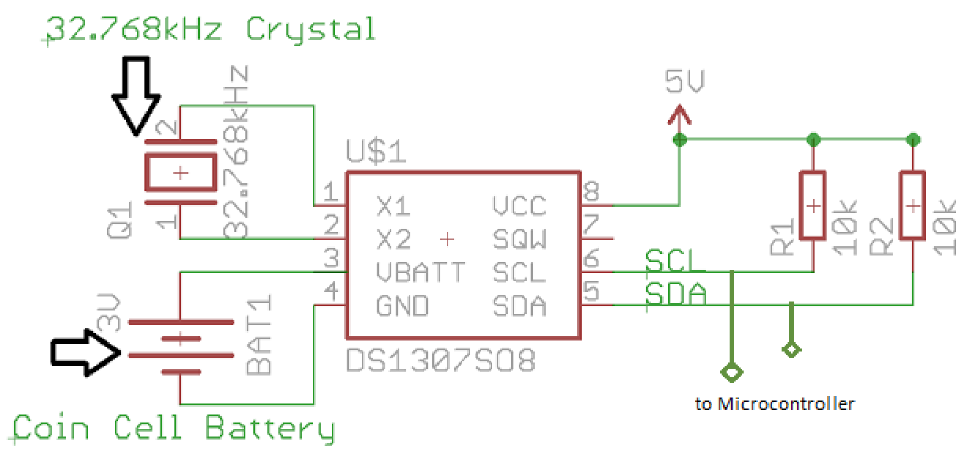
Real-Time Clock

Real Time Clock (RTC) is utilized to keep a record of time during descent of Re-Entry Container and Glider. The data is then sent with the telemetry.

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

Selected RTC : DS1307 (for Glider)

- Faster initialization
- More Accurate
- Reset Tolerance Level is 100ppm



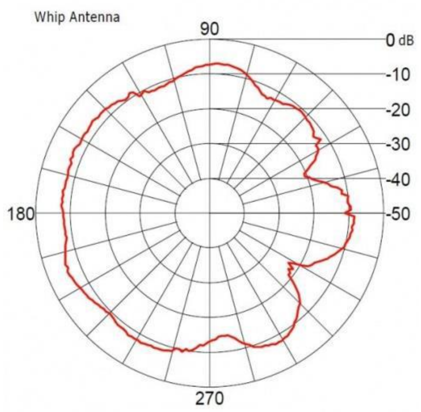
Antenna Selection

XBEE PRO S2B (on Glider):

Antenna Type	Outdoor distance (line-of-sight)	Indoor distance
Chip	1690 ft. (515 m)	140 ft. (43 m)
Whip	4382 ft. (1335 m)	140 ft. (43 m)

Selected: Whip Antenna

The whip antenna has a range advantage over the chip antenna, but only outdoors

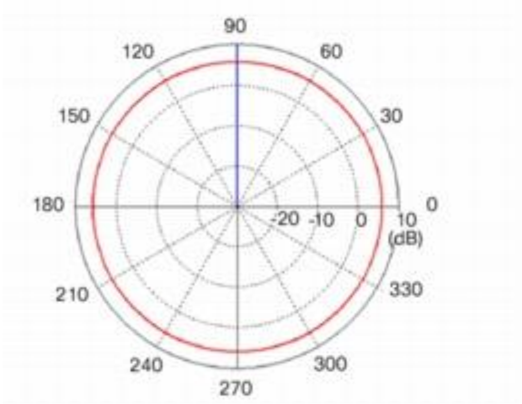


Radiation Pattern of XBee Pro Omni-Directional Whip Antenna

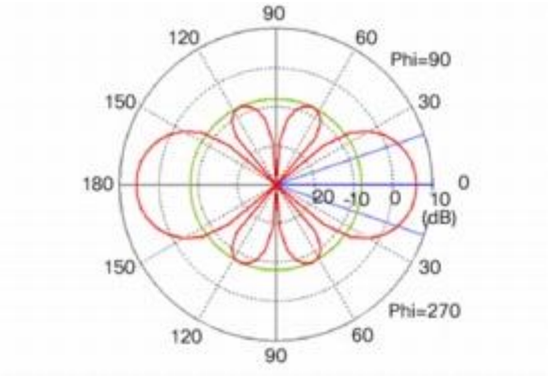
XBEE PRO S2B (at Ground Station):

XBEE LONG RANGE OMNI-DIRECTIONAL DIPOLE ANTENNA

- High Gain 9dBi & Field Pattern are utilized.
- Larger Dimension allows better reception.
- Higher Range Antenna
- Frequency same as that of XbeePro S2B(Specific for XbeeRadios)
- **Mass : 55gms**



Omni Elevation Plane Pattern



Omni Azimuth Plane Pattern

Radio Configuration

The **XBEE Radio** is configured is accomplished using AT Mode (Ground Station being Coordinator AT & Glider Xbee as Router AT). The Xbees Module transfers data at a rate of 250Kbps.

- Indoor transmission and Receiving Range is 90m and the RF Line-of-Site-range is **3200m.**
- **XBEE Radio Module** is interfaced to the microcontroller, Arduino Uno using USART Communication Transmission(Tx) and Receiving(Rx) Ports.
- The PAN ID for data communication will be the team number-**1274**

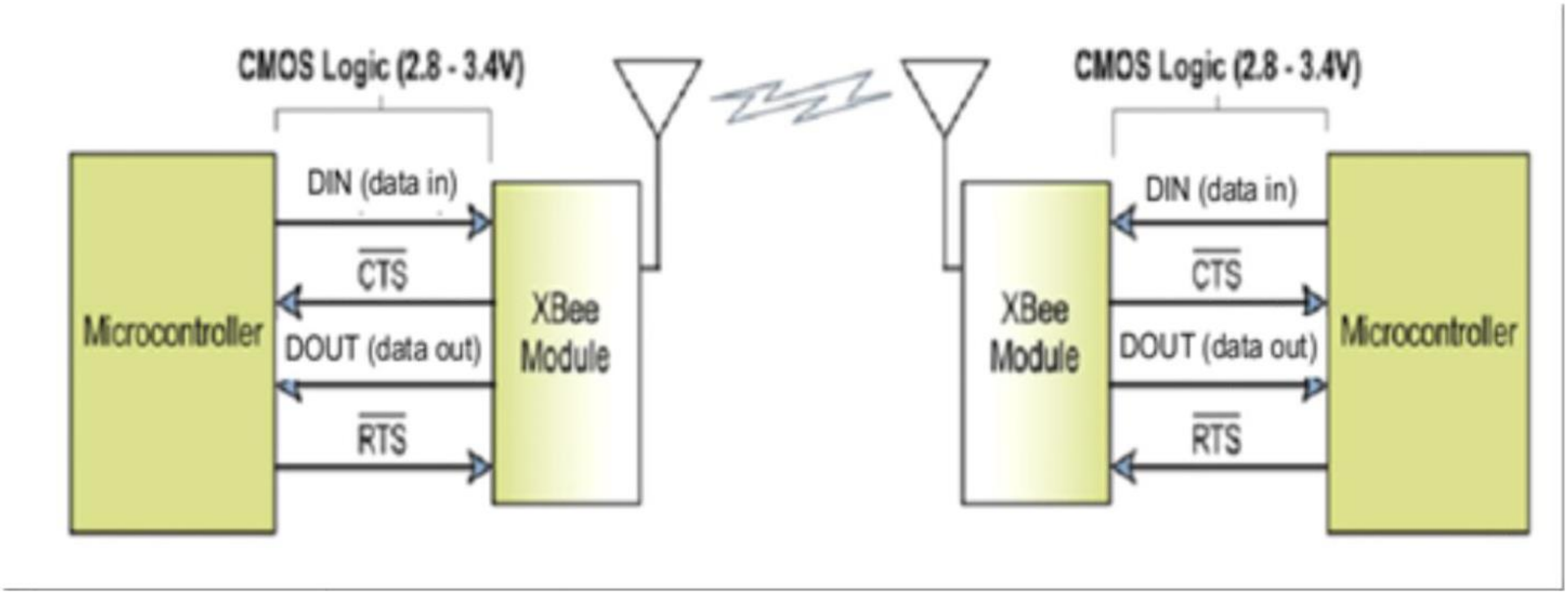
Though Omni-directional, Antennae for Glider will be facing downward for ease in transmission of data packages.

Modes in USART with XBEE PRO ZB	
DATA BITS	8
BAUD RATE	9600
CONTROL RATE	NONE
PARITY COUNTER	NONE
TRANSMISSION MODE	ASYNCHRONOUS
STOP BITS	1
UART RECIEVER	ON
UART TRANSMITTER	ON

Radio Configuration

- The radio configuration protocol will be transmitting data at every 1 second of descent.
- All transmitted data will be received by the Ground Control System and logged on to the developed software.
- Data is transferred through the entire time of ascent and during FSW and Descent time effectively.
- At every phase, logging is done onto the software at the Ground Control.
- RADIO PROTYPING IS ACCOMPLISHED and TESTING IS YET TO BE DONE.

Radio Configuration



Telemetry Format

START BIT → SENSOR DATA → VOLTAGE DATA → GPS DATA → STOP BIT

DATA FORMAT FOR GLIDER SYSTEM

The Above mentioned Data Flow comprises of :

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

Telemetry Format:

TEAMID, MISSION TIME, PACKETCOUNT, ALTSENSOR, PRESSURE, SPEED, TEMP, VOLTAGE,
GPS LATITUDE, GPS LONGITUDE, GPS ALTITUDE, GPS SAT NUM, GPS SPEED, COMMAND TIME, COMMAND COUNT, [BONUS]

Example : 1274, 2, 44, 810.1234, 101325, 5.523, 30.123, 8.23, 33.312234, 77.324211, 808.2522, 6, 5.6435, 56, 1, [BONUS]

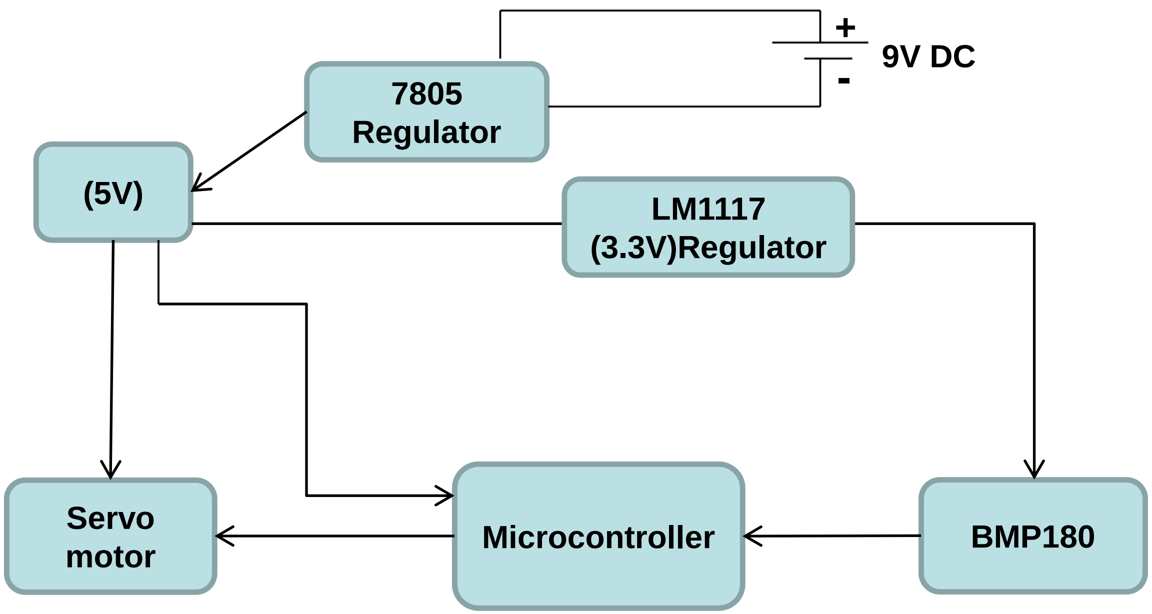
The above format matches the competition guide requirements for CanSat.

Electrical Power Subsystem Design

Shambhavi Dubey

For the Glider and Re-Entry container, we use different electrical power system as per the requirement :

For Re-Entry Container:



EPS Overview

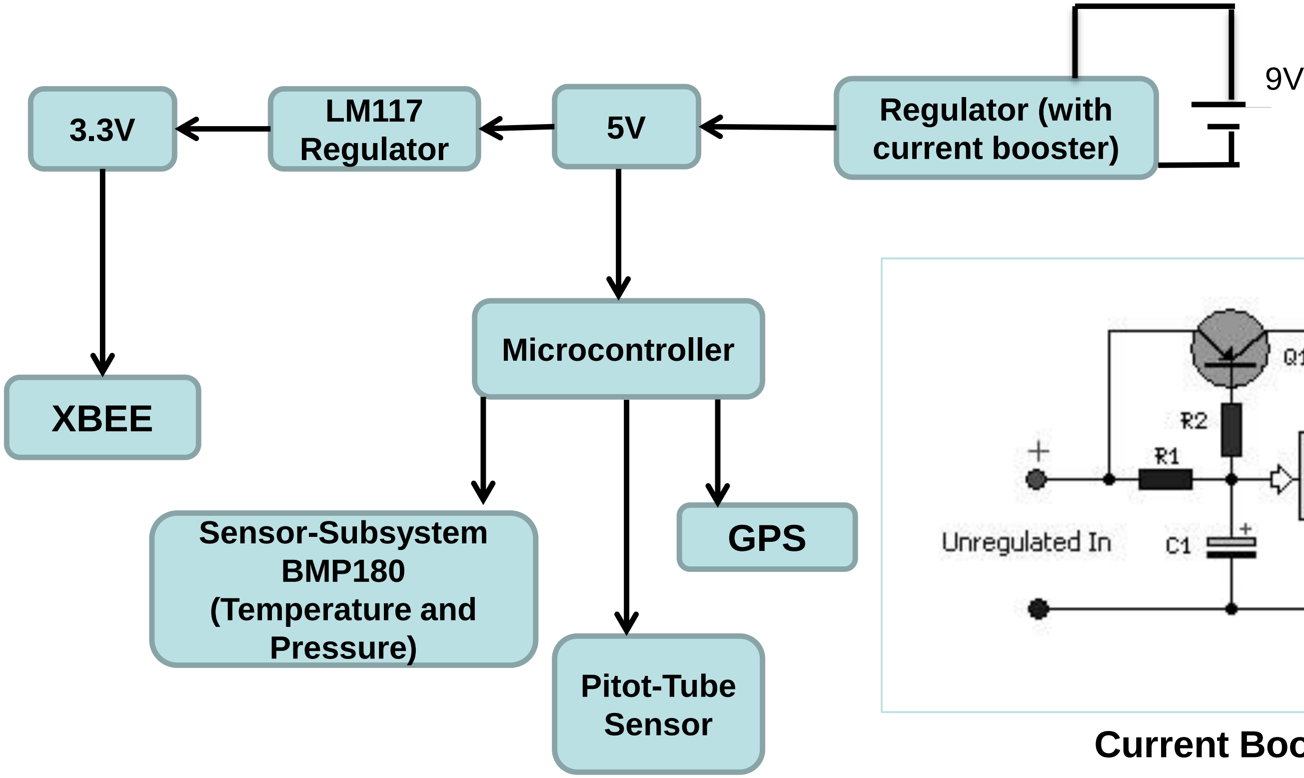
For Re-Entry Container:

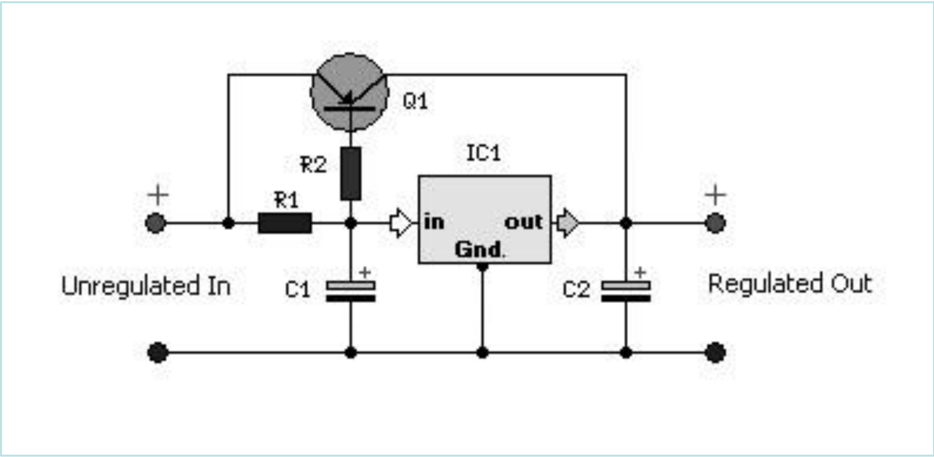
Component	Requirement
9V Alkaline Battery	It is used as a power source of the re-entry container.
Regulator (IC 7805)	Installed so as to stabilize the voltage used by the microcontroller and other components.
Microcontroller (Arduino)	The Controller on which the code resides to interface and drive the Servo Motor, for separation of Glider.
Servo motor	Shift-Rod Mechanism for Separation of Glider.

