CanSat 2017
Vellore Institute of Technology
Preliminary Design Review (PDR)

Team # 2617

Team SEDS VIT

Presentation Outline

1. Introduction

2. Systems Overview

3. Sensor Subsystem Design

4. Descent Control

5. Mechanical Subsystem Design

6. Communication and Data Handling Subsystem Design

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8. Flight Software Design

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10. CanSat Integration and Test

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11. Mission Operations & Analysis

12. Requirements Compliance

13. Management

14. Conclusion

Presentation Outline

Sr. No	Name	Grade	Branch	Position/Role
1	Akshay Girish Joshi	Junior	Mechanical Engineering	Team Leader
2	Pranav Naidu	Junior	Computer Science Engineering	Alternate Team Leader
3	Ases Akas Mishra	Junior	Mechanical Engineering	Mechanical Subsystem Design
4	Roshan Murali	Junior	IT Engineering	Descent Control Design
5	Kumar Yash	Junior	Electrical Engineering	Electrical Power Subsystem, Communication and Data Handling
6	Rakshit Vig	Junior	Electrical Engineering	Communication and Data Handling, FSW Design
7	Aman Gupta	Sophomore	Electrical Engineering	Sensor Subsystem Design
8	Devesh Bajaj	Sophomore	Computer Science Engineering	Ground Control Software
9	Malhar Joshi	Sophomore	Mechanical Engineering	Descent Control Design
10	Kunal Pandey	Sophomore	Mechanical Engineering	Mechanical Subsystem Design,Team Manager

Team Organization

Tony Mai, Amazon Web Services (Team Mentor)

Prof. Geetha Manivasagam (Faculty Coordinator)

- Akshay Girish Joshi (Team Leader)
  - Pranav Naidu (Alternate Team Leader)
  - Systems Overview: Akshay Girish Joshi, Ases Akas Mishra
  - Sensor Subsystem Design: Aman Gupta
  - Descent Control Design: Roshan Murali, Malhar Joshi
  - Mechanical Subsystem Design: Kunal Pandey, Ases Akas Mishra
  - CDH Subsystem Design: Rakshit Vig, Kumar Yash
  - EPS Design: Kumar Yash
  - FSW Design: Rakshit Vig, Pranav Naidu
  - GCS Design: Pranav Naidu, Devesh Bajaj
  - CanSat Integration & Test: Roshan Murali, Malhar Joshi
  - Mission Operations & Analysis: Ases Akas Mishra, Aman Gupta
  - Requirements Compliance: Kunal Pandey
  - Management: Kunal Pandey

Acronyms

Sr. no.	Acronyms	Full Form
1.	A	Analysis
2.	ADC	Analog to Digital Converter
3.	Alt	Altitude
3.	ARM	Advanced RISC Machines
5.	CDH	Communication and Data Handling
6.	CDR	Critical Design Review
7	COG	Centre of Gravity
8.	CSV	Comma Separated Value
9	D	Development
10	DCR	Decent Control Requirements
11	EEPROM	Electrically Erasable Programmable Read Only Memory
12	EPS	Energy Power Subsystem
13	FSW	Flight Software

Acronyms

Sr. no.	Acronyms	Full Form
14	GCS	Ground control station
15	GPS	Global Positioning System
16	GUI	Graphical User Interface
17	HDPE	High Density Polyethylene
18	I	Inspection
19	I2C	Inter Integrated Circuit
20	IDE	Integrated Development Environment
21	Li	Lithium
22	MCU	Microcontroller Unit
23	MSR	Mechanical Sub-System Requirements
24	P	Process
25	PANID	Personal Area Network Identification Number

SEDS VIT Think Infinite...

Acronyms

ANNUAL CANSAT COMPETITION

Sr. no.	Acronyms	Full Form
26.	PCB	Printed Circuit Board
27.	PDR	Preliminary Design Review
28.	RTC	Real Time Clock
29.	T	Testing
30	T<number>	Threads
31	SD	Secure Digital
32	Sqrt	Square Root
33	SRS	System Requirement summary
34	SSR	Sensor Subsystem Requirement
35	UART	Universal Asynchronous Receiver/Transmitter

Systems Overview

Akshay Girish Joshi

Ases Akas Mishra

Mission Summary

Mission Objectives

General Objectives

- To design and fabricate a solar powered CanSat that travels through the planetary atmosphere sampling the atmospheric composition during flight.
- The CanSat system consists of two primary components, namely a glider(Payload) and a re-entry container that protects the glider.
- The glider payload records the desired reading and sends it to the ground station while descending in a helical path.

Mechanical Objectives

- The mass of the CanSat should be 500g with a tolerance of +/-10g and the container dimensions should be less than 310 mm x 120 mm.
- The container should use a passive descent up to 400 m.
- The glider payload is separated from the container at 400m +/- 10m.
- The glider should not be remotely or autonomously steered.
- The glider should take a helical path of diameter less than 1000 m and the flight time should be as close to two minutes as possible.

Mission Summary

Electrical Objectives

- Telemetry(air pressure, outside air temperature, altitude, mission time, flight software state, compass direction, air speed and voltage of power bus) should be collected and transmitted to the GCS at 1 Hz.
- All the glider electronics must be solar powered except for the time keeping device.
- The electronic components should be totally shielded from the environment with the exception of sensors.

Bonus Objectives

- A colored camera has to be mounted in nadir position to take photos as frequently as possible.
- It should be powered by the same solar source as the glider electronics.
- Images should be stored in the SD card and a count of the number of images stored should be kept.

Rationale-

- Easy to interface with the microcontroller
- Easy to store images in SD card
- We have sufficient power budget to support bonus objective

Bonus Objective is being attempted

External Objective- Our personal objective is to create a real time 3D simulation of the glider during its descent.

System Requirement Summary

ID	Requirement	Rationale	Mission Requirement Number	Priority	Parent	Child	VM			
							A	D	I	T
SRS-01	Total mass of the CanSat will be 500g with a tolerance of +/- 10g.	Mission requirement	1	High		MSR-01			X	
SRS-02	• Container length must be less than 310mm and diameter less than 125mm. • The glider will be completely confined inside the container.	Mission requirement. Prevention from getting stuck in the rocket	2,3	High		DCR-01 MSR-02	X		X	
SRS-03	Parachute with a spill hole will be used as a passive descent control system for the container.	To maintain reasonable descent rate and reduce swaying	4	High		DCR-02 DCR-03 MSR-03			X	X
SRS-04	Container and glider should be fluorescent colored.	To ensure easy recovery	6	High		MSR-04			X	
SRS-05	Container will not have sharp edges.	To prevent it from getting stuck in rocket payload section	5	Low		DCR-04 MSR-05				
SRS-06	Glider must be released at 400m +/- 10m from the container.	Mission requirement	10	High		DCR-05 MSR-06 SSD-05 FSW-09				X

System Requirement Summary

ID	Requirement	Rationale	Mission Requirement Number	Priority	Child	VM			
						A	D	I	T
SRS-07	The glider will not be remotely or autonomously steered.	Mission requirement	11	High	GCS-17			X	
SRS-08	The glider should take a helical path of a diameter less than 1000m.	Mission requirement.	11	High	DCR-06	X	X	X	X
SRS-09	All the structures shall be built to survive 30 Gs of shock and 15 Gs of acceleration .	To ensure that the CanSat can withstand the rocket deployment conditions	13,15,16	High	MSR-07 SSD-08			X	X
SRS-10	All electronics should be hard mounted using proper mounts	To avoid lose connections and ensure that they maintain their configuration in all states.	17	High	MSR-09			X	
SRS-11	Telemetry(air pressure, outside air temperature, compass direction, air speed, power bus voltage, mission time, FSW state, altitude,etc) should be collected and transmitted to the GCS at 1Hz. Telemetry should be maintained even in the case of processor resets.	Mission requirement	21,23	Low	GCS-01 SSD- 01 to 07 EPS-08 CDH-02,16 FSW- 01,03,04	X			X
SRS-12	Glider electronics must be solar powered (except for the time keeping device).	Mission requirement	27	High	EPS-01				X

System Requirement Summary

ID	Requirement	Rationale	Mission Requirement Number	Priority	Child	VM			
						A	D	I	T
SRS-13	XBEE pro S2B, 2.4 GHz is used for telemetry transmission(will not be in broadcast mode)	To establish communication between the CanSat and the GCS.	24	High	CDH-01 CDH-09			X	
SRS-14	Cost of the CanSat should be less than $1000	Competition requirement	28	High		X		X	
SRS-15	The XBEE radio NETID/PANID should be set to the team number	To avoid interference with other team data	25	High	CDH-07			X	X
SRS-16	The teams should plot the telemetry data field in real time during flight and a 2D map of the glider position should be displayed by the GCS	Mission Requirement	32	High	GCS-02	X		X	X
SRS-17	Ground station should be portable and must have a laptop with minimum of 2hrs of battery operation, XBEE radio and antenna.	Mission Requirement	33,34	Low	GCS-03 GCS-04		X		X
SRS-18	Container and the glider must be labelled with team contact information including email address	To ensure easy recovery	35	High				X	

System Requirement Summary

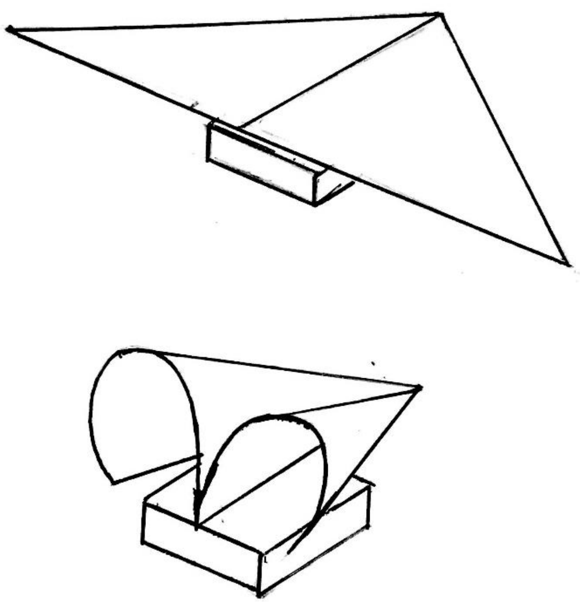
ID	Requirement	Rationale	Mission Requirement Number	Priority	Child	VM			
						A	D	I	T
SRS-19	The flight software should maintain a count of the packets transmitted and should increment with each packet transmission in the mission.	Mission Requirement	36	High	FSW-04			X	
SRS-20	An easily accessible power switch must be included in the glider and container	To switch on/off the system	38	High	EPS-03	X		X	
SRS-21	The container should contain all the electronics and mechanisms to release the glider at the required altitude	Mission Requirement	39	High	MSR-08 SSD-12			X	X
SRS-22	The container electronics should be powered by alkaline batteries	Mission Requirement	40	High	EPS-05			X	
SRS-23	The glide duration should be as close to 120 seconds as possible.	Mission Requirement	41	Low	DCR-07	X			
SRS-24	The CanSat container should have a payload release override command to act as an alternate ejection mechanism in case the autonomous release fails.	To ensure ejection of the CanSat glider from the container.	42	High	GCS-05 FSW-11	X			X
SRS-25	The container should transmit telemetry from time being turned (placed on the launch pad) until 2sec after ejection of the glider	To ensure continuous telemetry data is delivered to the GCS	46	High	CDH-06,12		X		X

System Requirement Summary

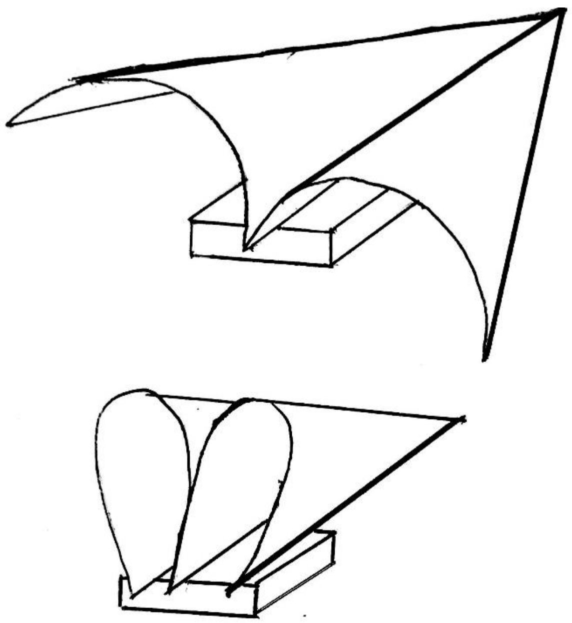
ID	Requirement	Rationale	Mission Requirement Number	Priority	Child	VM			
						A	D	I	T
SRS-26	The container telemetry should include team number, altitude, temperature, pressure, mission time, indication of container telemetry, software state, etc.	Mission Requirement	48	High	SSD - 01,03,05 ,06 FSW-02			X	
SRS-27	Audio beacons should be included in the glider and the container	For easy recovery	49,50	High	FSW-08 SSD-11	X		X	
SRS-28	Glider must be fixed wing glider.	Mission Requirement	43	High	MSR-10	X		X	
SRS-29	Colour camera with a resolution of 640x480pixels will be added to take images of the ground which will be stored on the glider	Bonus Objective	—	High	GCS-09 SSD- 09,10 CDH-14 FSW-07			X	X
SRS-30	Count of number of pictures taken must be kept and included in telemetry.	Bonus Objective	—	High	CDH-10 FSW-07			X	
SRS-31	The camera should be powered by the solar source.	Bonus Objective	—	Low	EPS-01				
SRS-32	The GCS shall simulate the heading data	Bonus Objective	—	Low	GCS-10	X			X

System Level CanSat Configuration Trade & Selection

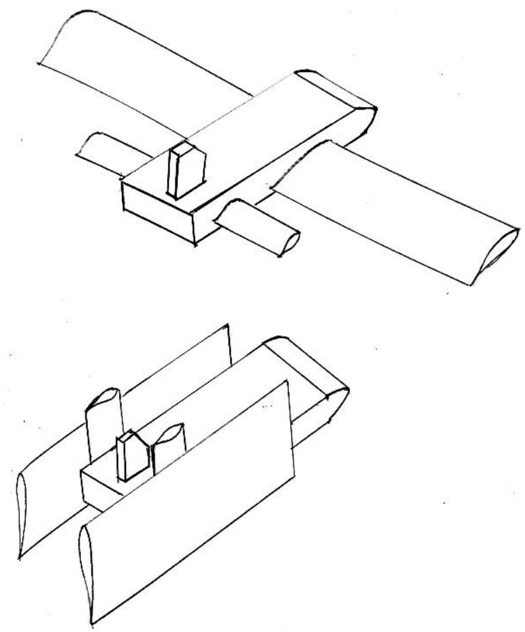
- **Considered Preliminary system level configurations:**



Hang Glider Design



Rogallo Wing Design



Constant Chord Configuration

System Level CanSat Configuration Trade & Selection

Sr. No	HANG GLIDER DESIGN	ROGALLO WING DESIGN	CONSTANT CHORD CONFIGURATION
1	Simple Geometry	Simple Geometry	Complex Geometry
2	Very high lift to drag ratio	Comparatively lower lift to drag ratio	Lowest lift to drag ratio
3	Easy folding mechanism	Easy folding mechanism	Complex folding mechanism
4	Easy to manipulate COG	Easy to manipulate COG	Difficult to manipulate COG
5	High available surface area to accommodate more solar panels	Highest available surface area to accommodate more solar panels	Low available surface area to accommodate more solar panels
6	High wind resistance	High wind resistance	Low wind resistance
7	Easy and cheap to manufacture	Easy and cheap to manufacture	Difficult and costly to manufacture
8	Dacron type 52 will be used to make the hang glider sail.	Dacron type 52 will be used to make the rogallo wing sail	Balsa Wood will be used to manufacture the wing

System Level CanSat Configuration Trade & Selection

Selected Configuration- Hang Glider

Selection Rationale:

- Easy and cheap to manufacture
- High lift to drag ratio
- Easy to fold and unfold
- Easy to manipulate COG
- Simple Geometry
- High available surface area to accommodate more solar panels
- Dacron type 52 will be used to make the hang glider sail. This has high strength to weight ratio.

Physical Layout

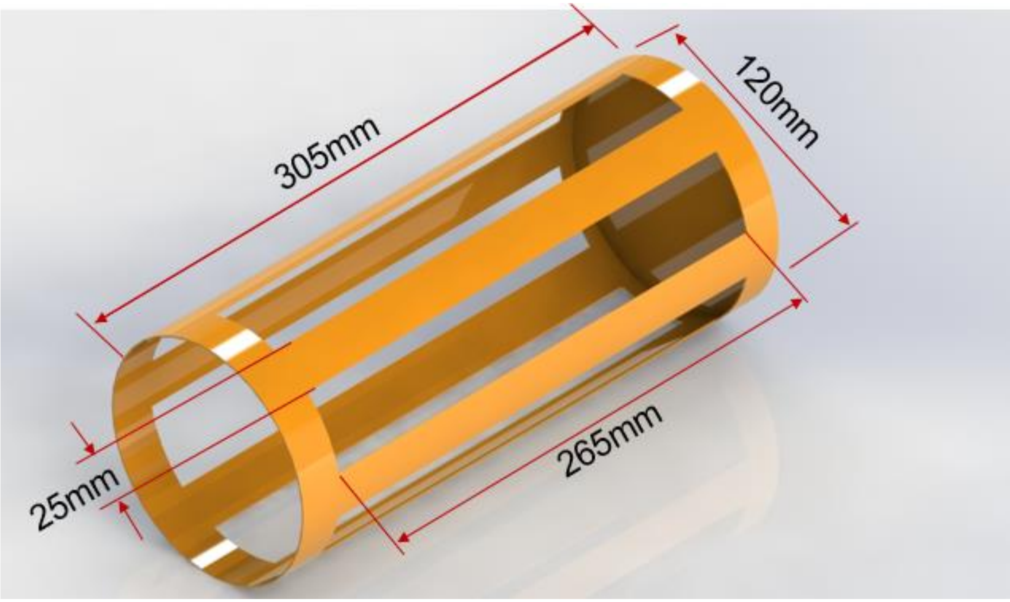
- The container is a cylindrical enclosing of 305mm length and 120mm diameter with a material thickness of 2mm. 3D printed using HDPE(High Density Polyethylene), the container will have slots along the curved surface area to reduce its weight.

- As the container can't be an open component, the slots will be covered using polyethylene sheet that will protect the contents of the container from the external environment and the adverse in- flight conditions.

- One side of the container will be closed using HDPE lid and the other side will be open for the glider deployment. On the closed side, the parachute will be folded and placed so that it doesn't get stuck in the hooks which hold the rubber band for the ejection mechanism.

- The container dimensions were fixed in accordance with the dimensions of the rocket . A clearance of 5mm was given to facilitate any tolerances. It will be made sure that the container has no sharp edges for its easy release from the rocket payload section.

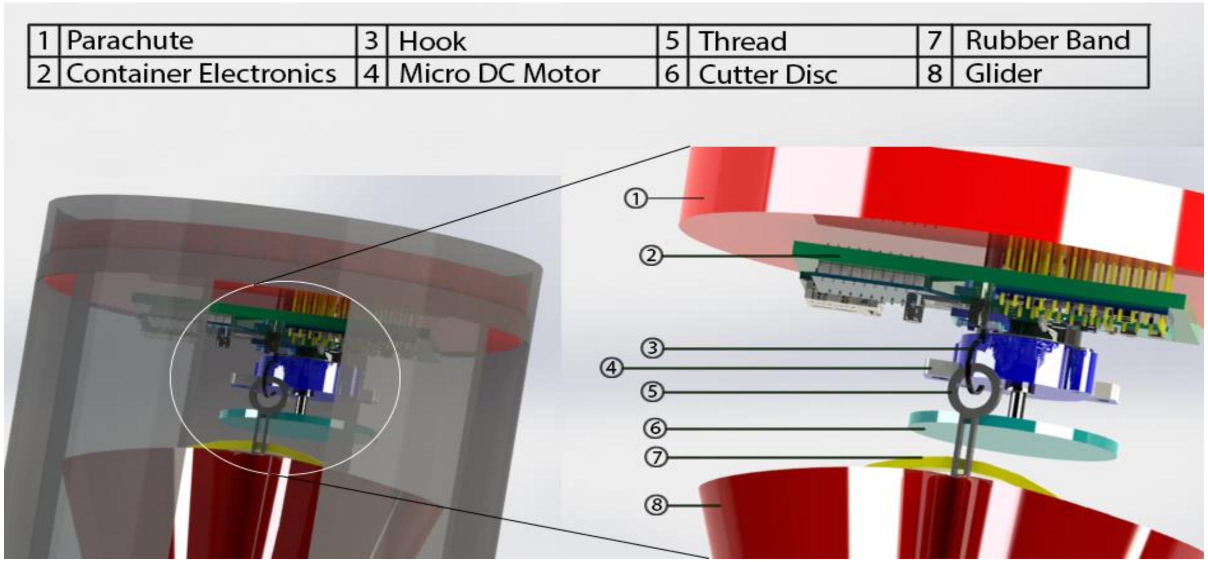
- The rocket payload compatibility will be checked with the help of a dummy rocket payload section. No part of the rocket will be used for CanSat operation .

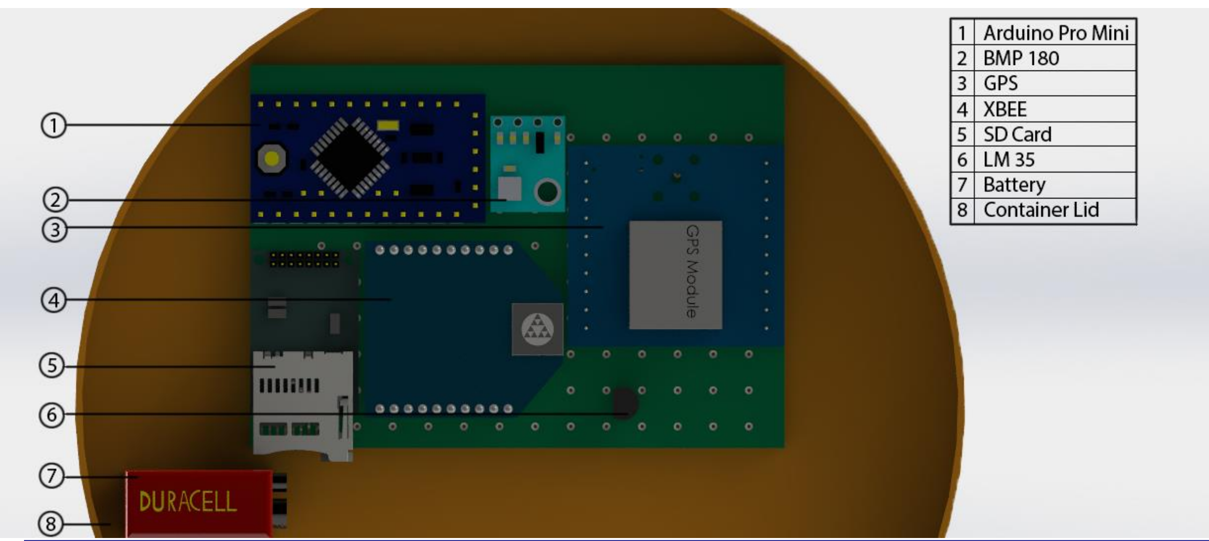


CONTAINER

Dimensions (in mm)	Rocket	Container	Clearance given
Length	310	305	5
Breadth	125	120	5

Physical Layout



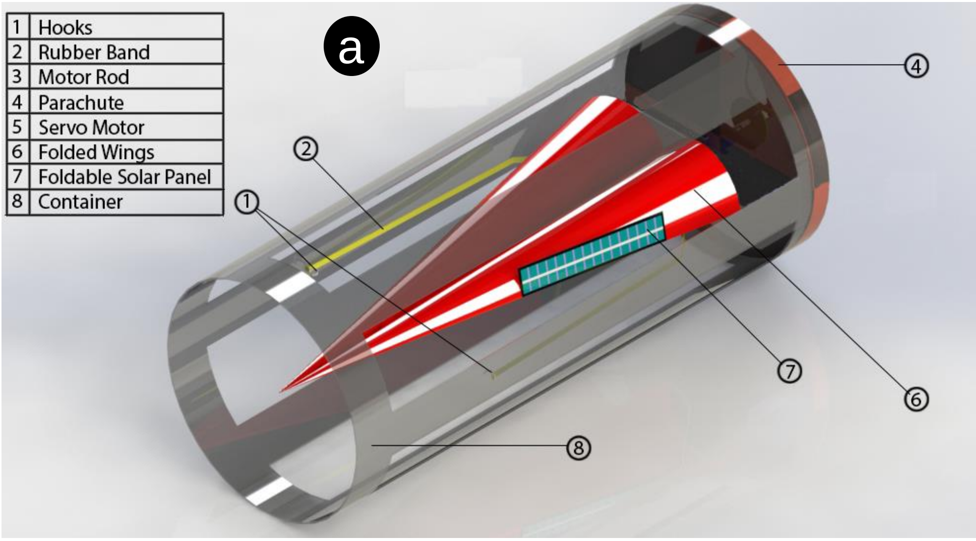


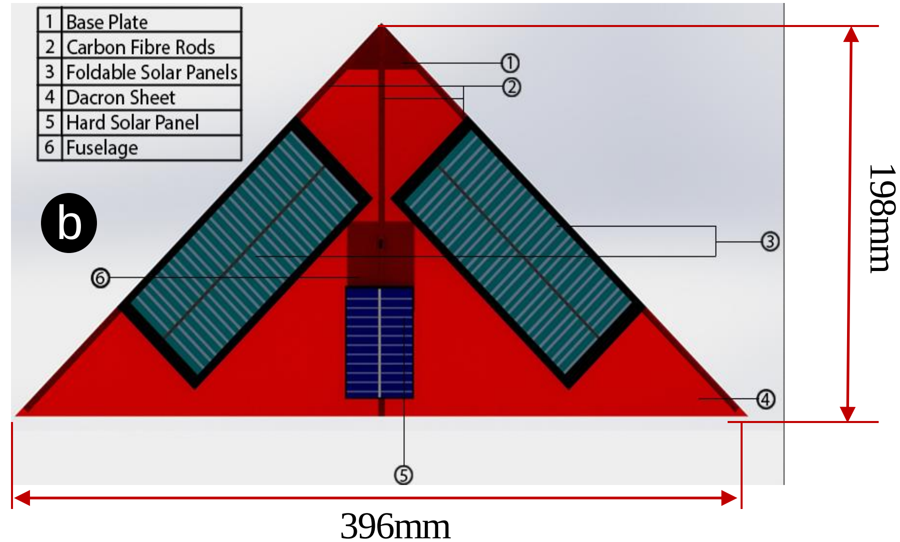
Component	Dimensions(mm)
Arduino Pro Mini	l=18,b=33
BMP180	l=13, b= 14, h=2.54
lm 35	l=15, b= 4, h=2
sd card	l=45, b=28
Xbee	l=32, b=24, h=8
Battery	d=20, h=6
GPS	l=80, b=80, h=30

Where,
l=length, b=breadth, h=height, d=diameter

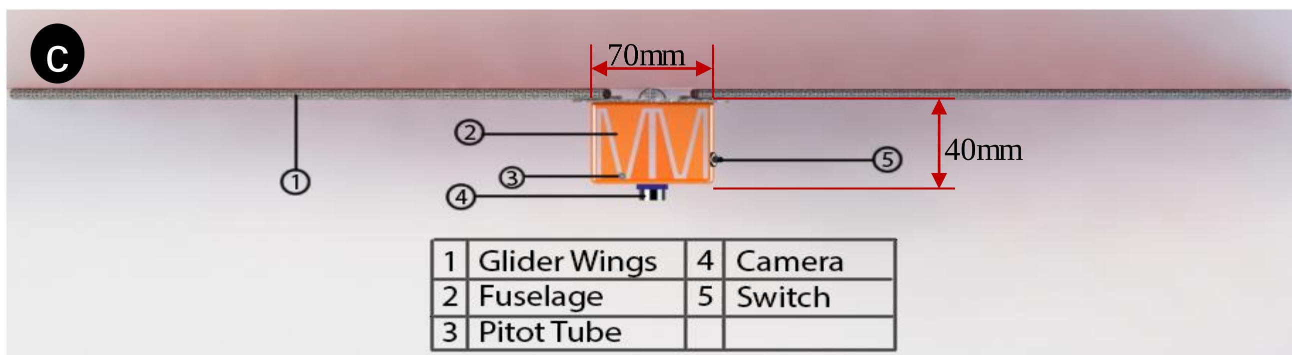
Container Electronics

Physical Layout

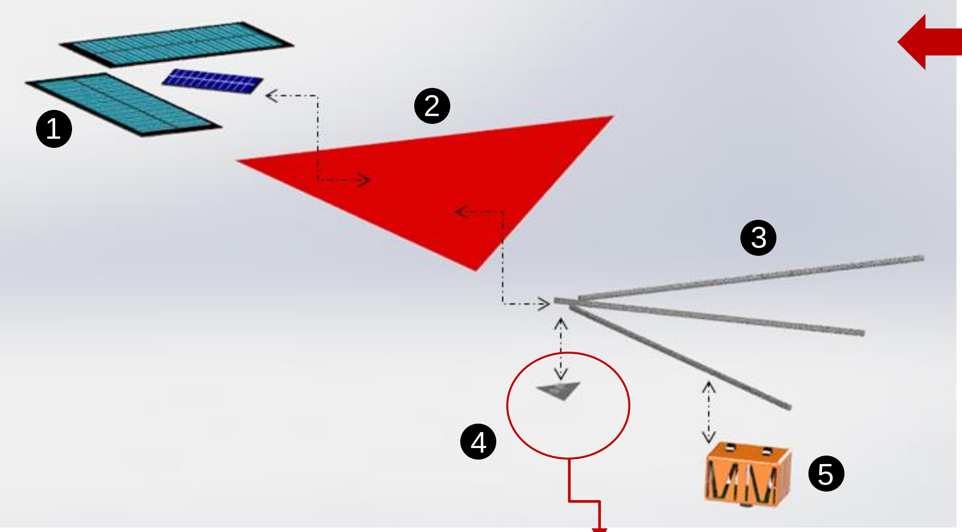




a- Stowed/launch configuration
b- Deployed Configuration Top View
c- Deployed Configuration Front View

