Mars Glider

Annual Cansat Competition 2016

Texas, USA

BACHELOR OF TECHNOLOGY
(Team Astral)

SUBMITTED TO
UNIVERSITY OF PETROLEUM AND ENERGY STUDIES, DEHRADUN

BY

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August, 2016

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DEHRADUN

CANDIATES’ DECLARATION

We hereby certify that the Project Work entitled “**Mars Glider : Annual Cansat Competition 2016**” in partial fulfilment of the requirement for the Degree of Bachelor of Technology submitted to the Department of Aerospace Engineering, Department of Electronics Engineering and Department of Mechanical Engineering at the University of Petroleum and Energy Studies, Dehradun is an authentic record of our work carried out during the period **August 2015** to **June 2016** under the supervision of **Dr. Ugur Guven** and **Mr. Zozimus Labana**, Aerospace Engineering.

The matter presented in this project has not been submitted by us for the award of any other degree of this or any other university.

Aditya Savio Paul

Aman Arora

Amitabh Yadav

ACKNOWLEDGEMENT

Team Astral pertains itself humbly towards **The University of Petroleum and Energy Studies, Dehradun** for having provided the base and platform to make us eligible to stand confident at the International Level.

We would like to place on record our deep sense of gratitude to **Mr. Ugur Guven,** Dept. of Aerospace Engineering, UPES, Dehradun for his generous guidance, help with the resources and useful suggestions in the procedure of the Project.

We express our sincere thanks to **Professor Zozimus Labana**, Dept. of Aerospace Engineering, UPES, Dehradun for his stimulating guidance, continuous encouragement and supervision throughout the course of the work.

I wish to extend obligation to the faculty, Department of Mechanical Engineering, UPES and the School of Design Studies, UPES for their valuable aid in the designing of our model and other colleagues and batch mates for attending to our queries and for their constructive suggestions to improve the quality of this project work.

A requisite mention to Mr. Jude David Absolom (Hyderabad) for having been a constant support; providing us routes towards designing the electronics sub-system of our model and Md. Asif (Dehradun) who’s insightful comments helped us fabricate our model in the actual sense.

Aditya Savio Paul
(Team Leader)

Aman Arora
(Alternate Team Lead)

Amitabh Yadav
(Electronics Team Lead)

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Chap 01: Introduction

Hosted by the *National Aeronautics and Space Administration (NASA)* and *American Astronautical Society (AAS)* along with the amalgamation of Jet Propulsion Laboratory (JPL), American Institute of Aeronautics and Astronautics (AIAA) and Ball Laboratory, 'Cansat Competition' is an Annual International Competition held at Burkett, Texas, USA.

The CanSat Competition is a design-build-fly competition that provides Teams from across the Globe with an opportunity to experience the Design Life-Cycle of an Aerospace System. The competition is designed to reflect a typical program on a small scale and includes all aspects from the preliminary design review to post mission review. The mission and its requirements are planned to reflect various aspects of real world missions including telemetry requirements, communications, and autonomous operations. Each team is scored throughout the competition on real-world deliverables such as schedules, design review presentations, and demonstration flights.

The Flights are closely studied and used for the implementation and betterment of Extra Terrestrial Space related Projects at the National Aeronautics and Space Administration (NASA) and associated organizations.

Chap 02: Mission Statement

The 2016 Cansat Mission simulated *a sensor payload* traveling through a planetary atmosphere sampling the atmospheric composition during flight.

The 2016 mission simulated a sensor payload traveling through a planetary atmosphere sampling the atmospheric composition during flight. The overall CanSat system is composed of two primary components, a glider and a re-entry container that protects the glider during ascent, "near-apogee" deployment and initial reentry/descent.

The model is ascended from the earth's surface by a Sounding Rocket. When deployed from the rocket the re-entry container shall descend with the glider secured in the container. Either the container shall release the glider or the science glider shall release itself from the container any time after deployment from the rocket. The intention of the container is to protect the glider from the violent deployment and provide a more stable and less forceful release environment.
When the glider is released from the container, it shall glide in a circular pattern with a diameter of no more than 1000 meters.

During flight, the glider shall sample the Air Pressure and Temperature at a rate of 1 sample per second and transmit the data to a ground station. Position data of the sample data shall also be recorded and included in the telemetry at the same rate. Speed of the glider shall be 5 measured with a Pitot tube and compared with GPS generated velocity data.

The glider shall take a picture of the ground with the camera pointing at the ground when requested by the ground station judge. The imaging shall be initiated by a command sent from the ground station to the glider. The images shall be recorded for retrieval after landing.

Telemetry shall indicate the time the last command was received and the number of times the command was received. When the glider lands, transmission shall automatically stop and an audio beacon shall be activated automatically for recovery.