EPS Overview

For Glider:

- The volt regulator LM7805 needs to provide a little bit more current than it actually can handle, for interfacing Xbee alongside the Microcontroller (Arduino Uno).
- The power transistor (such as the 2N3772 or similar) is used to boost the extra needed current above the maximum allowable current provided via the regulator.





Current Booster Circuit

EPS Overview

For Glider:

Components	Purposes
Battery(9V)	It is used as a power source for the Glider section for the purpose of data collection
Regulators	Installed so as to stabilize the voltage and use it for the microcontroller and X-bee.
Microcontroller	Controller on which the code resides to interface or drive GPS and Pitot tube.
XBEE	Wireless communication module that will send the data to the ground control station
Sensors	Used to collect information regarding the temperature and pressure
Pitot tube	Used to measure the air speed
GPS	To Transmit exact location of the Glider

EPS Changes Since PDR

- The problem with the transmit current and power consumption of the xbee has rectified.

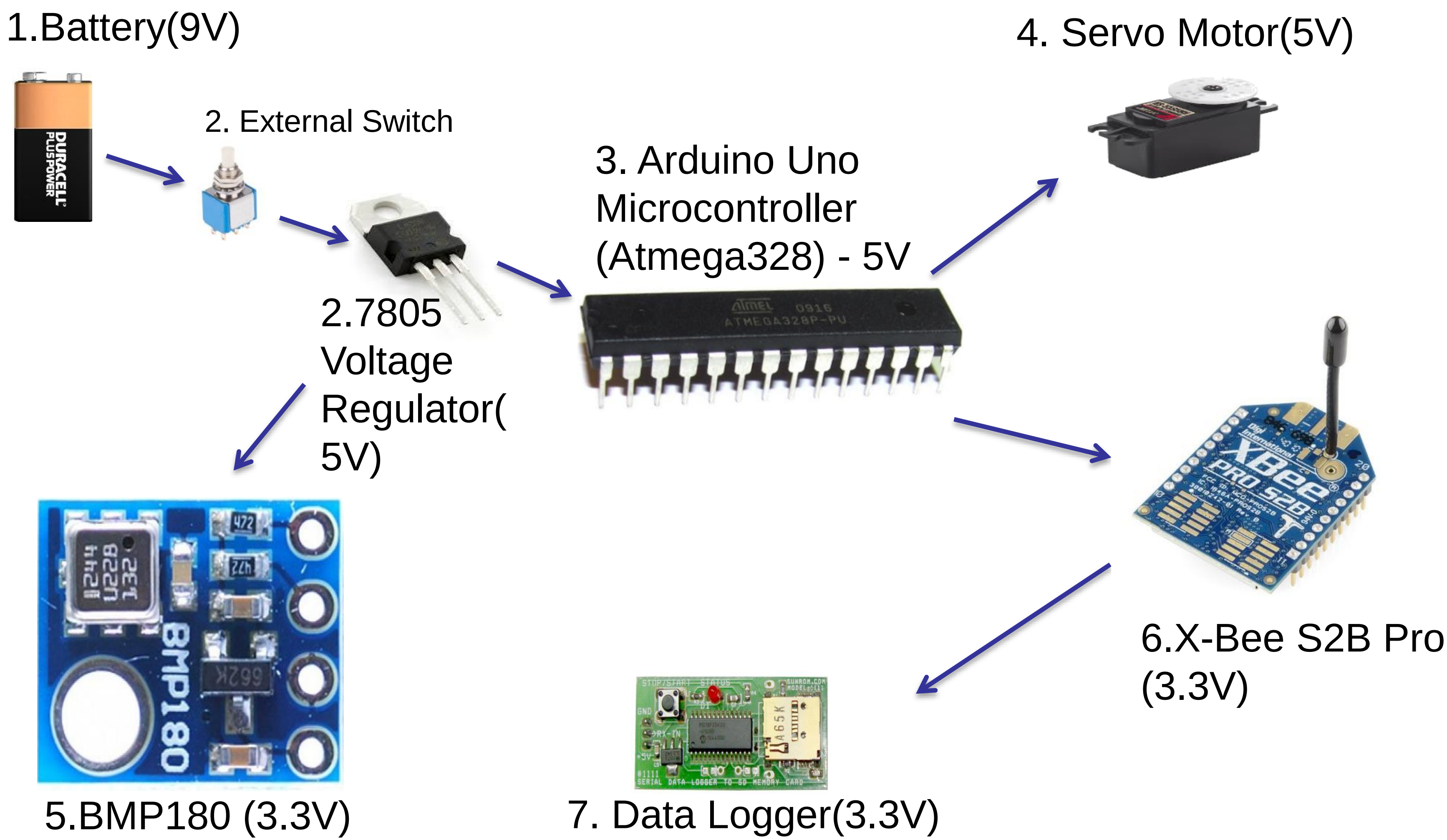
- The current and power consumption of all the components is crosschecked again in the power budget slide.

EPS Requirements

ID	REQUIREMENT	RATIONALE	PARENT	PRIORITY	VM			
					A	I	T	D
EPS-01	Battery Requirement (9V)	4.5V required for Micro Controller and Pressure, Temperature Sensor, Servo 3.3V for Memory, GPS and Transceiver 3V required for Camera.	SR-21	HIGH		✓		✓
EPS-02	Battery Requirement (9V)	To be able to provide adequate power for the whole period of flight	SR-21	HIGH		✓		

Electrical Block Diagram

RE-ENTRY CONTAINER:

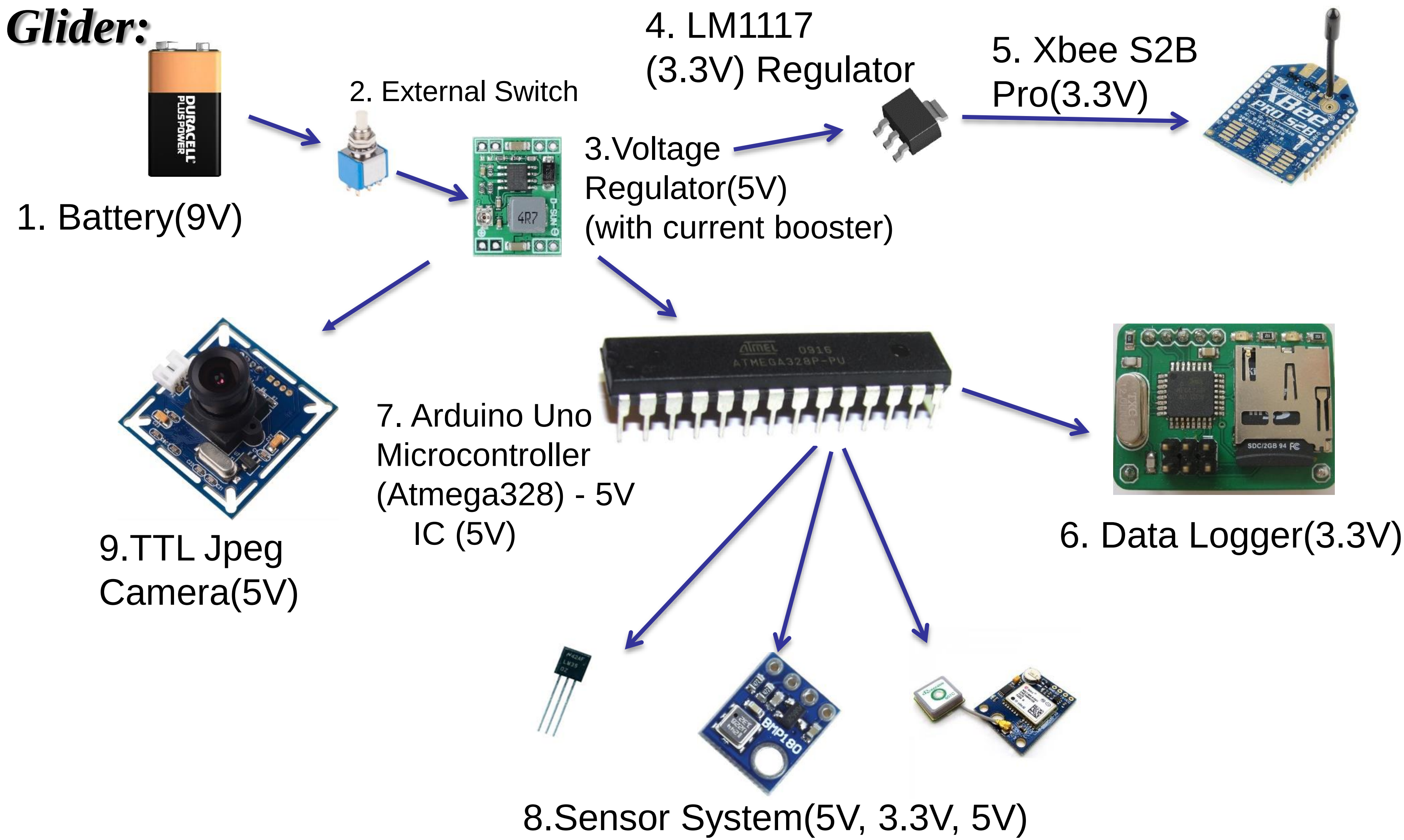


Electrical Block Diagram

RE-ENTRY CONTAINER:

S No.	Component	Function
1.	Battery	Power Source for the reentry container 9 V alkaline battery – Only power (battery) source in the entire mission
2.	Voltage Regulator	Voltage regulator to bring the voltage to desired level 3.3 – 4.7 v for all the functioning of components
3.	Microcontroller IC	Controller on which the code resides to get the data and to control the servo and to send the data through wireless module
4.	Servo Motor	Servo to start and disconnect the Glider using release mechanism
5.	BMP 180	Measures altitude to check the instant for separation mechanism
6.	X-bee Module	Wireless link which communicates with Ground Control Station
7.	Data Logger	Data is stored on to SD card using data logger device

Electrical Block Diagram



Electrical Block Diagram

Glider:

S No.	Components	Function
1.	Battery	Provides power during descent to power all the components for data collection
2.	Voltage Regulator	Stabilizes the voltage to 5V (LM7805) and 3.3V(LM1117) and regulates it
3.	X-Bee S2B Pro	Sends all the data instantaneously to the GCS which would be seen on the FSW software at the ground
4.	Data Logger	Saves the picture that sent by camera on memory card
5.	Microcontroller	Controller on which the code resides to run the sensor system and camera.
6.	Sensor System	Sensor network consisting of temperature, speed and altitude measurements and GPS
7.	Camera	Used to click the required picture when instructed.

Payload Battery Selection

We use alkaline 9V battery for power source to provide constant power supply to the payload.

Features:

- **Battery Capacity : 9V, 570 mAh**
- **High Energy Density**
- **Low internal resistance**
- **Performs equally well in low and as well as high rate of discharge**

Power Budget

- **Power Budget of Container**

Device	Avg. Power Consumption	Voltage	Current	Time
Microcontroller	0.11mW	3V to 5V	28 mA	100%
X-bee	63 mW	3.3V to 3.6V	40mA	100%
Pressure Sensor	2.5mW	5V	1mA	100%
SD Card	0.3mW	5V	1mA	100%

Source : Datasheet

Total Power Consumption	1093.8 mW
Power Available	9.5 W
Margins	8.41 W

Power Budget

- **Power Budget of Glider**

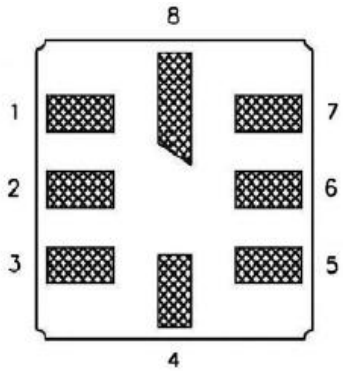
Device	Avg. Power Consumption	Voltage	Current	Time
Microcontroller	0.11mW	3 to 5V	28mA	100%
Regulator	0.1mW	3.4 to 4.5V	92% eff.	100%
XBee	63 mW	3.3 to 5v	40 mA	100%
Pressure Sensor	2.5mW	5V	22.7mA	100%
SD Card	0.3mW	5V	1mA	100%
Camera	60mW	2.5 to 3V	20mA	100%

Source : Datasheet

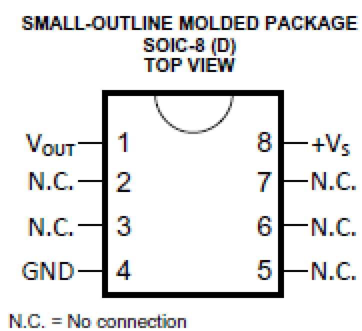
Total Power Consumption	123.01 mW
Power Supply	9.5W
Margins	9.376 W

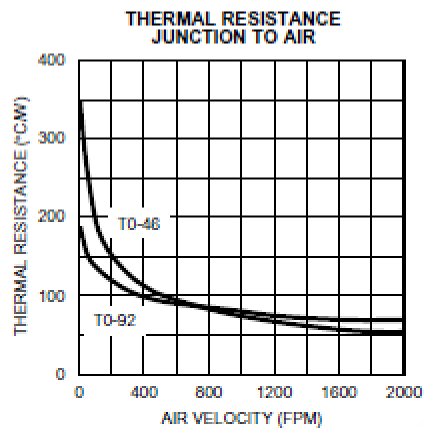
Power Budget

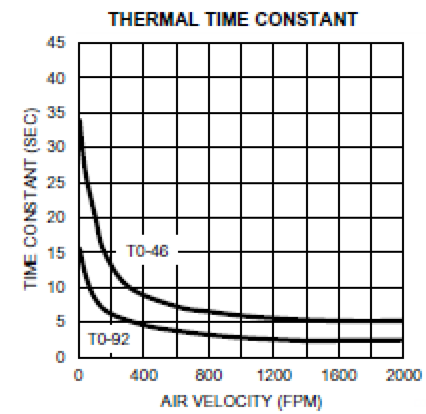
- **Pressure Sensor**



Pin No.	Name	Function	Type
1	GND	Ground	Power
2	EOC	End of conversion	Digital output
3	V_{DDA}	Power supply	Power
4	V_{DDD}	Digital power supply	Power
5	NC	no internal connection	-
6	SCL	I^2C serial bus clock input	Digital input
7	SDA	I^2C serial bus data	Digital bi-directional
8	XCLR	master clear (low active) input	Digital input