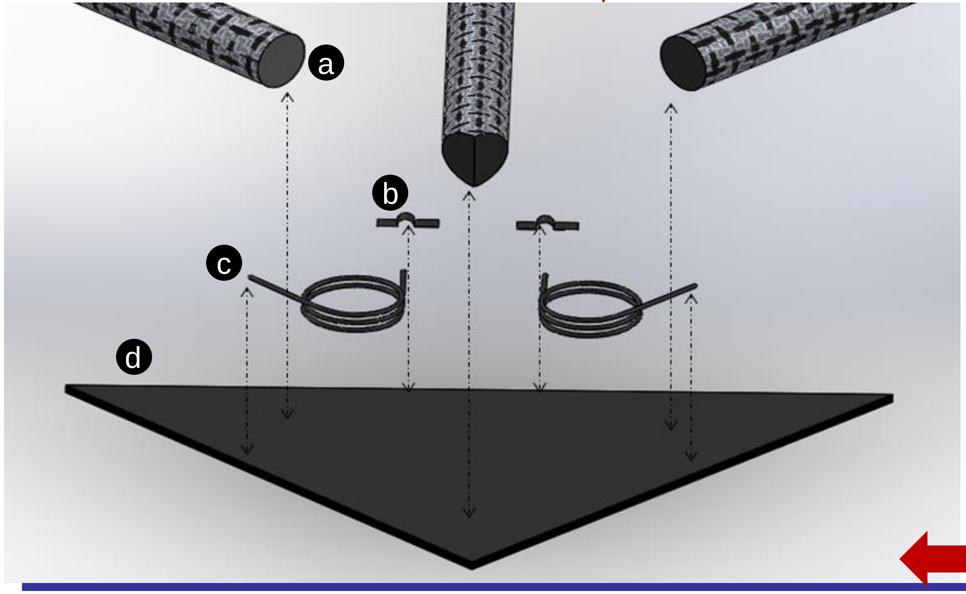


Physical Layout



Exploded view of the CanSat glider

Number	Component	Description
1	Solar Panels	3 solar panels, 2 foldable and 1 rigid
2	Sail Cloth	Dacron type 52
3	Skeleton	Thornel Mat VMA Carbon fibre rod
4	Triangular plate	Base plate to hold skeleton folding mechanism
5	Fuselage	Slotted cuboid containing the electronics

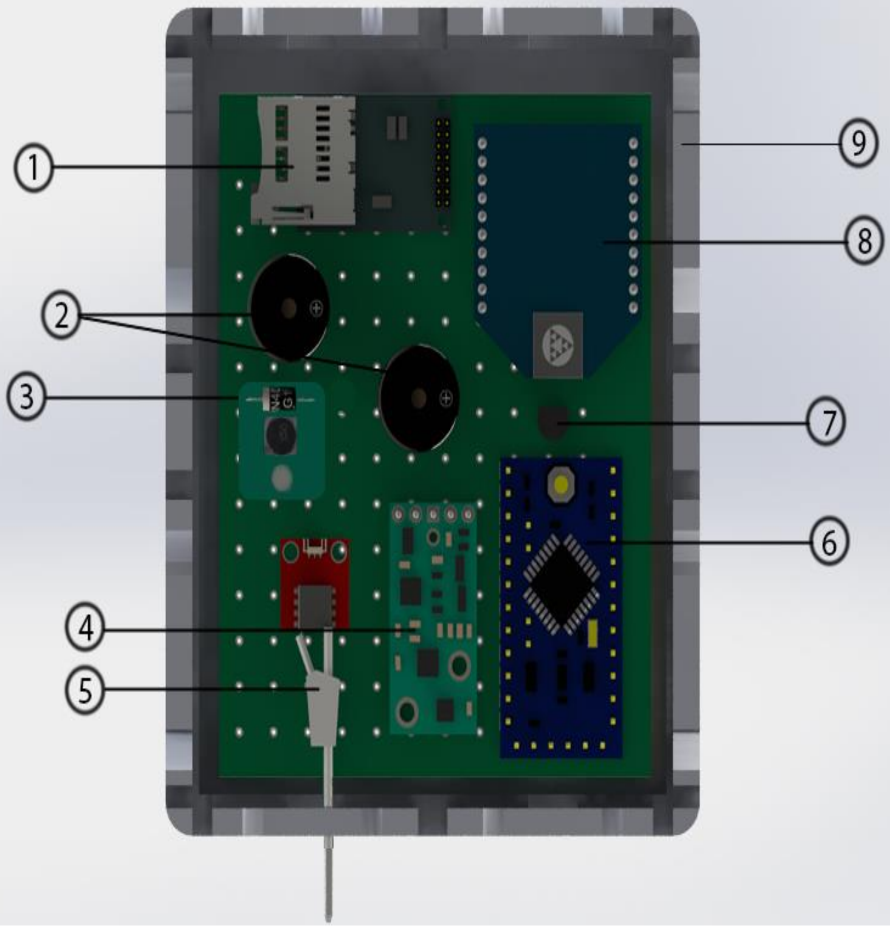


Number	Component	Description
a	Skeleton	4mm diameter Carbon Fibre rods
b	Clamp	Clamps to hold spring
c	Coil Spring	Heat treated steel coil spring to fold the skeleton
d	Triangular plate	Base plate to hold skeleton folding mechanism

Exploded view of Base plate

Physical Layout

1	SD Card
2	Buzzers
3	Volatge Regulator
4	LSM303D, BMP180, L3GD20
5	Pitot Tube
6	Arduino Pro MIni
7	LM 35
8	XBEE
9	Fuselage



Component	Dimensions(mm)
Arduino Pro Mini	l=18,b=33
LSM303D,BMP180 , L3GD20	l=33, b= 23
lm 35	l=15, b= 4, h=2
pitot tube	l=14, b=20, h=14
sd card	l=45, b=28
Xbee	l=32, b=24, h=8
Buzzer	d=12.0, h=8.5
Fuselage	l=70, b=70, h=40
Voltage Regulator	l=20.9,b= 43.18 h=9.65

Where,
l=length, b=breadth, h=height, d=diameter

System Concept of Operations

Pre-Launch Test

- CanSat will be inspected for any surface abrasions, scratches and damages.
- The solar panels will be cleaned.
- All the on-board electrical circuits will be verified .
- The sail material will be checked for any rips.
- The GCS will be initiated and the software will be checked for proper functioning of each sub process and the initial FSW state will be shown on the GCS .
- Radio communication and sensors will be tested.

Loading of CanSat

- The glider will be folded and slid into the container and the ejection mechanism will be set in place.
- The parachute will be folded and placed in the closed end of the container opening for easy release.
- The CanSat will be switched ON and will start transmitting telemetry data.
- The CanSat will be placed into the payload section of the rocket.
- A final system check will be conducted through telemetry.
- The FSW state will be updated on GCS.

Rocket Deployment

- FSW will initiate its next state and the same will be updated on the GCS.
- CanSat will be deployed from the rocket at 1000m and the parachute will be inflated to aid its descent.

System Concept of Operations

Detachment

- As the CanSat attains an altitude of 400m+/- 10m , the FSW will go into detachment state.
- At 400m+/- 10m the ejection mechanism will be activated and the glider will eject from the container.
- If the automatic ejection mechanism is not activated until the glider reaches 400m+/- 10m , ejection mechanism will be forced by the GCS.
- The container will continue to transmit the telemetry data for 2 seconds after the release of the glider.

Glider Descent

- Glider descent state will be initialized on the FSW and updated on the GCS.
- The glider wings will be fully deployed.
- The solar panels will start supplying sufficient power to the system.
- The glider will start descending in a helical path of diameter 96.46 m.

Landing

- The FSW state will be updated to landing. Buzzer will be turned ON.
- Telemetry will be stopped
- Recovery crew will recover the CanSat.
- Data will be presented to the judges

Launch vehicle compatibility

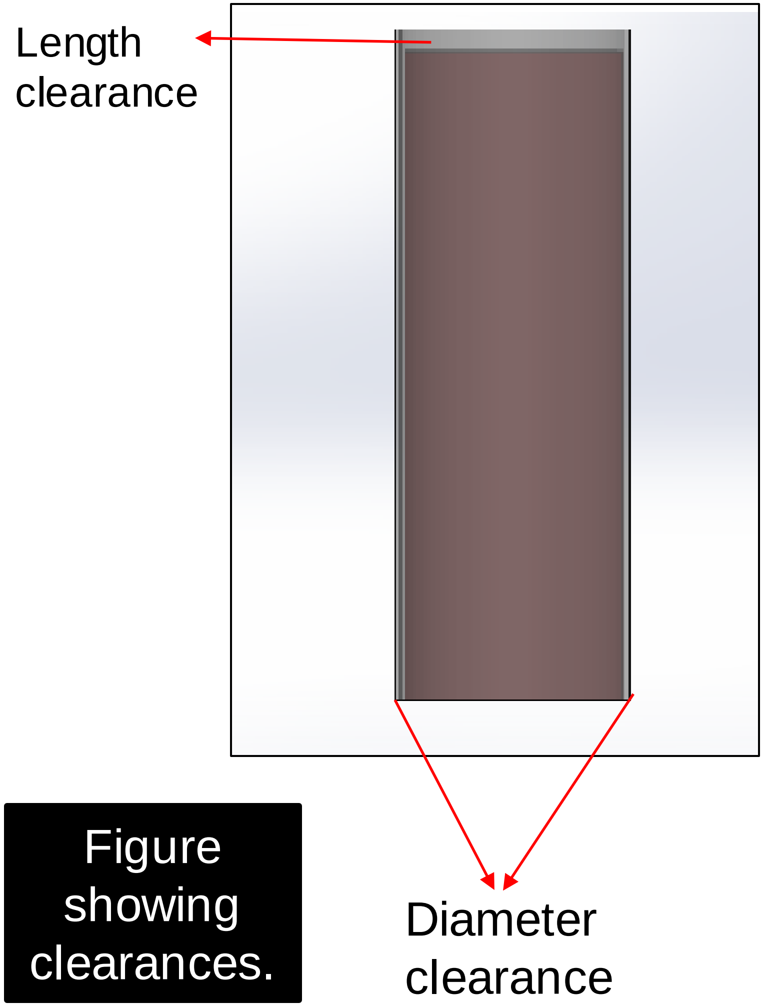
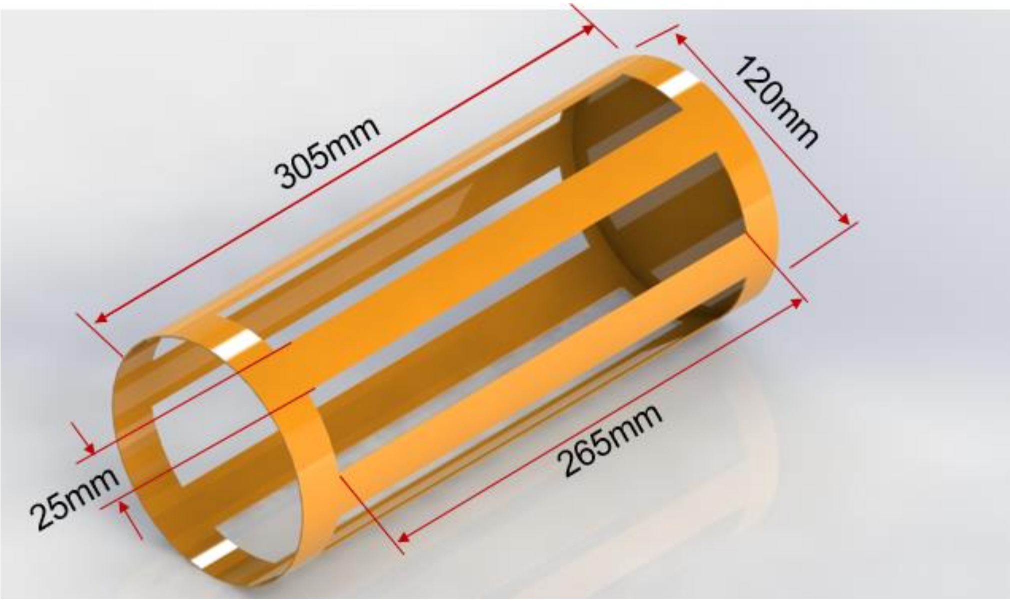


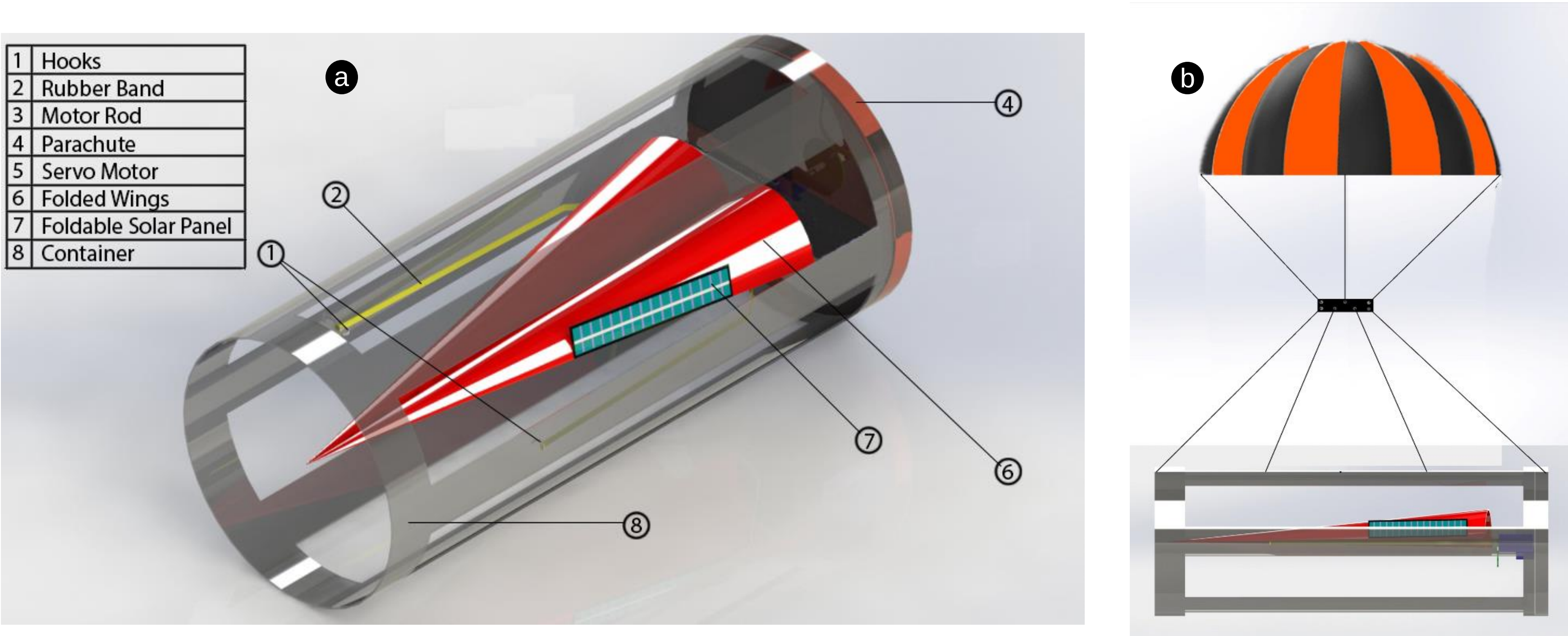
Figure showing clearances.



CONTAINER

Dimensions (in mm)	Rocket	Container	Clearance given
Length	310	305	5
Breadth	125	120	5

Launch vehicle compatibility



a) Launch configuration(container+ payload).
There are no sharp protrusions
b) Descent control apparatus

Sensor Subsystem Design

Aman Gupta

Sensor Subsystem Overview

S.No	Sensor Type	Model Number	Purpose	Location
1.	Temperature Sensor	LM 35	To measure outside air temperature	Payload and Container
2.	Pressure Sensor	BMP 180	To measure air pressure	Payload and container
3.	Magnetometer	LSM 303D	To measure compass direction	Payload
4.	Altimeter	BMP180	To measure altitude	Payload
5.	Air speed sensor	HK Pilot air speed sensor	To measure air speed	Payload
6.	Camera	Adafruit TTL Camera	To take images	Payload
7.	Altimeter	Adafruit ultimate GPS breakout	To measure altitude	Container
8.	Voltage sensor	Voltage divider circuit R1=300Ω R2=500Ω (payload) R1=100Ω R2=500Ω (container)	To measure voltage of the power bus	Payload and Container

Sensor Subsystem Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
SSD-01	To measure air pressure of container and payload	Mission requirement	High	SRS-11 SRS-26	CDH-05	X			X
SSD-02	To measure compass direction of the glider	Mission requirement	High	SRS-11	CDH-05 GCS-10	X			X
SSD-03	To measure outside air temperature of the container and payload	Mission requirement	High	SRS-11 SRS-26	CDH-05	X			X
SSD-04	To obtain air speed of the glider	Mission requirement	High	SRS-11	CDH-05	X			X

Sensor Subsystem Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
SSD-05	To measure altitude of container and payload	Mission requirement	High	SRS-06 SRS-11 SRS-26 MSR-06	CDH-05 DCR-05 FSW-09		X		
SSD-06	Voltage of container and glider power bus to be procured	Mission requirement	High	SRS-11 SRS-26	CDH-05	X	X		
SSD-07	All the sensor data should be updated every one second	To update the telemetry at 1 Hz	High	SRS-11	FSW-01	X	X	X	
SSD-08	All sensor shall survive 15 Gs of acceleration and 30 Gs of shock	Mission requirement	High	SRS-09 MSR-07		X	X		

Sensor Subsystem Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
SSD-09	SD card is used to store images and telemetry	To backup the data	High	SRS-29	CDH-13 FSW-06 FSW-07		X		
SSD-10	Camera of resolution 640 x 480 is used to capture images as frequently as possible and a count of the number of images will be maintained	To fulfill bonus objective	Medium	SRS-29	CDH-14 CDH-05 FSW-07		X		
SSD-11	Audio beacon to be used on container as well as on payload	To recover payload and container	High	SRS-27 FSW-08		X			X
SSD-12	Container should contain all the electronics for ejection of glider	For the ejection of glider at required height	High	SRS-21 MSR-08		X	X		

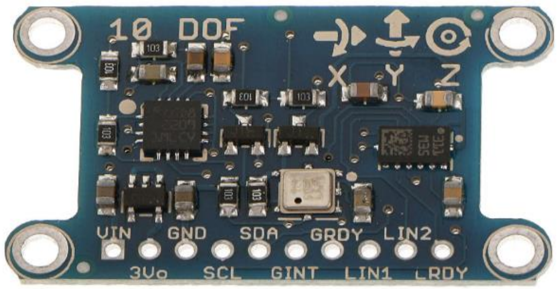
Payload Magnetometer Trade & Selection

S.No	Model number	Operating voltage	Range	Connection Type	Price
1.	LSM303D	2.16 V to 3.6 V	±12 gauss	I2C	$12.5
2.	MPU 9250	2.4V-6V	± 8 gauss	Analog	$6.65
3.	Razor IMU	3.5V-16V	±8 Gauss	I2C	$74.95

Sensor chosen : LSM303D

Reasons:

- Optimized input current and operating voltage .
- Has a good range of ±12 gauss.



Light Weight(1g) and small size (33mmx23mm)

Note:

It is included in 10DOF Gyro Accelerometer Compass Altimeter

Payload Air Pressure Sensor Trade & Selection

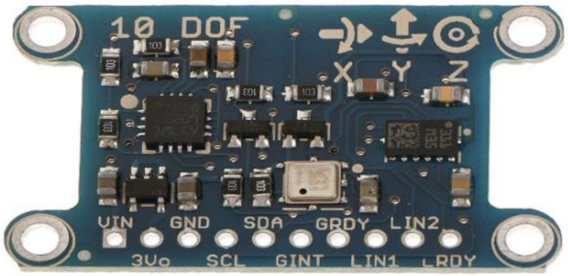
S.NO	Model Number	Weight (g)	Operating voltage	Range	Accuracy	Connection Type	Price
1.	BMP 180	0.92	3V - 5V	300 -1100 hPa	0.1 kPa	I2C	$2.66
2.	MPX 4115	4	4.85V - 5.35V	15 -115 kPa	+/- 0.015 hPa	Analog	$ 22.58
3.	Spark fun MPL 3115A2	1	1.6V – 3.6V	20 -110 kPa	+/- 0.05 kPa	I2C	$14.95

Sensor Chosen : BMP180

Reasons:

- High accuracy
- Light weight
- Easy to interface
- Up to 0.03hPa / 0.25m resolution
- Low cost and easily available

Note:
BMP 180 is integrated in 10DOF Gyro Accelerometer Compass Altimeter



Light Weight(1g) and small size (33mmx23mm)

Container Air Pressure Sensor Trade & Selection

S.NO	Model Number	Weight (g)	Operating voltage	Range	Accuracy	Connection Type	Price
1.	BMP 180	0.92	3V - 5V	300 -1100 hPa	0.1 kPa	I2C	$2.66
2.	MPX 4115	4	4.85V - 5.35V	15 -115 kPa	+/- 0.015 hPa	Analog	$ 22.58
3.	Spark fun MPL 3115A2	1	1.6V – 3.6V	20 -110 kPa	+/- 0.05 kPa	I2C	$14.95

Sensor Chosen : BMP180

Reasons:

- High accuracy
- Light weight
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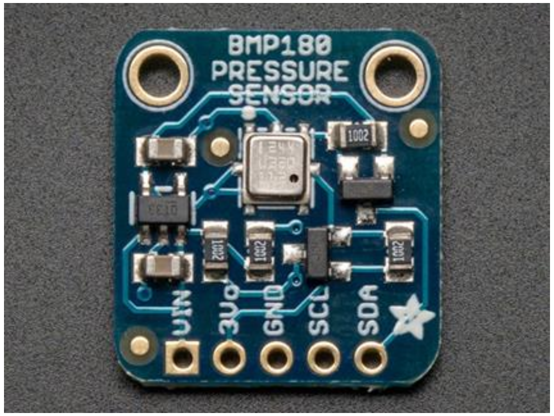
- Low cost and easily available



Payload Pitot Tube Trade & Selection

S.No	Model Number	Weight(g)	Operating Voltage	Maximum velocity measure	Connection type	Price
1.	HK pilot air speed sensor	18	5V	30 m/s	ADC	$26.03
2.	Pixhawk air speed sensor	13	5V	100 m/s	I2C	$78.03

Sensor Chosen: HK Pilot Air Speed Sensor

Reasons:

- Cheaper
- ADC connection
- Sufficient velocity measure
- Easy to use

Payload Air Temperature Sensor Trade & Selection

S.NO	Model Number	Operating Voltage	Range	Accuracy	Connection Type	Price
1.	TMP 36	2.7V-5.5 V	-40°C-125°C	+/- 2°C	Analog	$ 1.5
2.	LM 35	4V-30V	-55°C – 150 °C	+/- 0.5°C	Analog	$1.05
3.	AD 592	4V-30V	-25°C - 105°C	+/- 0.5°C	Analog	$ 5.92

Sensor Chosen: LM 35

Reasons:

- Wide temperature range
- Cheaper
- Negligible weight
- Easy to interface

Container Air Temperature Sensor Trade & Selection

S.NO	Model Number	Operating Voltage	Range	Accuracy	Connection Type	Price
1.	TMP 36	2.7V-5.5 V	-40°C-125°C	+/- 2°C	Analog	$ 1.5
2.	LM 35	4V-30V	-55°C – 150 °C	+/- 0.5°C	Analog	$1.05
3.	AD 592	4V-30V	-25°C - 105°C	+/- 0.5°C	Analog	$ 5.92

Sensor Chosen: LM 35

Reasons:

- Wide temperature range
- Cheaper
- Negligible weight
- Easy to interface

Payload Solar Power Voltage Sensor Trade & Selection

S.No	Model Number	Range	Error	Interface	Weight	Price
1.	ePro lab Voltage Sensor Module	< 25 V	1%	I2C	8 g	$ 2.5
2.	Voltage Divider	25 V	< 1%	Analog	neglible	neglible

Sensor Chosen: Voltage Divider

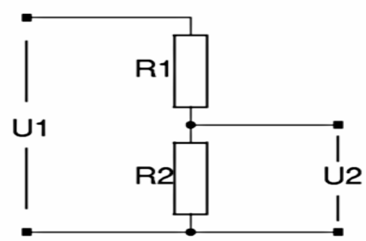
Reasons:

- Negligible weight
- Better range
- Greater accuracy
- Lesser space consumption
- Analog interface

R1 = 300Ω

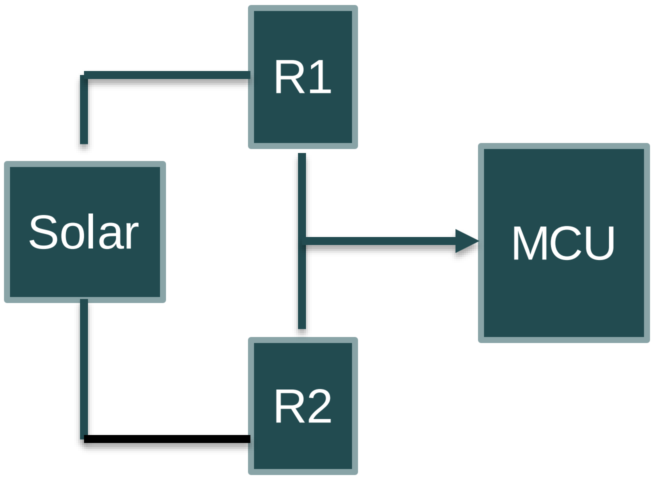
R2 = 500Ω

Voltage divider circuit



$$U2 = \frac{U1 * R2}{R1 + R2}$$

Payload Solar Power Voltage Sensor Trade & Selection



- Output of the voltage divider circuit is given of the ADC pin of the microcontroller
- The voltage across the power bus is calculated using

  $(R2/R1+R2)\ V_{Solar} = V_{ADC}$

  $V_{Solar} = V_{ADC}(R1+R2)/R2$

- Maximum voltage provided by the ADC pin of the MCU is 5V and solar source will provide a constant voltage of 8V

Therefore $(R1+R2)/R2=8/5$

$5(R1+R2)=8R2$

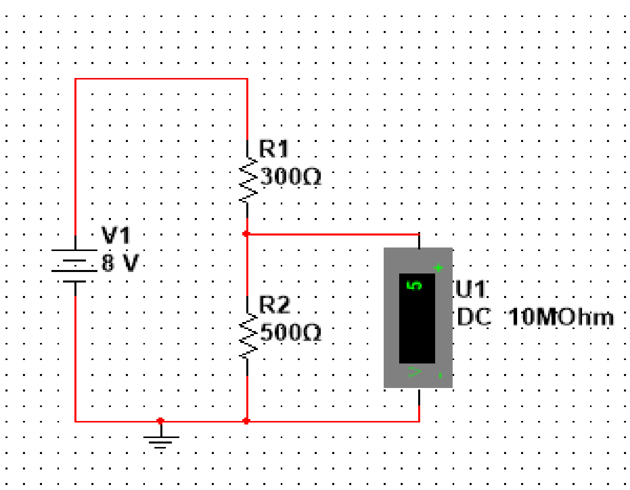
$R1/R2=3/5$

Hence resistances selected are 300Ω and 500Ω

- Resolution of the ADC pin is 10 bits

  Therefore, accuracy=5/1024=0.00488 V

Simulation



Container Solar Power Voltage Sensor Trade & Selection

S.No	Model Number	Range	Error	Interface	Weight	Price
1.	ePro lab Voltage Sensor Module	< 25 V	1%	I2C	8 g	$ 2.5
2.	Voltage Divider	25 V	<1%	Analog	neglible	neglible

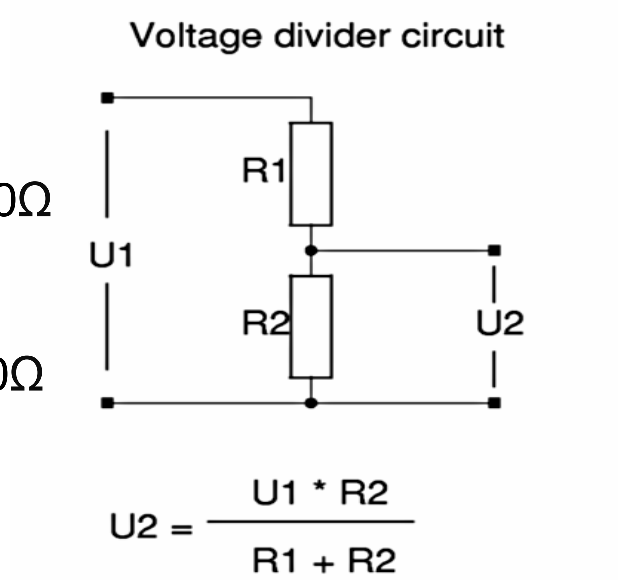
Sensor Chosen: Voltage Divider

Reasons:

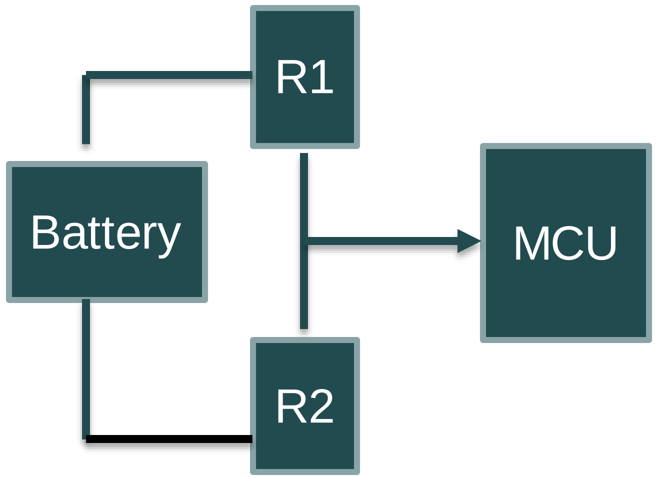
- Negligible weight
- Better range
- Greater accuracy
- Lesser space consumption
- Analog interface

R1=100Ω

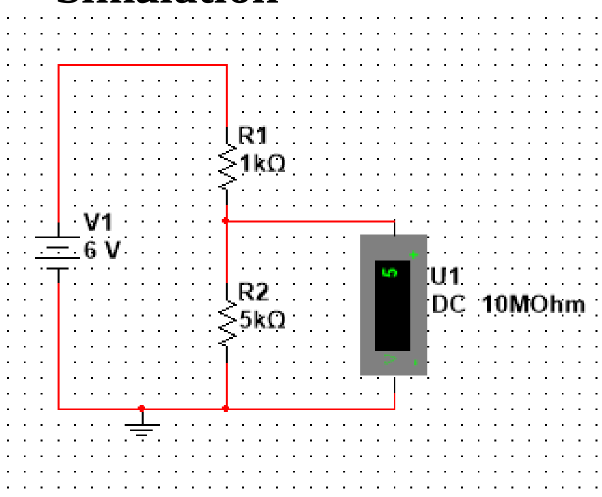
R2=500Ω



Container Solar Power Voltage Sensor Trade & Selection



Simulation



- Output of the voltage divider circuit is given of the ADC pin of the microcontroller
- The voltage across the power bus is calculated using