Following the Flight Launch Day, all the participating Teams compiled a Post Flight Review Presentation as a competition requirement and presented it before the Judges.

Chap 03: The Team

Ever since its inception in 2013, **Team Astral**, under the able guidance of Dr. Ugur Guven as the Faculty Advisor, has been representing The University of Petroleum and Energy Studies, Dehradun at the competition in the United States of America. The Team is majorly divided into Mechanical, Aeronautical, Design and Electronics Domains.

The Team Designs and Fabricates the Mission Statement provided by the Competition and finally launches it at the competition site.

Initiating with the Design Reviews and the Interviews, Team Astral paved its way into the top 40 participants out of 73 aspiring teams with an aggregate percentage of 97.35%; the list included global ranking colleges viz. Princeton University, Manchester University, University of Alabama Huntsville, Ecole Polytech, Carleton University and many others.

Enlisted the Team Members for Cansat 2016.

S. No.	Name	Year of Study	Major	Position
1.	Aditya Savio Paul	Junior	Mechatronics	Team Leader
2.	Aman Arora	Junior	Aerospace	Alt. Team Leader
3.	Amitabh Yadav	Junior	Electronics	Electronics Team Lead
4.	Shashank Bopche	Junior	Aerospace	Mechanical Team
5.	Ena Goel	Junior	Aerospace	Mechanical Team
6	Vipul Mani	Sophomore	Aerospace	Mechanical Team
7.	Devarrishi Dixit	Sophomore	Material Science	Mechanical Team
8.	Shambhavi Dubey	Sophomore	Electronics	Electronics Team
9.	Raghav Garg	Sophomore	Computer Science	Electronics Team
10.	Yash Agrawal	Junior	Electronics	Electronics Team
11.	Archit Agarwal	Sophomore	Electronics	Electronics Team
12.	Meenakshi Talwar	Sophomore	Electronics	Electronics Team
13.	Pritish Raj	Fresher	Electronics	Electronics Team
14.	Anisha Absolom	Fresher	Designing	Designing Team

Table 01: Members –Team Astral

Team Astral

Chap 04: Team Distribution

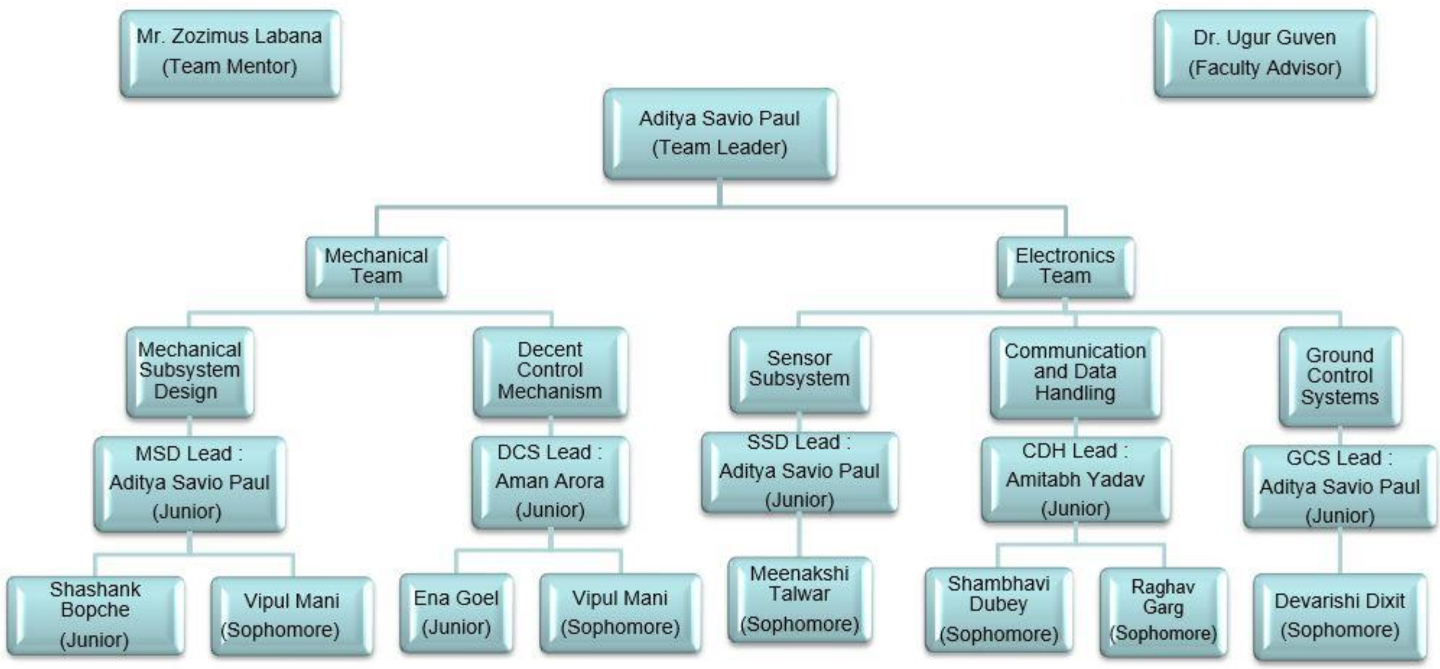


Fig 01: Team Distribution

Chap 05: Concept of Operations (CONOPS)