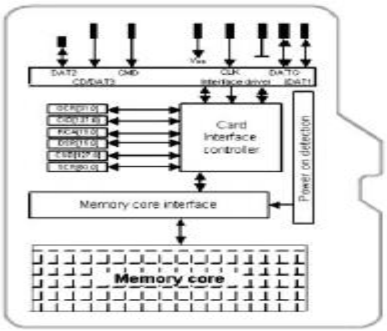






Power Budget

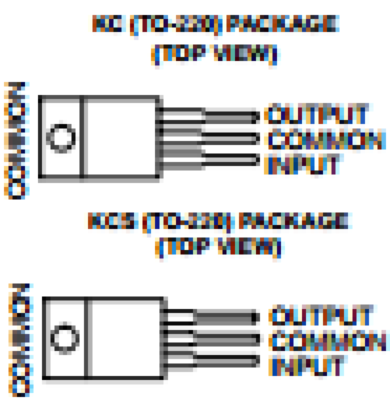
- **SD Card**



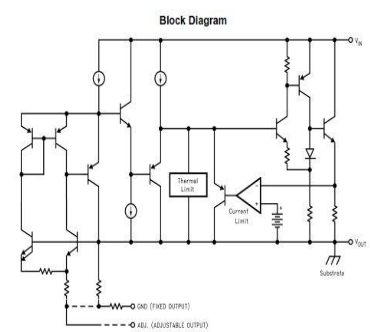
Pin Definition

Pin No.	SD Mode			SPI Mode		
	Name	Type	Description	Name	Type	Description
1	DAT2	I/O/PP	Data Line [Bit2]	RSV		Reserved
2	CD/DAT3	I/O/PP	Card Detect / Data Line [Bit3]	CS	I	Chip Select
3	CMD	PP	Command / Response	DI	I	Data In
4	V_{DD}	S	Supply voltage	V_{DD}	S	Supply voltage
5	CLK	I	Clock	SCLK	I	Clock
6	V_{SS}	S	Supply voltage ground	V_{SS}	S	Supply voltage ground
7	DAT0	I/O/PP	Data Line [Bit0]	DO	O/PP	Data out
8	DAT1	I/O/PP	Data Line [Bit1]	RSV		Reserved

- **Regulator**

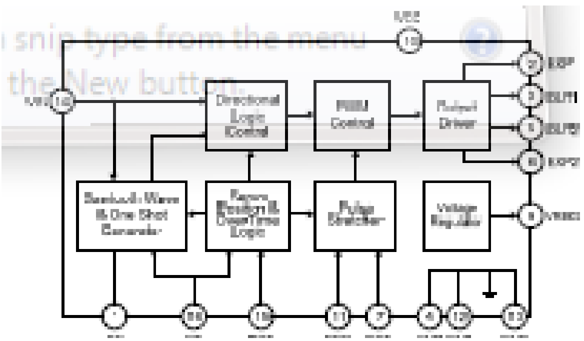


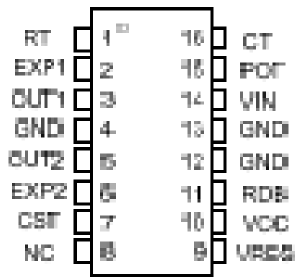
Maximum Input Voltage (V_{IN} to GND)		20V
Power Dissipation(3)		Internally Limited
Junction Temperature (T_J)(3)		150°C
Storage Temperature Range		-65°C to 150°C
Lead Temperature	TO-220 (T) Package	260°C, 10 sec
	SOT-223 (IMP) Package	260°C, 4 sec
ESD Tolerance(4)		2000V



Power Budget

- **Servo Motor**



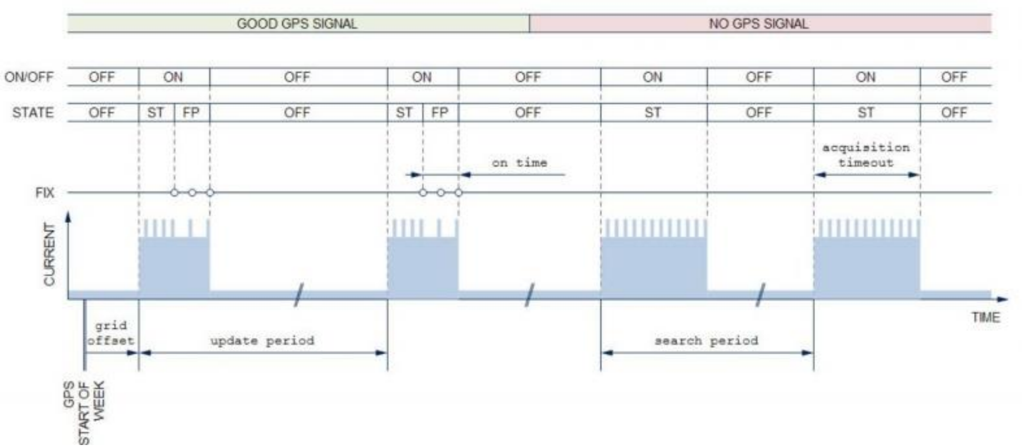


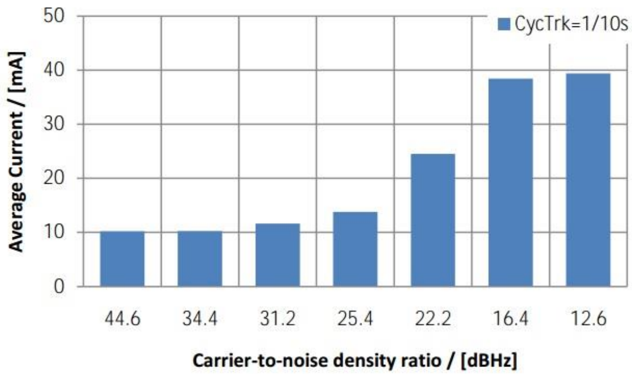
PIN NO.	PIN NAME	FUNCTION
1	RT	Timing Resistor
2	EXP1	External PNP Transistor 1 output
3	OUT1	Output Driver 1
5	OUT2	Output Driver 2
6	EXP2	External PNP Transistor 2 output
7	CST	Stretcher capacitor
8	NC	No Connection
9	VREG	Regulated Voltage output
10	VCC	Power supply pin
11	RDB	Error pulse output
4,12,13	GND	Ground pin
14	VIN	Input signal
15	POT	Servo position voltage
16	CT	Timing Capacitor

Xbee Pro S2B:

- Transmit power :2 mW (+3 dBm) boost mode
- Receiver sensitivity: 96dbm in boost mode
- Supply Voltage : 2.1-3.6 VDC
- Power down Current : 35 mA to 45 mA boost mode@ 3.3VDC
- Transmit current : 38 to 40 mA boost mode @ 3.3 VDC
- Receive Voltage :< 1µA @ 25 ºC

GPS Sensor

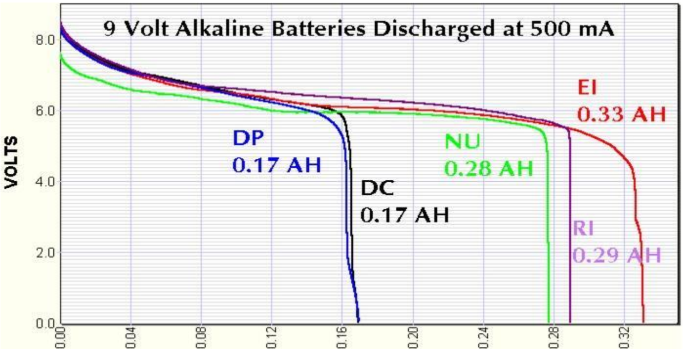




- ON/OFF operation is available for update periods of 5 s and longer whereas cyclic tracking operation is used for update periods between 1 s and 5 s with FW6.02 and between 1 s and 10 s with FW703.

Battery Storage Selection

9V Alkaline Battery has been selected because it possesses a long discharging rate as compared to other battery sources.

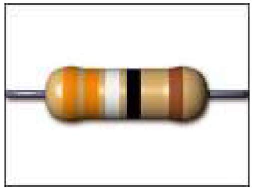


Power Bus Voltage Measurement

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

Device	Accuracy	Weight	Range
DS2438	±0.5%	4 gm.	0 to 10 V
Voltage Divider	±0.1%	Negligible	Any Range

A comparison was made between DS2438, RB-Phi- 86 and Voltage Divider.



Voltage Divider resistive circuit is preferred

- Low Cost Small in Size and Weight.
- Highly Accurate .
- Easily available .

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

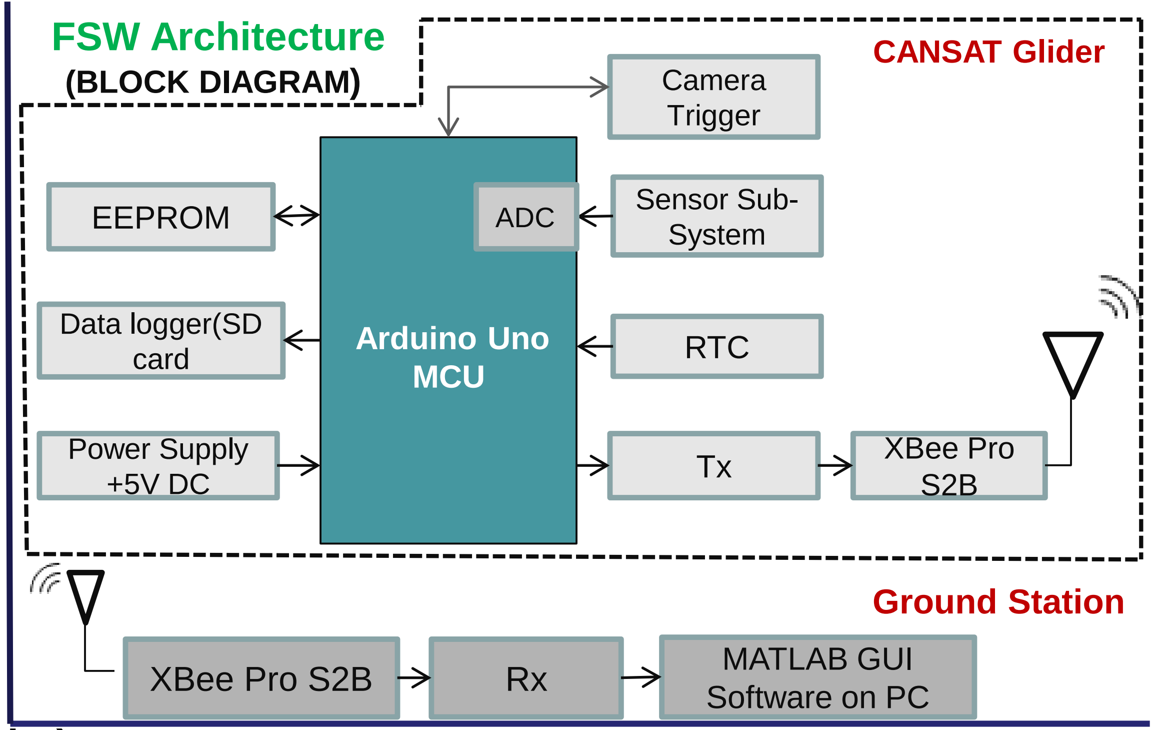
Flight Software (FSW) Design

Raghav Garg

FSW Overview

– A procedural programming approach is followed to simplify the glider telemetry operations.

- **Basic FSW architecture**
  - It tells what programming paradigm has to be employed to run on the hardware.
  - Gathers data and runs at a loop rate of 1 Hz.
- **Programming languages**
  - Arduino Programming
  - C/C++
- **Development environments**
  - Arduino IDE



- **Brief summary FSW tasks (on glider)**
  - Receive and plot air pressure, altitude, air temperature, speed, GPS data and battery voltage.
  - Transmit all real time flight telemetry at a 1 Hz rate.
  - Capture image of ground when told and store for later retrieval.
  - Check & Change the FSW_State parameters using the altitude reading from BMP180 sensor.
  - Activate Separation Mechanism.
  - Maintain packet counts transmitted + save the recorded data on system in a .CSV file.
  - Recover to correct state during processor rest.

FSW Changes Since PDR

- The section under FSW tasks on glider has been modified.
- A detailed Pseudo-code of operations has been added with a little detailed description to the State Flow diagram.
- Flight Software development has been divided into two teams A and B being assigned with respective tasks.
- Phase I of the plan is successfully completed and currently working on Phase 2.

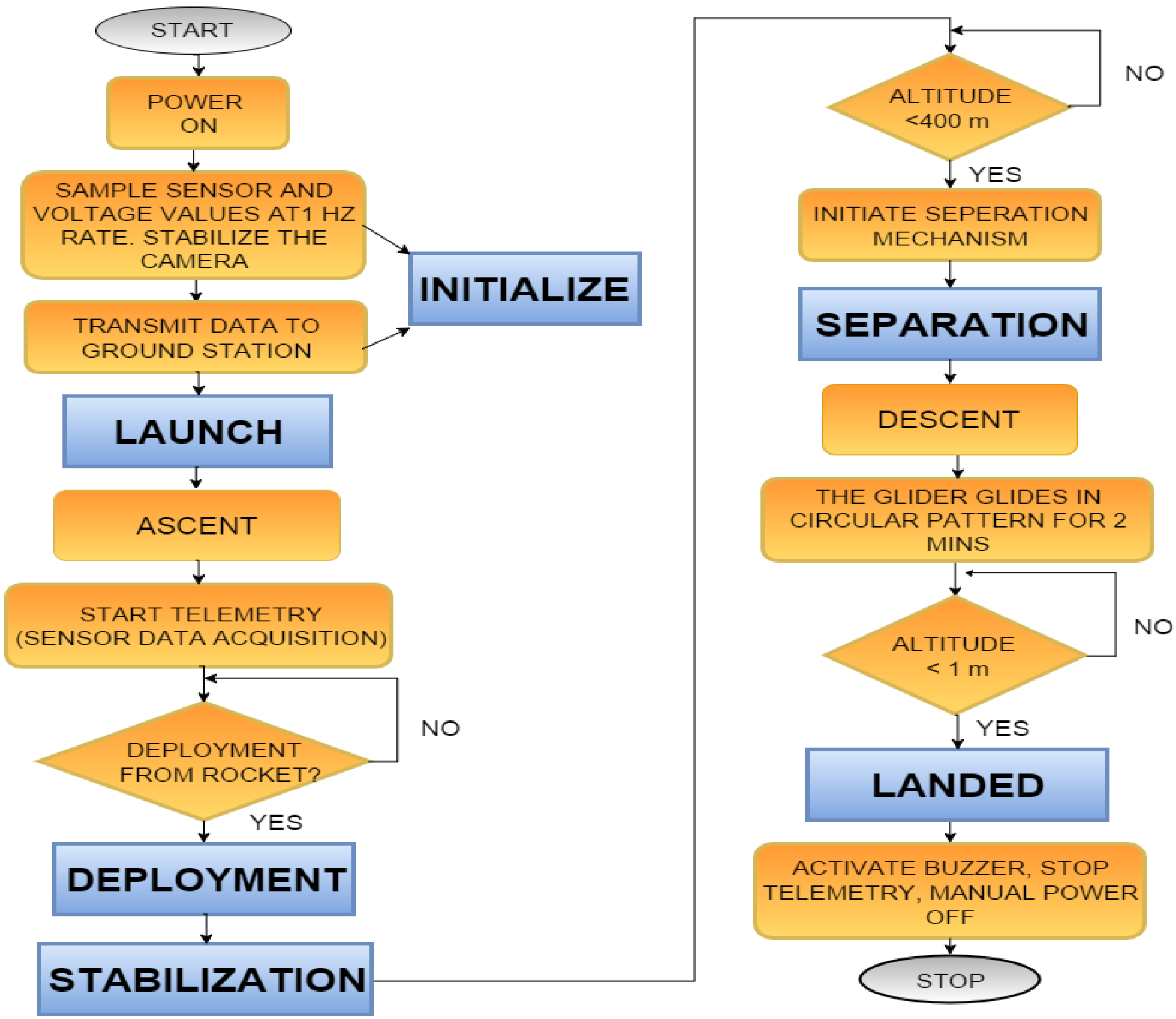
FSW Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
FSW-01	Detection of appropriate condition and initialization for Glider deployment	Competition Requirement	HIGH	SR-06	✓			
FSW-02	Sampling and collection of sensor data in processor	Competition Requirement	HIGH		✓	✓	✓	
FSW-03	Transmit real time telemetry at 1 Hz rate throughout the mission	Competition Requirement	HIGH	SR-18	✓		✓	
FSW-04	Telemetry will include mission time with one second or better resolution	Competition Requirement	HIGH	SR-18	✓		✓	✓
FSW-05	Telemetry data will be displayed in engineering units	Competition Requirement	HIGH	**SR-16**	✓	✓		
FSW-06	Maintain the count of packets transmitted	Competition Requirement	HIGH	SR-18	✓		✓	
FSW-07	Plotting of Data in real time	Competition Requirement	High	SR-12	✓	✓	✓	✓

FSW Requirements

ID	REQUIREMENT	RATIONALE	PRIORITY	PARENT	VM			
					A	I	T	D
FSW-08	Capture the image of ground when given command and store for later retrieval	Competition Requirement	HIGH	SR-22	✓	✓		
FSW-09	The telemetry shall indicate the time the last imaging command was received and the number of commands received.	Competition Requirement	HIGH	SR-13	✓			
FSW-10	Transmission must cease upon landing and a buzzer must be activated	Competition Requirement	HIGH	SR-25	✓	✓		
FSW-11	Recover from any momentary power loss or unexpected processor reset	Competition Requirement	HIGH	SR-15	✓			

CanSat FSW State Diagram



The flowchart of the container and Glider are merged together. The separation mechanism is connected to the Container.