  $(R2/R1+R2)\ V_{battery} = V_{ADC}$

  $V_{battery} = V_{ADC}(R1+R2)/R2$
- Maximum voltage provided by the ADC pin of the MCU is 5V and solar source will provide a constant voltage of 6 V

  Therefore $(R1+R2)/R2=6/5$

  $5(R1+R2)=6R2$

  $R1/R2=1/5$

  Hence resistances selected are 100Ω and 500Ω
- Resolution of the ADC pin is 10 bits

  Therefore, accuracy=5/1024=0.00488 V

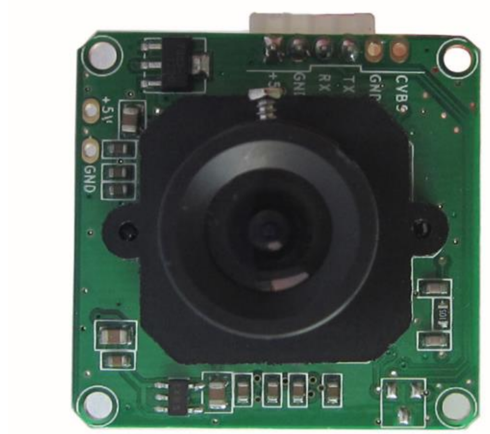
Bonus Camera Trade & Selection

S.No	Model Number	Operating Voltage	Operating Current	Weight	Dimensions	Resolution
1.	DIY OV7670 300KP VGA Camera module	1.7V-3V	25 mA	13 g	35 X 35 X 34 mm	640 X 480 pixels
2.	Adafruit TTL JPEG camera	5 V	75 mA	13 g	32 X 32 mm	640 X 480 pixels

Camera Chosen: Adafruit TTL JPEG Camera

Reasons:

- It uses UART to communicate with Arduino.
- It is easy, less bulky interface and the camera comes with on-chip image processor.
- It has a viewing angle of 60 degrees



Descent Control Design

Roshan Murali

Malhar Joshi

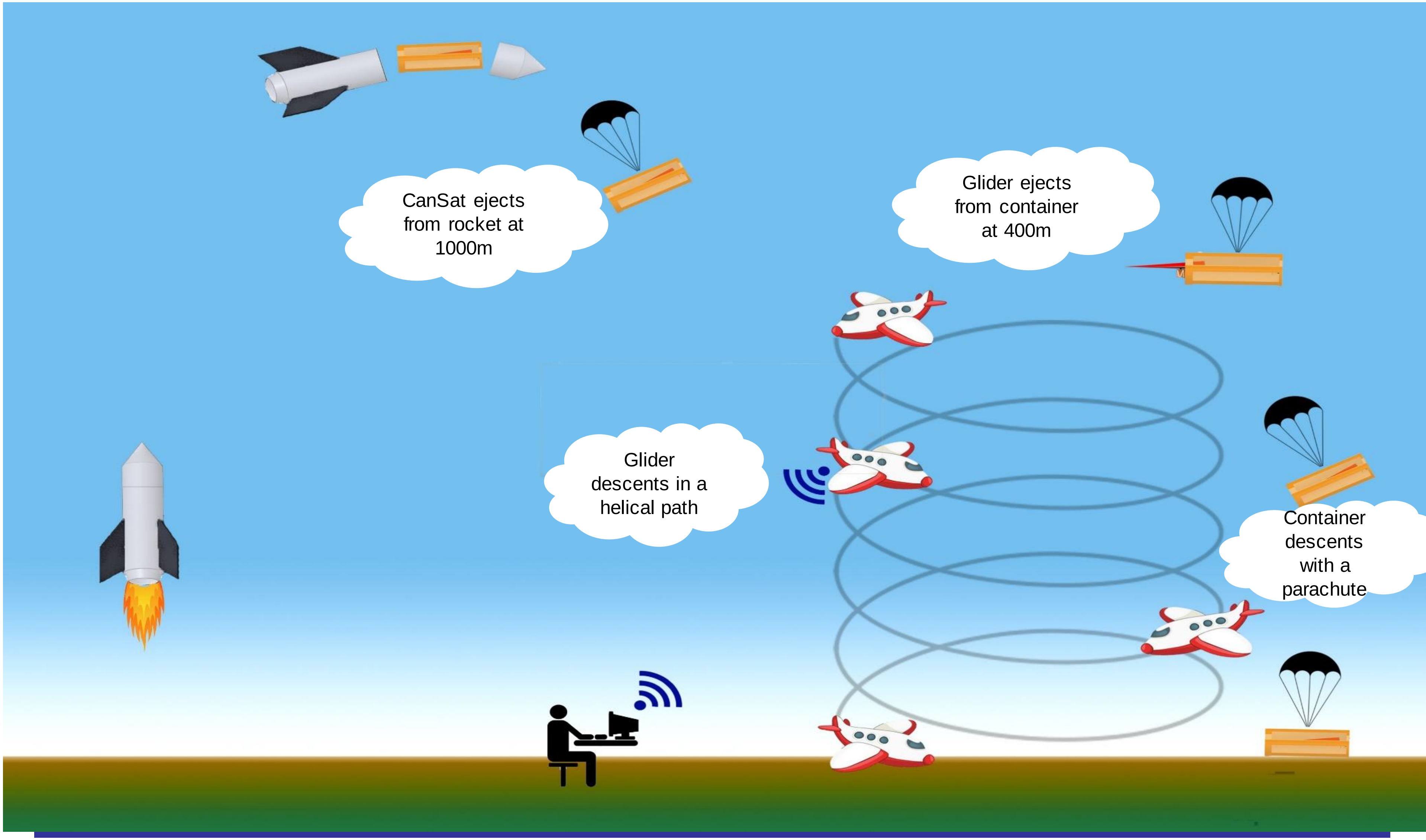
Descent Control Overview

- **Descent control system will contain a parachute attached on the container and a hang glider with a single flexible wing.**
- **The descent control system will be used for obtaining a constant descent velocity of the CanSat system between 2m/s to 4m/s.**
- **Descent control system will work in two phases:**

1) **The first phase of DCS will use a parachute** placed within the container and deployed after the CanSat is ejected from the rocket
   - The glider is securely fixed inside the container during this phase.
   - The container and glider are interfaced using a hook system controlled by a DC motor.
   - The airflow will inflate the parachute and the spill hole will help the CanSat to stabilize.
   - During deployment the system will be stable.

2) **Second phase of DCS will include the ejection and descent of the hang glider**.
   - At an altitude of 400m+/-10m, the DC motor will initiate the glider ejection mechanism
   - The ejection mechanism consist of a rubber bands pulled back and held by a string. The DC motor will be attached to a disc that will be used to cut the aforementioned string and launch the glider
   - The glider is ejected from the CanSat with a forward velocity in a banked position
   - After ejection the wings will deploy allowing the glider to descend in helical path

Descent Control Overview



Descent Control Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
DCR-01	The glider shall be completely contained within the container	Mission requirement and To have easy ejection	High	SRS-02 MSR-02				X	
DCR-02	Container shall contain a passive descent control mechanism	Mission requirement and to avoid free fall	High	SRS-03	MSR-03			X	X
DCR-03	Parachute shall contain a spill hole	To stabilize the system	High	SRS-03 MSR-03					X
DCR-04	Container shall have no sharp edges.	Mission requirement and To ensure easy deployment	High	SRS-05 MSR-05				X	
DCR-05	An ejection mechanism shall ensure detachment of glider at 400 m +/-10 m	Mission requirement	High	SRS-06 SRS-21 SSD-5 MSR-06 FSW-09			X		X
DCR-06	Glider shall descend in a helical path of diameter lesser than 1000m	Mission requirement	High	SRS-08			X		X
DCR-07	Glider shall have a flight time as close to 2 mins as possible	Mission requirement	High	SRS-23			X		X

Container Descent Control Strategy Selection and Trade

Material	Diameter (cm)	Type	Mass (g)	Price ($)
Nylon	61	Elliptical	35	65
Nylon	61	Mid power	35	35
Nylon	56	Mid power	28	28

- Nylon mid power parachute with 61 cm diameter will be used due to it's low cost and required descent rate.
- Parachute will be attached to the container so as to allow it to descend horizontally.
- The parachute will be attached to connecter which will be connected to the container on 4 individual points so as to reduce the rotation of the container
- Elastic strings will be used to attach the connector to the container as it will absorb the shock.
- Preflight review testability:

  Checking whether the parachute is attached and will be deployed properly.

Component	Colour
Parachute	Orange
Container	Florescent orange

The parachute will be attached to the container by making 4 holes on the container through which the parachute thread will be passed and a knot will be made to secure it.

Payload Descent Control Strategy Selection and Trade

A comparative study of flexible single surface wing and rigid wing gliders

	Single surface flexible wing glider	Rigid wing glider
Design	Simple	Complex
Weight	17g	>30g
Surface area	High	Low
Structural requirement	Does not require battens	Requires rigid leading edge and many battens
Aspect Ratio	High	Low
Glide ratio	3:1	14:1

The single surface flexible wing hang glider was chosen for the following reasons

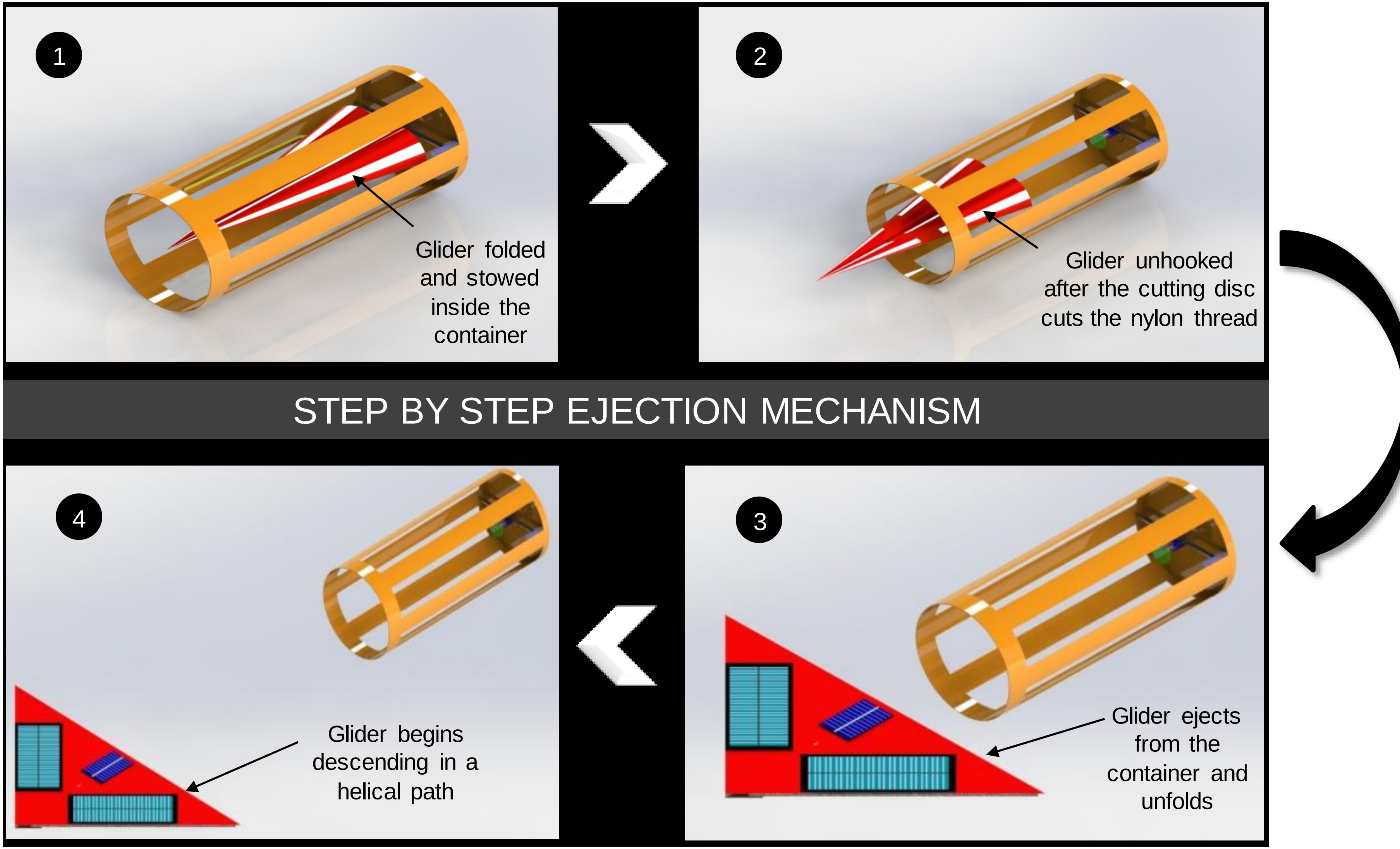
- Can be easily manufactured
- Lightweight
- Provides a larger surface area to meet the power requirements
- Allows for easier control using weight shift mechanism
- Can be easily folded and stowed inside the container

Wing dimensions and parameters

- The wing will be a isosceles right angled triangle (Due to the largest available surface area)
- Length of the leading edge = 28 cm
- Glide ratio : 2.71:1
- Coefficient of lift : 1.63
- Coefficient of drag: 0.60

Rigid wing glider

Single surface flexible wing glider



1
Glider folded and stowed inside the container
2
Glider unhooked after the cutting disc cuts the nylon thread
STEP BY STEP EJECTION MECHANISM
4
Glider begins descending in a helical path
3
Glider ejects from the container and unfolds

Descent Rate Estimates

Numeric estimation of descent rate of the Container

Formula used:

$$mg = \frac{1}{2}\rho C_d(\pi r^2)v^2$$

From this we get

$$v = \sqrt{\frac{2mg}{\rho C_d(\pi r^2)}}$$

Where,
r=Radius of the Parachute (0.305 m)
m=Mass Of the System
g=Acceleration Due To Gravity(9.81m/s)
ρ=Density Of Air
C_d=Drag Coefficient (1.75)
v= Descent velocity

Assumptions:

1.Air resistance is neglected.
2.Mean air density at operating altitude and 30℃ is used
3.Drag coefficient (estimated according to shape of parachute=1.75)

Parameter	Container + Payload	Container
Altitude	1000m-400m	400-0m
Average air density	1.055 kg/m^3	1.121 kg/m^3
Weight	0.5 kg	0.2 kg
Descent rate	$\sqrt{2\frac{0.5 \times 9.81}{1.055 \times 1.75 \times (\pi \times 0.305^2)}}$	$\sqrt{2\frac{0.2 \times 9.81}{1.121 \times 1.75 \times (\pi \times 0.305^2)}}$
Descent velocity	**4.26 m/s**	**2.616 m/s**

Descent Rate Estimates

Calculation of initial velocity of the glider

- Energy stored in the rubber bands is the kinetic energy of the glider

$$\frac{1}{2}kx^2 = \frac{1}{2}mv^2$$

From this we get

$$v = \sqrt{\frac{kx^2}{m}}$$

Where

k = *Force constant of the rubber band*

$(81.4 \times 2 = 162.8\ N/m)$

x = *Extension of the rubber band* $(0.175\ m)$

m = *Mass of the glider* $(0.30\ kg)$

v = *exit velocity of the glider*

From this the exit velocity is calculated to be $\mathbf{4.07\ m/s}$

Numeric estimation of descent rate of the Glider

Formula used:

$$v = \sqrt{\frac{2mg{C_d}^2}{\rho A {C_l}^3}}$$

Where

v = *Descent velocity*

m = *mass of the glider* $(0.30\ kg)$

C_d = *Coefficient of drag* (0.60)

C_l = *Coefficient of lift* (1.63)

ρ = *Average density of air* (1.121)

A = *Surface area of the glider* $(0.0392\ m^2)$

From this the descent velocity is calculated to be 3.33 $\boldsymbol{m/s}$

The glide time is calculated to be 120 seconds

Descent Rate Estimates

Turning radius of the glider

It is estimated using

$$F_l \sin\theta = \frac{mv^2}{r}$$

Hence we get

$$\frac{1}{2} C_l A \rho v^2 \sin\theta = \frac{mv^2}{r}$$

Solving for r

$$r = \frac{2m}{C_l A \rho \sin\theta}$$

Radius of the glider is Calculated to be = 48.23 m

Where
F_l = *Lift force generated*
θ = *Bank angle of the glider (assumed* 10°*)*
m = *mass of the glider (0.30 kg)*
C_d = *Coefficient of drag (0.54)*
C_l = *Coefficient of lift (1.63)*
ρ = *Average density of air (1.121)*
A = *Surface area of the glider* $(0.0392\, m^2)$

Descent Rate Estimates

Final descent rates

Parameter	Calculated Value
Descent rate of Container + Payload	$\mathbf{4.26}\ \boldsymbol{m/s}$
Descent rate of only Container	$\mathbf{2.61}\ \boldsymbol{m/s}$
Exit Velocity of the payload	$\mathbf{4.07}\boldsymbol{m/s}$
Descent rate of the payload	$\mathbf{3.33}\ \boldsymbol{m/s}$
Turning radius of the glider	$\mathbf{48.23}\ \boldsymbol{m}$

Mechanical Subsystem Design

Ases Akas Mishra

Kunal Pandey

Mechanical Subsystem Overview

Category	Components	Materials	Usage
Container	Cylindrical tube	High Density Polyethylene	It will protect the payload in the rocket
Container descent control	Parachute	Nylon	It will stabilise the system before ejection of the glider
Ejection mechanism	Hook, micro DC motor, rubber bands, cutting disc	High Density Polyethylene	It will systematically eject the payload from the container
Wing folding mechanism	Wings, arc shaped slot, rubber band	Dacron type 52	Wings will be folded in the container and they will be unfolded after the ejection of the payload.
Payload descent control	Hang glider structure	Carbon fiber Thornel MAT and Dacron type 52	Ensure smooth helical path for the glider's descent
Payload helical descent	Solar Panels	-	Solar panels will be positioned in such a way that the CG shifts and banks the glider

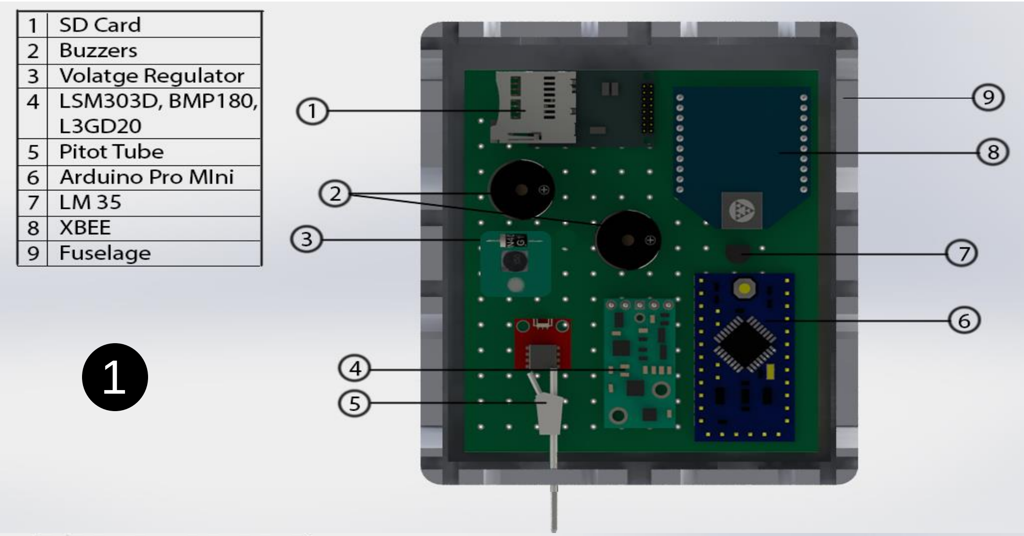
Mechanical Sub-System Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
MSR-01	Total mass of the CanSat(container+payload) will be 500g with a tolerance of +/- 10g.	Mission requirement	High	SRS-01		X		X	X
MSR-02	• Container length must be less than 310mm and diameter less than 125mm. • The glider will be completely confined inside the container.	Mission requirement. Prevention from getting stuck in the rocket	High	SRS-02	DCR-01	X		X	
MSR-03	Parachute with a spill hole will be used as a passive descent control system for the container.	To maintain reasonable descent rate and reduce swaying	High	SRS-03 DCR-02 DCR-03				X	X
MSR-04	Container and glider should be fluorescent colored.	To ensure easy recovery	High	SRS-04				X	
MSR-05	Container will not have sharp edges.	To prevent it from getting stuck in rocket payload section	Low	SRS-05	DCR-04	X		X	
MSR-06	Glider must be released at 400m +/- 10m from the container.	Mission requirement	High	SRS-06 SSD-05	DCR-05 SSD-05 FSW-09			X	X

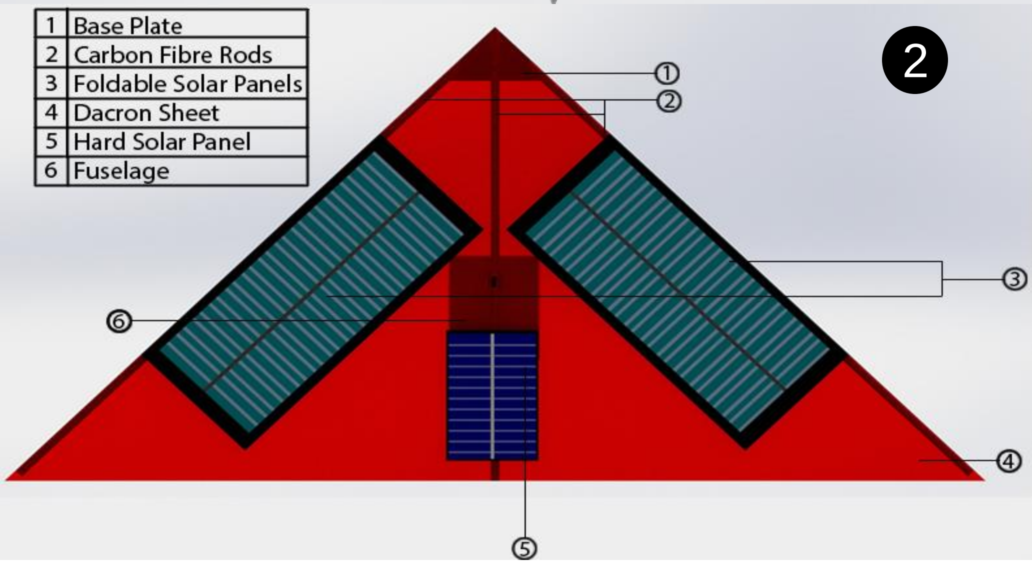
Mechanical Sub-System Requirements

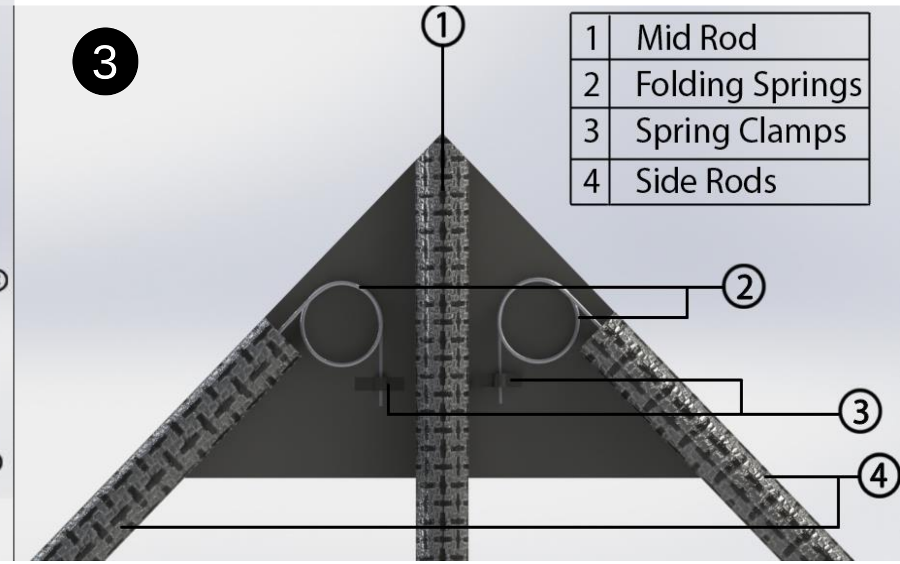
ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
MSR-07	All the structures shall be built to survive 30 Gs of shock and 15 Gs of acceleration .	To ensure that the CanSat can withstand the rocket deployment conditions	High	SRS-09	SSD-08			X	
MSR-08	The container should contain all the electronics and mechanisms to release the glider at the required altitude	Mission Requirement	High	SRS-21	SSD-12	X		X	
MSR-09	Mountings for electronic devices shall be made	To avoid damage to the electronic components.	High	SRS-10		X		X	
MSR-10	The glider shall be a fixed wing glider	Mission Requirement	High	SRS-28		X		X	

Payload Mechanical Layout of Components Trade & Selection

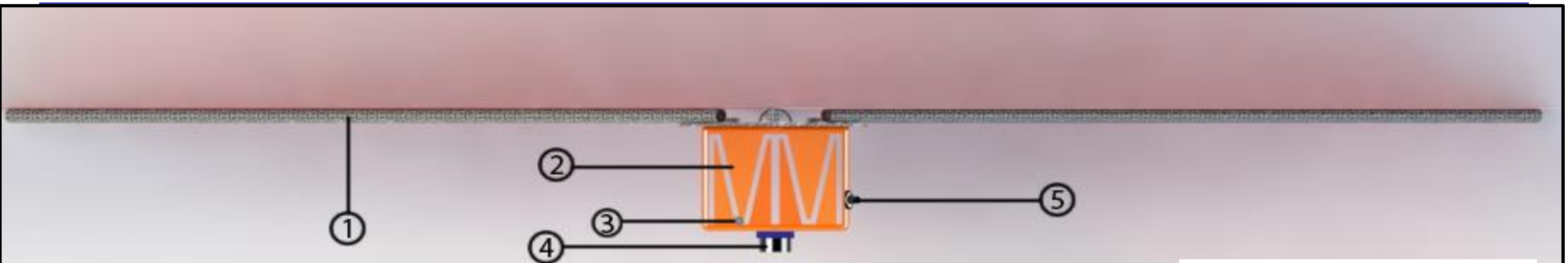


1)Figure showing Glider Electronics
2) Figure showing mechanical configuration of solar panels on the glider
3) Figure showing glider folding mechanism

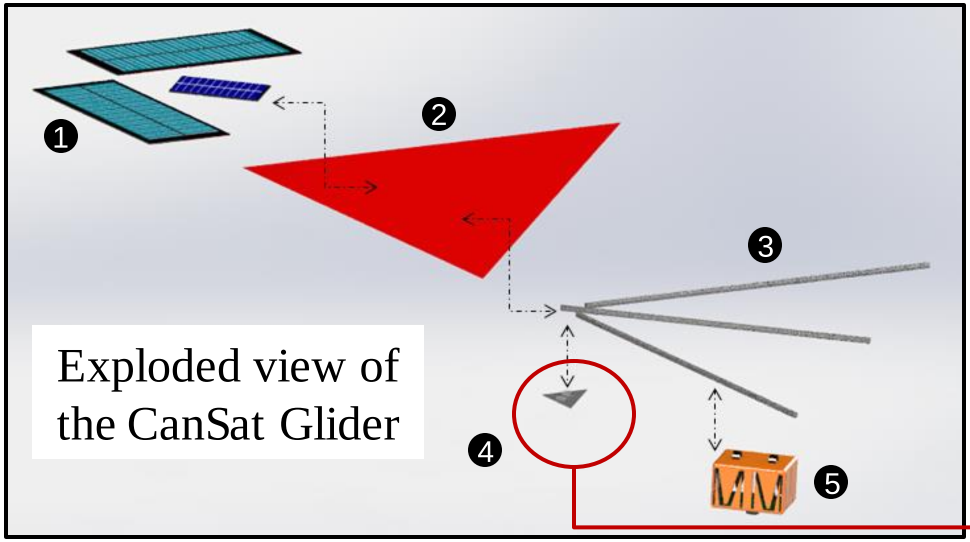




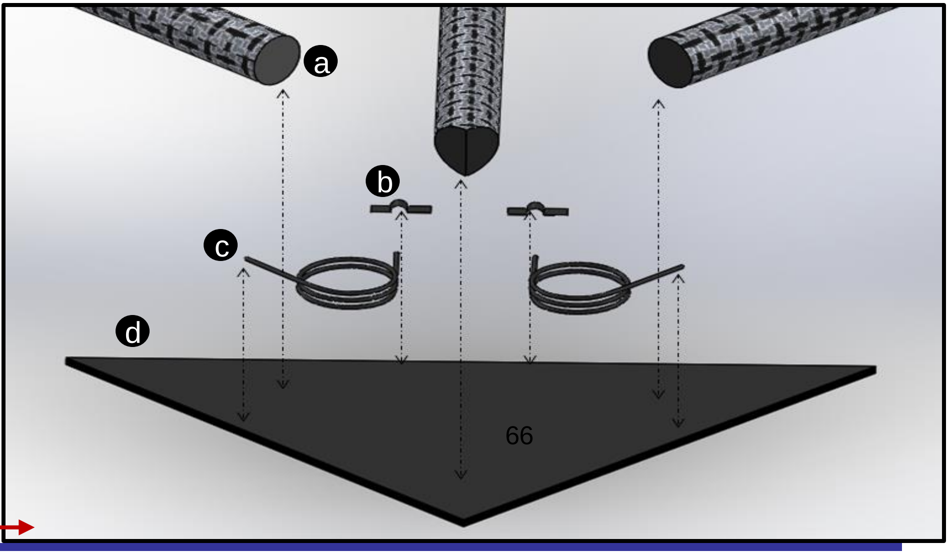
Payload Mechanical Layout of Components Trade & Selection



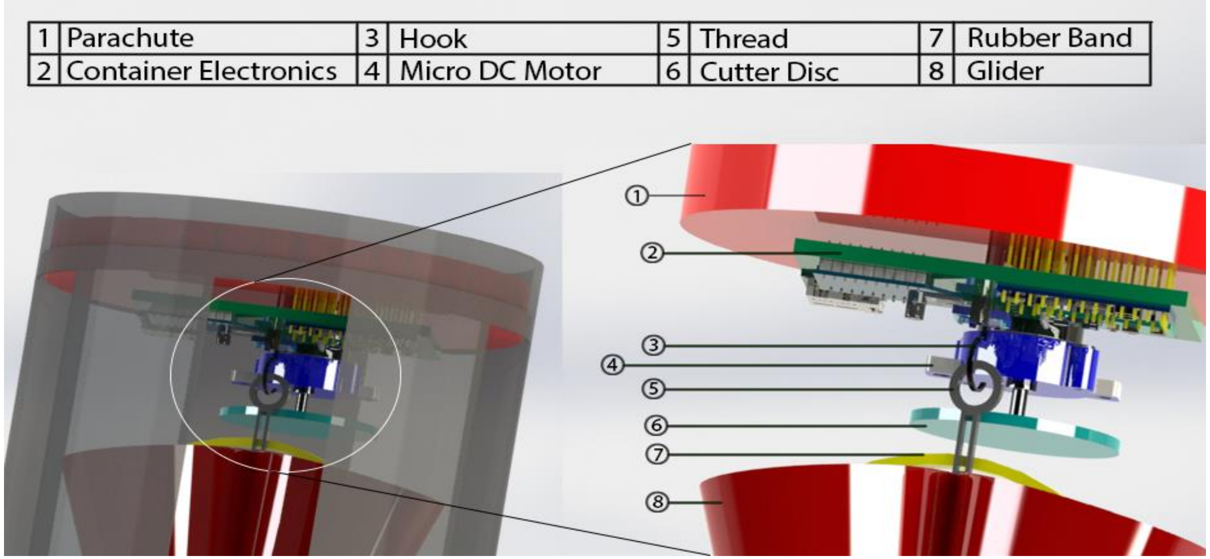
Mechanical configuration of the fuselage



Exploded view of the CanSat Glider



Payload Mechanical Layout of Components Trade & Selection



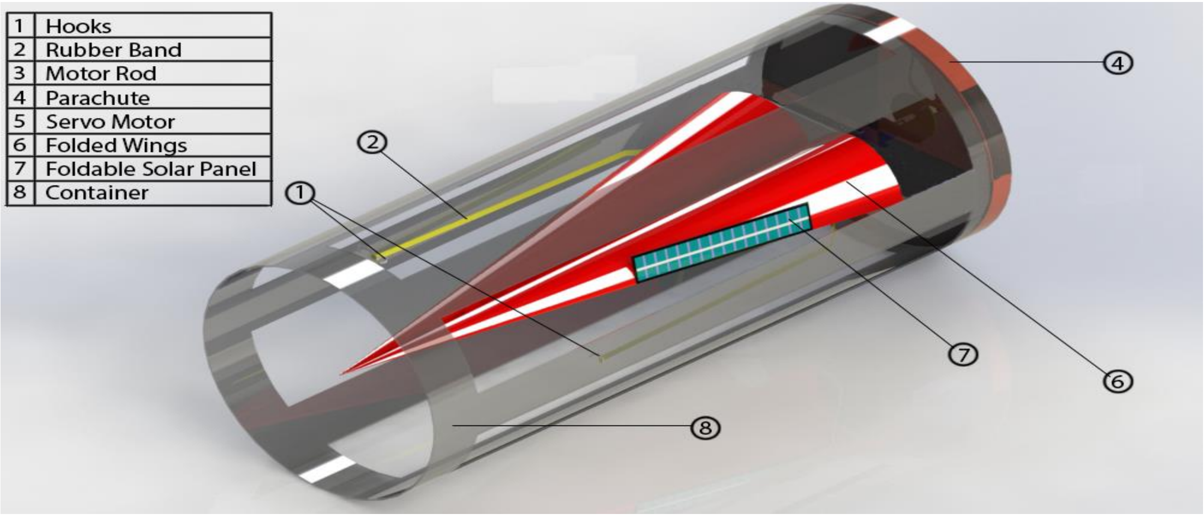


Figure showing
- Placement of all major components inside the container
- Container attachment points
- Ejection Mechanism components

Payload Mechanical Layout of Components Trade & Selection

Properties	Carbon Fibre Thornel MAT VMA	Balsa Wood
Density(g/cm^3)	1.81	0.2
Specific Strength (kN*m/kg)	2457	521
Thermal conductivity (W/m-K)	21-180	0.048
Machinability (out of 10)	7	10
Cost ($/Kg)	50	892

- **Subsystem – Hang Glider Rods**

1. Material Selected – Carbon Fibre Thornel MAT VMA
2. Reason -

➢ Carbon fibre was selected to manufacture the hang glider because of its high specific strength.