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

FSW STATES :

CanSat FSW State Diagram

:: Pseudo Code ::

```
Start //Power ON the system
Start_RTC();
Memory.fetch_FSW_state(); //initially, FSW State set to 0
//Memory refers to OnBoardMemory preferably EEPROM or
SD Card
If(FSW_state()==0) //recovery to correct state after reset
{
While (1)
{
FSW_State=1; //"Initialize"
readSensorData();
WriteSensorData_toSdCard_CSV();
//Write Sensor Data, RTC& FSW_state
TransmitSensorData(); //Perform Pre-flight test, initializing
If(Launch_Button==HIGH && FScount1==0)
{
FSW_State=2; //"Launch"
WriteFSW_StateToMemory();
FScount1=1;
//FScountX ensures that this condition is checked only once
}
If(FSW_State==2)
{
while (1)
{
readSensorData();
WriteSensorData_toSdCard_CSV();
TransmitSensorData();
```

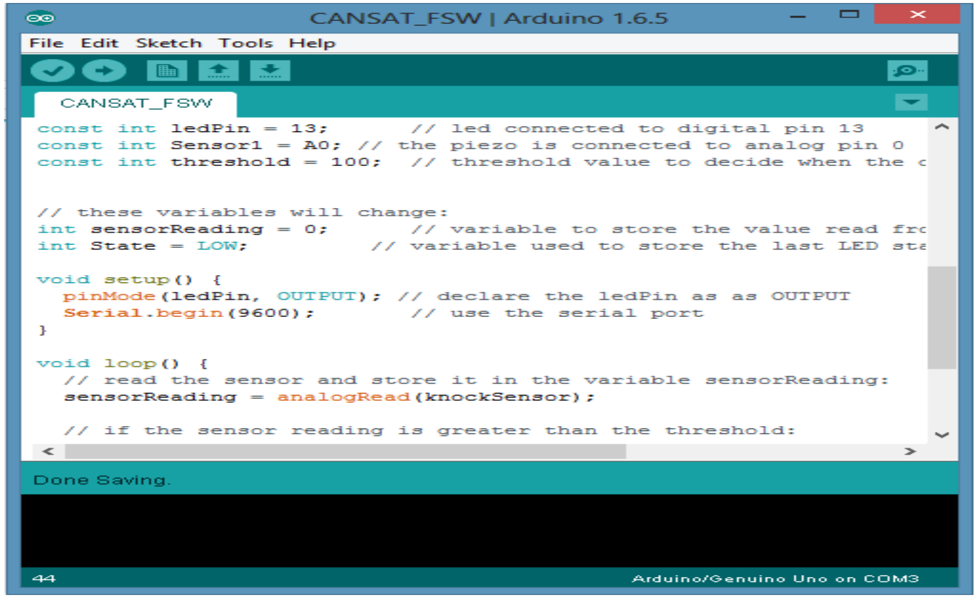
```
preAlt=Fetch_Previous_Altitude_Reading();
if(preAlt>AltNow&& FScount2==0)
//Previous Altitude > AltitudeNow
{
FSW_State=3; //"Deployment"
WriteFSW_StateToMemory();
FScount2=1;
}
if(Stabilization Condition && FSW_State==3 && FScount3==0)
//Previous Altitude > Altitude Now
//Stabilization Condition by seeing a stable decrease in altitude for
//a specified period
{
FSW_State=4; //"Stabilization"
WriteFSW_StateToMemory();
FScount3=1;
}
If (alt_reading<=450 && FSW_State==3 &&cnt==0)
{
FSW_State=4;
WriteFSW_StateToMemory();
cnt=1;
}
If(alt_reading<=400 && (FSW_State==4 || FSW_State==3) &&
FScount4==0){
ActivateSeparationMechanism();
FSW_State=5; //"Glider Separated"
WriteFSW_StateToMemory();
```

Pseudo-Code Contd…

Pseudo-Code Contd…

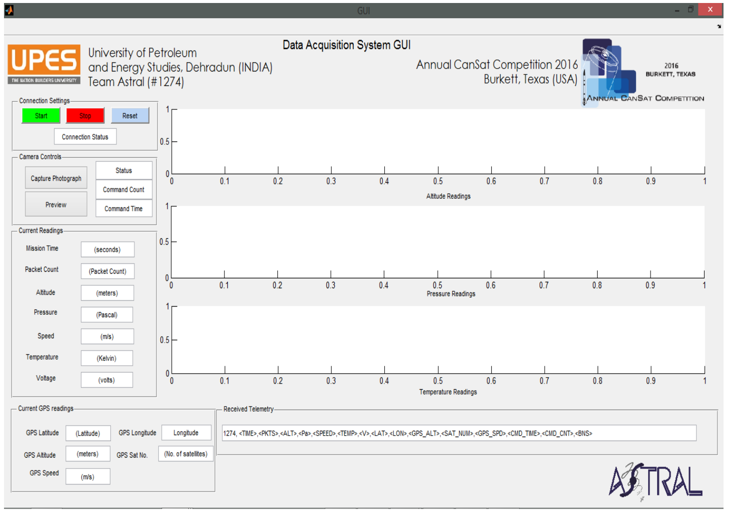
```
FScount4=1;
while (1)
{
readSensorData();
WriteSensorData_toSdCard_CSV();
TransmitSensorData();
if(alt_reading<1m && FSW_State==5 && FScount5==0)
{
FSW_State=6; //"Glider landed"
WriteFSW_StateToMemory();
FScount5=1;
while(1)
{
readSensorData();
WriteSensorData_toSdCard_CSV();
TransmitSensorData();
Activate_BUZZER();
while(1)
{
//Blink LED Infinite Loop. Data Transmission Stops here!
} } } } } } } }}
Else If(FSW_state()==1) //or 2, 3, 4, 5, 6
{
//Call the desired functions after that particular FSW_state
}
```

Note: Data is always transmitted until landing, to keep the design simple and we can always use extra data in analysis.



Arduino 1.6.5 IDE *(up)*

Real Time Data Acquisition Software using Matlab GUI *(right)*



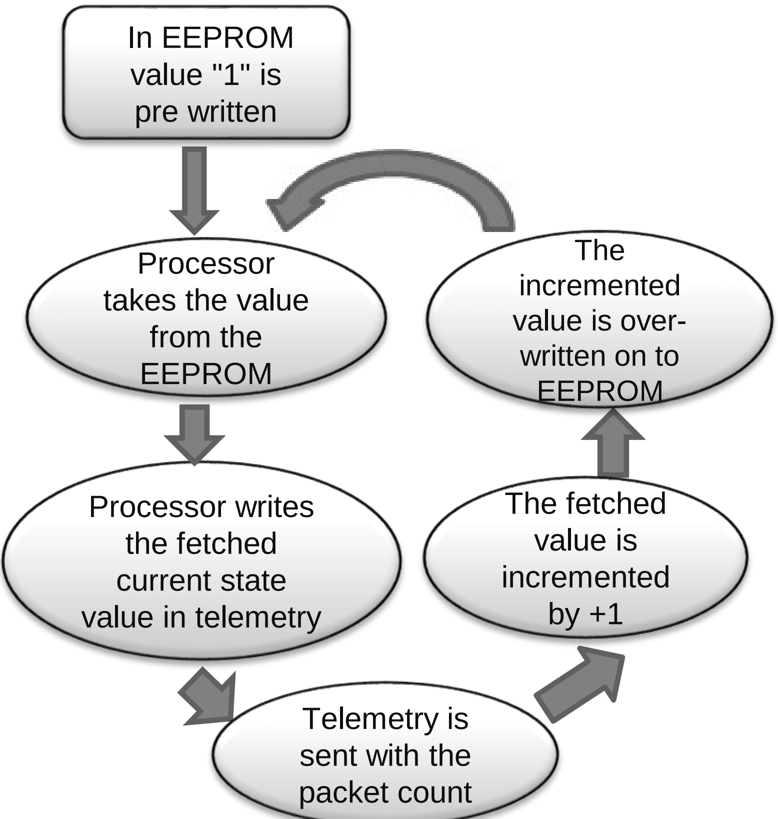
CanSat FSW State Diagram

- Sampling rate for all sensor reading is set to 0.5sec. CANSAT will transmit telemetry at 1Hz rate.
- The Flight software code runs in a loop, samples readings from each sensor at the desired rate and transmits data via 2.4 GHz Xbee at 1 Hz rate.
- The telemetry data from CANSAT is saved as a Comma Separated Value (CSV) file on the Ground Station Software and also, on an on-board SD Card.
- Various mechanisms are activated by checking the altitude readings from BMP180 sensor. Release from rocket is determined by seeing a stable decrease in altitude for a specified period. We choose that because adding extra sensors will add extra weight and complexity.
- On receiving capture command from the GCS software, the camera is triggered to click and transmit the image through the Xbee Radio.
- Major changes in FSW_State parameter are controlled using the data from BMP180 sensor.
- Major Decision Points:
  1. Checking for Rocket Deployment using altitude reading.
  2. Activation of separation mechanism at the desired point.
  3. Trigger the camera on receiving capture command.
- Power Consumption from battery is kept as low as possible by avoiding any unnecessary component/resistors etc.

CanSat FSW State Diagram

Processor Reset Control

- ✓ To power the payload 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 Uno) will be controlling the irregular pattern of the telemetry count

(Selected)

Alternative solution :

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

Software Development Plan

- **Prototyping and prototyping environments :**
  – Prototypes are tested using Breadboard and Arduino serial monitor is used for Debugging.
- **To avoid late software development :**
  – Long slowdowns will be avoided and will try to work as continuously as possible.
  –The work pertaining to hardware development will be divided into small tasks.
  –Will try to keep the things planned to the schedule.
- **Software subsystem development sequence :**
  The software subsystem development has been divided into 3 phases:

PHASE I
- 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 II
- 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 III
- Removing any potential bugs
- Final software will be integrated and tested in real time

Software Development Plan

- **Development Team**

Team A (Raghav Garg and Amitabh Yadav) - Algorithm design, Reset Mechanism and GCS Software Development using Matlab.
Team B (Archit Agarwal and Devarrishi Dixit) - Sensor Sub-System Programming to gather multiple sensor data and communication.

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

Current Progress since PDR :

Phase I is successfully completed. Phase II is in progress & is nearly complete. Data transfer between the sensors and the microcontroller has been tested and verified since PDR. FSW_State operation testing is in progress.

Ground Control System (GCS) Design

Devarrishi Dixit

GCS Overview

Laptop Adapter

Power supply for board

GCS uses the data to populate real time plot graphs

Sends command to capture picture.

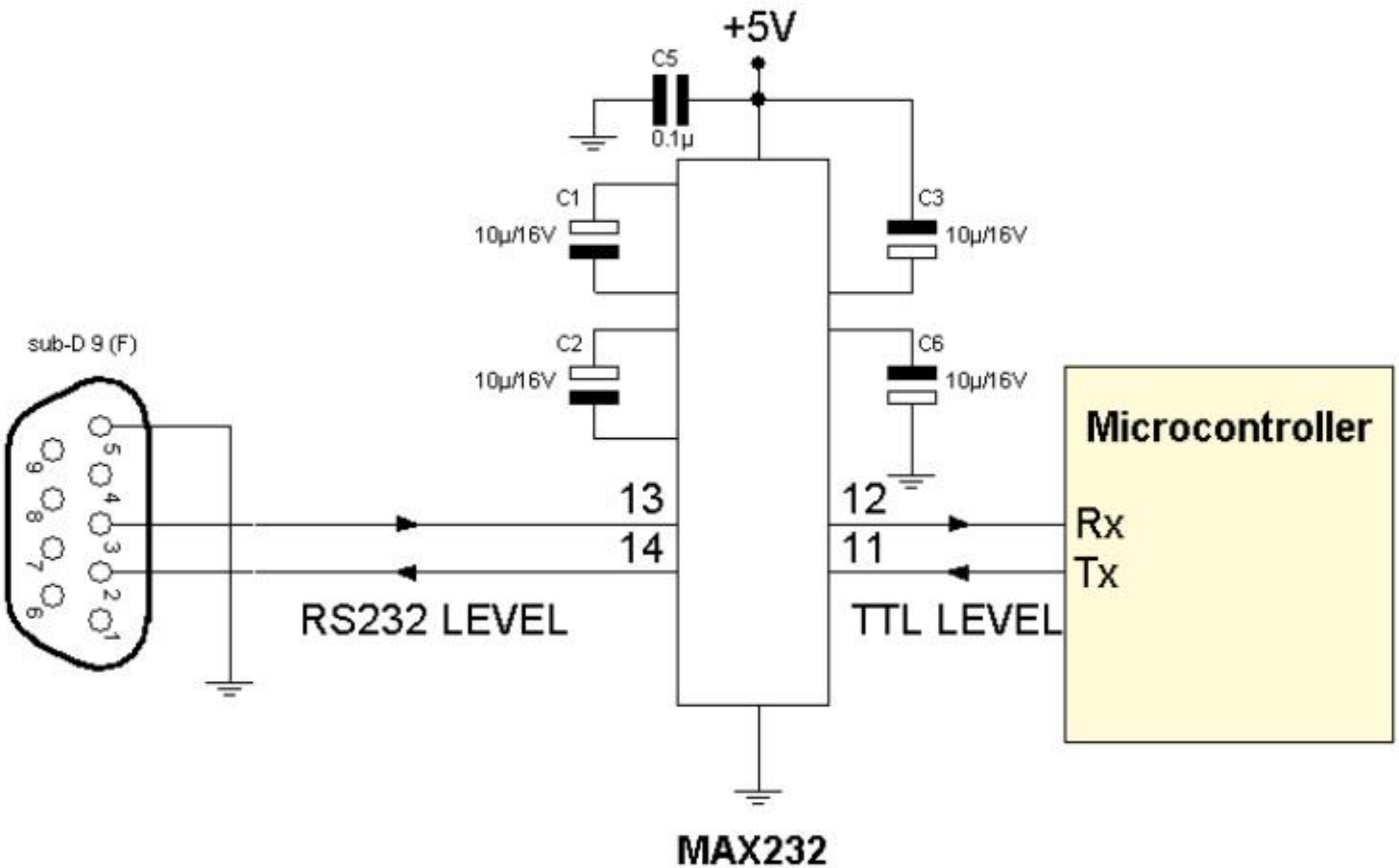
Antenna receives data from the SV system through X-Bee at 2.4 GHz

Microcontroller interface connected to USB of the Laptop

GCS Overview

- Serial interface between microcontroller and laptop will connect to a circuit having Arduino through UART Serial Communication Protocol using MAX232 IC which is used to convert signal voltage levels.
- To communicate over UART or USART, we just need three basic signals vij, Rx(receive), Tx (transmit), GND (common ground). To interface MAX232 with any microcontroller, the three basic signals are required.
- At ground station we will be having a X-bee Pro S2B module which will receive data from another X-bee modules in glider.
- Arduino will receive and transmit signal from X-bee Pro S2B module and transmit to MAX232 IC which will be received by serial port of the computer.

- **Communication Between Laptop and Microcontroller**



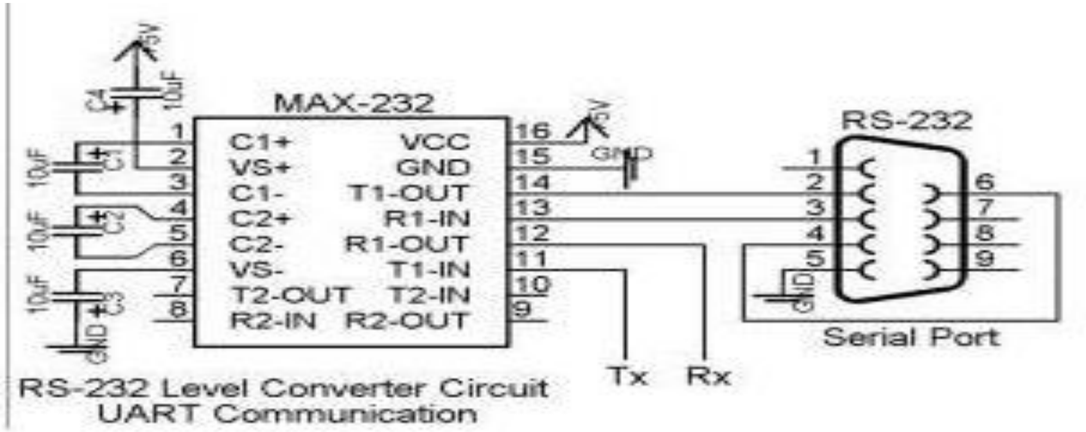
GCS Changes Since PDR

- **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	PARENT	PRIORITY	VM			
					A	I	T	D
GCS-01	Antenna placement : Antenna must point upward, towards the CanSat	For better signal reception.	SR-15	MEDIUM	✓	✓		
GCS-02	Computational requirements : Data is received at 1 Hz	Computational speed is not a big issue. (Assuming GCS laptop has a fast processor)	SR-13	LOW	✓		✓	✓
GCS-03	Power Requirement Should be able to receive and display data for about 4 hrs	GCS has to be ready always for the communication. Not a big issue as ample power is available.	SR-21	MEDIUM	✓			
GCS-04	Initialization of Telemetry in the Software	To initiate data receiving on the software	SR-13	HIGH		✓	✓	
GCS-05	Real Time Plotting of Data Received from the Glider	Competition Requirement	SR-13	HIGH	✓	✓		
GCS-06	Transmit Image to Ground Station after each picture is taken.	Selected Bonus Objective	SR-14	HIGH	✓	✓		

- **Ground control system will comprise of a computer which will be connected to a circuit having Arduino through MAX232 IC.**
- **At ground station, an XBeePro S2B module will be interfaced which will receive data of various sensors from another paired Xbee Pro S2B module in the glider via antenna at the ground station.**
- **Data will be provided in real time at the ground station.**
- **Arduino will receive and transmit data signal via MAX232IC which will be received by serial port of the laptop.**

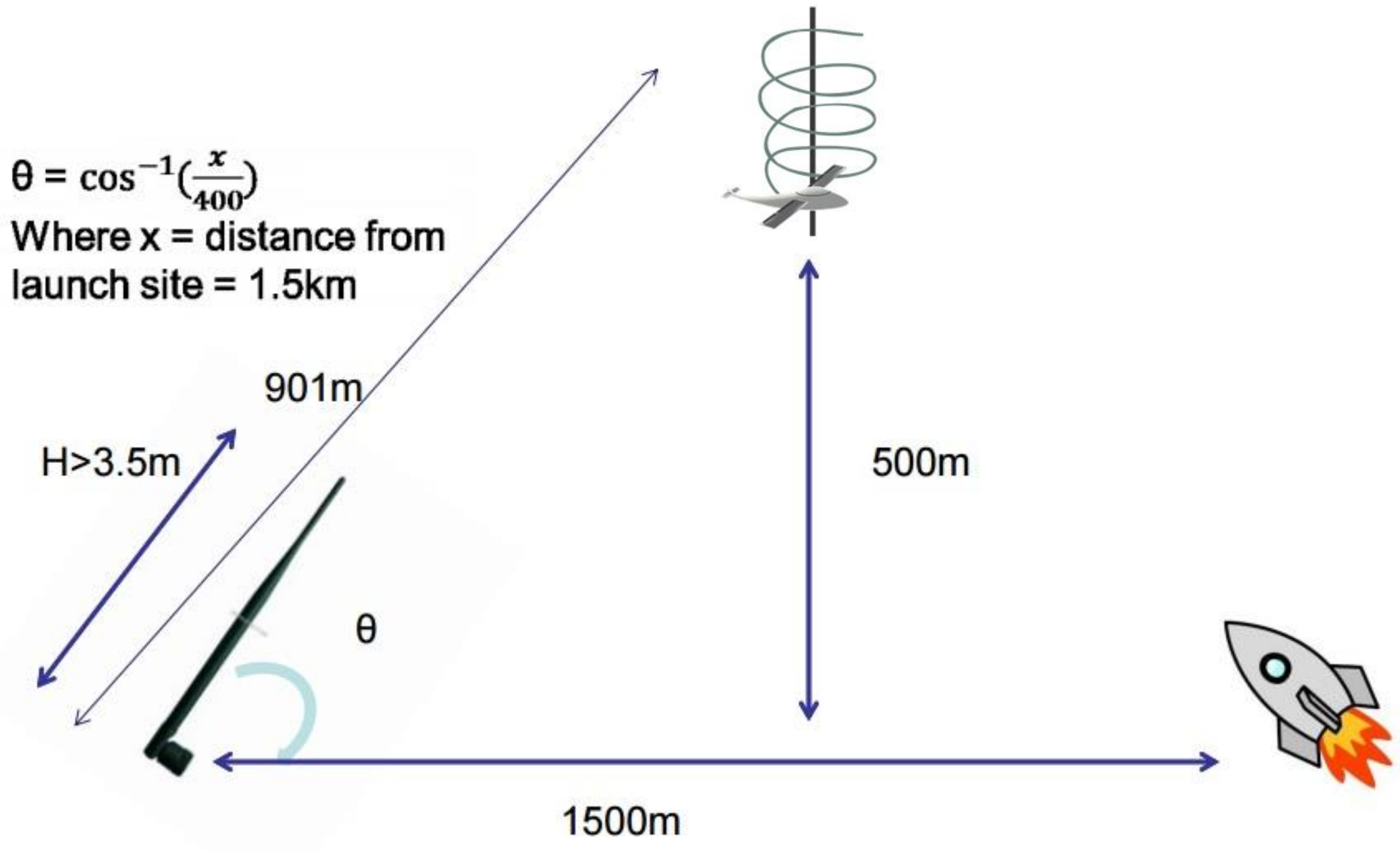


Model	Gain	Height	Frequency
XBEE LONG RANGE OMNI-DIRECTIONAL DIPOLE ANTENNA	9dBi	380mm	2.4Ghz

Antenna is selected due to the following features :

- High Gain – 9dbi & Field Pattern are utilized.
- Larger Dimension – allows better reception.
- Easy Availability
- Higher Range Antenna – upto 3200m Open Ground
- Long Range Antenna– 50,000 sqm
- Frequency – same as that of Xbee Pro S2B
- Portability- Being a Rspma connector
- Hand held Antenna
- Larger dimension allows better reception

GCS Antenna


$\theta = \cos^{-1}(\frac{x}{400})$
Where x = distance from launch site = 1.5km
901m
H>3.5m
500m
θ
1500m

- **Distance Link Margin**

$$FSL = 20log(\frac{4\pi Rf}{c})$$

where –

R = 901m

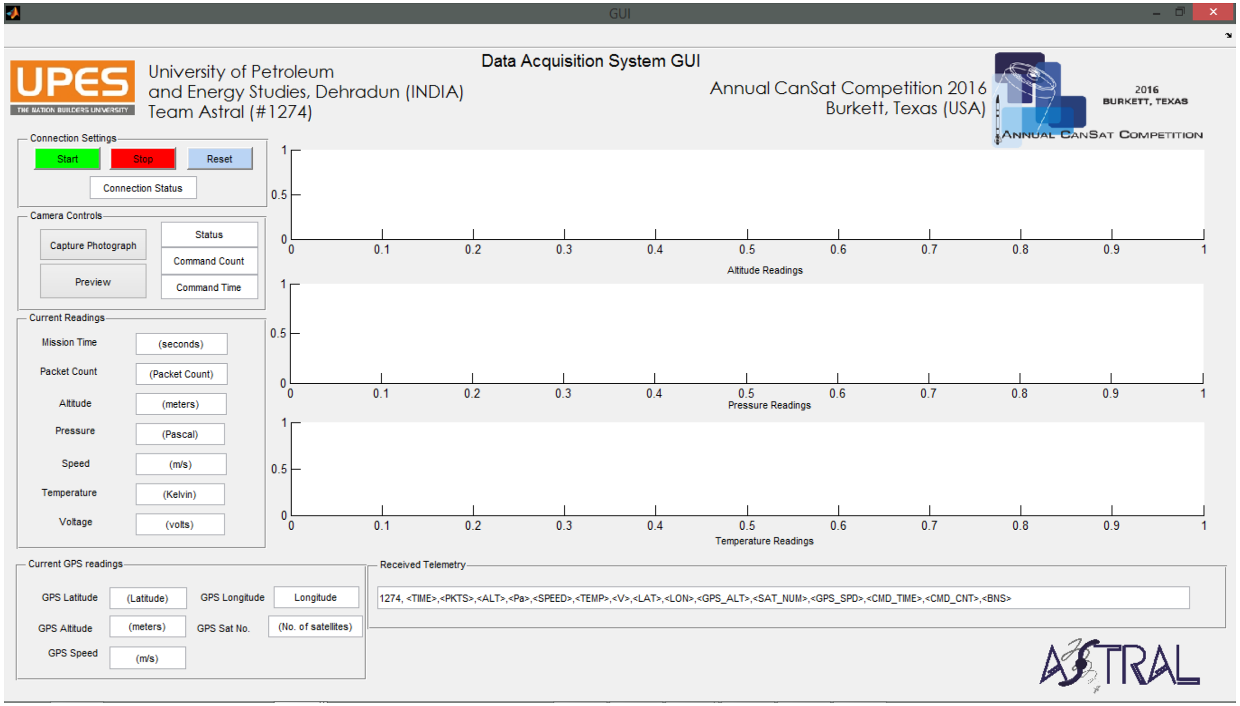
f = 2.4GHz

The estimated loss is about 70-80db without counting the gain of the receiving antenna from which it can be concluded that the receiving antenna is appropriate for efficient receiving of data from the CanSat.

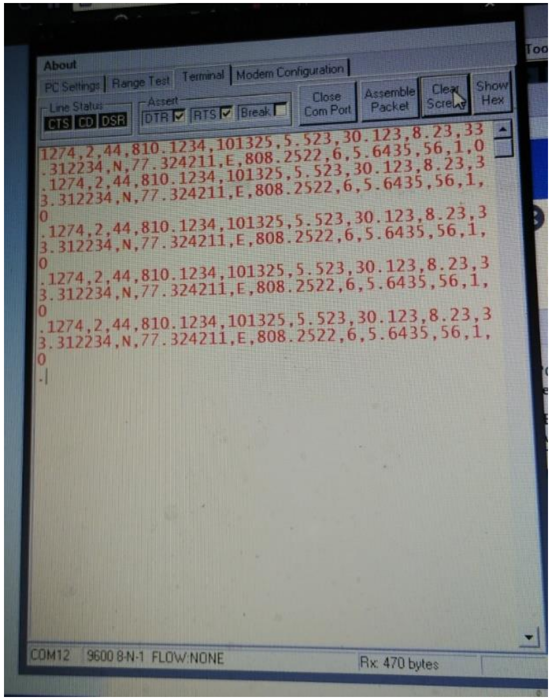
GCS Software

Overview of GCS software

- Real-time plotting design is achieved in the GUI which has been developed in MATLAB software using MATLAB Simulation.
- Telemetry data recording and testing is done in Putty software / x-ctu.
- The data will be stored in a ‘.csv; file and then stored in memory card in real time.
- Push Button commands for Picture Clicking has been provided in ‘Camera Controls Panel’.



Screenshot of Telemetry Data



Note : The Telemetry Data corresponds to the Telemetry Competition Format

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 by using the Matlab command, ‘’

- **Progress Since PDR**
  - The GCS software is ready and underway for use.
  - A Few debugging issues are to be catered to, to reduce complexity.

- **Testing Phase of the Electronics and Receiving Data on GUI has begun.**

CanSat Integration and Test

Shashank Bopche

&

Meenakshi Talwar

CanSat Integration and Test Overview

Descent Control
• *First subsystem to be integrated because it is responsible for the desired revolving of the Glider within the stipulated diameter.*

Communications
•*Second subsystem to be integrated. Vital for other sub-systems.*
•*Base Competition Requirement.*

Sensors
•*Third subsystem to be integrated. Responsible for gathering the required data.*

Electrical
•*Fourth subsystem to be integrated. After the PCB is assembled, FSW integration can initiate, and Mechanical assembly.*

Flight Software
•*Fifth subsystem to be integrated. Vital for the interpretation of the communicated data and graph plotting.*

Mechanical
•*Final subsystem involved with the CanSat to be integrated. Incorporates all other subsystems.*

Ground Station
•*Not located within the CanSat. Final system to be integrated and assembled.*

CanSat Integration and Test Overview

The CanSat subsystems will be integrated as discussed below (sequence-wise):

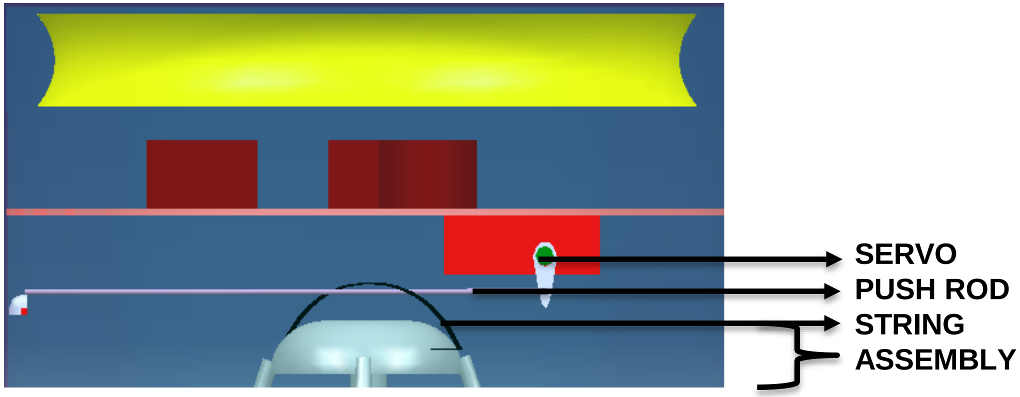
OUTSIDE THE Glider:

•The **Release Mechanism** includes a push rod controlled by a servo motor is used inside the container over which a string attached to the glider is rounded.

•This holds the **Glider-Container assembly** intact, till BMP180 sends a signal to the microcontroller.