➢ Carbon fibre has a higher thermal conductivity than balsa wood and hence can perform better in thermal test.

The selected materials can use 30Gs of shock and 15Gs of acceleration

- **Subsystem – Glider Sailcloth**

1. Material Selected – High Tenacity Dacron type - 52
2. Reason -

➢ Dacron was selected to make the glider sailcloth because of its high tenacity and easy availability in the market

➢ Dacron has higher strength to weight ratio than nylon and a limited stretch under control (initial modulus) making it favourable for hang glider.

Properties	Rib stop Nylon	Dacron type-52
Density(g/cm^3)	1.15	1.38
Tenacity (denier)	9.5	7.9
Elongation to break	12-13 %	8 %
Cost ($/m^2)	1 (per m)	19
Initial Modulus (denier/m)	45	100

Payload Pre Deployment Configuration Trade & Selection

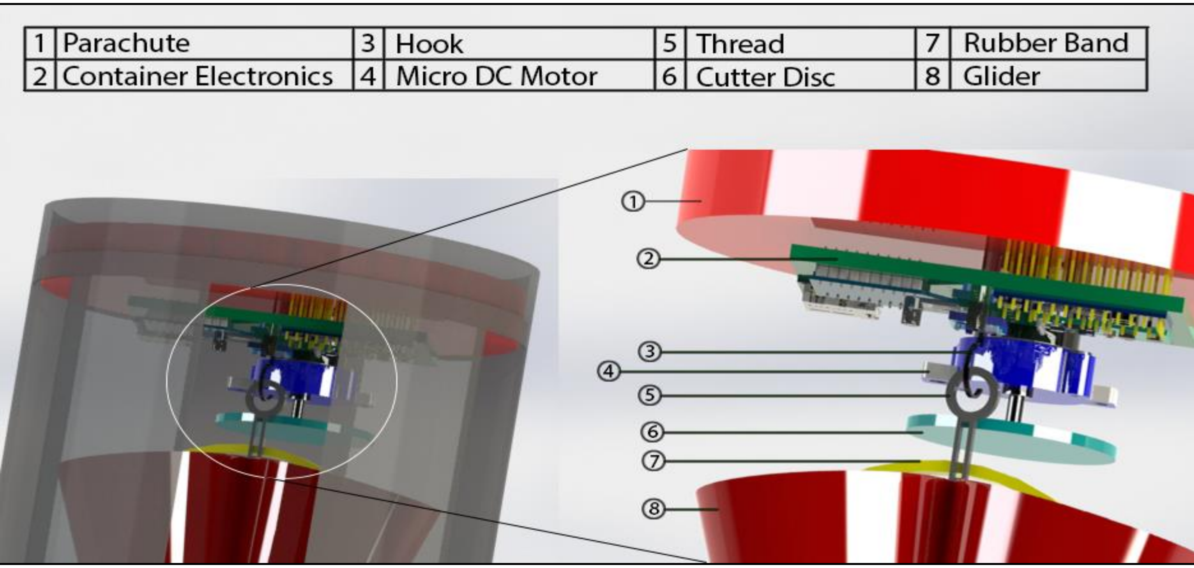


Figure showing the mechanical configuration of the major components inside the container

Mechanism used to keep payload in Stowed Configuration

The glider is folded and placed carefully inside the container. While placing it inside, the rubber band attached internally in the container using hooks, is stretched and fixed at this position using a nylon thread attached to a hook. A micro DC motor is attached to the wall using adhesive. A cutting disc is attached to the motor shaft. This is the ejection mechanism. At the required altitude, the cutting disc rotates and cuts the nylon thread which ejects the glider forcefully.

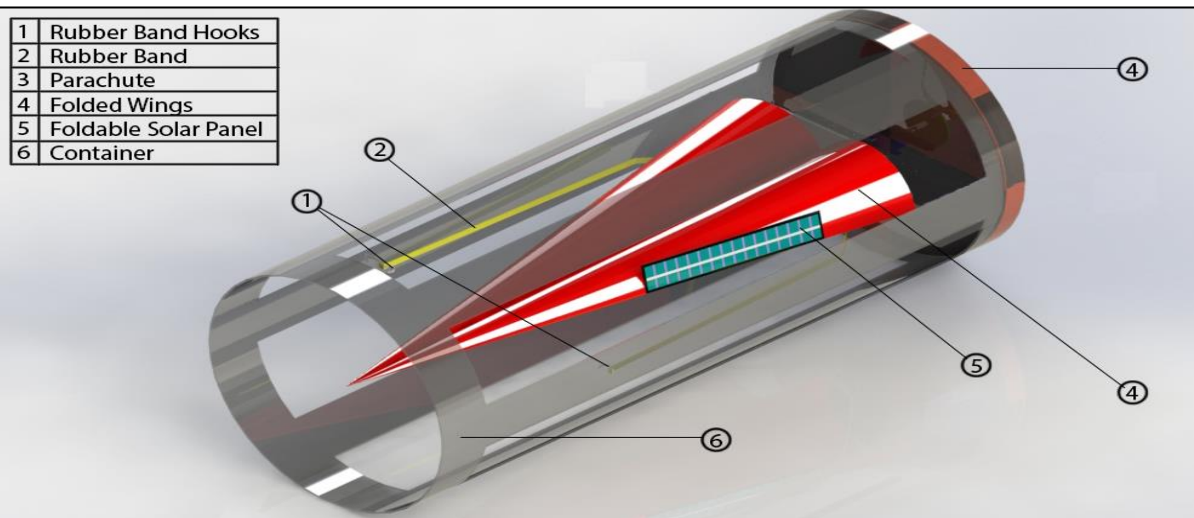


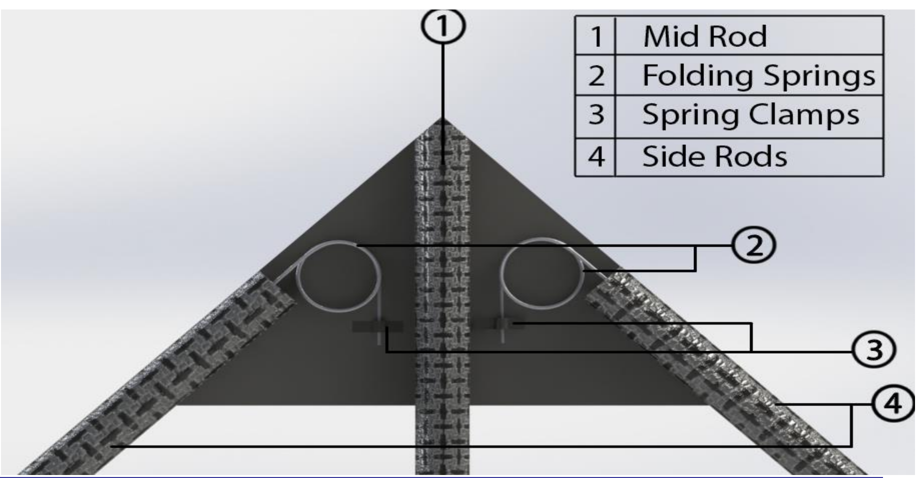
Figure showing the mechanical configuration of the glider inside the container

Payload Deployment Configuration Trade & Selection

- The open side of the container will have a rubber band attached inside it using hooks.
- The glider will be folded using the folding mechanism(coil springs) attached to the carbon fibre rods on the base plate of the glider and will be pushed inside the container, stretching the rubber band to the extreme.
- The tension in the rubber band ensures that the glider remains in its folded position. Slots carved on the carbon fibre rods ensure that the rubber band doesn't slip off the glider.
- At the required altitude the glider ejects with a forward velocity. As the glider leaves the container, the springs ensure that the glider unfolds.

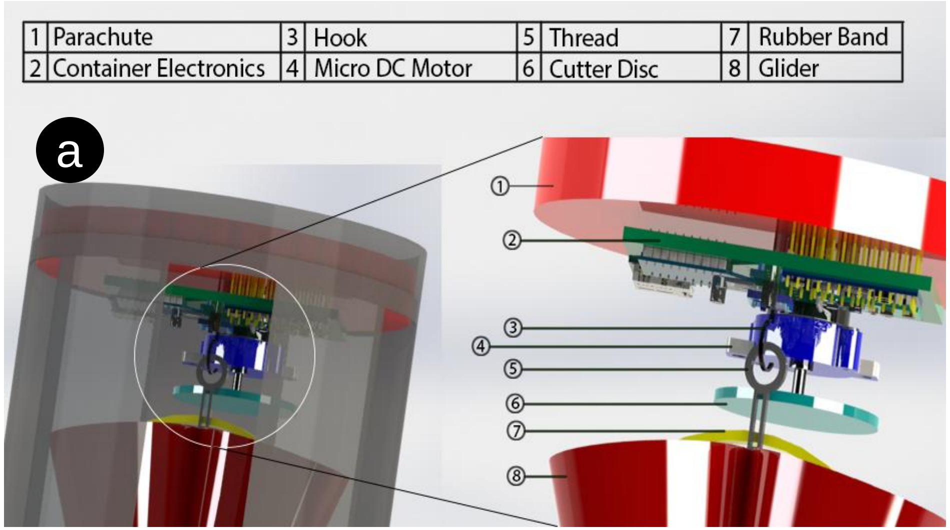
.

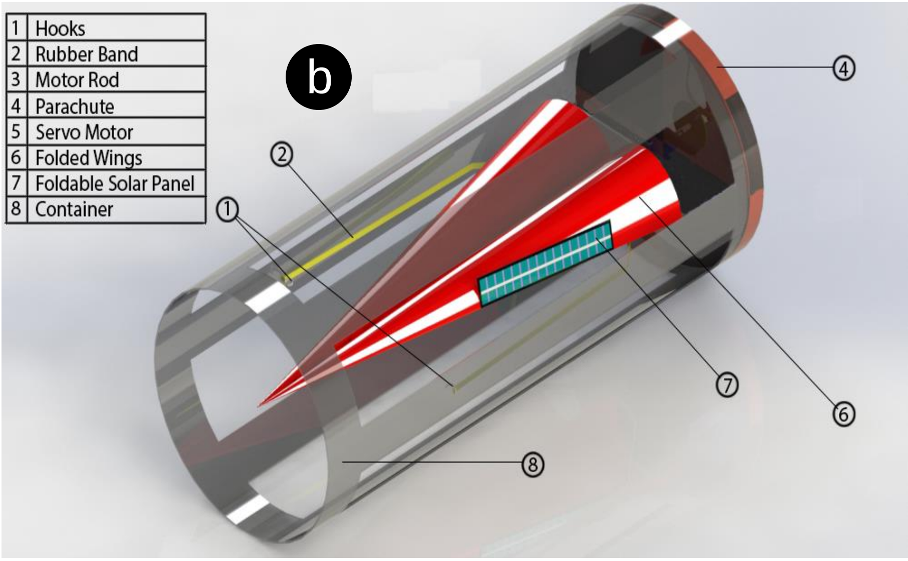
Component	Material	Rationale
Rubber Band	Natural Rubber	To keep the glider stowed inside the container
Rubber Band Hook	Nylon	To hold the Rubber band in the required position .
Thread	Nylon	To release the glider when the thread is cut
Cutting Disc	Aluminium disc(3cm diameter)	To cut the nylon thread and release the glider
Micro DC Motor	-	Cutting disc is mounted on motor shaft
Hook to hold Nylon thread	Nylon	To hold the nylon thread in taut position.



1	Mid Rod
2	Folding Springs
3	Spring Clamps
4	Side Rods

Container Mechanical Layout of Components Trade and Selection





a- major mechanical parts
b- container attachment points

Properties	High Density Polyethylene	Fibre glass
Density(g/cm^)	0.958	2.55
Thermal conductivity(W/m-K)	0.48	0.04
Machinability (out of 10)	10	8
Cost ($/Kg)	1.3	3
Impact Strength (ft-lb/in)	0.5-20	3.74

- **Subsystem – Container**

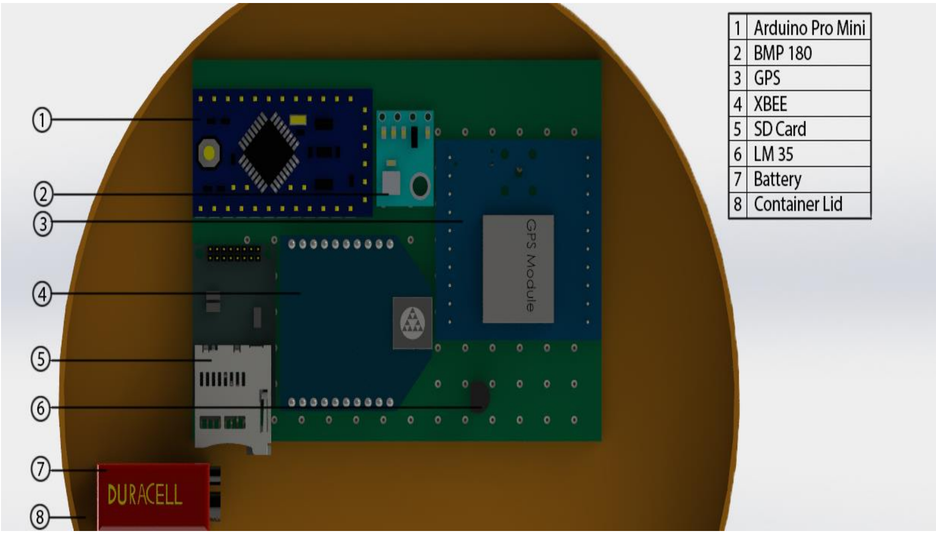
1. Material Selected - High Density Polyethylene
2. Reason -

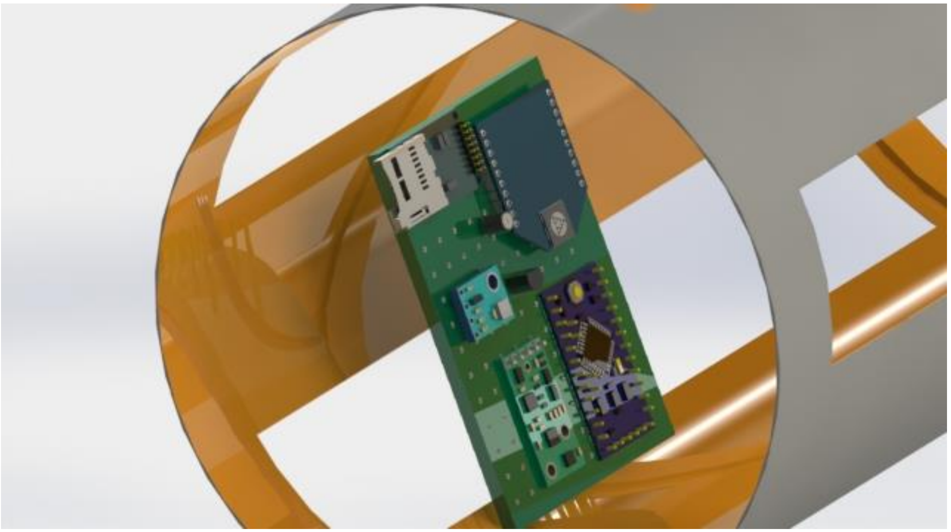
➢ HDPE was selected to manufacture the container because of its lower weight as compared to fibre glass. Fibre glass requires reinforcement of composites which adds to the weight of the container .

➢ HDPE has higher impact strength as compared to fibre glass helping the container to survive 30Gs of shock.

Container Mechanical Layout of Components Trade and Selection

Comparison of designs having Container electronics at two different positions





Position- on the closed lid

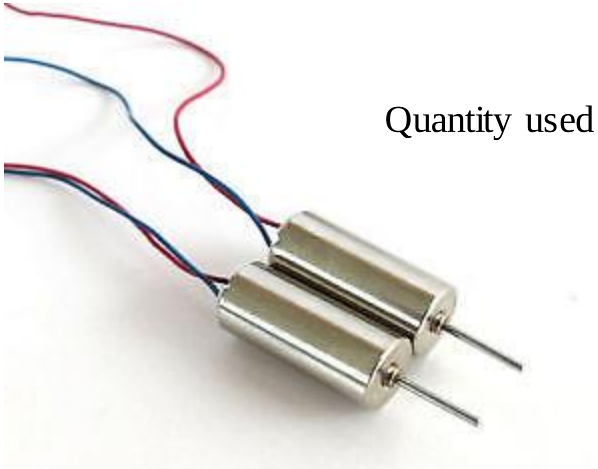
Position- on the curved surface

Design in which the electronics is on the flat closed lid is selected because of the following reasons-

1) Allows for easier hard mounting of the electronics
2) Doesn't interfere with the glider ejection
3) Consumes lesser space as it is mounted on a flat surface rather than a curved one

Payload Release Mechanism

- The open side of the container will have a rubber band attached inside it using hooks.
- The glider will be folded using the folding mechanism(coil springs) attached to the carbon fibre rods on the base plate of the glider and will be pushed inside the container, stretching the rubber band to the extreme.
- A nylon thread is attached at the end of the glider. This thread is then fixed on the hook positioned at the closed end of the container.
- A micro DC motor is placed at the closed end of the container. Attached to the shaft of the motor is a cutting disc.
- At the required altitude the cutting disc spins and cuts the nylon thread forcefully releasing the glider and giving it a forward velocity. As the glider leaves the container, the springs ensure that the glider unfolds .



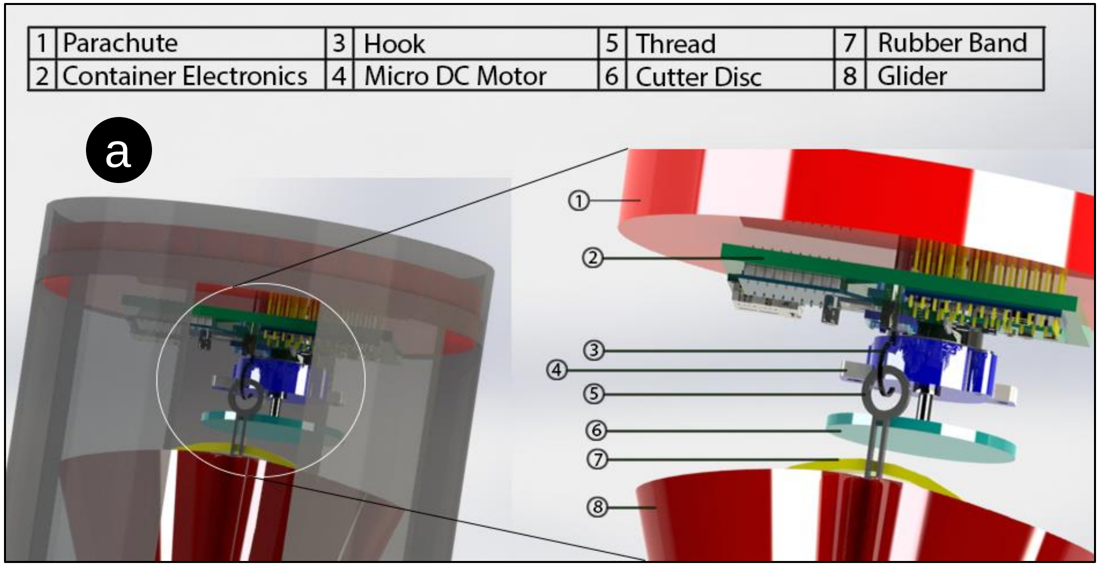
Quantity used =1

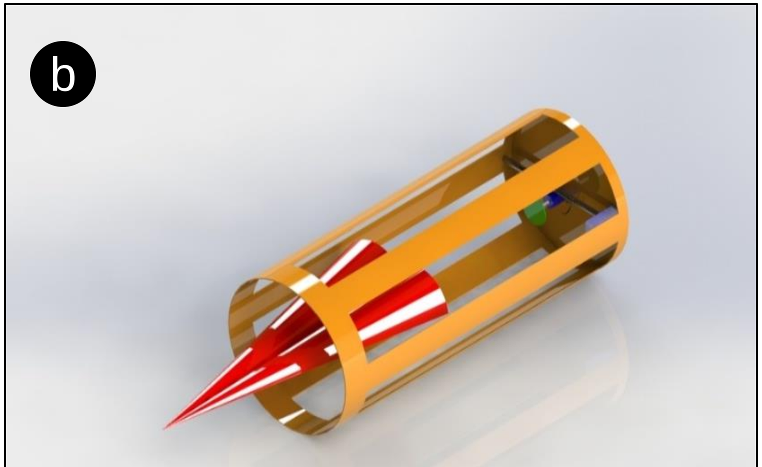
DC selected for ejection mechanism:

Selection Rationale :

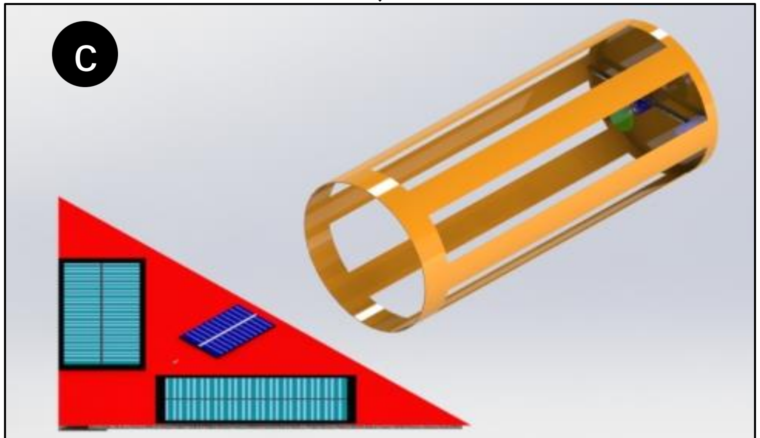
- 3.7V 40000RPM micro DC Motor
- Overall Size(Approx) 16x 7mm
- Shaft Length 8mm
- Shaft Dia 0.8mm
- Cable Length 80mm
- No-load current 110mA
- Speed 40000 RPM

Payload Release Mechanism





Folded Glider being released from the container



Glider unfolded and ejected from the container

a- Container components and ejection mechanism
b- Just after ejection mechanism is activated
c- Deployed Configuration

Electronics Structural Integrity

- Double sided foam carpet tape will be used to mount the PCB inside the fuselage. Silicone Glue will be used to fix and protrude the Pitot tube outside the fuselage. A camera and a switch will be fixed on the outer side of the fuselage using double sided tape as well.

- The PCB used in the container electronics will be attached to the closed end of the container using double sided tape. The micro DC motor used to cut the nylon thread is fixed to the curved surface of the container using silicone glue. All the hooks will be attached to the container using silicone glue as well

- All the electrical components except the sensors are laminated.
- Plastic casing is used to protect the battery.
- The pitot tube will be placed at the tip of fuselage.

Descent Control Attachments-

The parachute will be attached to the container by making 4 holes on the container through which the parachute thread will be passed and a knot will be made to secure it.