•At an altitude of 400m, after receiving the signal, the servo rotates and the pushrod moves. Thus the string which was previously hung upon it gets released along with the Glider detaching it from the assembly.

•CanSat shall have an external power switch and LEDs to indicate ON/OFF state.



CanSat Integration and Test Overview

Glider Mechanism

- The electronics system is placed inside the fuselage of the glider.
- The pitot tube will be placed at the nose of the glider.
- The camera will be placed at the bottom of the fuselage.
- The separation mechanism will be connected with the tail of the glider.
- Electronics except for sensors will be enclosed and shielded from the environment.

INSIDE THE CONTAINER:

- The parachute will be placed in the topmost position inside the re-entry container.
- The electronics will be below the parachute along with the servo and the push rod assembly.
- Below this will be the Glider attached with the help of the servo-push rod release mechanism.

CANSAT SYSTEM-LEVEL TESTS:

(As per the Environmental Testing Guide Provided)

Drop Test:

This test was done to verify that the container parachute and attachment point will survive the deployment from the rocket payload section which can be very violent. The release mechanism was also tested to verify it can hold the Glider in the container. Component mounts and battery mount were also tested.

Equipment necessary: non-stretching Kevlar cord, floor mat, ceiling.

Procedure:

- Secure the cord to the ceiling.
- Secure 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.
- 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.

Screenshots of the Drop Test:




CanSat raised to roughly 80 cm with respect to cord.

CanSat during the fall.

Final position of the CanSat. No attachment was broken or deformed.

Observations:

- The parachute attachment point did not fail.
- The Glider was intact inside the container, and did not separate.
- This test produced about 48Gs of shock which the CanSat survived.

Conclusion: Pass.

***NOTE: These images are undoctored and as recorded by the video camera on a mobile phone. They are cropped for a comparatively better view.**

Thermal Test:

This test was done to verify that CanSat and container can operate in a hot environment.

Equipment: Oven

Procedure:

- The Glider was placed inside the oven.
- After putting inside the oven, its electronics was turned on.
- Seal of the oven was closed and the heat source 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.
- Procedure was followed for next two hours.
- Heat source was turned off and visual inspection and other functional tests were performed to verify that the CanSat is surviving the thermal exposure and can be operated as expected.

CanSat Integration and Test Overview

Observations from Thermal Test:

- Electronics of the Glider was working perfectly and giving the telemetry for full 2 hours of test.
- No other parts of the Glider were damaged due to the heat exposure of 50^{o}C.

Conclusion: Pass.

Vibration Test:

This test was to verify the mounting integrity of all components, electronics and battery connections.

Equipment: orbit sander, benchtop vise, duct tape, power switch

Procedure:

- Turn the power switch of the sander to the on position while it is not plugged in.
- Turn the sander upside down and secure it in the bench vise.
- With the power switch on the power strip in the off position, plug the sander into the power strip and the power strip into the local mains.
- Secure the CanSat on the sander, the part where sand paper is installed.
- Perform a functional test of the CanSat.
- Mount the Glider on the vibration fixture and secure it in place.
- Over a 1 minute period, turn the sander on. Let it power up to full speed, wait 2 seconds and turn off. As soon as the sander stops moving, repeat until one minute is complete.
- Remove CanSat from test fixture and inspect it for any damage.
- Perform a functional test.

Observations: All mounts were intact and did not detach from the Glider.

Conclusion: Pass.

Fit Check:

This test is to verify the CanSat will properly fit in the rocket payload section and slide out at deployment time.

Equipment: Aluminium Sheet, Re-entry container

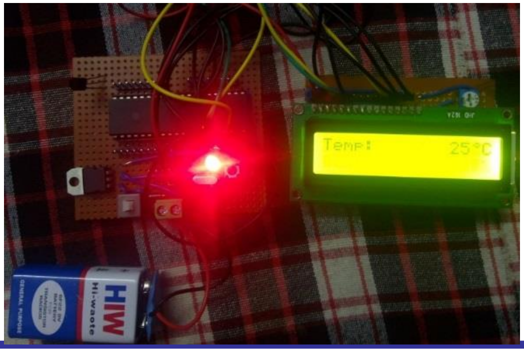
Procedure:

- Cut a hole in the sheet with a diameter of 125.5mm.
- Secure the test fixture so it is rigidly held in place.
- Slide the CanSat container through the hole to verify it is within the required envelope.

Observations: The cansat will fit properly inside the rocket section.

Sensor Subsystem Testing Overview

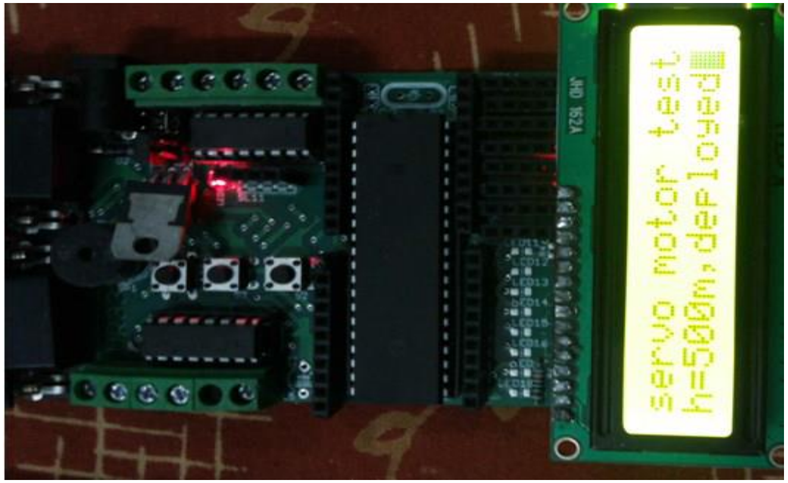
What to Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
Electronics Component Integration: To verify the functionality of all the sensors and connecting them in one PCB.	• Sudden variation in temperature would inhibit data transmission until it stabilizes. • GPS and Arduino must have constant power supply for optimal operation	• GPS • Servo Motor • Arduino • 16x2 LCD Display	• Temperature and altitude sensors have been tested till now for elevated temperature conditions. • GPS and servo motor were tested using Arduino, MCUs, ADC, I2C and PWM ports.	Pass: If the required data is displayed on the LCD screen. Fail: If the data isn't displayed on the LCD screen.	Mentioned tests were successfully conducted by obtaining the readings at various temperatures, on a 16x2 LCD display.



Conclusion: Pass.

Sensor Subsystem Testing Overview

What to Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
Servo Motor Tests: To ensure that the servo motor will rotate to release the Glider from the Re-entry container.	Wouldn't rotate if appropriate data is not received by it.	• Servo motor • PWM port • Altitude sensor	• Servo Motor tests were conducted by varying its angle with the gap of 0° till 180°, by sending PWM signal to control the servo to the correct angle	• Pass: If the servo motor moves up to the desired angle. • Fail: If the rotation is incomplete or incorrect.	The servo showed movement to different specified angles, as according to the program running on the Arduino MCU.



Conclusion: Pass.

Sensor Subsystem Testing Overview

- The data received for various sensors has been tested to appear in the following format:

  TEAM ID,MISSION TIME,PACKET COUNT,ALT SENSOR,PRESSURE,SPEED, TEMP,VOLTAGE,GPS LATITUDE,GPS,LONGITUDE,GPS ALTITUDE,GPS SAT NUM,GPS SPEED,COMMAND,TIME,COMMAND COUNT,[BONUS]

- Tests have been conducted to display the values on a 16x2 LCD to demonstrate the process of data acquisition. The gathered data is redirected to Arduino's Rx and Tx pins and are serially communicated via Xbee to the GS software.

- **Initially, all the sensor subsystem tests are conducted using independent programs for various units. These will be integrated as functions in the main FSW of the overall Cansat system.** A function based approach is preferred in order to make the code readable and also integrate the Auto FSW_state recovery at processor reset. More details presented in Pseudo-code in FSW.

Descent Control Subsystem Testing Overview

What to Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
Wind tunnel test: • To verify experimentally the Lift, and Drag produced by the Glider.	Electric fluctuations can disrupt the flow of air in the wind tunnel.	• Wind tunnel • Glider stand to fit inside the wind tunnel • Glider	• Glider were kept inside the wind tunnel. • The fan of the wind tunnel was allowed to rotate. • It was checked whether the Glider is sufficient lift or not.	Pass: If the glider is producing more lift and less drag. Fail: If the glider is producing too much drag.	The Glider produced lift of about 6 N. Which is as per the descent rate estimates.

Conclusion: Pass.

Descent Control Subsystem Testing Overview

What to Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
Weather Balloon Test: This test was done to verify the functioning of the DCS and its purpose to check the helical motion of the glider.	If high cross winds are present then chances are there that the balloon will get drifted.	• Weather balloon • nylon cords • Sextant • pressure gauge • Ties • Tape • helium gas	• Glider was tied to a weather balloon filled with helium gas. • A cutting mechanism was fitted to cut the cords at right time. • Height of the balloon was calculated using a sextant. • Members were ready to perform the exact actions as in the real competition	• Pass: If the distance of the landing site was less than 500m. If the glider performed the helical motion. • Fail: If the glider would have fallen freely in air, telemetry would have been not received and landing site was more than 500m..	• The glider separated at 400m. • The glider performed helical motion. • Telemetry was received as was expected • The Landing site was 350m away from the drop site.

Conclusion: Pass.

Descent Control Subsystem Testing Overview

Filling Helium in the balloon

Sextant – to measure the height attained by the weather balloon

Weather balloon at a height of 250 m right before the release of the Glider.

Descent Control Subsystem Testing Overview

What to accomplish	Constraints	Equipment used	Procedure	Pass/Fail Criteria	Results
Drop Test: This test was done to verify that during descent the glider descends in helical path.	High cross winds can disrupt the motion of glider.	• high rise building • video camera • Glider	• Glider • Instead of electronics dead weight of equivalent mass was added. • Glider was allowed to be dropped from a high rise building. • The drop flight was recorded.	• Pass: If the Glider descends in helical path. • Fail: If the Glider falls freely.	The Glider descends in helical path as can be seen by the screenshots from the video.

Conclusion: Pass.

Descent Control Subsystem Testing Overview

The descent was recorded in day-light conditions. The Helical spin of the glider can be seen from the stills.

***NOTE: These images are undoctored and as recorded by the video camera on a mobile phone. They are cropped for a comparatively better view.**

Mechanical Subsystem Testing Overview

What to Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
Release Mechanism Test: This is to test the release mechanism of the Glider from the container.	N/A	• Glider-container assembly • servo motor • Pushrod • String • varying weights • GPS	• This involves releasing the Glider from the re-entry container with the help of a servo motor and a microcontroller by moving the pushrod and releasing the string attached with the Glider. • A test on release mechanism for Glider weighing more than 350g has been performed to check if the release mechanism works effectively for Glider heavier than 350g.	• Pass: If the Glider is released from the container without any problem. • Fail: If it gets stuck while being released.	The release mechanism test was Pass as the mechanism worked for the weights experimented and released the Glider at command from GPS.

Conclusion: Pass.

Mechanical Subsystem Testing Overview

What to Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
Structure Survivability Test: This is to test the structure survivability of the Glider.	Crosswinds might drift the weather balloon.	• high rise building • weather balloon.	• The Glider was dropped from heights of 250m and 150m, with the help of a weather balloon. • This was recovered and checked for any damage or detachment.	• Pass: If the structure survives all the shocks and accelerations without any failure of it. • Fail: If any structural deformation or failure is seen.	The structure is surviving 30 Gees of shock force as per the tests conducted.

Conclusion: Pass.

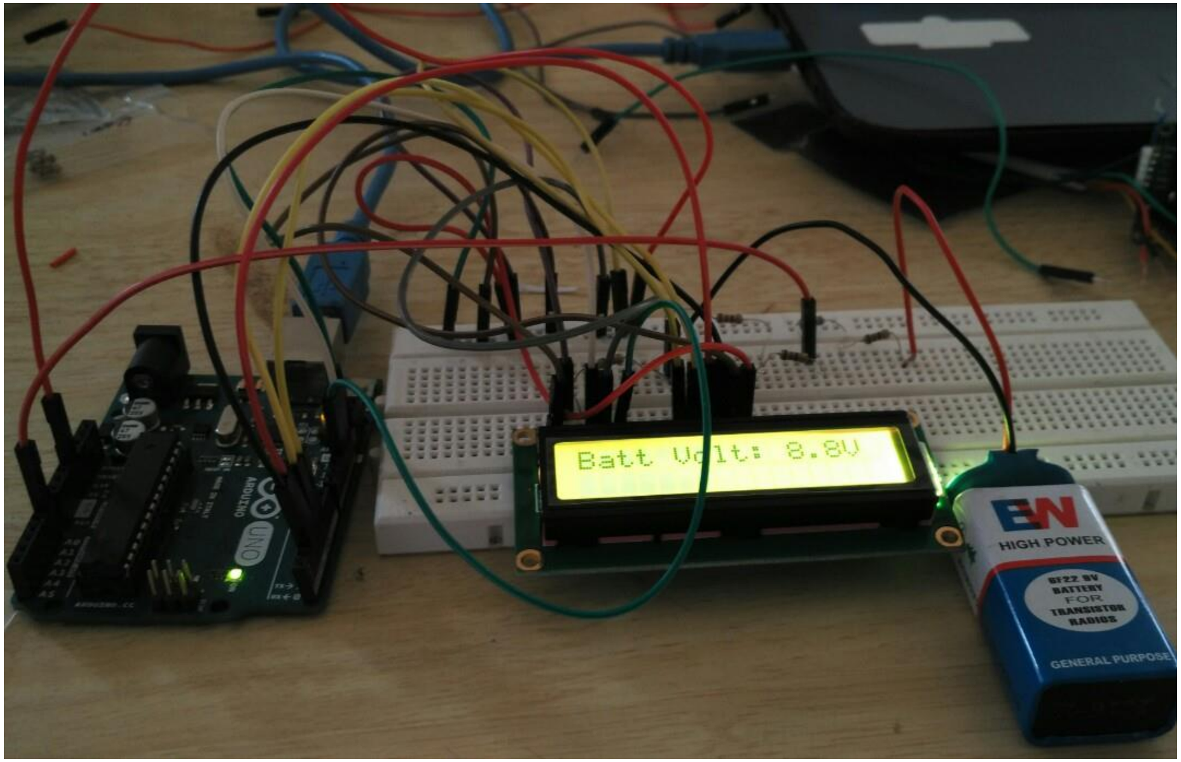
CDH Subsystem Testing Overview

What To Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
To test the range of communication and the extent of data transmission.	• XBEE Pro S2B has a range of 3200 m but maintaining proper line of sight is difficult for efficient data transmission and reception.	• ATmega328 PCB self designed developer board • XBee Pro S2B module both receiver and transmitter, • power source • Atmel Studio 6.1 for programming. • Balloon and Helium	1. Transmitter was attached with the helium filled weather balloon. 2. Receiver was at ground. 3. Weather balloon was release to the altitude of 250m. 4. Data was displayed on 16x2 LCD and also on Ground Station Software built on MATLAB R2013a. 5. Pictures are shown in FSW testing section.	• Pass: If the data gets transmitted and received correctly by the ground station. • Fail: If the data is not received properly.	Worked correctly up to 250m. Data received in correct format.

EPS Testing Overview

What To Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
Obtain the desired voltage from 9V battery.	• Any wire left unattended would result in short circuiting. • All connections should be rendered tight.	• Linear Regulator (LM1117) used • 9V battery. • Oscilloscope • MultiMeter • Microcontroller Board	• 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%.	• Pass: If constant output is observed. • Fail: If the output is not constant, distorted or has noise.	• Efficiency = 85% - 90 %. Constant 3.3v output is observed. • Same result also obtained for voltage regulator LM7805. • Voltage successfully tested by obtaining constant curve on Oscilloscope.
For power saving in CanSat			• Power saving is achieved during idle mode and power down mode of AtMega328. The Glider uses capacitor and current buffer circuit to store power temporarily.		

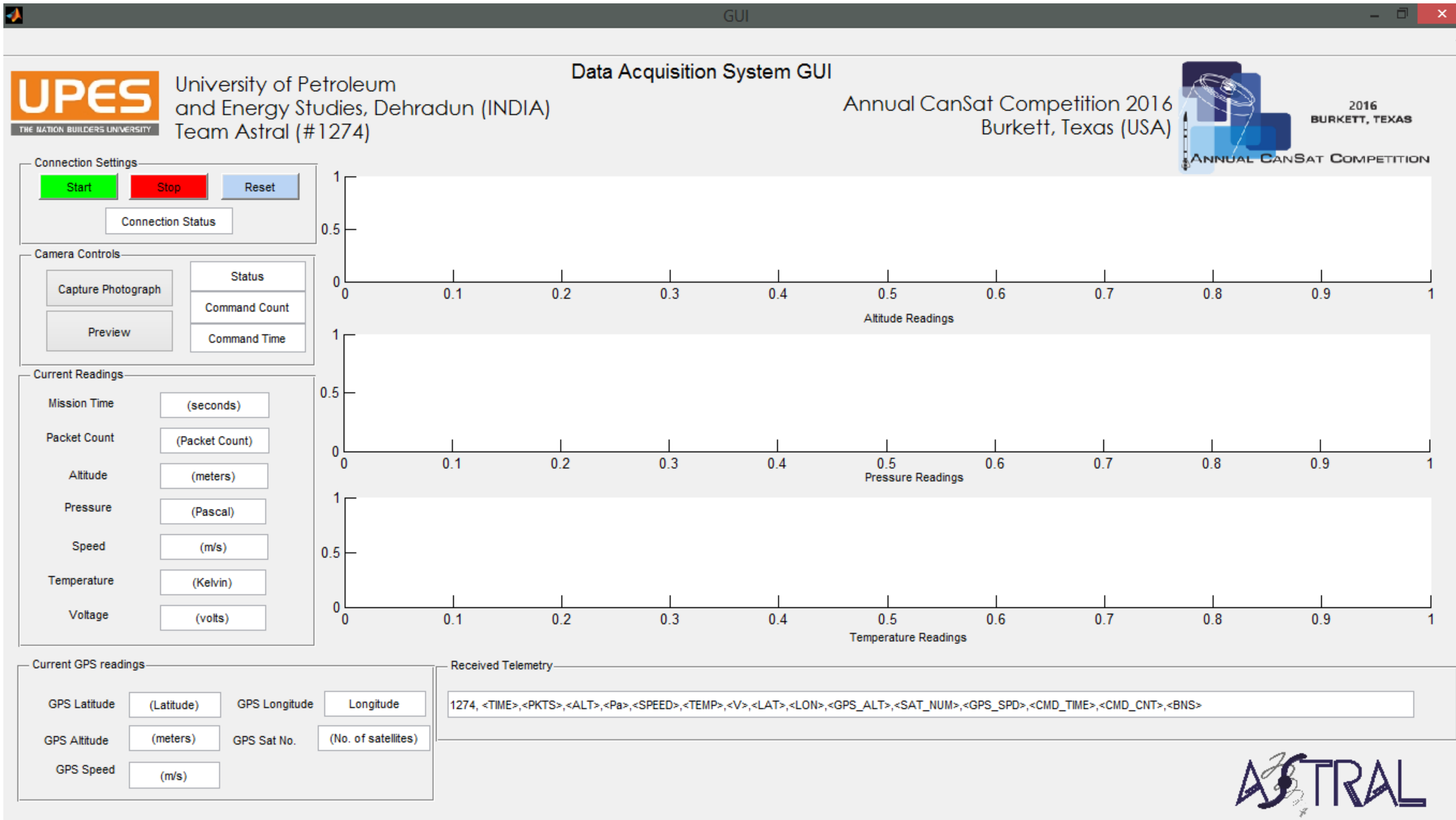
- **Battery Voltage Testing**



FSW Testing Overview

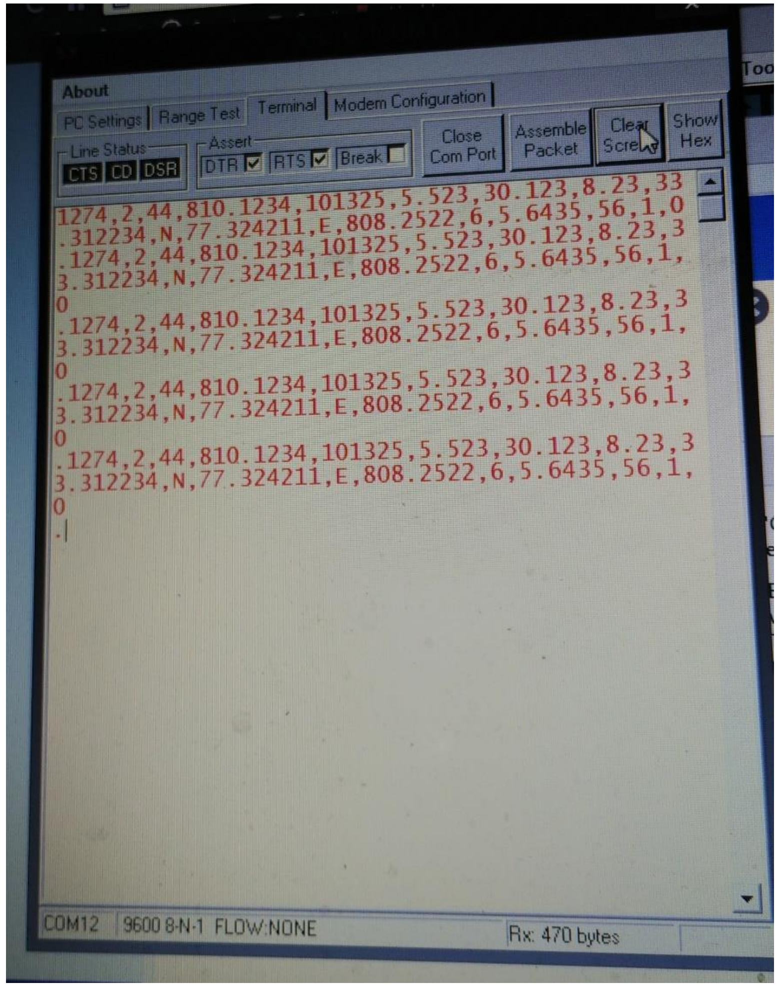
What To Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
• To verify that data acquisition takes place. • To transmit data to the ground station. • To plot the acquired data in real time.	The complexity of the program of the FSW determines the proper functioning of the MCU. Too much complexity may result in lag in data transmission and/or processor hanging.	• Atmel Studio 6.1 • Atmega328 development Board and RTC • X-bee Pro S2B transmitter and receiver • MATLAB R2013b • Various sensors for collecting data • X-CTU	• The data acquisition was programmed using a function based approach. • The initial test of auto-restore mechanism to correct FSW_State has been performed, using just two state parameters, HIGH and LOW, with correct readings on X-CTU.	• Pass: If the data is getting transmitted to the ground station and if the graph can be plotted based on the received values. • Fail: If the data is not transmitted properly.	Correct Readings of two parameters is obtained at the ground station.

Ground Station GUI



FSW Testing Overview

- **Telemetry Data**



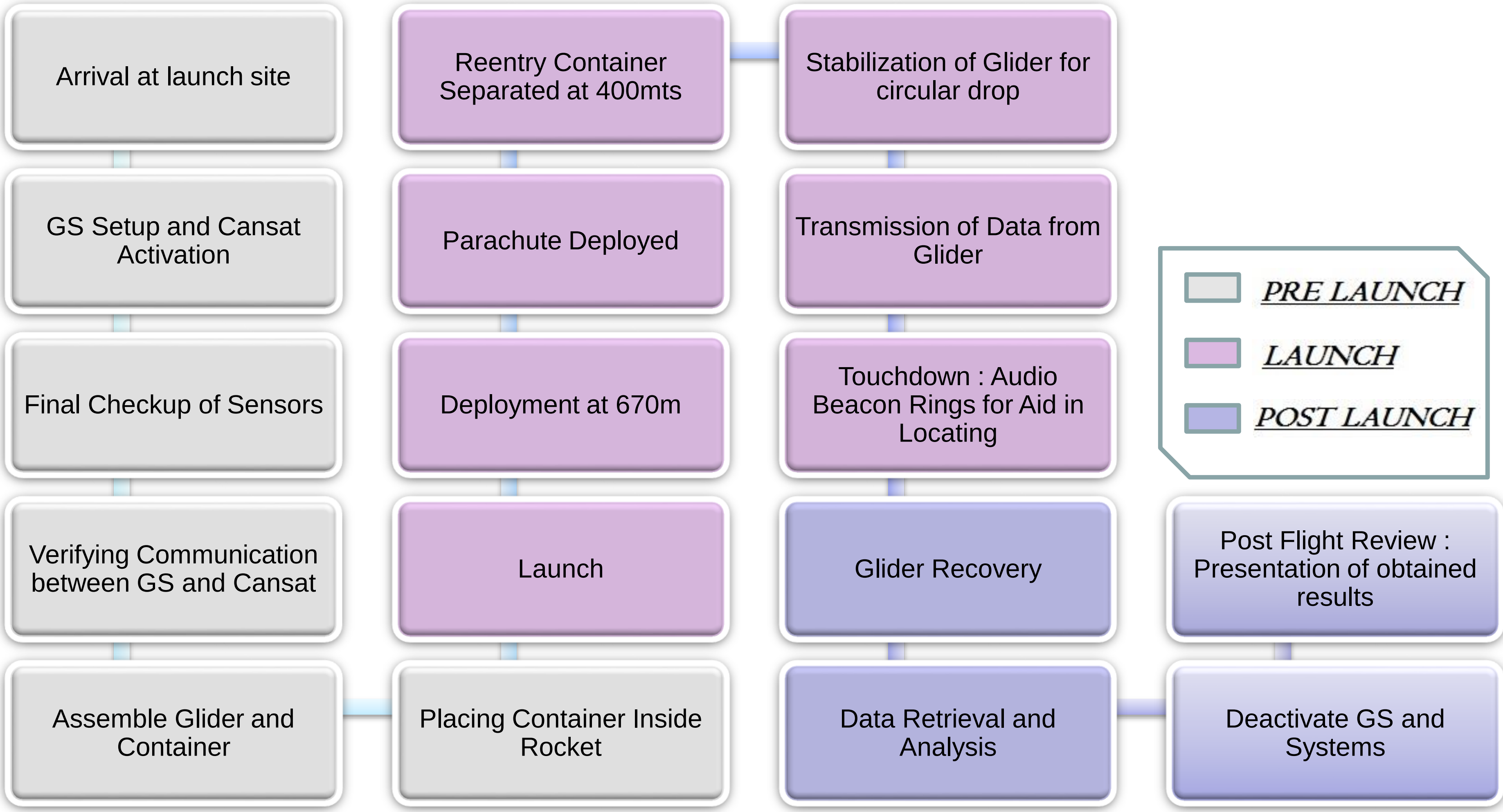
GCS Testing Overview

What To Accomplish	Constraints	Equipment Used	Procedure	Pass/Fail Criteria	Results
• To ensure that combined data received successfully on the ground station. • Display the data with respective graphs.	Constant voltage power supply is required for efficient working of the Development Board	• ATmega328 PCB self designed development board • Laptop • LCD(16x2) • USB serial cable • XCTU hyper terminal (for initial tests) • Matlab GUI built using Matlab R2013b.	• 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 Software.	• Pass: If the data is received by the GCS. • Fail: If the data is not received.	Displayed the received data on LCD(16x4) and also on laptop by using serial communication on XCTU hyper terminal and later on Matlab GUI, graph was obtained.

Mission Operations & Analysis

Gopal Krishna Panigrahi

Overview of Mission Sequence of Events



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
Aditya Savio Paul	Cansat Crew /Recovery
Aman Arora	Mission Control Officer
Vipul Mani	Cansat Crew/ Recovery
Raghav Garg	Ground Station Crew
Amitabh Yadav	Ground Station Crew
Devarrishi Dixit	Cansat Crew
Shambhavi Dubey	Cansat Crew
Anisha Absolom	Cansat Crew

Overview of Mission Sequence of Events

- After setting the ground station, it is important to connect all the communication devices and verify whether the ground station is operational or not.
- The Sensors and electronic subsystems inside the Glider must be operational and must transmit data to the ground station.
- Correct positioning of Antennae on board the Cansat and GS, and verification of successful communications between the Glider and the GS is essential.
- Cansat will be assembled and tested for weight and dimensions as per the rocket payload section.
- Telemetry Data collected from Data Logger and the Flight Software shall be submitted to the Field Judges in the prescribed '.csv' format.

Field Safety Rules Compliance

- Development of operations manual is almost done and includes the basic checklist for the 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.

- The manual with the members with the major components being:
  - –Ground station setup
  - –Final CanSat systems test
  - –CanSat GS communication verification checklist
  - –Re-entry container and rocket integration checklist
  - –Final pre-launch checklist and preparations
  - –CanSat in-flight procedures
  - –Glider recovery and data analysis
  - –The manual is expected to be completed in next 3-4 days.

CanSat Location and Recovery

- The GPS sensor fitted inside the SV will continuously transmit its position to the GS.
- The body of the Glider and Re-Entry will be painted with a bright and shiny color which will allow us to maintain visual contact even before they reaches the ground.
- Audio Beacon will be fitted inside the Glider and it will start buzzing when it has landed.
- The Glider and the re-entry container will have the following written for identification :

Team Name
Team Leader Name
Team Leader Contact Number
Team Leader Email Id

Mission Rehearsal Activities

REHARSAL ACTIVITIES:

1. GROUND STATION RADIO LINK CHECK PROCEDURES

- We verified the communication procedures by using XBEE-PRO S2B, MAX-232 and DATALOGGER . The data was transmitted from XBEE and was received on the ground successfully.

2. LOADING GLIDER INTO RE-ENTRY CONTAINER

- We rehearsed loading this into our CanSat prototype during testing. Smooth deployment of Glider from re-entry and desired fall was achieved.

3. POWERING ON/OFF THE CANSAT

- We rehearsed it 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

- The 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

- We verified that our CanSat will fit into the payload section of rocket by assembling it and fitting it into a can of similar size.

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 it showed accurate altitude and temperature values.

7. RECOVERY

- We practiced it by recovering the CanSat after drop tests from 250m and 150m. We had florescent pink color as the color of our parachute so it was easier to locate.

Requirements Compliance

Vipul Mani

Requirements Compliance Overview

Current Design compliance to requirement:-

- Base requirements comply to the required requirements.
- All the descent and recovery requirements comply to the required requirements..
- The communication requirements comply to the required requirements.
- The requirement that the glider shall descend in a helical path complies.
- The flight software requirements comply to the required requirements, the GUI is complete.
- Structure requirements comply to the required requirements.
- Mechanisms requirements comply to the required requirements.
- The requirement that during descent, the Glider shall transmit the telemetry data once every 1 second complies with current requirement.
- Selectable objective requirement is complete and the final testing of the CanSat is yet to be done.