Silicone Glue

Double Sided Tape

Mass Budget

ELECTRICAL

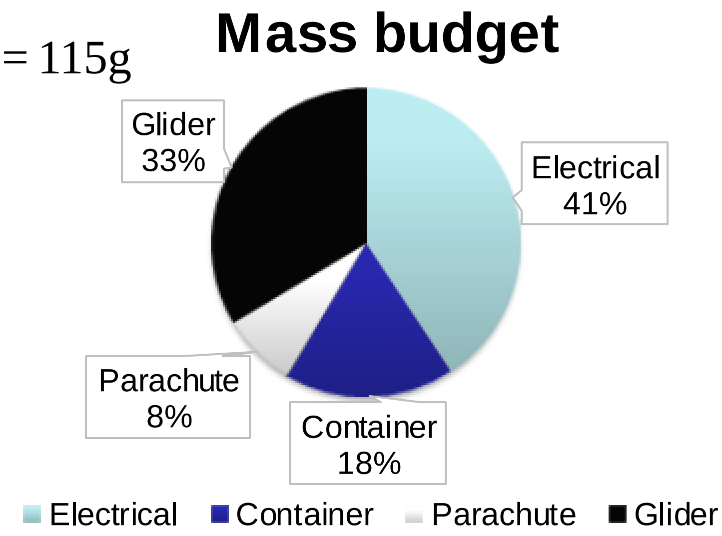
Sr. no.	Component	Mass(grams)	Source	Placement (Container/Payload)
1	Arduino Pro Mini x 2	4	Datasheet	Container and Payload
2	10DOF Gyro Accelerometer Compass Altimeter (L3GD20 LSM303D BMP180)	1	Measured	Payload
3	BMP 180	0.92	Datasheet	Container
4	LM 35 x 2	0.42	Datasheet	Container and Payload
5	Pitot tube	18	Measured	Payload
6	Camera	13	Datasheet	Payload
7	SD card with shield x 2	12	Measured	Container and Payload
8	Xbee x 2	12	Measured	Container and Payload
9	Buzzer x 4	4	Datasheet	Container and Payload
10	GPS	8.5	Measured	Container
11	Micro DC motor	3	Datasheet	Container
12	Antenna x 2	2.4	Measured	Container and Payload
13	Solar panels	57.72	Measured	Payload
14	Container battery	37	Datasheet	Container
15	Voltage regulator	7.5	Datasheet	Payload

Mass Budget

Sr. No.	Component	Mass(in grams)	Source
1	Container(only casing)	80	Measured
2	Parachute	35	Measured
3	Glider	150	Measured

Mechanical

Weight of container= 80(container casing)+ 35(parachute)= 115g
Weight of Container electronics= 66.83g
Weight of Glider= 150g
Weight of Glider Electronics= 114.63g
Total weight of Container= 181.83g
Total weight of Glider= 264.63g
Total Weight of CanSat = 446.46g
10% margin = 44.6g
Weight with margin= 491.06g

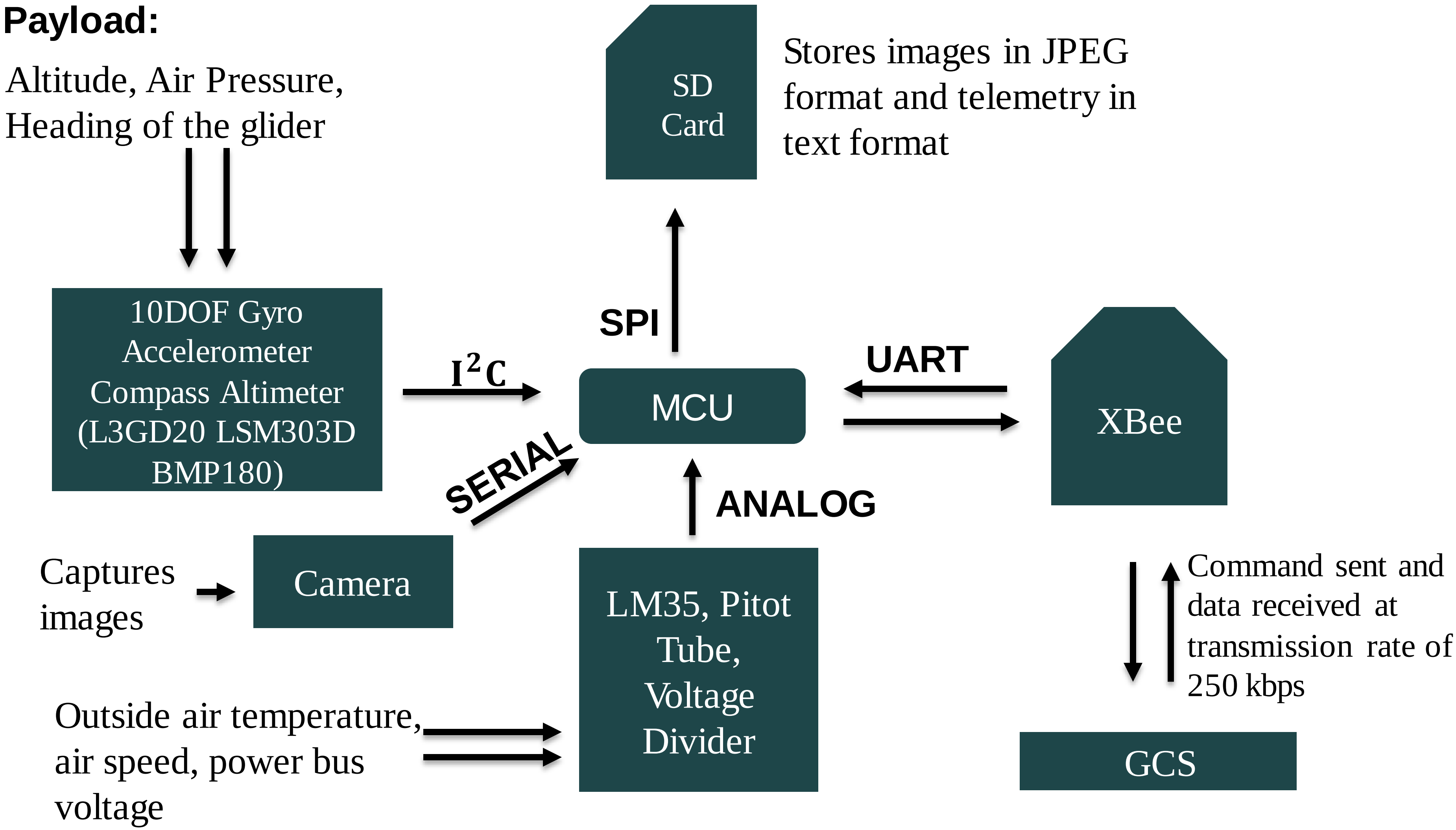


Communication and Data Handling (CDH) Subsystem Design

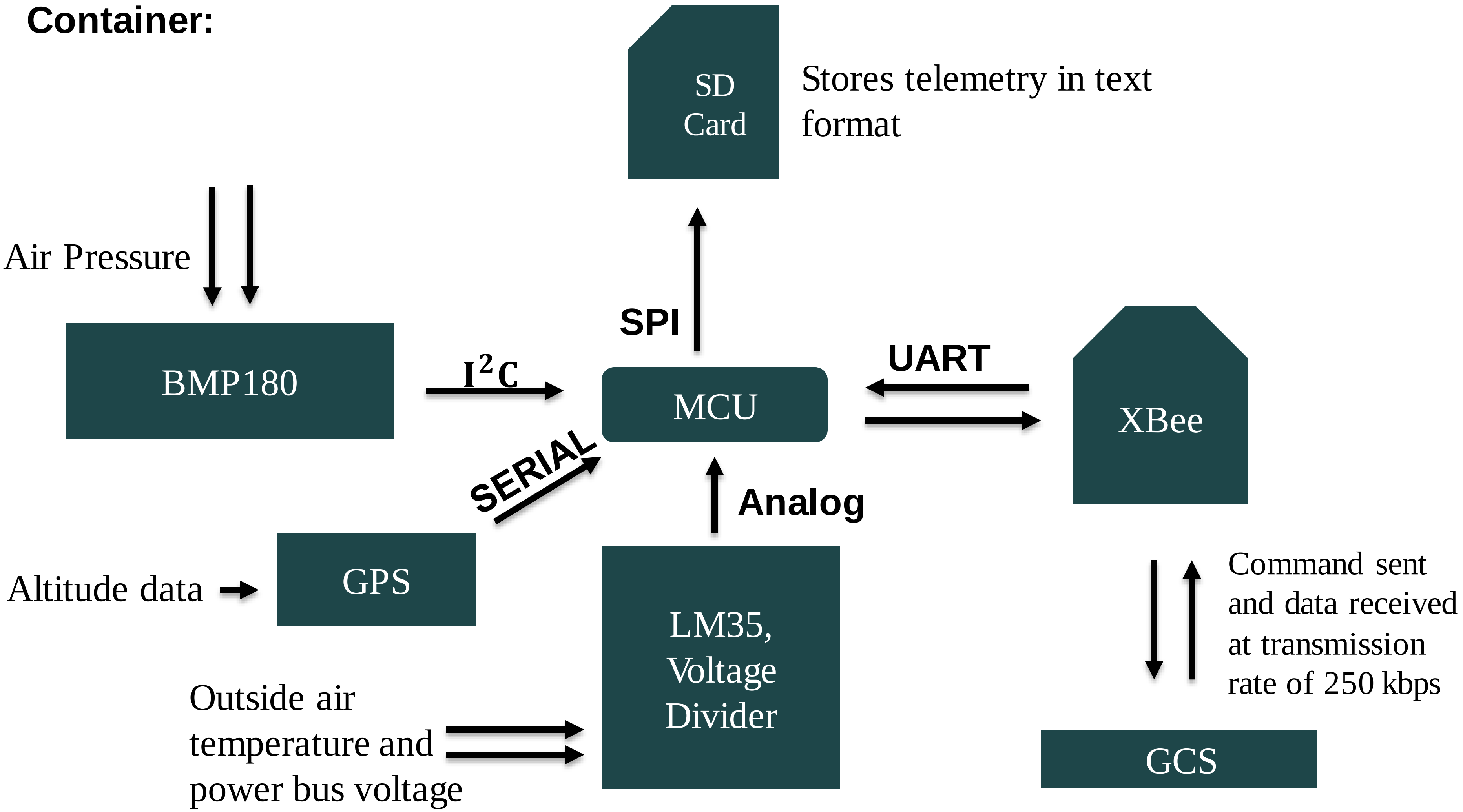
Rakshit Vig
Kumar Yash

CDH Overview

Payload:



Container:


SD Card
Stores telemetry in text format
Air Pressure
BMP180
I^2C
SPI
MCU
UART
XBee
SERIAL
Analog
Altitude data
GPS
LM35, Voltage Divider
Command sent and data received at transmission rate of 250 kbps
Outside air temperature and power bus voltage
GCS

CDH Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
CDH-01	Glider and container shall transmit telemetry using XBee PRO S2B of 2.4GHz at a frequency of 1 Hz	Mission requirement	High	SRS-13 FSW-02	GCS-05 CDH-11	X		X	X
CDH-02	All (container and glider) telemetry shall include mission time with one second or better resolution	Mission requirement	High	SRS-11 FSW-03			X		
CDH-03	Telemetry shall be transmitted in burst or continuous mode	Mission requirement and to prevent data loss	High	FSW-02			X	X	
CDH-04	All telemetry in a packet shall be comma separated	Telemetry requirement	High		GCS-08 FSW-12		X		

CDH Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
CDH-05	Microcontroller on the payload and container shall have sufficient number of communication protocol	To support the requirement	High	SSD-01 to 06 ,10 EPS-08		X	X	X	
CDH-06	Container shall transmit telemetry until 2 seconds after the ejection of glider	Mission requirement	High	SRS-25			X		
CDH-07	XBee radios shall have their NETID/PANID set to their team number	Mission requirement	High	SRS-15			X	X	
CDH-08	The glider telemetry shall end as soon as it lands	Mission requirement	High				X	X	

CDH Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
CDH-09	XBee shall not be used in broadcast mode	Mission requirement	High	SRS-13			X	X	
CDH-10	Telemetry shall include number of images captured by camera on glider	Bonus objective	Medium	SRS-30			X		
CDH-11	Suitable antenna shall be used to boost the Xbee communication range to a minimum of 2km.	Required for reliable communication	High	CDH-01		X	X		
CDH-12	The container shall start transmitting telemetry as soon as it is powered on	Mission requirement	High	SRS-25			X		

CDH Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
CDH-13	SD card will be used to save telemetry of the container as well as of payload	To backup data	High	SSD-09 FSW-06			X		
CDH-14	SD card shall be used to save images captured by camera on glider	To fulfill bonus objective	Medium	SRS-29 SSD-09,10 FSW-07			X		
CDH-15	Flight software state shall be sent to the GCS along with telemetry	Telemetry requirement	High	FSW-05			X		
CDH-16	Internal RTC of microcontroller will be used to maintain time	Mission requirement	High	SRS-11		X			X

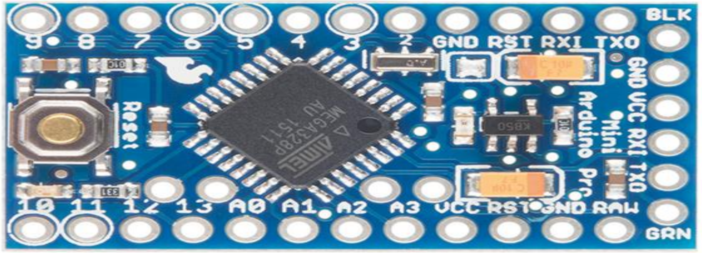
Payload Processor & Memory Trade & Selection

Processor	ATSAMD21G18, 32-Bit ARM Cortex MO+ (Arduino zero)	ATmega328 (Arduino pro mini)	Intel Curie (Arduino genuino 101)
Operating Voltage	3.3 V	5 V	3.3 V
Digital I/O Pins	20	14	14
PWM Pins	All except 2 and 7	6	4
UART	2 (Native and Programming)	1	1
Analog Input Pins	6	6	6
Flash Memory	256 KB	32 KB	196 KB
SRAM	32 KB	2 KB	24 KB
Clock Speed	48 MHz	16 MHz	32 MHz
Weight	12 g	< 2 g	34 g
I2C	Programmable	1	1
SPI	Programmable	1	1

Processor Chosen: ATmega328

Reasons:

- ATmega328 running at 16MHz with external resonator(0.5 % tolerance)
- 0.8mm Thin PCB
- USB connection off board
- Over current protected
- Sufficient memory and clock speed
- **Weight less than 2 grams**
- Less cost
- Sufficient types of data interface are available.



Payload Processor & Memory Trade & Selection

ID	Model	Weight (in grams)	Interface	Memory Space	Price
1	Arduino SD card Module	6	SPI	16GB and expandable	$7.34
2	EEPROM AT24C256C	<1	I2C	256 KB	$1.34

Memory selected – Arduino SD card Module

Reasons:

- Memory space available is sufficient to store the photos captured by the camera.
- Easy to interface with the camera.
- I2C multiplexing is avoided.

Container Processor & Memory Trade & Selection

Processor	ATSAMD21G18, 32-Bit ARM Cortex MO+ (Arduino zero)	ATmega328 (Arduino pro mini)	Intel Curie (Arduino genuine 101)
Operating Voltage	3.3 V	5 V	3.3 V
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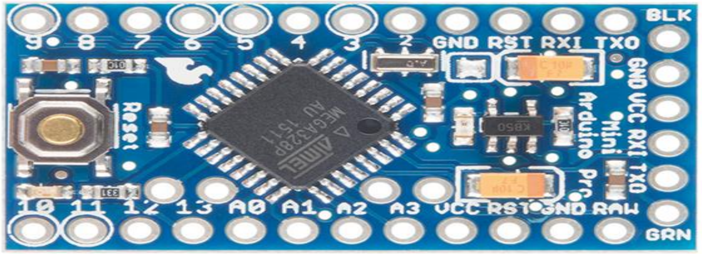

Container Processor & Memory Trade & Selection

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1	Arduino SD card Module	6	SPI	16GB and expandable	$7.34
2	EEPROM AT24C256C	<1	I2C	256 KB	$1.34

Memory selected – Arduino SD card Module

Reasons:

- Memory space available is more .
- Easy to interface.
- Faster writing speed.
- I2C multiplexing is avoided.

Payload Real-Time Clock

ID	Type	Model Number	Operating Voltage	Input current	Weight	Connection type	Price
1.	Hardware	DS1307	4.5 V-5.5 V	1.5 mA	4 g	I2C	$ 7.95
2.	Software	Internal clock of Arduino pro mini	-	-	-	-	-

Real-Time Clock selected: Internal clock of Arduino Pro mini

Reason:

- No additional hardware required
- No use of coin cell battery, so weight is not compromised
- I2C multiplexing is avoided
- Budget is not compromised

Reset Tolerance:

- We will be using millis() function of arduino which returns the millisecond as soon as the arduino board began running the program
- SD card will be used to store the telemetry, so incase the processor resets it will check the last time data on SD card and will resume from that data.

Container Real-Time Clock

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Payload Antenna Trade & Selection

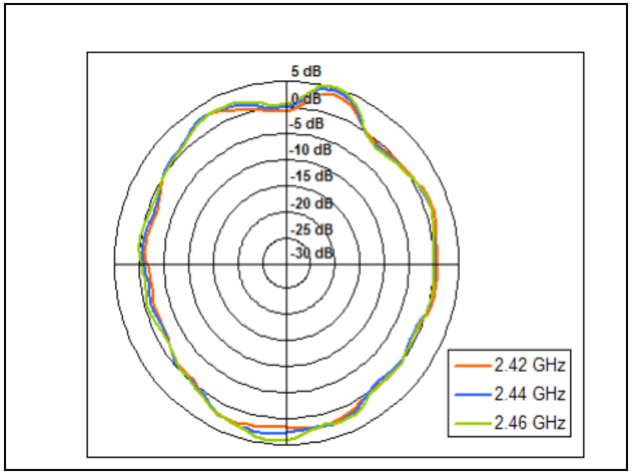
Antenna Parameters	Rubber duck antenna	FXP70 Freedom (patch antenna)
Gain	2-3 dBi	5dbi
Dimensions	length=50mm	27 X 25 X 0.08 mm
VSWR	1.5	≤1-1.5
Weight	3.5g	1.2g
Adhesive property	Not adhesive	Adhesive 3M 467
Radiation pattern	Omni directional	Omni directional
Range of Communication	~1.5km	~2km

Antenna chosen : FXP70 Freedom (patch antenna)

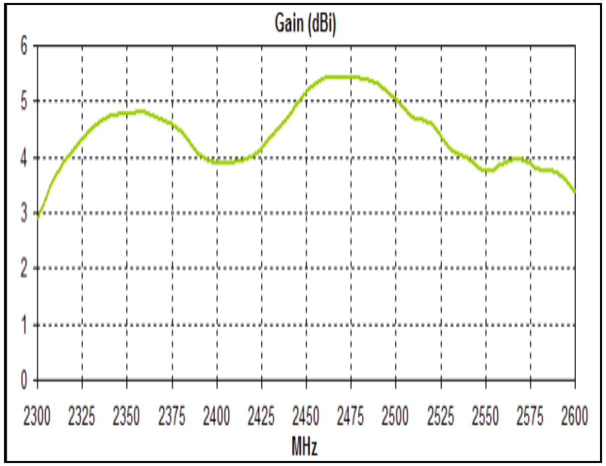
Reasons :

- High gain
- Lesser VSWR
- Longer range of communication
- Small size
- Lesser weight.

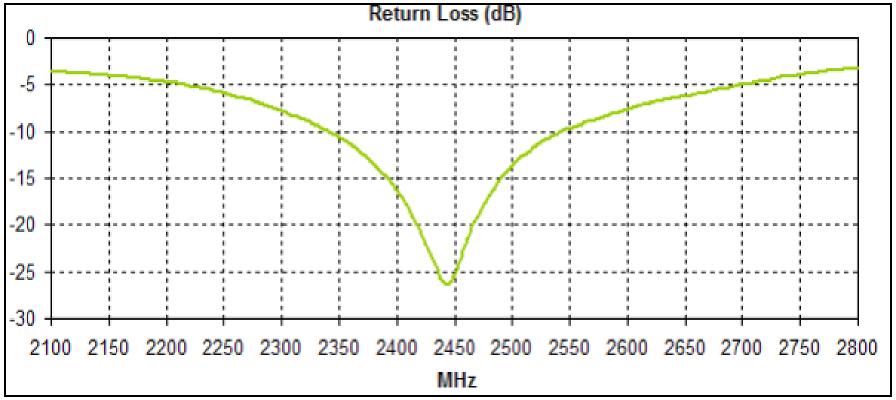
Payload Antenna Trade & Selection



Radiation pattern XZ Plane



Gain data



Return loss

Container Antenna Trade & Selection

Antenna Parameters	Rubber duck antenna	FXP70 Freedom (patch antenna)
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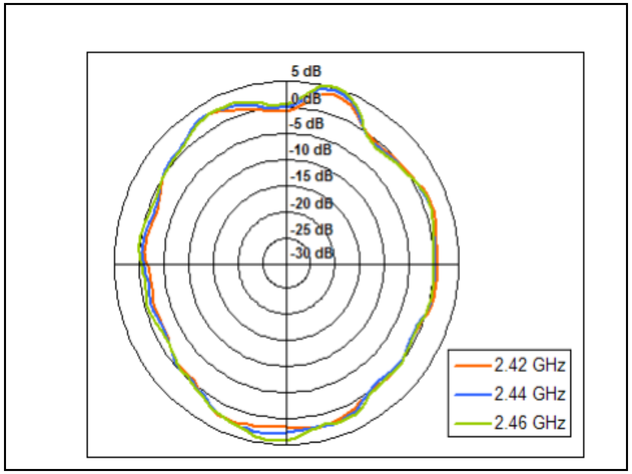
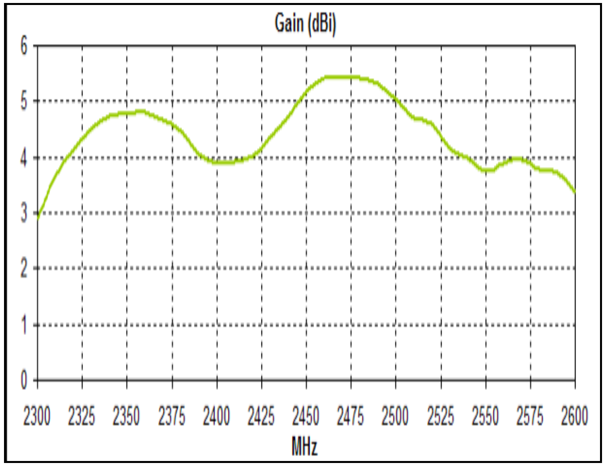


Radiation pattern XZ Plane



Gain data

Return loss

Payload Radio Configuration

- Xbee Radio is used at a frequency of 2.4Ghz
- Xbee at payload and ground station are configured at AT mode
- Xbee pro S2B is used which has an indoor range of 60m and outdoor line of sight range of around 2 miles.
- Xbee PANID shall be set to team number i.e, #2617
- Xbee will not be in broadcast mode.
- Data will be converted to packet of string and will be sent to ground station Xbee every second starting from the CanSat being powered on.
- One of the Xbee will be in coordinator mode and the other will be in router mode.
- XCTU software will be used to configure Xbee mode, setting destination address, enabling/disabling JV pin, setting PAN ID etc.

Container Radio Configuration

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- One of the Xbee will be in coordinator mode and the other will be in router mode.
- XCTU software will be used to configure Xbee mode, setting destination address, enabling/disabling JV pin, setting PAN ID etc.

Payload Telemetry Format

Telemetry Requirements	
<TEAM ID>	Assigned Team identification
GLIDER	Telemetry source
<MISSION TIME>	Time since power up (seconds)
<PACKET COUNT>	Number of packet transmitted
<ALTITUDE>	Measured altitude with one meter resolution (m)
<PRESSURE>	Measurement of atmospheric pressure (Pa)
<SPEED>	Speed measured from pitot tube (m/s)
<TEMP>	Outside temperature with one degree resolution (Celsius)
<VOLTAGE>	Power bus voltage (V)
<HEADING>	Heading of glider (degree)
<SOFTWARE STATE>	Operating state of software
<BONUS>	Count of images captured

Payload Telemetry Format

- The telemetry data will be sent in **Continuous Mode** at a frequency of 1Hz.
- The telemetry data will be sent in form of packets. Each data in a packet will be comma separated

General telemetry format:

<TEAM ID>, GLIDER, <MISSION TIME>, <PACKET COUNT>, <ALTITUDE>, <PRESSURE>, <SPEED>, <TEMP>, <VOLTAGE>, <HEADING>, <SOFTWARE STATE>, [<BONUS>]

Example telemetry format:

2617, GLIDER, 0010 s, 0010 , 0350 m, 0262 Pa, 0035.0000 m/s , 0030.0000 °C , 5 V , x: 10.1°, y:28.2°, z:32.3° , 2, [0010]

The above example telemetry matches the competition guide requirement

- **SD card will be used to store the telemetry in a text format and image will be stored in JPEG format**
- **Number of images captured will also be sent along with telemetry**
- **Note – All the telemetry data will be displayed in Engineering units .**

Container Telemetry Format

Telemetry Requirements	
<TEAM ID>	Assigned Team identification
CONTAINER	Telemetry source
<MISSION TIME>	Time since power up (seconds)
<PACKET COUNT>	Number of packet transmitted
<ALTITUDE>	Measured altitude with one meter resolution (m)
<PRESSURE>	Measurement of atmospheric pressure (Pa)
<TEMP>	Outside temperature with one degree resolution (Celsius)
<VOLTAGE>	Power bus voltage (V)
<SOFTWARE STATE>	Operating state of software

Container Telemetry Format

- The telemetry data will be sent in **Continuous Mode.**
- The telemetry data will be sent in form of packets. Each data in a packet will be comma separated

General telemetry format:

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

Example telemetry format:

2617, CONTAINER, 0010 s, 0010, 0350 m, 0262 Pa, 0035.0000 °C, 0030.0000 V, 2

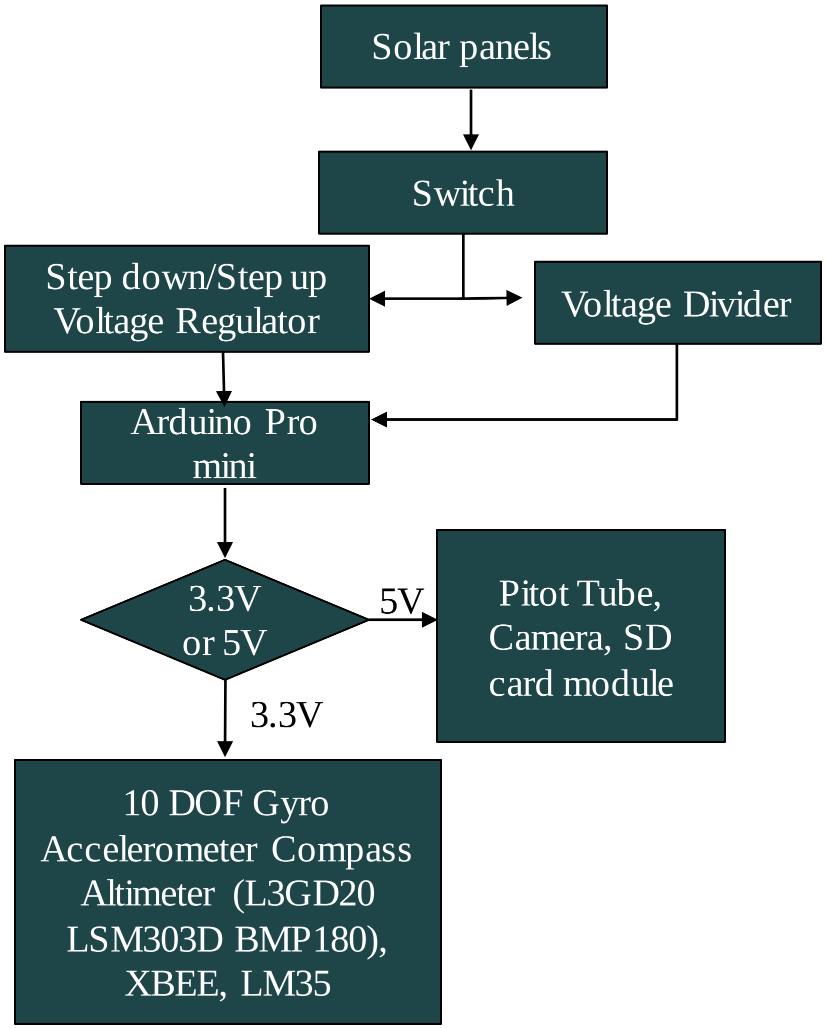
The above example telemetry matches the competition guide requirement

- **SD card will be used to store the telemetry in a text format**
- **Note – All the telemetry data will be displayed in Engineering units .**

Electrical Power Subsystem (EPS) Design

Kumar Yash

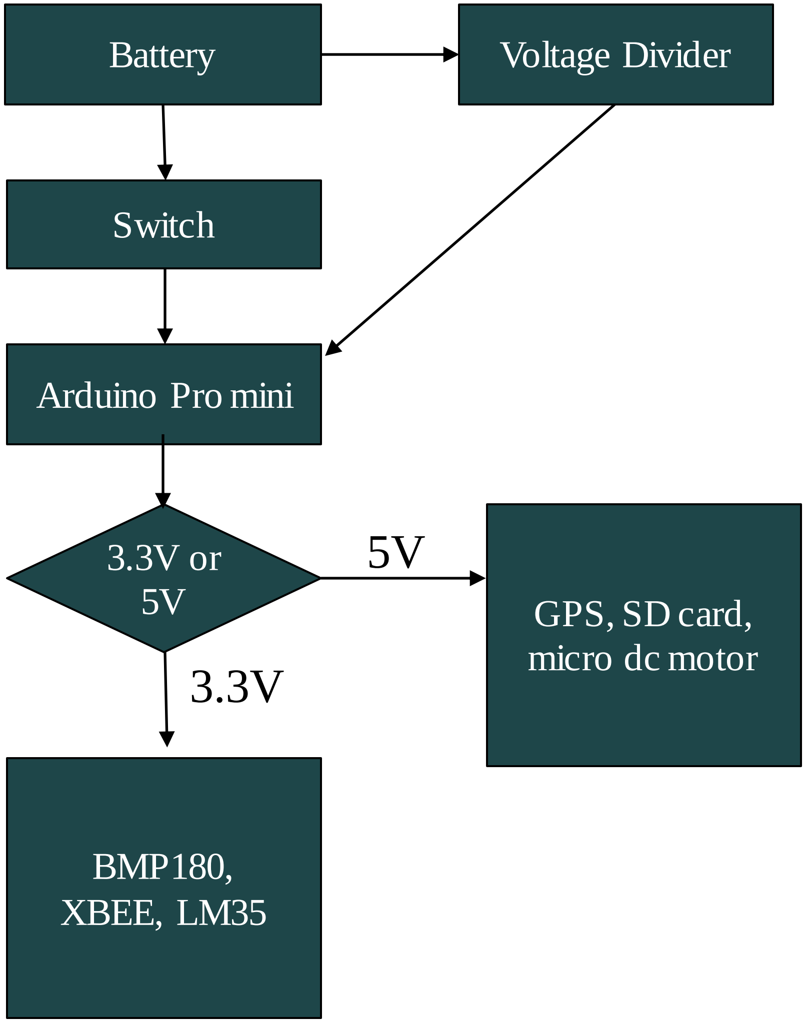
EPS Overview



Payload:

- Solar panels will be used to power up all the components.
- A step down/step up voltage regulator will be used to provide a constant voltage of 6V for input voltage 3-30V with maximum current allowance of 2A.
- Arduino pro mini works on the voltage range of 5-12V
- Two rails of 3.3V and 5V are carried from arduino and various components are connected accordingly.
- The voltage of the power bus is measured using a voltage divider circuit whose output is given to Arduino for the instantaneous voltage measurement.
- An easily accessible switch is provided on the fuselage.

EPS Overview



Container:

- The components of container are powered by a 6V 1400mAh battery.
- Arduino pro mini is used here as a microcontroller which works in a voltage range of 5-12V.
- Same as payload, two rails of 3.3V and 5V are made and various components are connected accordingly.
- The voltage of the circuit is measured on a continuous basis using a voltage divider circuit and its value is given to arduino which is further transmitted to GCS.
- A switch is also provided which can be easily accessed.
- GPS is used to retrieve absolute altitude. This will give precise data for ejection mechanism.