Req ID	Requirement	Comply / No Comply / Partial	Slide(s) Demonstrating Compliance	Team Comments or Notes
3.1	Base Requirements	--	--	--
3.1.1.1	Total mass of CanSat, container, and all descent control devices shall be 500 grams. Mass shall not vary more than +/-10 grams.	Comply	64,67	
3.1.1.2	The Glider shall neither be remotely steered nor autonomously steered.	Comply	67,69	
3.1.2	The Glider must be installed in a container to protect it from deployment out of the rocket.	Comply	68	--
3.1.2.1	The container shall fit inside the cylindrical Glider section of the rocket defined by the cylindrical Glider envelope of 125mm x 310 mm length control system including the descent	Comply	69	
3.1.2.2	The Container shall use a passive descent control system. It cannot free fall. A parachute is allowed and highly recommended. Include a spill hole to reduce swaying.	Comply	74,75	
3.1.2.3	The container shall not have any sharp edges that could cause it to get stuck in the rocket Glider section.	Comply	68	
3.1.2.4	The container must be a florescent color, pink or orange.	Comply	68	
3.1.2.5	No protrusions beyond the envelope defined are allowed while stowed in the rocket.	Comply	69	
3.1.2.6	The rocket airframe cannot be used to restrain any deployable parts of the cansat.	Comply	69	
3.1.2.7	The rocket airframe and Glider section shall not be used as part of the Cansat operations.	Comply	67,68	
3.1.2.8	The Cansat shall deploy from the rocket Glider section.	Comply	65	

Requirements Compliance (2 of 7)

Req ID	Requirement	Comply / No Comply / Partial	Slide(s) Demonstrating Compliance	Team Comments or Notes
3.1.3	The CanSat shall comply with the following descent and recovery requirements.	--	--	--
3.1.3.1	The descent control system shall not use any flammable or pyrotechnic devices.	Comply	67	
3.1.3.2	The Container or Glider shall include electronics and mechanisms to determine the best conditions to release the Glider at altitude of 400 metres +/- 10m	Comply	67	
3.1.3.2	The Glider must glide in a preset circular pattern of no greater than 1000 meter diameter.	Comply	79,80	
3.1.3.3	Total glide duration must be close to 2 minutes.	Comply	17,78	
3.1.3.4	Glider must be a fixed wing Glider.	Comply	67	
3.1.3.5	All descent control device attachments must survive 30 Gs of shock.	Comply	67	Testing has been done.
3.1.3.6	All descent control devices must survive 30 Gs of shock.	Comply	68	Testing has been done.

Requirements Compliance (3 of 7)

Req ID	Requirement	Comply / No Comply / Partial	Slide(s) Demonstrating Compliance	Team Comments or Notes
3.1.4	The CanSat shall comply with the following communications requirements	--	--	--
3.1.4.1	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	98,100	
3.1.4.2	The XBEE radios shall have their NETID/PANID set to the team number.	Comply	98	
3.1.4.3	The XBEE radio shall not use the broadcast mode.	Comply	98,99	
3.1.4.4	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	90	
3.1.4.5	The XBEE radio can operate in any mode as long as it does not interfere with other XBEE radios.	Comply	93	
3.1.4.8	The telemetry is displayed in engineering units in real time	Comply	90	

Requirements Compliance (4 of 7)

Req ID	Requirement	Comply / No Comply / Partial	Slide(s) Demonstrating Compliance	Team Comments or Notes
3.1.5	The CanSat shall comply with the following power requirements:	--	--	--
3.1.5.1	The CanSat shall have an external power control such as a power switch and some indication of being turned on or off.	Comply	105,109,111	
3.1.5.3	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	113	
3.1.6	The CanSat shall comply with the following flight software requirements:	--		--
3.1.6.1	The CanSat flight software shall maintain and telemeter 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	122,124,126	

Req ID	Requirement	Comply / No Comply / Partial	Slide(s) Demonstrating Compliance	Team Comments or Notes
3.1.7	The cost of the cansat flight hardware shall be under $1000 (USD). Ground support and analysis tools are excluded.	Comply	16,192	
3.1.8	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	14,15	
3.1.9	Structure Requirements	--	--	--
3.1.9.1	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		
3.1.9.2	The structure must support 15 Gs acceleration.	Comply	15,48	
3.1.9.3	The structure must survive 30 Gs shock force.	Comply	15,49	
3.1.9.4	Electronic circuit boards must be hard mounted using proper mounts such as standoffs and screws. High performance adhesives are acceptable.	Comply	15,16	
3.1.9.5	Both the container and Glider shall be labeled with team contact information including email address	Comply	17	

Requirements Compliance (6 of 7)

Req ID	Requirement	Comply / No Comply / Partial	Slide(s) Demonstrating Compliance	Team Comments or Notes
3.1.10	Mechanisms Requirements	--	--	--
3.1.10.1	Mechanisms must be capable of maintaining their configuration or states under all forces such as acceleration and shock forces.	Comply	15,16	
3.1.10.2	Mechanisms must not use pyrotechnics or chemicals.	Comply	15	
3.1.10.3	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	15	
3.1.10.4	The Container or Glider shall include electronics and mechanisms to determine the best conditions to release the Glider based on stability and pointing.	Comply	24,25,69	
3.1.10.5	The Glider vehicle shall incorporate a Pitot tube and measure the speed independent of GPS.	Comply	18,36	
3.1.10.6	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	17,43	

Req ID	Requirement	Comply / No Comply / Partial	Slide(s) Demonstrating Compliance	Team Comments or Notes
3.1.11	During descent, the Glider shall transmit the following telemetry data once every one second:	--	--	--
3.1.11.1	Pressure in Pascal. Altitude in meters above sea level Air temperature. Battery voltage in volts.	Comply	138,139	
3.1.11.2	The external power connection shall be a sturdy connector that is easily accessible when the Glider is stowed in the container.	Comply	24,105,109	
3.1.11.3	Flight software maintained mission time and real time plots of data.	Comply	126,127,128	
3.2	The flight software shall maintain a count of packets transmitted, which shall increment with each packet transmission throughout the mission.	Comply	127,128,129	

Management

Aditya Savio Paul

Status of Procurements

Part	Quantity	Order Date	Expected Arrival	Status
Flight Hardware				
Data Logger	1	01/10/16	-	Received
PCB	2	01/10/16	-	Received
Transistor	2	01/10/16	-	Received
Programmer	1	01/23/2016	-	Received
Battery	2	01/25/2016	-	Received
Regulator	5	01/25/2016	-	Received
Pressure Sensor	2	02/03/2016	-	Received
Camera	2	03/02/2016		Received
GCS Hardware		03/05/2016		
Antenna	2	03/15/2016	04/04/2016	Ordered
XBEE	2	02/17/2016	-	Received
OTHERS			-	Received

CANSAT HARDWARE BUDGET	
Mechanical	263.95$
Electronics	373.46$
Ground Control Systems	143.00$
TOTAL	**780.41$**

Thus, the total hardware expenses are less than $1000.

Separate tables are provided for the detailed electronics and mechanical hardware costs:

Electronics Hardware

Component	Model	Quantity	Cost	Determination
Antenna	X-Bee Pro S2B With Whip Antenna	1	$ 73.56	Estimated
Battery	Alkaline,9V	3	$ 8.00	Exact
Circuit Base Boards	Zero Size PCB	2	$ 5.00	Exact
Misc.			$ 20.00	
SUBTOTAL			$ 373.46	

Mechanical Hardware

Category	Model	Quantity	Cost	Determination
Glider Material	Nylon	-	$ 35	Estimated
Re-Entry Container Material	Carbon Fiber	4 meter square	$ 100	Estimated
Parachute	-	1	$ 31.95	Actual
Fabrication of Glider	-	-	$ 80	Estimated
Servo Motor	RKI-1129	1	$ 17	Actual
SUBTOTAL			$263.95	

CanSat Budget – Hardware

Ground Control Costs

Component	Model	Quantity	Cost	Determination
Antenna		1	$ 18.00	Estimate
Micro Controller	Arduino Uno	1	$ 35.00	Exact
Communication Module	Xbee Pro S2B	1	$ 70.00	Exact
Others			$ 20	
SUBTOTAL			$ 143	

CanSat Budget – Other Costs

Component	Quantity	Cost	Determination
Prototyping		$ 5500	Estimate
Travel	10	$ 15,000	Estimate
Accommodation/ Hotel Room	2	$ 900	Estimate
Transport	6	$ 500	Budgeted
Food	6	$ 700	Budgeted
SUBTOTAL		$ 22,500	

Sources of Funds:

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

Program Schedule

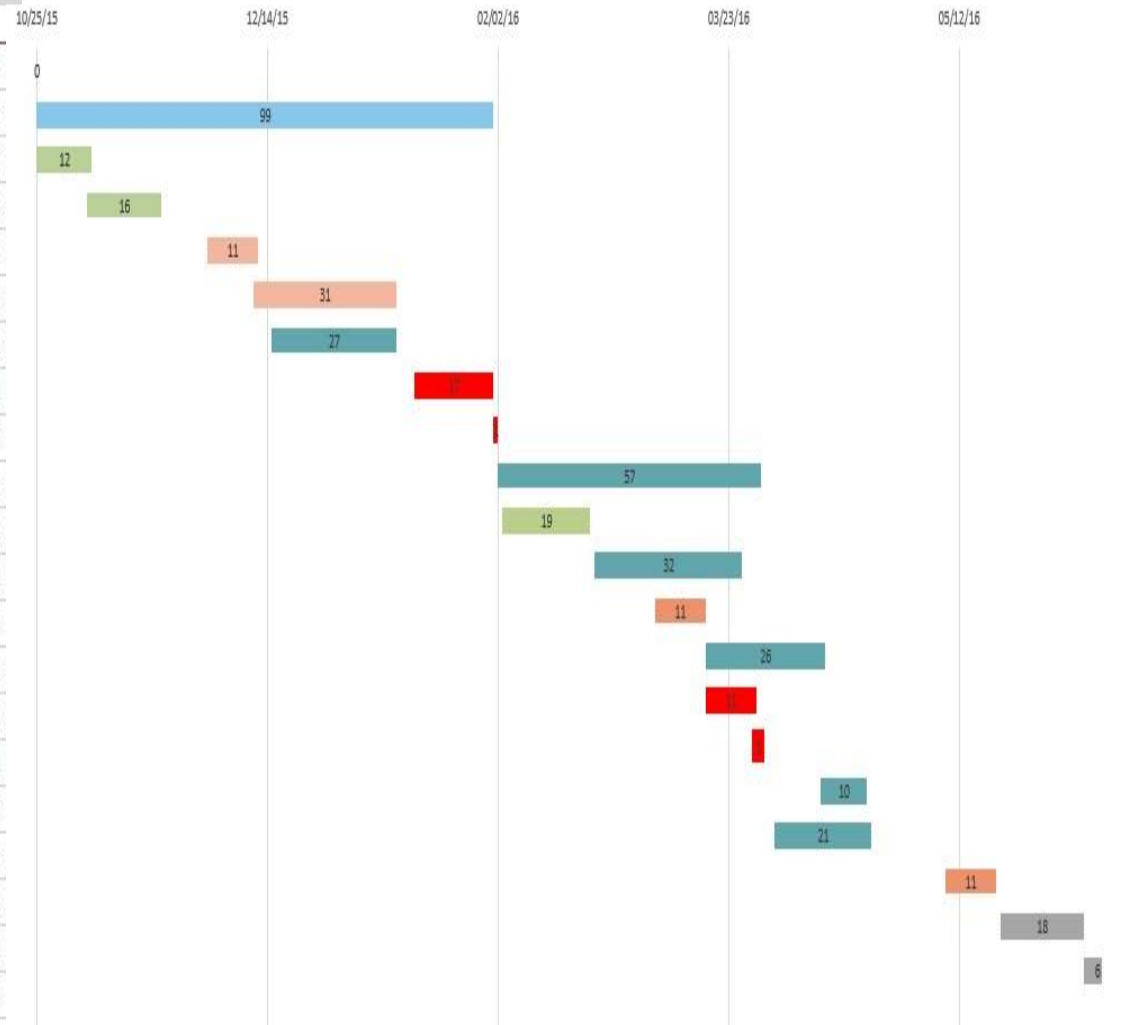
- Competition started in **October ’15** with formation of team by selecting students who could best contribute to the Team Requirement. The focus was then converged onto the mission statement, probing the ideas which could complete the task in the most efficient and effective way
- .
- In **December ’15**, the Team was registered following which we began with the **End Semester exams** during which the Brochure was worked upon to attract sponsors.
- In **January ’15**, different designs were discussed and an apt design was chosen to work upon. Around **January 10th 2016**, work on **PDR** started and it was divided among different team members. The PDR was compiled by the 25th of January 2016, and was mailed on the 31st of January 2016.
- In **February ‘15**, small scale fabrication of the Glider shall begin along with building of the electronic circuits. By the mid of February, we intend to start testing our model by drop tests from the college campus buildings and on the basis of the test results we shall decide the further modus operandi.

Program Schedule

- By **March '16**, our **Mid semester exams** will begun. Mid of March witnessed us start work on **CDR** and intended to compile it until 25th March 2016 for final reviewing.
- CDR will be submitted on **29thMarch '15**. Also Team Members who do not hold U.S. VISA, have applied for their VISA application.
- In **April '16**, we will start full scale fabrication of the Glider; UAV Drop Tests and Balloon Testing from a height of ~300m will be done to ensure proper working.
- Any failures, would lead us to make more improvements in our model and thus bring us closer to our success. The required changes will be incorporated immediately to the model and will be retested.
- By **May '16**, our **End semester exams** will start. Our final model for the CanSat Competition2016 will be fabricated with precision by the end of May 2016.
- In **June '16**, miscellaneous errands like team T-shirts, Team Banner and Proper packaging of the CanSat will be done. And finally, on 8thJune, our team will depart for participating in the competition.

Program Schedule

TASK	Start Date	Duration	End Date
Start of Project	10/25/15	0	10/25/15
Preliminary Design Phase	10/25/15	99	01/31/16
Understanding the Project	10/25/15	12	11/05/15
Structure Design	11/05/15	16	11/20/15
End Semester Exams	12/01/15	11	12/10/15
Semester Breaks	12/11/15	31	01/10/16
CAD Modelling	12/15/15	27	01/10/16
PDR Assembly	01/15/16	17	01/31/16
PDR Submission	02/01/16	1	02/01/16
Critical Design Phase	02/02/16	57	03/29/16
Final Design Imporvement	02/03/16	19	02/21/16
Initiating Fabrication	02/23/16	32	03/25/16
Mid Semester Exams	03/07/16	11	03/17/16
Fabrication of Final Structure	03/18/16	26	04/12/16
CDR Assembly	03/18/16	11	03/28/16
CDR Submission	03/29/16	1	03/29/16
Hardware Intergration	04/12/16	10	04/21/16
Final Testing	04/02/16	21	04/22/16
End Semester Exams	05/09/16	11	05/29/16
Mission Planning	05/21/16	18	06/07/16
Travel to Texas	06/08/16	6	06/13/16
Post Flight Review	06/12/16	1	06/12/16



Shipping and Transportation

- **Plans For Shipping / Transporting The Cansat Hardware**
- We are planning to transport the CanSat hardware by air with us in June.
- We have decided to first dismantle 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.
- We will inquire from and request airlines travelling to the States before booking our tickets about making special arrangements for our team since we will carry 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.

- **Other Options For Shipping**
- Water Transportation –It's a good option and relatively inexpensive and less complicated but generally takes a lot of time .We will use this as our back up option and consider shipping by water if 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 dismantle 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 dismantled 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

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:

- **MAJOR ACCOMPLISHMENTS:**
  - Physical design and material for CanSat body has been finalized.
  - Release mechanism has been finalized and tested.
  - Descent Control mechanism has been finalized and tested and is undergoing final fabrication.
  - Most of the electronic components have been purchased and tested.
  - Programming and logic of the electronic circuits have been completed.

Conclusions

- **MAJOR UNFINISHED WORK:**
  - Flight software has been tested with two sensors. Integration of all sensors and their testing will be complete by the second week of April.
  - Mission Operations Manual building is underway and should be completed in less than a week.
- **TESTING TO COMPLETE:**.
  - Flight software tests incorporating all sensors is yet to be done.
- **FLIGHT SOFTWARE STATUS:**
  - Data acquisition from two sensors has been tested with reset mechanism with two independent states namely, HIGH and LOW, using AtMega328.
  - The ground station GUI has been developed and tested using two sensors. It will be completed by the mid of April.

Conclusions

Any Questions?