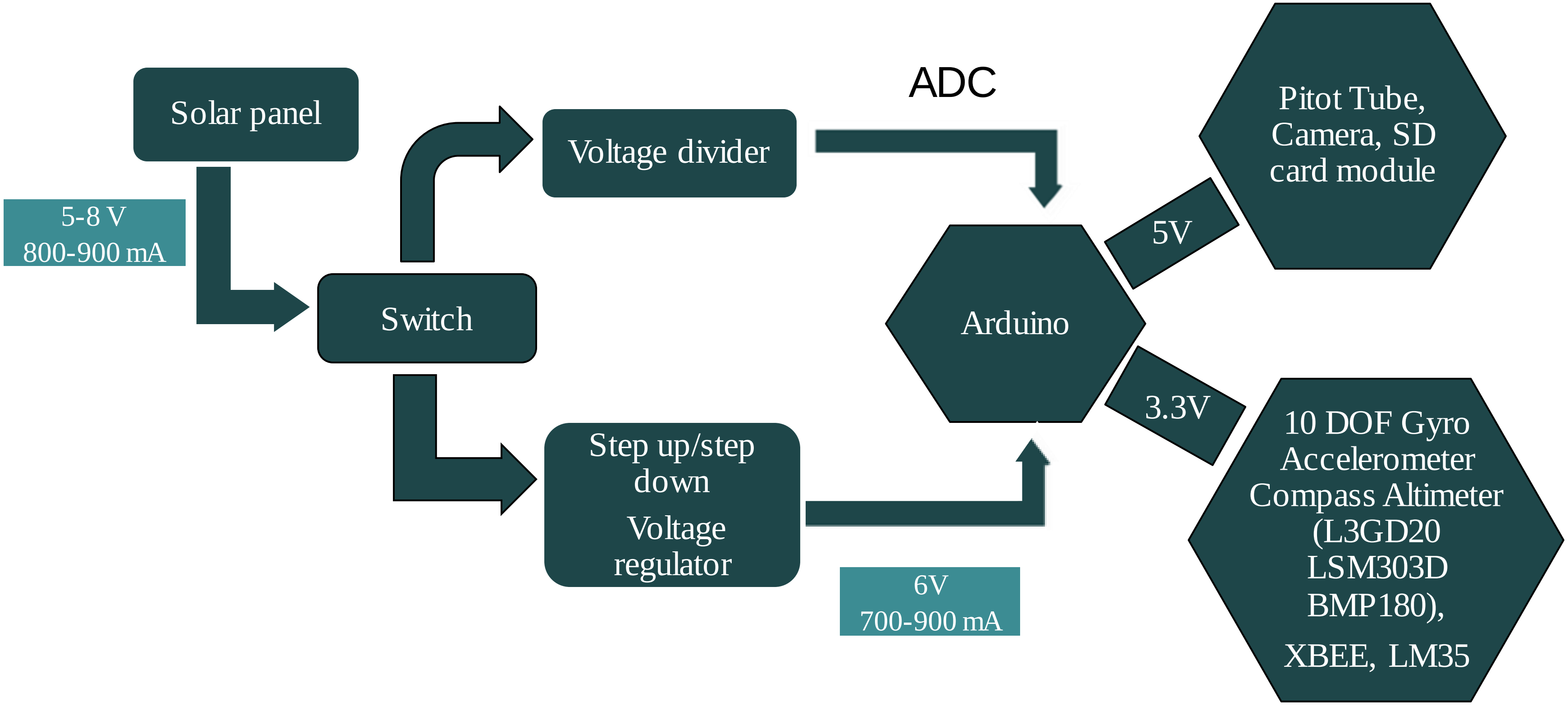
EPS Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
EPS-01	Glider electronics must be solar powered including camera	Mission requirement	High	SRS-12 SRS-31		X		X	X
EPS-02	Step down/Step up voltage regulator will be used at glider	To provide constant 6V for input voltage of 3 to 30V	High				X		
EPS-03	Glider must include a switch	Mission requirement and to control glider power supply	High	SRS-20				X	
EPS-04	Container shall include a switch	For easy access to container power bus	Medium					X	

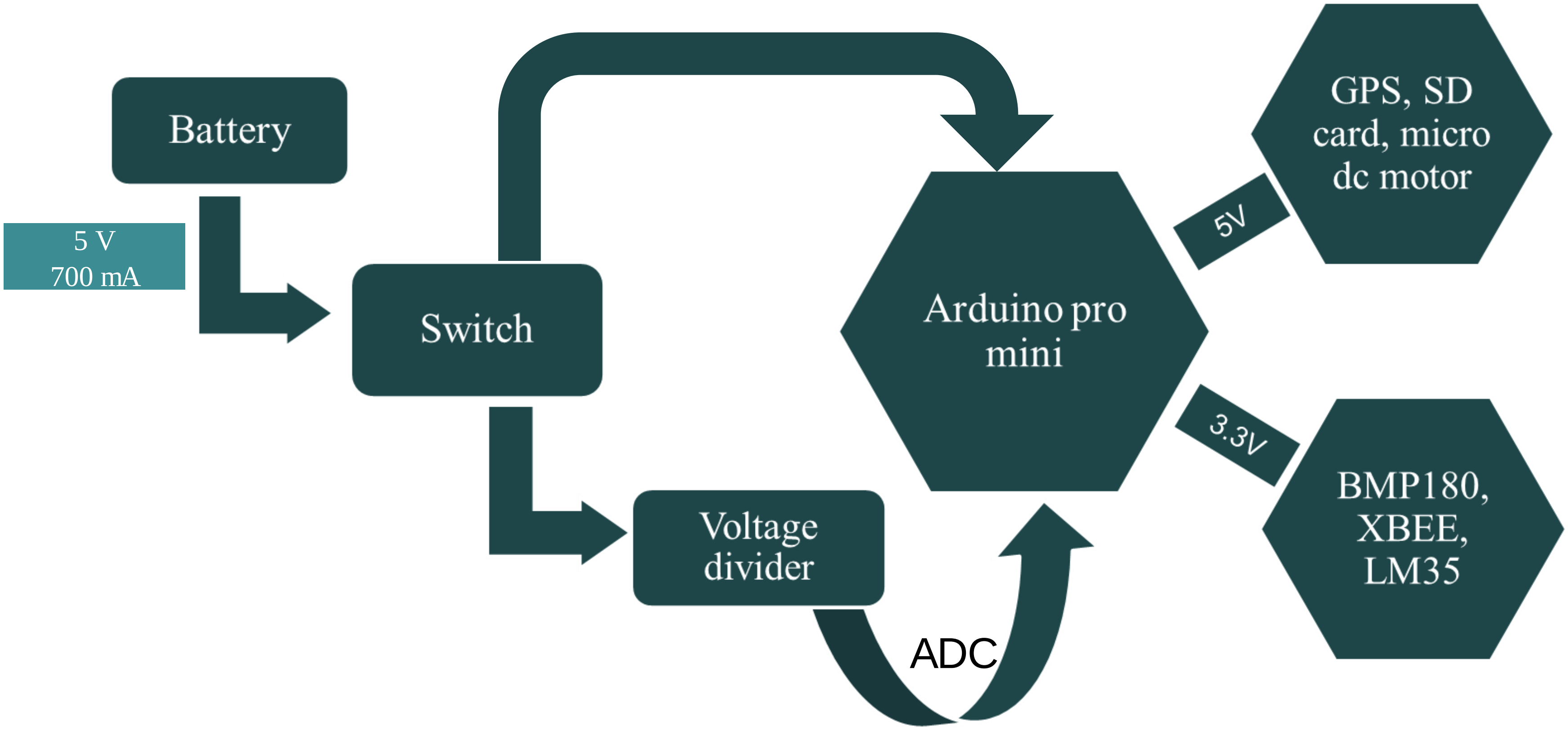
EPS Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
EPS-05	Alkaline battery shall provide minimum of 5V and 700 mAh	To fulfill power requirements of container electronics	High	SRS-22				X	X
EPS-06	Solar panels shall provide minimum 6V and 700 mA	To fulfill power requirements of the glider electronics	High			X		X	X
EPS-07	Separate rails of 3.3 V and 5 V to be maintained	To distribute power as required	High				X		
EPS-08	Voltage divider circuit to be used	To calculate voltage of the power bus.	High	SRS-11	CDH-05		X		
EPS-09	Li-Po batteries shall not be used	To prevent fire hazard	High					X	

Payload Electrical Block Diagram



Container Electrical Block Diagram



Payload Solar Power Trade & Selection

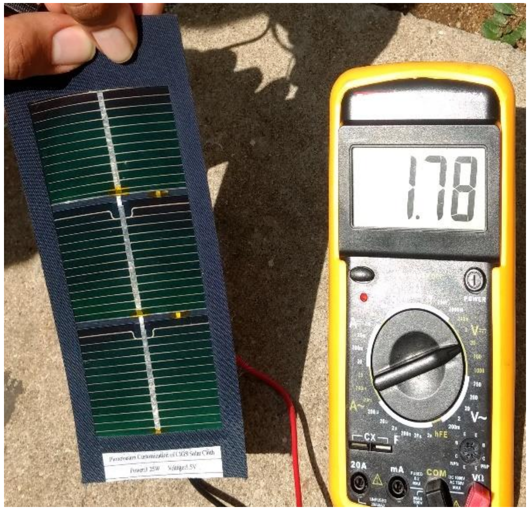
S. No	Model	Weight (g)	Voltage (V)	Current (mA)	Efficiency (%)	Dimensions (mm)	Price ($)
1	0.6W Solar cell	13.72	6.24	100	16	80 x 55	2.14
2	0.52W Solar cell	25	4.4	120	14	95 x 60	2.85
3	1.44W Solar cell	50	14.4	100	14	105 x 135	3.57
4.	1.25W CIGS Solar Cloth	22	1.78	650	14	180 x 90	9.90

Solar chosen: One 0.6W Solar cell and two 1.25W Solar cloth

Reason:

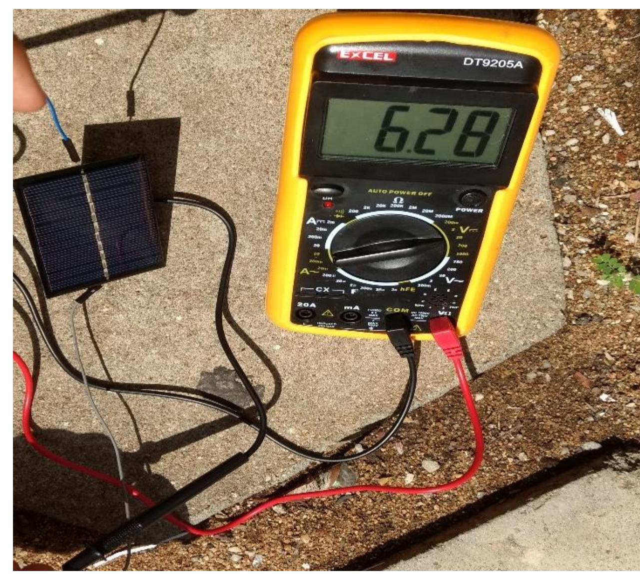
- Two 1.25W CIGS Solar Cloth will be connected in parallel resulting in an average current of 800-900mA.
- This combination will further be connected in series to 0.6W solar resulting in an average voltage of 6V-7V.
- The weight of the combination is 57.72g.
- The power supplied by chosen solar panels (**4.8-5.4W)**.

Payload Solar Power Trade & Selection



1.25W SOLAR CLOTH
- 1.78V supply
- 640 mA current

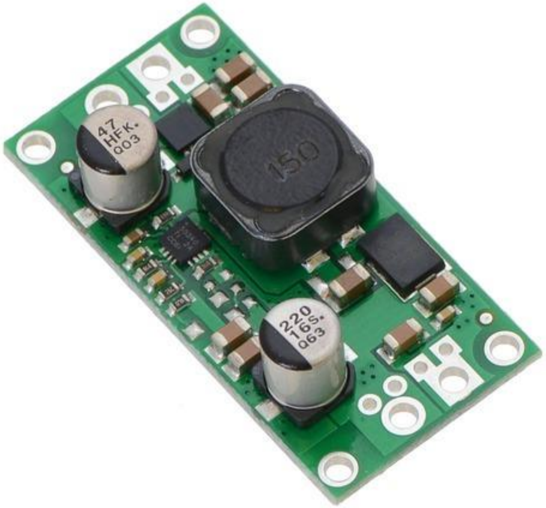
0.6W SOLAR CELL
- 6.28V supply



Payload Energy Management Strategy Trade Study

Strategy 1: Not using a storage device (direct supply from solar panel)

- Since we have a good current and voltage margin, energy storage devices are not used
- Maximum voltage supplied by solar panel is 8.24V which is regulated to 6V (within the range of microcontroller)
- Maximum current supply by solar panels is around 1300 mA, average current noted is 800-900 mA which is sufficient for the load
- Solar panels are tested with different angle of incidence of sunlight providing a minimum power of 3.3W



Strategy 2: Using an energy storage device like supercapacitor

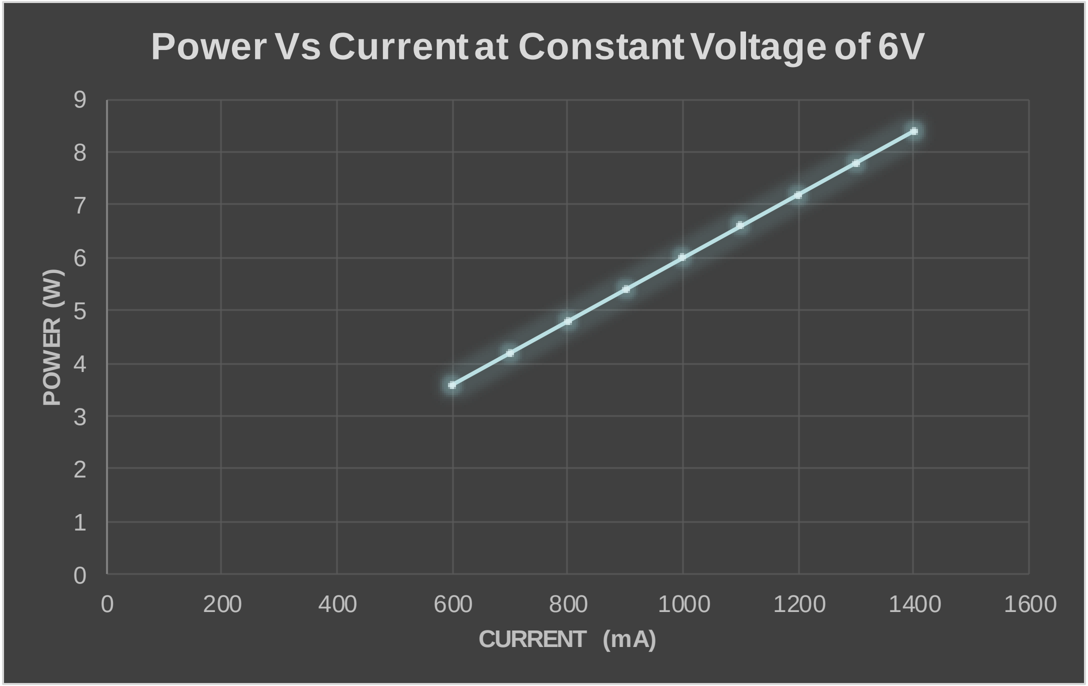
Chosen : Strategy 1

Reasons:

- Since we have adequate power supply from solar panels, energy storage devices are not taken into account
- A **Pololu 6V Step-Up/Step-Down Voltage Regulator S18V20F6** is used to supply a constant voltage of 6V and will allow a maximum of 2A current

Payload Energy Management Strategy Trade Study

- Power profile of the glider will be almost constant with time.
- All the data of solar panels are measured at 25 °C.As the temperature will increase the power efficiency will go down by 15%(average).



Average power supplied by solar panels=5.1W
15% of 5.1W=0.77W
Available power = 4.33W (enough to sustain the glider)

Container Battery Trade & Selection

S. No	Model	Weight (g)	Voltage (V)	Capacity (mAh)	Dimensions (mm)	Price ($)
1	Duracell Ultra 223(CR-P2)	38	6	1400	35 x 19.5 x 36	9.95
2	Sony NP-BN1 Rechargeable battery	15	3.7	630	35.5 x 4.9 x 40.8	31.39

Battery chosen: Duracell Ultra 223(CR-P2)

Reason:

- Cheaper
- Long-lasting
- Sufficient voltage supply by selected battery
- Less space required

Payload Power Budget

S. No	Model number	Input voltage (V)	Input current (mA)	Power consumption (W)	Usage ratio	Source
1.	Arduino pro mini 5v	5.0	50	0.2500	100%	Datasheet
2.	10DOF Gyro Accelerometer Compass Altimeter (L3GD20 LSM303D BMP180)	3.3	8	0.0264	100%	Datasheet
3.	LM 35	5.0	0.06	0.0003	100%	Datasheet
4.	Pitot tube	5.0	10	0.0500	100%	Datasheet
5.	Camera	5.0	75	0.3750	50%	Datasheet
6.	SD card	5.0	100	0.5000	100%	Datasheet
7.	XBee	3.3	295	0.9735	100%	Datasheet
8.	Buzzer	3.3	12	0.0396	10%	Datasheet
9.	Voltage divider	8.0	10	0.08	100%	Measured
10.	Voltage regulator	3.0	5	0.015	100%	Datasheet
	Total		565.06	2.08666		

Payload Power Budget

Amount of power required:
2.08666W

+

Margin:
20%
i.e., 0.4173W

=

Total:
2.5039W

- **Total average power available: 4.8-5.4W**
- A step up/ step down voltage regulator is used to supply a constant voltage of 6V and current allowance of 2A with input voltage range of 3-30V.
- **NOTE: No storage devices are used**
- **The voltage and current supply is sufficient to power the glider.**

Container Power Budget

S. No	Model number	Input voltage (V)	Input current (mA)	Power consumption (W)	Usage ratio	Source
1.	Arduino Pro mini (5V)	5	50	0.250	100%	Datasheet
2.	LM 35	5	0.06	0.0003	100%	Datasheet
3.	BMP 180	3.3	0.005	0.0000165	100%	Datasheet
3.	GPS	5	20	0.100	100%	Datasheet
4.	XBee	3.3	295	0.9735	100%	Datasheet
5.	SD card	5	100	0.500	100%	Datasheet
6.	Micro DC motor	5	110	0.550	10%	Datasheet
7.	Voltage divider	6	10	0.06	100%	Measured
	Total		585.065	1.9415165		

Container Power Budget

Amount of current required:
585.065 mA

+

Margin:
20%
i.e., 117.013mA

=

Total:
702.078mA

- **Battery capacity: 1400 mAh**
- Given the **total current (702.078 mA)** required, the battery is sufficient to run for approximately **2 hours**
- Therefore, the total power consumed by container is **2.3298198W** (including 20% margin)
- Note: No storage device is used in the container. Battery is the only power source.

Flight Software (FSW) Design

Rakshit Vig

FSW Overview

Basic FSW Architecture:

CanSat is powered on → Loop updates sensor data → FSW state is decided on the basis of sensors filter → Tasks are performed on the basis of sensor data

- Switching from container telemetry to glider telemetry also depends on sensor data .

Programming language used :

- C++

Development environment :

- Arduino Integrated Development Environment 1.6.11

Brief summary of FSW tasks :

- Sensor data is updated every second.
- Based on the sensor data filters, FSW state is decided.
- Telemetry packet is updated and transmitted per second to GCS using XBee.
- During decent, at the height of 400m +/-10m a micro dc motor will be powered on to execute ejection mechanism.

FSW Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
FSW-01	All the sensor data shall be collected and updated every second	Mission requirement	High	SRS-11 SSD-07			X	X	
FSW-02	The telemetry should be sent to GCS using XBee, every second .	Mission requirement	High	SRS-26	CDH-03 CDH-01	X	X		X
FSW-03	The processor should calculate mission time and maintain it during reset	Mission requirement	High	SRS-11	CDH-02	X			X
FSW-04	The FSW shall maintain and update packet count even during reset	Mission requirement	High	SRS-11 SRS-19			X		

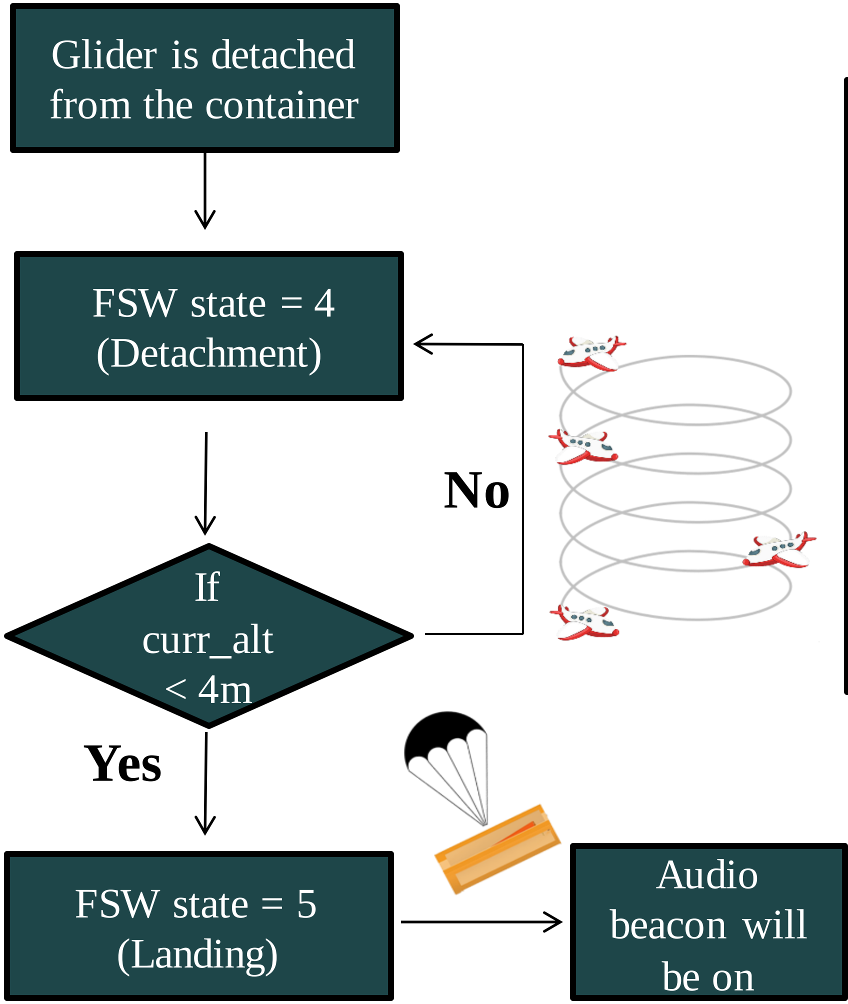
FSW Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
FSW -05	FSW shall assign different states	To perform certain tasks and take decisions accordingly	High		CDH-15		X	X	
FSW-06	All the telemetry data shall be stored in SD card	For backup data	Medium	SSD-09	CDH-04		X		
FSW-07	Image to be clicked and stored in SD card as frequent as possible	Bonus objective	Medium	SSD-10 SSD-09 SRS-29 SRS-30	CDH-14 CDH-07 GCS-10	X	X		
FSW-08	An audio beacon shall be powered on in container and glider after landing	Recovery of container and glider	High	CDH-05 SRS-27	SSD-11	X			X

FSW Requirements

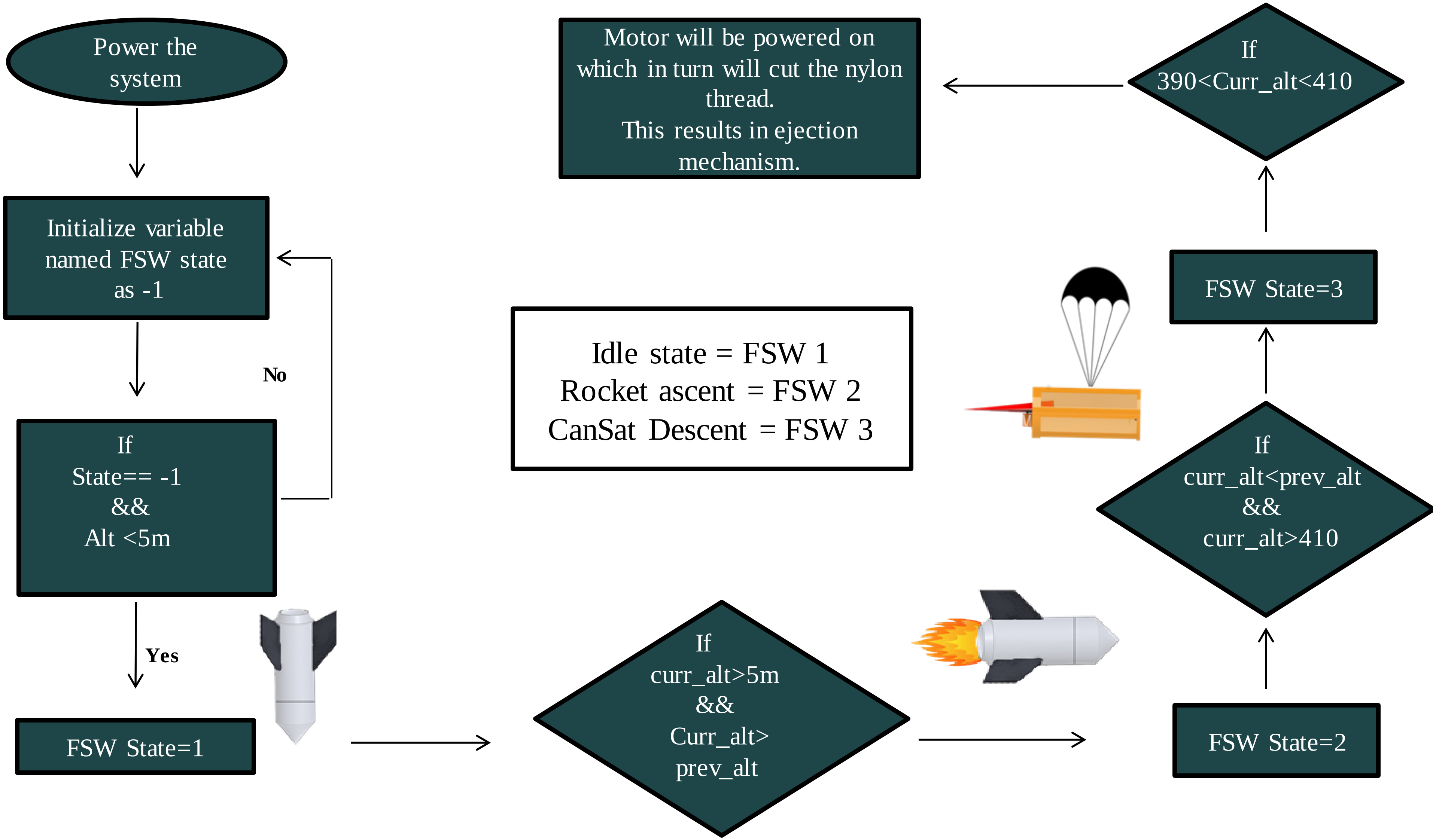
ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
FSW -09	Based on sensor data payload shall be detached from container	Ejection mechanism	High	SSD-05 SRS-06 SRS-21	DCR-05 MSR-06		X		
FSW-10	All sensor data must be in engineering units	Mission requirement	High		GCS-07	X	X		
FSW-11	In case autonomous ejection mechanism fails, CanSat shall receive an override ejection command from GCS	Fail safe mechanism	Medium	GCS-06 SRS-24			X	X	
FSW-12	Telemetry generated will be comma separated		Medium			X	X	X	

Payload FSW State Diagram



- All the sensors are sampled at 1 HZ
- Telemetry will be sent to the ground station in FSW state 4 at every second .
- Image will be taken at every 15 seconds.
- All the data including images will be stored in SD card.
- Telemetry will be stopped in FSW state 5 and audio beacon will be initiated.
- If the processor resets, SD card data will be retrieved and corrections will be made.
- Total power required 2.5039 W and minimum power supplied is 3.6 W which is sufficient for all the electronics.

Container FSW State Diagram



Container FSW State Diagram

- All the sensors are sampled at 1 Hz
- Telemetry will be sent using XBee to ground station in every FSW state at 1 Hz.
- All the telemetry data will be stored in SD card.
- If the processor resets, SD card data will be retrieved and corrections will be made.
- Total current required 702.078 mA, battery capacity of 1400 mAh, so its sufficient to run for approximately 2 hours

Software Development Plan

Prototyping language and environment :

- Prototyping language used is C++ and prototyping environment is Arduino IDE 1.6.11

Software subsystem development sequence:

- All the sensors will be interfaced with the processors individually. **DONE**
- An integrated software for all the sensors will be developed. **DONE**
- Full FSW will be developed and logics will be tested. **NOT DONE**
- Debugging will be done on the basis of results. **NOT DONE**

Development team:

- Rakshit Vig
- Pranav Naidu

Test methodology:

- All the sensors shall be integrated and the corresponding integrated code will be tested to check the telemetry frequency. Depending on the result, telemetry time will be optimized to a required level.
- To check the FSW, we will scale down all the parameters.
- Xbee range will be tested by transmitting telemetry across the two ends of the field in LOS(line of sight)

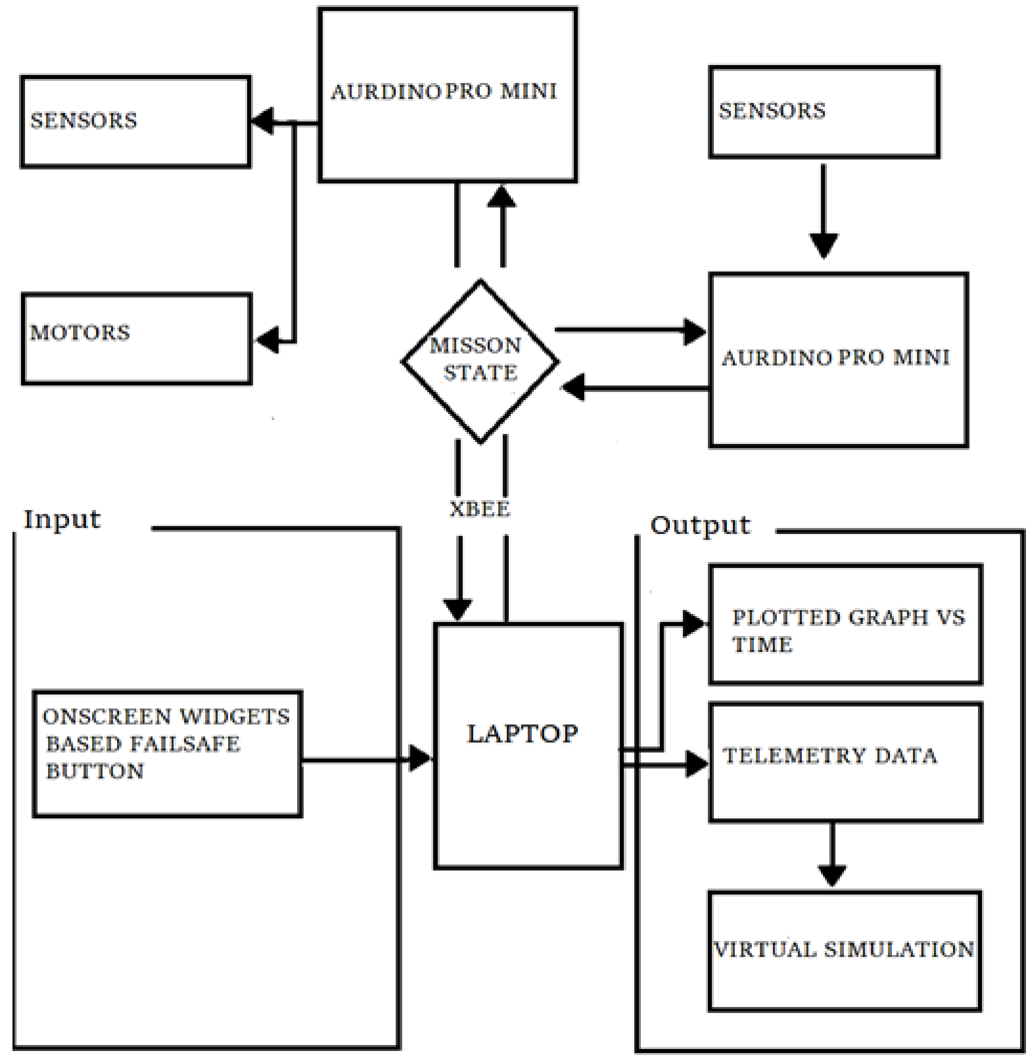
Ground Control System (GCS) Design

G Pranav Naidu

GCS Overview

Overview:

- The software will be designed keeping in mind that it effectively utilises the parallel processing power that modern computers utilise today.
- The telemetry data sent from the CanSat will be received by XBee radio module, which is interfaced with an Arduino.
- The data will be serially transferred to the laptop through the USB2.0 port of the laptop.
- The data will be first stored in a .csv file.
- The telemetry string will then be parsed and individual datum values will be sent to the respective processes for plotting and simulating.



GCS Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
GCS-01	Every team shall make its Ground control software	Mission requirement	High	SRS-11		X	X		X
GCS-02	During flight operations the GCS shall plot the data in real time	Mission requirement	High	SRS-16				X	X
GCS-03	The GCS shall have minimum of 2 hours battery backup	Mission requirement To ensure completion of GCS COSNOP	High	SRS-17					X
GCS-04	The GCS must be portable	Mission requirement To setup the GCS at the assigned station with ease	High	SRS-17		X			
GCS-05	Xbee Pro S2B will be interface with the MCU at ground station	To receive packet send from the CanSat	High	CDH-01					

GCS Requirements

ID	Requirement	Rationale	Priority	Parent	Child	VM			
						A	D	I	T
GCS-06	The GCS shall have an override ejection command.	To facilitate ejection incase autonomous release fails	High	SRS-24 FSW-11			X		X
GCS-07	GUI shall have a fully flexible unit system.	Engineering units displayed in accordance to the convenience of user	Low	FSW-10		X			
GCS-08	A Backup of telemetry data in a.csv file will be maintained.	Mission requirement	High	CDH-04 FSW-12				X	
GCS-09	GUI shall display all data using graphical plots.	Mission requirement and to ensure convenient analysis of data	High	SRS-16		X		X	
GCS-10	A 2D simulation of the glider is will be made using the heading data from the glider	Ease in user interpretation	Medium	SRS-32 SSD-02		X			X
GCS-11	Antenna of high gain should be used to avoid any loss in telemetry	To attain higher range	High				X		X

SEDS VIT
Think Infinite...

GCS Design

ANNUAL CANSAT COMPETITION

- The GCS will be running on Lenovo Z50 i7 proceesor which offers 4 hours of battery life(4 cell 2900 mAH) is used with Xbee 2.4 GHz, series 2B radios and hand held antenna. The GCS is portable and can be positioned whenever required.

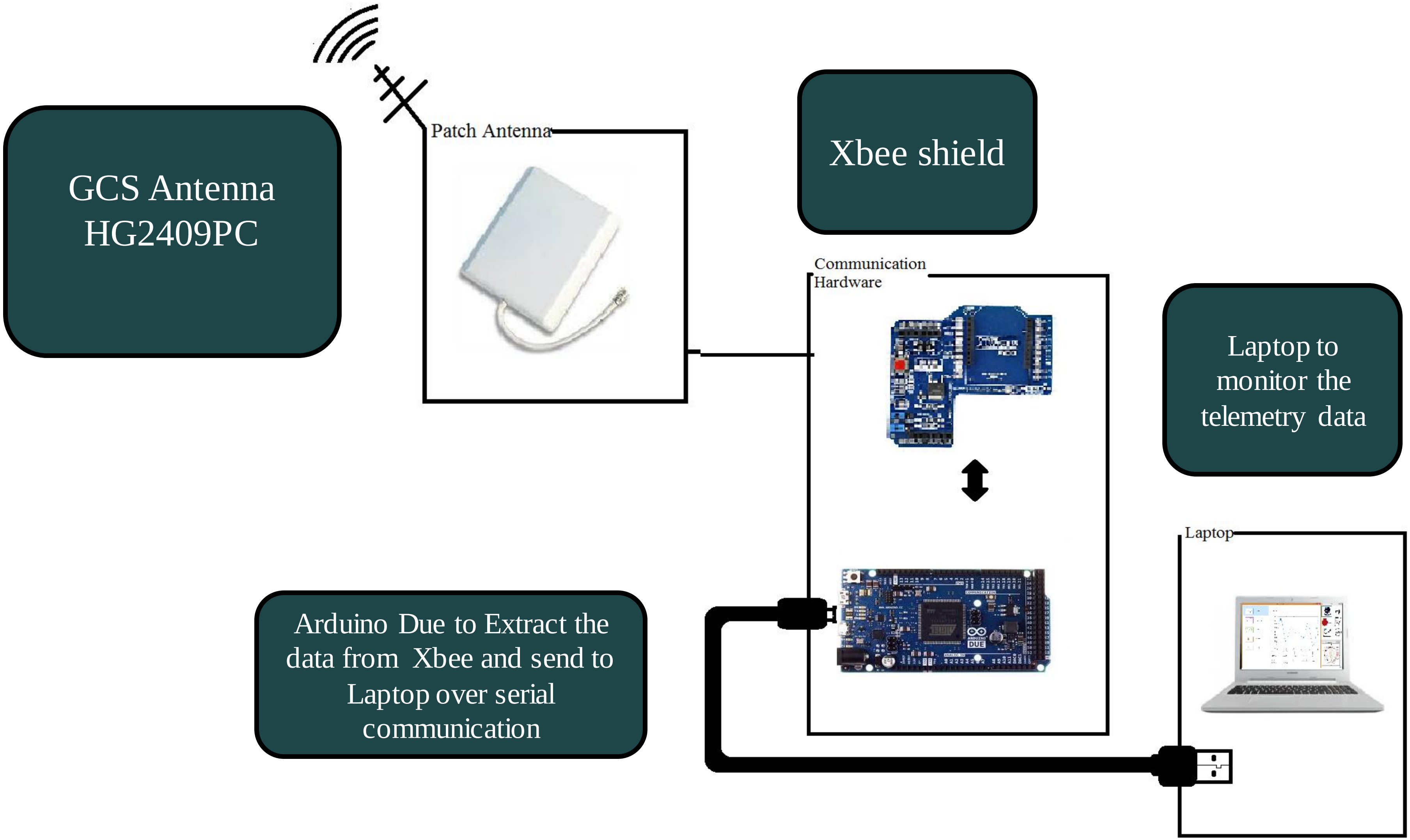
- The entire GCS uses 100MB of RAM which does not significantly affect the battery life of the system.

- A cooling pad will be provided with the laptop to prevent over-heating.
- The GCS will run on Linux, i.e. Ubuntu 15.01.

- Linux is chosen over windows as it provides very flexible customisation options compared to windows.

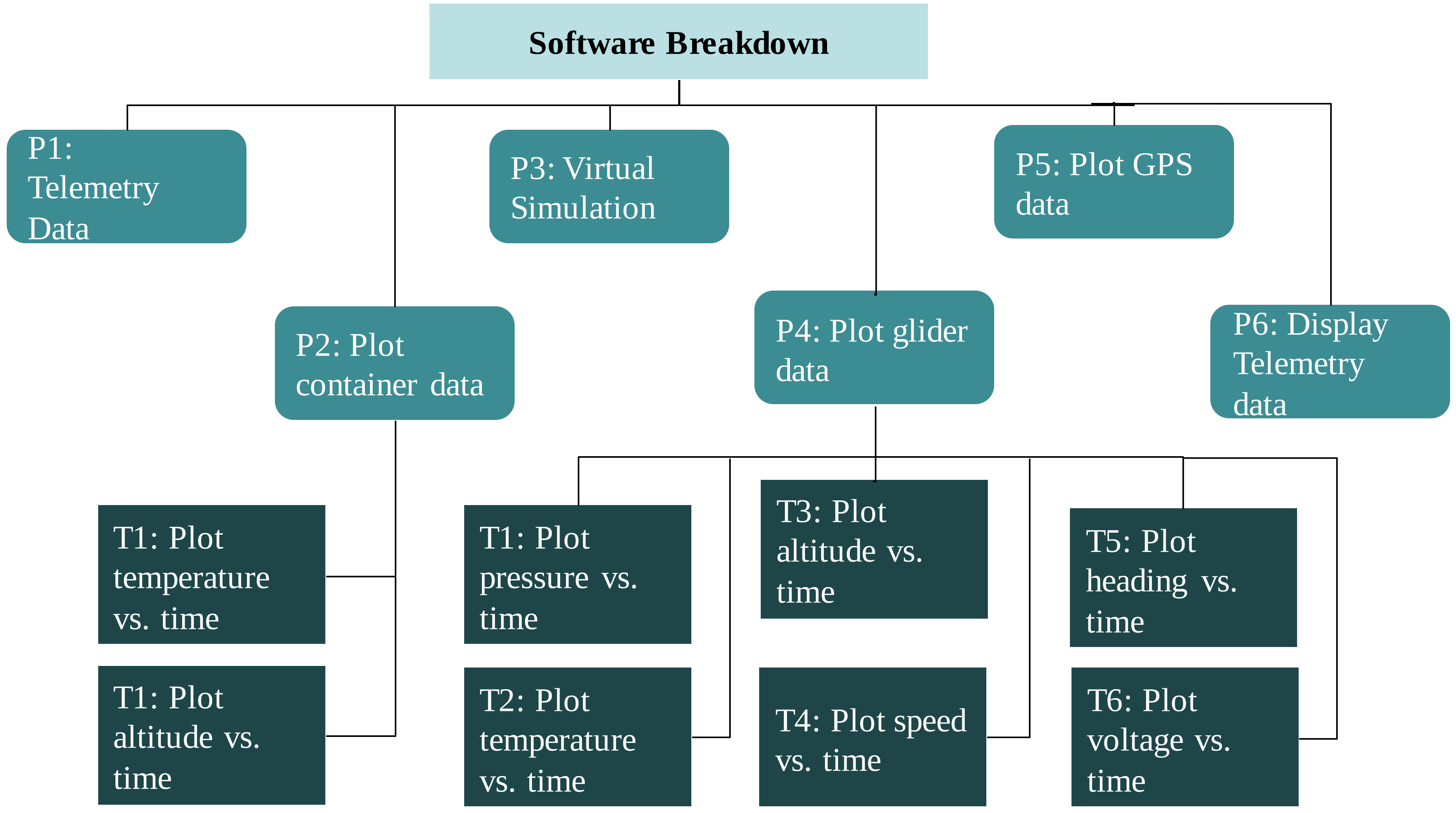
- The auto update provision in Linux can be disabled to prevent any kind of auto-update in midst of operation.

GCS Design



GCS Antenna HG2409PC
Patch Antenna
Xbee shield
Communication Hardware
Laptop to monitor the telemetry data
Laptop
Arduino Due to Extract the data from Xbee and send to Laptop over serial communication

GCS Design


Software Breakdown
P1: Telemetry Data
P2: Plot container data
P3: Virtual Simulation
P4: Plot glider data
P5: Plot GPS data
P6: Display Telemetry data
T1: Plot temperature vs. time
T1: Plot altitude vs. time
T1: Plot pressure vs. time
T2: Plot temperature vs. time
T3: Plot altitude vs. time
T4: Plot speed vs. time
T5: Plot heading vs. time
T6: Plot voltage vs. time

GCS Antenna Trade & Selection

Antenna	Gain (dBi)	Frequency Range (GHz)	Dimensions (cm)	Radiation Pattern
Parabolic reflector	23.5	2.4-2.483	60 x106	Directional
Patch Antenna HG2409PC	8	2.4-2.5	11.4 x 11.4 x 2.3	Omnidirectional
2.4 GHz Antenna , double pol.	17	2.4	20.3 x 20.3 x 65	Directional

FINAL SELECTION: PATCH ANTENNA (HG2409PC)

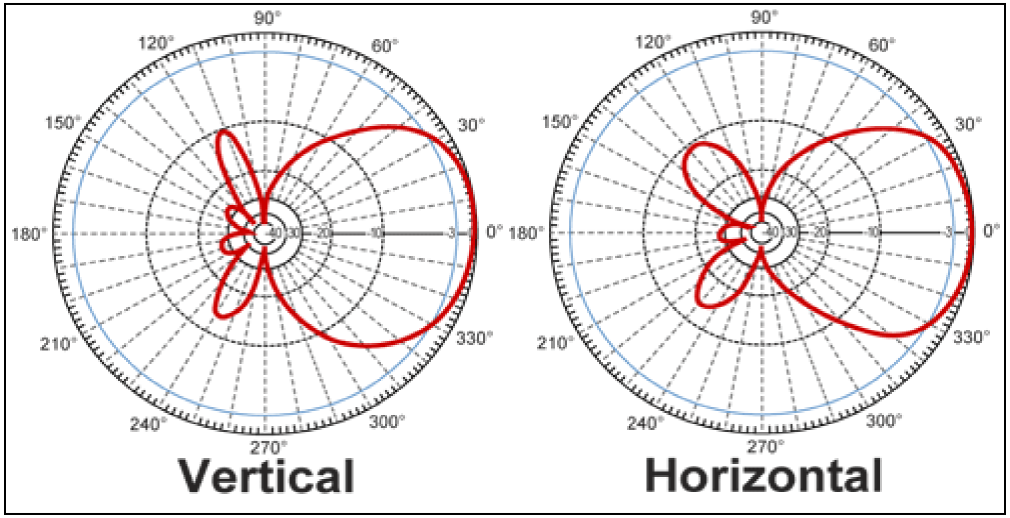
Rationale :

- Good Portability
- Radiation pattern
- Range
- Past experience.
- Consumes lesser power

- The antenna will be hand held by a member of the Ground Station crew.
- The antenna will be held on an antenna holder manufactured using Plastic so that crew member can hold it comfortably
- This antenna was previously used by our team in CanSat 2016, and was found to meet all the necessary requirements.

GCS Antenna Trade & Selection

Antenna Range and Patterns
The antenna that is selected for the glider is : PATCH ANTENNA



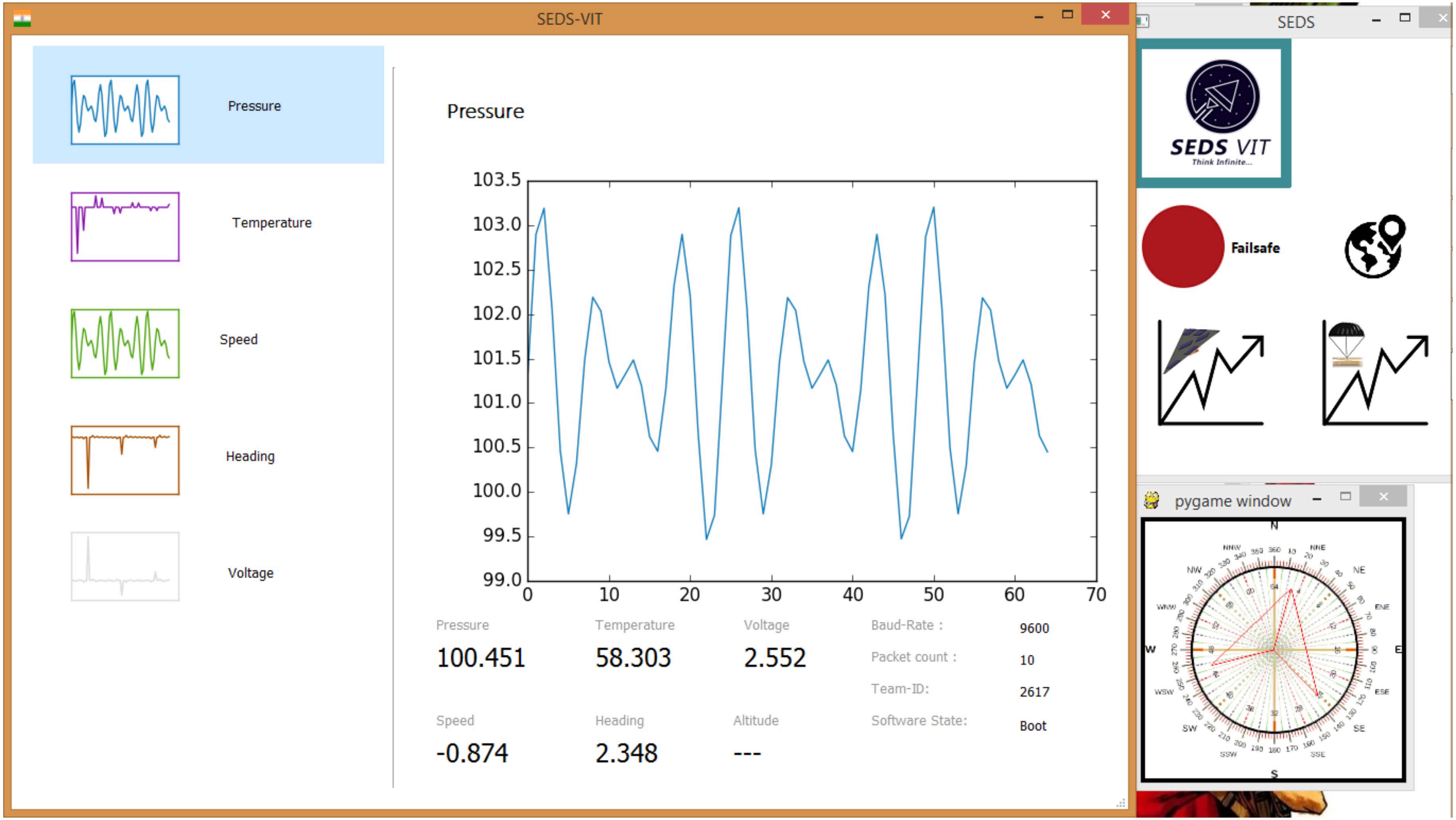
Frequency (Hz)	2400-2500
Gain (dBi)	8
Horizontal Beam Width (deg)	65
Vertical Beam Width (deg)	65
Impedance (Ohm)	50
Max. Input Power (W)	25
VSWR	<1.5:1 avg
Connector SMA-MaleP	48 inch coax feedline

GCS Software

Sr. No	Requirement	Rationale
1	Ubuntu 15.01	For faster data access and flexible customization option
2	PyQt5	Designing tool used along with python for designing the User Interface
3	Python3.4	User friendly, availability of prebuilt packages
4	Matplotlib	Plotting package for python, easy to plot data and availability of graph functionality.
5	pySerial	Used to receive the serial data from XBEE development board. It also provides various function to handle serial data.
6	os, signal, subprocess	For process management.
7	QT Designer	Tool used to designing and building Graphical User Interface (GUI).
8	OpenGL	To construct the simulation of the glider using magnetometer data.
9	Time	Used to provide time based synchronization.
10	Pygame	It will be used to plot the GPS mapping for retrieval of container.

GCS Software

Screenshot of the Graphical User Interface of the Ground Control Software



GCS Software

- **Data archiving and retrieval approach**
  - Data is being stored in a csv file which can be used to recover data at a later stage
  - Data is being written into a csv file and is then sent via shared memory to the GUI process
  - Over there it is used to plot the graphs, construct simulation and show data.

- **Telemetry data recording and media presentation to judges for inspection**
  - Data being sent is recorded in a csv file.
  - The image bits sent is compiled into a png file.
  - The csv file and the image will be given to the judges in a pen drive.

- **GCS also contains a emergency ejection button to enable force release of the glider in case of failure of the autonomous ejection.**

GCS Software

- **Describe .csv telemetry file creation for judges**
  - The GCS software creates a new csv file. It adds a heading describing different data being transmitted.
  - If already present, it writes the received data to the csv file.
  - csv file data format for container –
    - <TEAM_ID,CONTAINER,MISSION_TIME,PACKET_COUNT,ALTITUDE,TEMPERATURE,SOFTWARE_STATE>
  - csv file data format for glider –
    - <TEAM ID,GLIDER,MISSION_TIME,PACKET_COUNT,ALTITUDE SENSOR, PRESSURE,SPEED,TEMPERATURE,VOLTAGE,HEADING,SOFTWARE_STATE, BONUS>.
- **Telemetry display prototypes**
  - Telemetry is displayed in real time and engineering units.
  - The plots for telemetry of the container and glider will be plotted in separate windows. The above is done to enable systematic monitoring of data.
  - Using heading and speed data, the GCS shall predict and plot a 2D map of glider position.

CanSat Integration and Test

Roshan Murali

Malhar Joshi

CanSat Integration and Test Overview

- Analysing the mission guide and identifying the important requirements
- Making a preliminary design of the glider. First on software then making a prototype.
- Mechanical flight test to check flight dynamics. Finalising the best design.
- Procuring electrical components
- Testing of sensors and solar panels under different light intensities to find average power output
- Designing GCS software
- Finalizing GCS and CanSat antennae
- Procuring mechanical components, manufacturing the container and other parts
- Manufacturing and installing the glider folding and ejection mechanism
- Carrying out the GCS and antennae tests
- Integrating all the subsystems and carrying out a compatibility test
- Testing subsystems and carrying out final CanSat testing

CanSat Integration and Test Overview

Subsystem	Test	Testing Method
Descent control system	Descent control mechanism	Deploying the CanSat module using a helium balloon and monitoring its motion using a GPS. Also the helical descent path will be tested.
	Ejection mechanism	Loading the payload into the container and then sending a command from a laptop(using XBEE) to eject the system.
	Parachute	Deploying CanSat from a multistoried building.
Communication and data handling	Range test	Line of sight range test of the XBEE will be performed in an open ground of 1km
Sensor	Individual sensors test	Testing individual sensors and calibrating the data obtained from it.
	Integrated Sensor Test	All the sensors will be integrated and tested

CanSat Integration and Test Overview

Subsystem	Test	Testing Method
Flight software	Integrated FSW test	The parameters will be scaled down and FSW will be implemented on it.. The results will be analyzed.
Ground Control System	Software test	Using sample test values generated by the software a graph of the readings obtained will be plotted..
	Antenna test	Line of sight range test will be used for testing the Antenna.
Mechanical	Wing unfolding	Folding the wings and placing it inside the container. Sending a command from a laptop(using XBEE) to eject the glider and thus unfolding the wings

Integrated Level Functional Test Plan

Test	Testing Method
Glider testing	CanSat module will be deployed using a helium balloon and the helical descent path will be tested.
Communications	Line of sight range test of the XBEE will be performed in an open ground of 1km
Mechanisms	• For testing the parachute mechanism, the CanSat will be deployed from a multistoried building. • Wing unfolding mechanism will be tested by folding the wings and placing it inside the container. A command will be sent from a laptop(using XBEE) to eject the glider and thus unfolding the wings
Deployment	The payload will be loaded into the container and then a command will be sent from a laptop(using XBEE) to eject the system.

Environmental Test Plan

Test	Testing Method
Drop test	1. One end of a cord is tied to the ceiling and the other end is secured to the parachute attachment point. 2. The CanSat is raised to a height of 80 cm in line with the cord. 3. The cord is released and the CanSat is allowed to free fall. 4. The Container and Payload is checked for damage and the results are noted.
Thermal test	1. The CanSat is turned on and placed into a thermal chamber and sealed. 2. The heat source is turned on and monitored till it reaches 60°C, it is then allowed to cool to 55°C . 3. This temperature is maintained for 2 hours. 4. The heat source is turned off and the CanSat is visually and functionally inspected. 5. With the CanSat still hot, all mechanisms and structures will be inspected to make sure the integrity has not been compromised. 6. All epoxy joints and composites are inspected and all results are noted.
Vibration test	1. A functional test of the CanSat is carried out. 2. The CanSat is securely mounted on the vibration fixture. 3. The sander powered up to full speed, for 2 seconds and turned off. 4. As soon as the sander stops moving, the processes is repeated until one minute is completed. 5. The CanSat is removed from test fixture and inspected it for any damage. 6. A full functional test is performed and the results are noted.

Mission Operations & Analysis

Kunal Pandey

Overview of Mission Sequence of Events

Arrival at Launch Site

- Ground station is set up.
- Communication devices are connected.
- Assign different roles to the team members.
- Final inspection of all the sub systems of CanSat.
- Measure solar intensity for power estimates.
- Measure wind speed and direction for landing estimates.

Pre-launch Checks

- Go through pre-flight checklist and make sure every pre-launch requirement is met.
- Ensure that the ground station is operational and check its functioning.
- Check orientation of antenna and check telemetry transmission.
- Estimate the CanSat landing zone.

Integration into Rocket

- Seal all the electronic payload of the glider inside the fuselage.
- The hang glider is folded and placed inside the container and the ejection. mechanism is initiated
- The CanSat is powered on.
- The CanSat is installed in the designated payload section of the launching rocket.

- **Launch Sequence of Events:**

Rocket Launch

- According to the information given by the sensors, the flight software state is updated when each action takes place.

Deployment

- With the deployment of the CanSat, parachute is deployed.

- At deployment, the FSW State is updated.

Separation & Descent

- At a height of 400m, the glider is ejected from the container and glide within a diameter of 1000m.
- Telemetry is started and Data is received at GCS.
- The camera starts capturing images. The images are stored on the SD card
- FSW State updated to descent.

Landing

- The telemetry is stopped after the landing of the glider

- The audio beacon is activated for detection.

- FSW state updated to Landed.

• Post Launch Sequence of Events:

Recovery

- Recovery of the Glider and the Container.
- Both of them are examined for any possible damage during flight or landing.

Analysis

- The SD card is retrieved from the electronic section.
- The telemetry data and images are analyzed.

Post Flight Reporting

- The data obtained is utilized for making a presentation.
- A presentation is given on the following day

Overview of Mission Sequence of Events

Sr. No	Name	Position/Role(on launch day)
1	Akshay Girish Joshi	Allocating tasks to the crew members and overseeing all operations
2	Pranav Naidu	GCS Setup
3	Ases Akas Mishra	Final mechanical systems check before loading the CanSat in the rocket payload section
4	Roshan Murali	Descent Control Module inspection
5	Kumar Yash	Antenna construction on the launch day
6	Rakshit Vig	Electrical systems check before launch
7	Aman Gupta	Telemetry data transmission check
8	Devesh Bajaj	Post flight recovery and analysis of flight data
9	Malhar Joshi	CanSat recovery and extraction of SD card and submission to the ground control
10	Kunal Pandey	CanSat recovery and extraction of SD card and submission to the ground control

Mission Operations Manual Development Plan

- **Mission operation manual is divided into six sections:**
  - Allotment of different tasks to team members
  - Assembling of the CanSat
  - Pre-flight checks
  - Establishment of the ground station.
  - Procedures to handle frequent onsite issues
  - Safety check procedures

- **Mission operations manual will be developed and modified as we proceed with the fabrication and testing of the CanSat.**

CanSat Location and Recovery

- The payload and the container will be fitted with **audio beacons(buzzer)** which will guide the crew to the landing location.

- The glider and the container will be **fluorescent orange colored** so that they can be spotted from a distance.

- For the ease of recovery the container and the glider are labeled with **team's name, number and email address**.

- After the payload and container are recovered, the SD card is extracted and submitted to the ground control for further analysis.

Requirements Compliance

Kunal Pandey

Requirements Compliance Overview

- All the mission requirements are fulfilled.

- Bonus objective is decided to be attempted, which is capturing images as frequently as possible and keeping a count of the pictures taken.

- The external objective(3D simulation) is yet to be tested. The simulation will require accurate values from the magnetometer, according to which the simulation of the path of the glider can be projected. We are currently working on it, and if we get a proper result, we will implement it.

- According to the environmental test guide, environmental tests are yet to be performed. The compliance of these tests will be noted and changes will be made according to the requirements later.

- Two foldable solar panels(**1.25W CIGS Solar Cloth**) and one rigid solar panel(0.6W) have been decided to be used till now. It is currently been tested at various solar intensities. The panels may be changed in the future if a better alternative is found.

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
1	Total mass of the CanSat (container and payload) shall be 500 grams +/- 10 grams.	comply	76,77	
2	The glider shall be completely contained in a container. No part of glider may extend beyond the container. One end of the container may be open, without any extension of the glider.	comply	69	
3	The container shall fit inside the cylindrical payload section of the rocket defined by the cylindrical payload envelope of 125 mm x 310 mm length including all the systems.	comply	32,33	
4	The container must use a descent control system. It cannot free fall.	comply	54	
5	The container shall not have any sharp edges that could cause it to get stuck in the rocket payload section.	comply	25,32	
6	The container must be a florescent color, pink or orange.	comply	54	
7	The rocket airframe shall not be used to restrain any deployable parts of the CanSat.	25,32	25,32	
8	The rocket airframe shall not be used as part of the CanSat operations.	comply	25,32	
9	The CanSat (container and glider) shall deploy from the rocket payload section.	comply		
10	The glider must be released from the container at 400 meters +/- 10 m.	comply	73	
11	The glider shall not be remotely steered or autonomously steered. It must be fixed to glide in a preset circular pattern of no greater than 1000 meter diameter. No active control surfaces are allowed.	comply	58,59	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
12	All descent control device attachment components shall survive 30 Gs of shock.	Comply	54	
13	All descent control devices shall survive 30 Gs of shock.	Comply	54	
14	All electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Comply	26,29	
15	All structures shall be built to survive 15 Gs acceleration.	Comply	68	
16	All structures shall be built to survive 30 Gs of shock.	Comply	68	
17	All electronics shall be hard mounted using proper mounts such as standoffs, screws, or high performance adhesives.	Comply	75	
18	All mechanisms shall be capable of maintaining their configuration or states under all forces.	Comply	75	
19	Mechanisms shall not use pyrotechnics or chemicals.	Comply	-	
20	Mechanisms that use heat (e.g., nichrome wire) shall not be exposed to the outside environment to reduce potential risk of setting vegetation on fire.	Comply	-	
21	During descent, the glider shall collect air pressure, outside air temperature, compass direction, air speed and solar power voltage once per second and time tag the data with mission time.	Comply	39,40,42,43,45,46	
22	During descent, the glider shall transmit all telemetry either continuously or in bursts	Comply	100	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
23	Telemetry shall include mission time with one second or better resolution, which begins when the glider is powered on. Mission time shall be maintained in the event of a processor reset during the launch and mission.	Comply	91	
24	XBEE radios shall be used for telemetry. 2.4 GHz Series 1 and 2 radios are allowed. 900 MHz XBEE Pro radios are allowed.	Comply	97,98	
25	XBEE radios shall have their NETID/PANID set to their team number.	Comply	97,98	
26	XBEE radios shall not use broadcast mode.	Comply	97,98	
27	The glider electronics must be all solar powered except for the time keeping device may use a coin cell battery. No batteries are allowed. Super capacitors are allowed and must be fully discharged at the time of launch	Comply	104	
28	Cost of the CanSat shall be under $1000. Ground support and analysis tools are not included in the cost.	Comply	162	
29	Each team shall develop their own ground station.	Comply	129	
30	All telemetry shall be displayed in real time during descent.	Comply	140	
31	All telemetry shall be displayed in engineering units (meters, meters/sec, Celsius, etc.)	Comply	140	
32	Teams shall plot data in real time during flight. In addition, the ground system shall display a 2-D map of estimated glider position based on speed and heading telemetry date.	Comply	140	

Requirements Compliance

Rqmt Num	Requirement	Comply / No Comply / Partial	X-Ref Slide(s) Demonstrating Compliance	Team Comments or Notes
42	The CanSat shall have a payload release override command to force the release of the payload in case the autonomous release fails.	Comply	139	
43	Glider shall be a fixed wing glider. No parachutes, no parasails, no parafoils, no autogyro, no propellers. Hand glider design where electronics section has a hard attachment point is allowed.	Comply	55	
44	The glider shall use a time keeping device to maintain mission time. The time keeping device can use a small coin cell battery.	Comply	91	
45	The time keeping device battery shall be a coin cell battery with a capacity limit of 240 mAh and with no more than a 1 ma discharge rate.	Comply	-	
46	The container shall transmit telemetry from the time being turned on and placed on the launch pad until 2 second after releasing the glider.	Comply	30	
47	The container telemetry shall be transmitted once per second.	Comply	100	
48	The container telemetry shall include team number, indication of container telemetry, altitude, temperature and software state.	Comply	100	
49	An audio beacon for the glider shall be included and powered off of the solar power.	Comply	124	
50	An audio beacon is required for the container.	Comply	124	

Management

Kunal Pandey

CanSat Budget – Hardware Electrical

Part	Model	Quantity	Price($)	Total($)	Determination
Processor	Arduino Pro Mini (5 V model)	2	9.95	19.9	Actual
Magnetometer, Pressure sensor	10DOF Gyro Accelerometer Compass Altimeter (L3GD20 LSM303D BMP180)	1	9.95	9.95	Actual
Temperature sensor	LM 35	2	1.05	2.10	Actual
Pitot tube(air speed sensor)	HK pilot air speed sensor	1	26.03	26.03	Actual
Air pressure sensor (container)	BMP 180	1	2.66	2.66	Actual
Camera	Adafruit TTL JPEG Camera	1	39.95	39.95	Actual
SD Card along with Shield	16gb SanDisk class 10 with SD Card Shield	2	7.34	14.68	Actual
XBee radios	Xbee Pro S2B U.FL Connector	2	44.95	89.9	Actual
CanSat antenna	FXP70 Freedom (patch antenna)	2	3.35	6.7	Actual
Audio Beacon	Mini piezo buzzer	4	0.73	2.92	Actual
Altimeter(GPS)	Adafruit Ultimate GPS	1	39.95	39.95	Actual
Micro DC motor	Micro DC motor	1	2.94	2.94	Actual
Solar Panels(1)	CIGS Solar Cloth	2	9.90	19.80	Actual
Solar panel(2)	0.6W Hard Solar Panel	1	2.14	2.14	Actual
Voltage regulator	S18V20F6	1	14.95	14.95	Actual
Battery	Duracell Ultra 223(CR-P2)	1	9.95	9.95	Actual

CanSat Budget – Hardware

Part	Model/material	Quantity	Source	Price($)	Total($)	Determination
Container + Fuselage (Structure Material and Fabrication via 3D Printing)	HDPE	1	REALiz 3D printers	220	220	Estimated
Parachute	TARC-22	1	Fruity Chutes	35	35	Actual
Glider frame	Carbon Fibre	2	Local Supplier	3	6	Estimated
Sailcloth	Dacron type 52	2	Local Supplier	11	22	Actual
Miscellaneous (Hooks ,adhesives, rubber band etc)	-	-	Local Supplier	50	50	Estimated

Subsystem	Price($)
Electrical	304.52
Mechanical	333
Exact Total	607.52
Margin (15%)	91.13
TOTAL	698.65

Hence the total budget of CanSat is well within the limit of $1000.

CanSat Budget – Other Costs

Ground Control Station Costs

Part	Model	Quantity	Price ($)	Total ($)
Processor	Arduino Duo	1	57.90	57.90
Communication Module	Xbee Pro S2B	1	74.10	74.10
GCS Antenna	HG2409PC	1	42	42
Laptop	Lenovo Z50	1	620	620
Xbee Shield Module	Sain Smart 101-50-105	1	26	26
Total GCS Budget				820

Testing and Prototyping Costs

Part	Price($)
Prototyping	200
Testing	200

Testing and Prototyping cost includes the preliminary mechanical prototypes which ever used for flight test, determining glider ratios, and other experimental data

CanSat Budget – Other Costs

Expenditure incurred for the Competition

Expenditure	Quantity	Price ($)	Total ($)	Determination
Competition fee	1	100	100	Actual
Flights	10	1000	10000	Estimated
Meal	120	10	1200	Estimated
Accommodation	10	370	3700	Estimated
Transport	10	200	2000	Estimated
Total Cost			17000	Estimated

CanSat Budget – Other Costs

Source of Income for CanSat 2017

Our university, **Vellore Institute of Technology** will be providing us with financial aid for the project . We have also started approaching sponsors to provide us financial support. We have succeeded and received positive response from couple of sponsors and have scheduled meetings with them for the same. The documentation for approaching sponsors has been developed. We have been constantly updating our social media platforms to ensure that the potential sponsors get information about our previous accomplishments and approach us with ease.

We are also looking forward for companies to have partnership for providing us with concession on airline tickets and components.

Budget Summary	
Income (External Sponsors)	$2000 (Estimated amount to be procured)
University Funding	$700

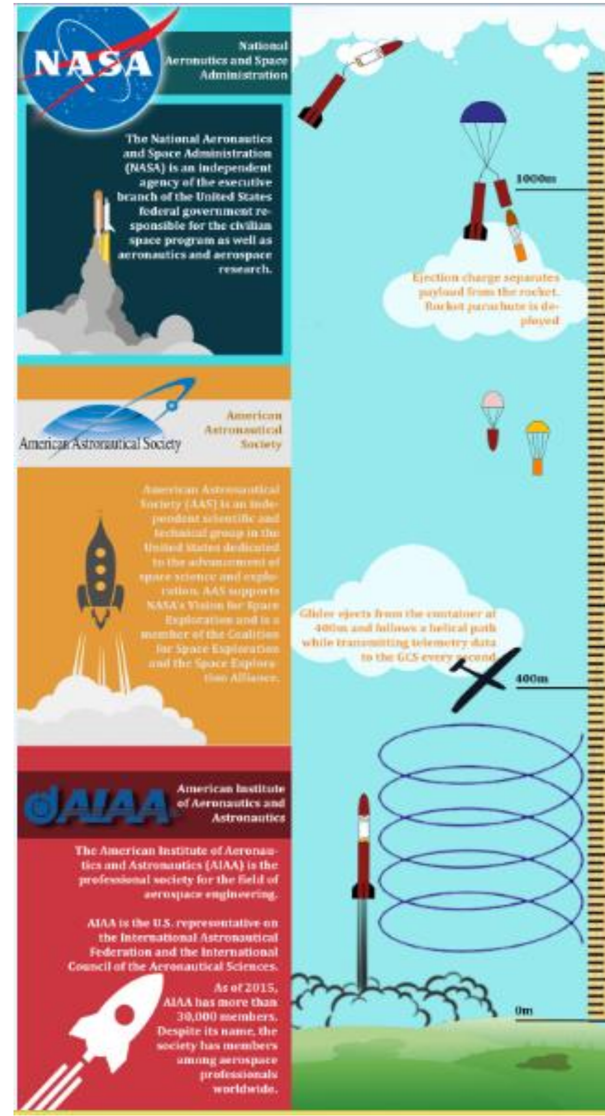
SPONSORSHIP LEVELS FOR SEDS-VIT FOR CANSAT'17

BENEFITS	TITLE Rs. 2,00,000	GOLD Rs. 1,25000	SILVER Rs. 75,000
PUBLICITY DURING OUR NATIONAL CONFERENCES & OTHER EVENTS	✓		
SPECIAL MENTION ON ALL PRESS RELEASE	✓		
STALL TO DISPLAY/SELL PRODUCTS DURING WORKSHOP AT VIT	✓	✓	
ON SITE PRODUCT SAMPLING	✓	✓	
PLAY SHORT VIDEO CLIPS AS ADVERTISEMENT FOR THE COMPANY PUBLICITY	✓	✓	✓
ONLINE ADVERTISEMENTS IN FACEBOOK PAGE, TWITTER,AND IN TEAM WEBSITE	✓	✓	✓
LOGOS ON ONLINE PUBLICITY POSTERS	✓	✓	✓
INCLUSION OF LOGO ON ALL EVENT MATERIALS: ROVER, BANNERS, FLEXES, PRINTED POSTERS, TAGS, T-SHIRTS.	✓	✓	✓

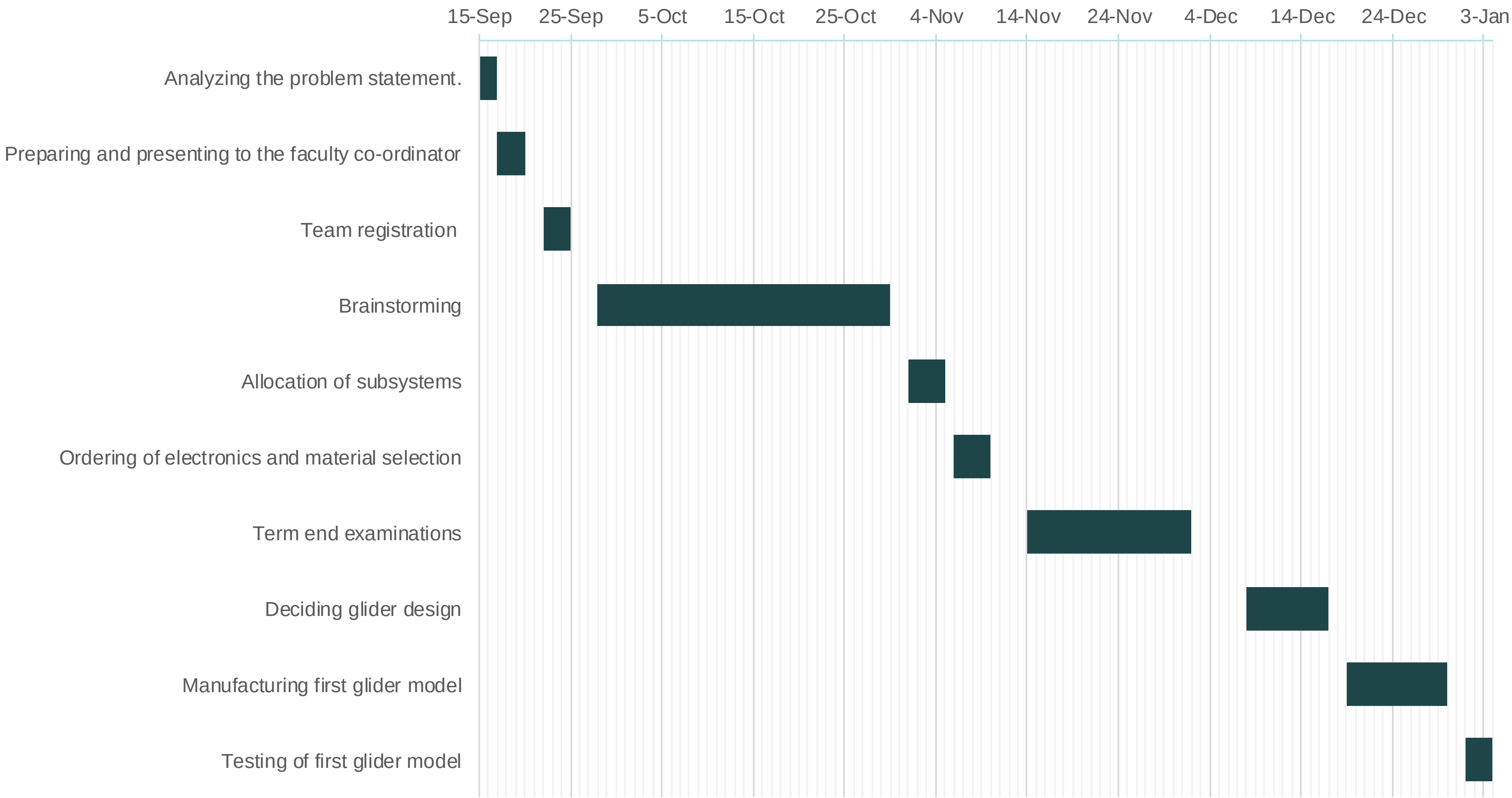
Sponsorship Levels Developed

CanSat Budget – Other Costs

Brochure and Infographic developed for social media platform and publicity

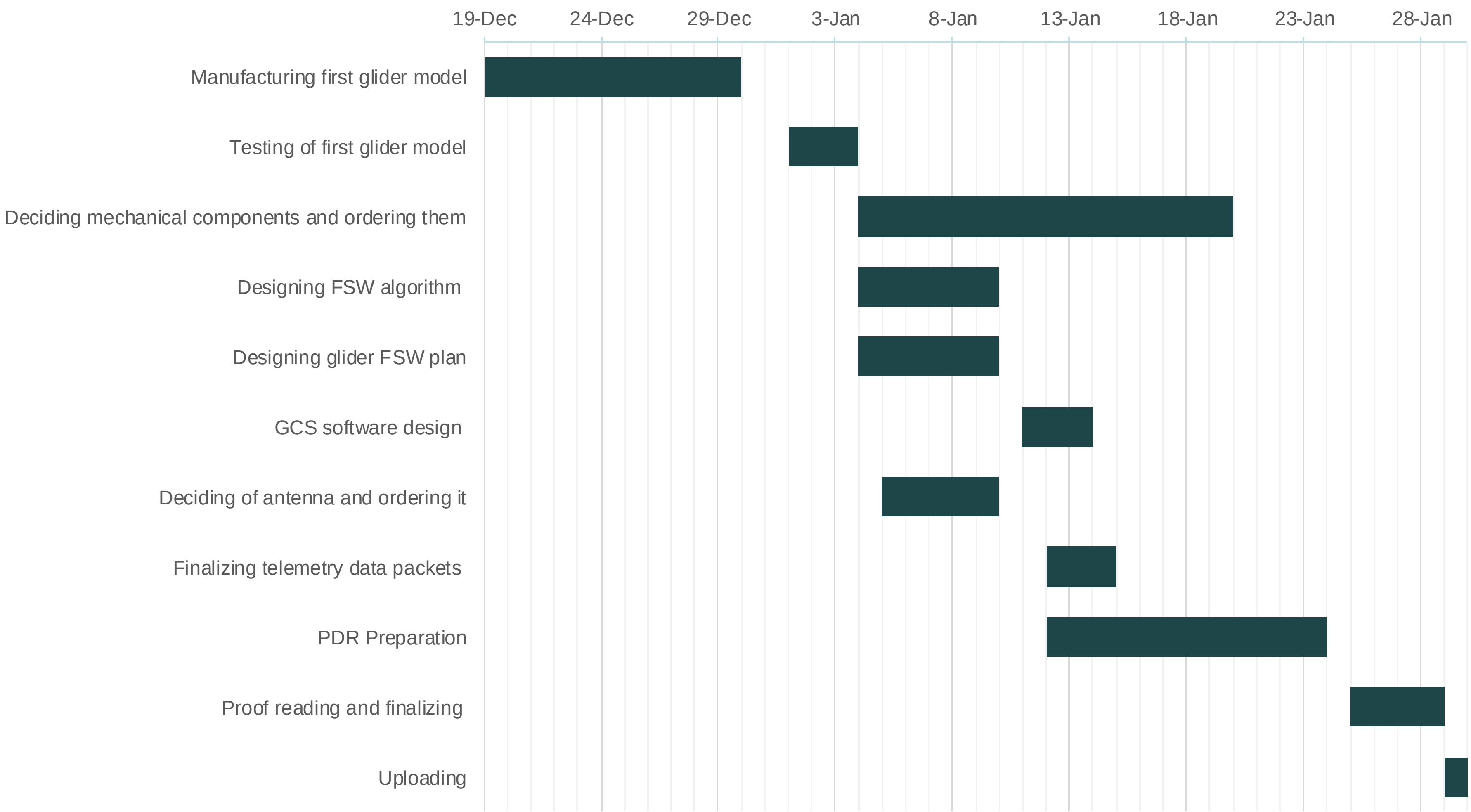


Up to PDR



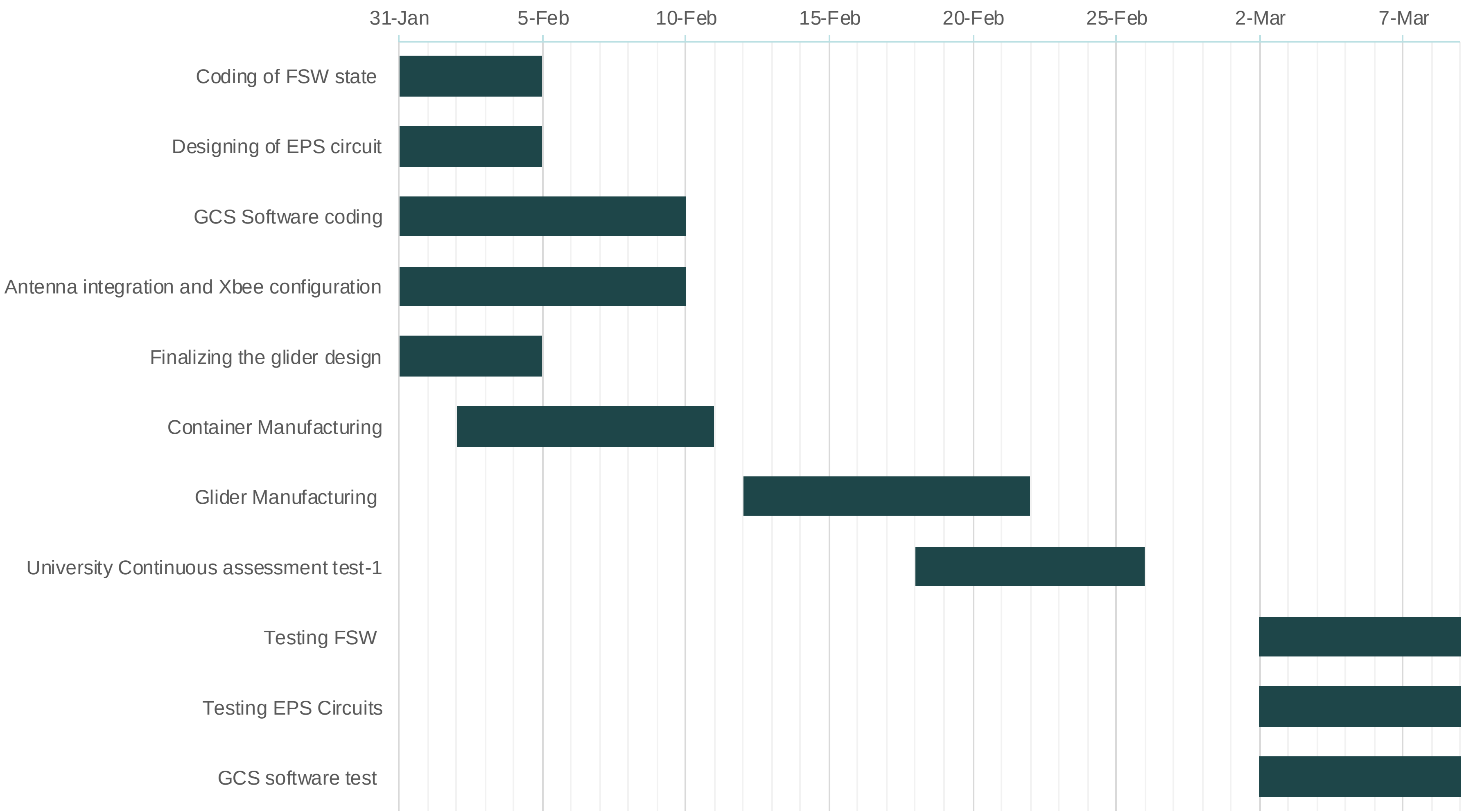
15-Sep
25-Sep
5-Oct
15-Oct
25-Oct
4-Nov
14-Nov
24-Nov
4-Dec
14-Dec
24-Dec
3-Jan
Analyzing the problem statement.
Preparing and presenting to the faculty co-ordinator
Team registration
Brainstorming
Allocation of subsystems
Ordering of electronics and material selection
Term end examinations
Deciding glider design
Manufacturing first glider model
Testing of first glider model

Program Schedule

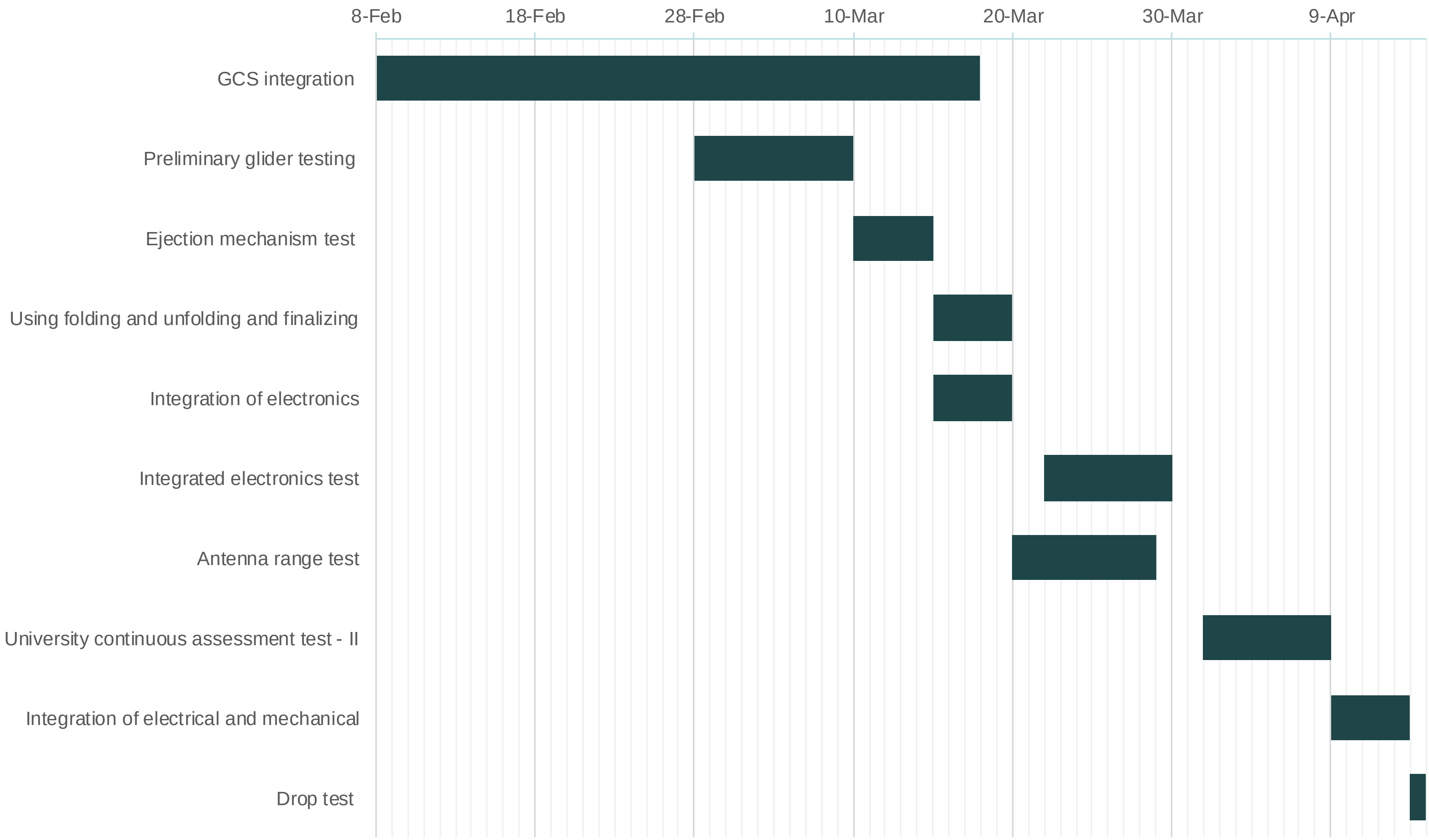


Program Schedule

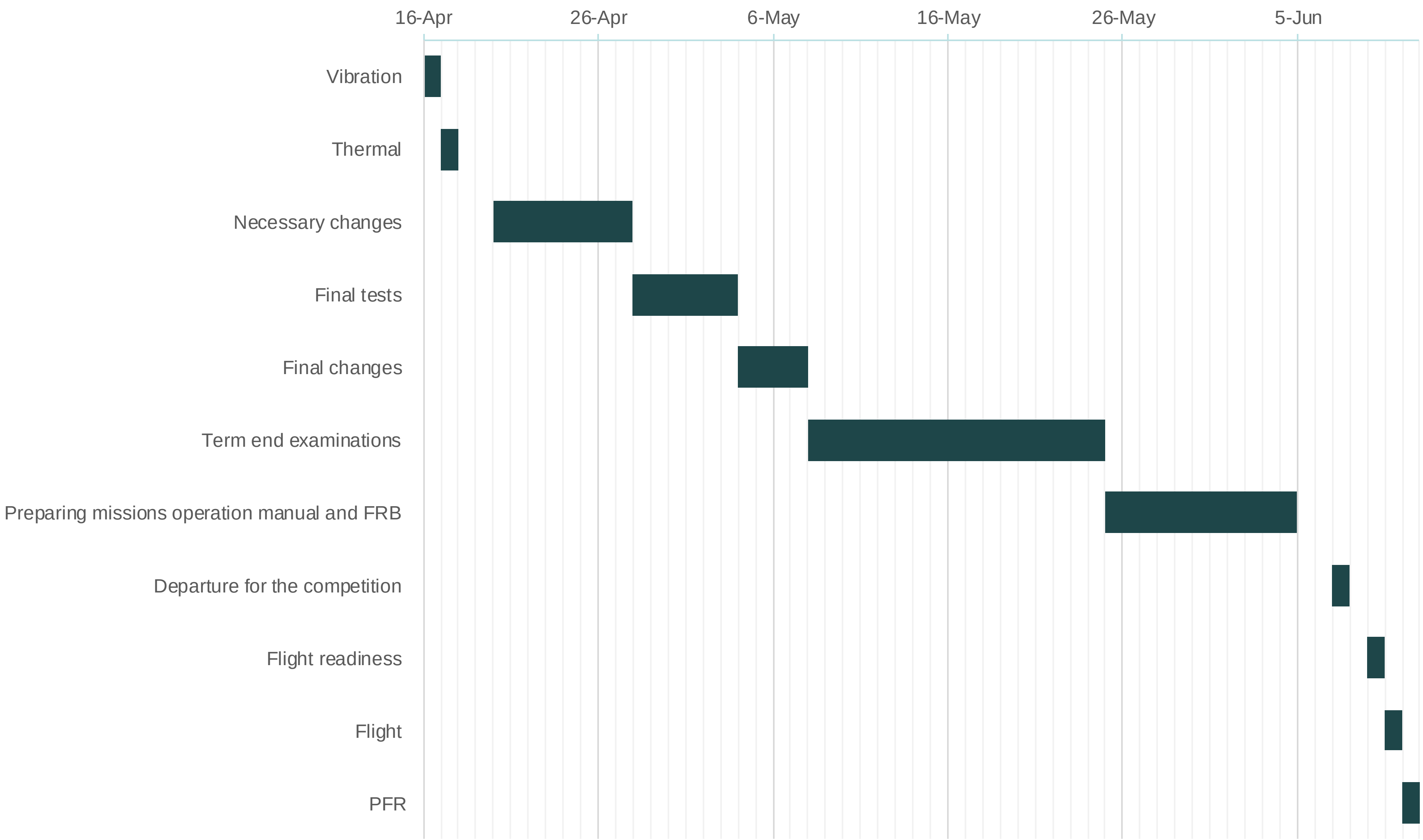
After PDR:



Program Schedule



Program Schedule



Conclusions

- **Presentation summary:**
  - Electrical:
    - All the sensors have been finalized and purchased. The sensors and other electronics are currently being tested for accuracy so that correction to the data can be applied.
    - The algorithm for flight control is decided, the coding is under progress.
    - Electrical power budget is ready, the required batteries and solar panels have been ordered. We are still testing the solar panels. We may change the current ones if we find better solar panels.
    - As soon as the coding is completed, sensors will be integrated and tested along with the FSW Communication and data handling:
    - GCS antenna and CanSat antenna have been decided and ordered.
    - Range tests and gain tests will be performed on these antennae shortly.

Conclusions

- Communication and data handling:
  - XBEE pro S2B has been configured and PAN_ID is set to 2617 and the packet format is decided according to the requirement, which we have mentioned earlier.
- Ground Control Station:
  - The GCS design is complete and GUI is made keeping in mind that data analysis is convenient and systematic.
  - The Plotting provision has been tested first hand using sample test values generated by Arduino Uno.
- Mechanical:
  - The Design of the glider is ready, a series of prototypes based on the design have been made for testing purposes.
  - Helical trajectory followed by the glider during descent has been tested and verified by dropping the glider from a tall building.

Conclusions

- Mechanical:
  - We have finalized the parachute and have already placed the order for the same.
  - Material for the container is finalized, we are currently in the process of contacting local 3D-printing companies for manufacturing.
  - Various prototypes have been made to test the release mechanism.
  - We will soon commence the manufacturing of the glider and final integration of all the electrical components.

- We have analyzed every aspect on the CANSAT problem statement and hence have undergone tremendous debate, discussion and experimentation.
- Fortunately we have had success in all our endeavors so far.
- We have directed all our efforts toward the making the best possible CanSat flight.