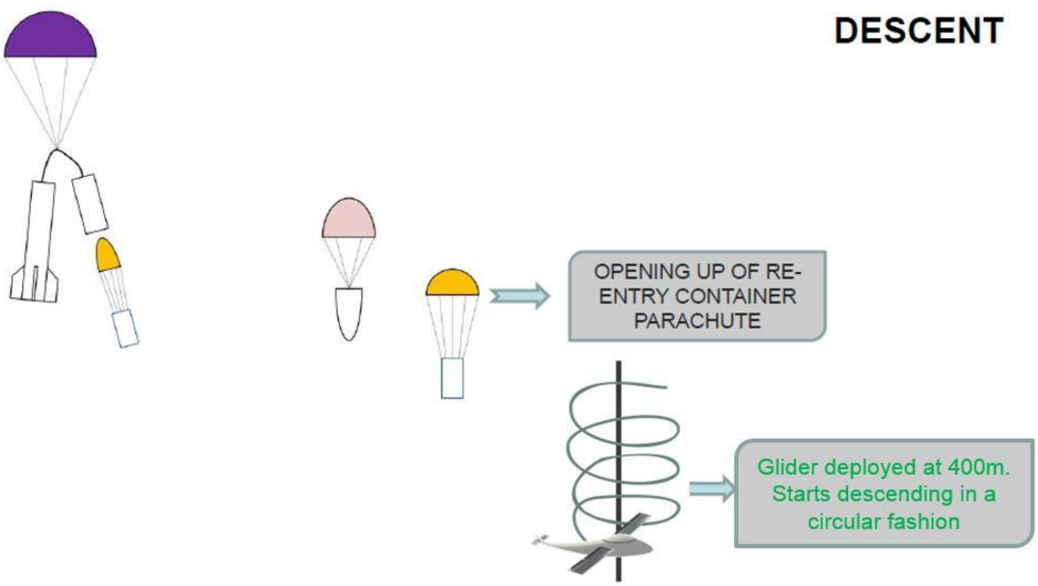


Fig 02: Descent Control

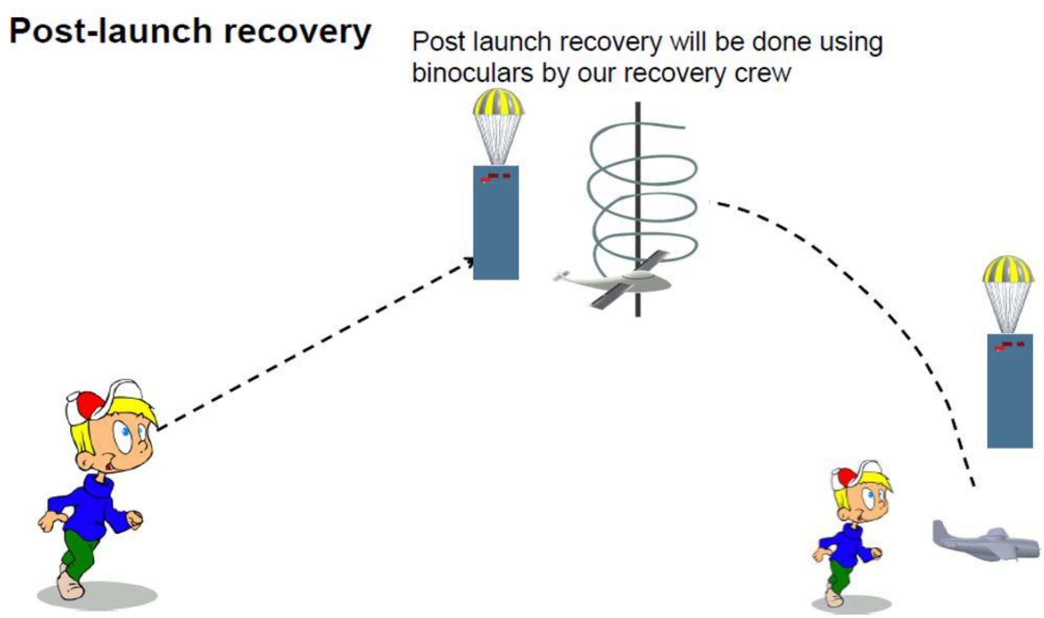


Fig 03: Recovery

Ground Station

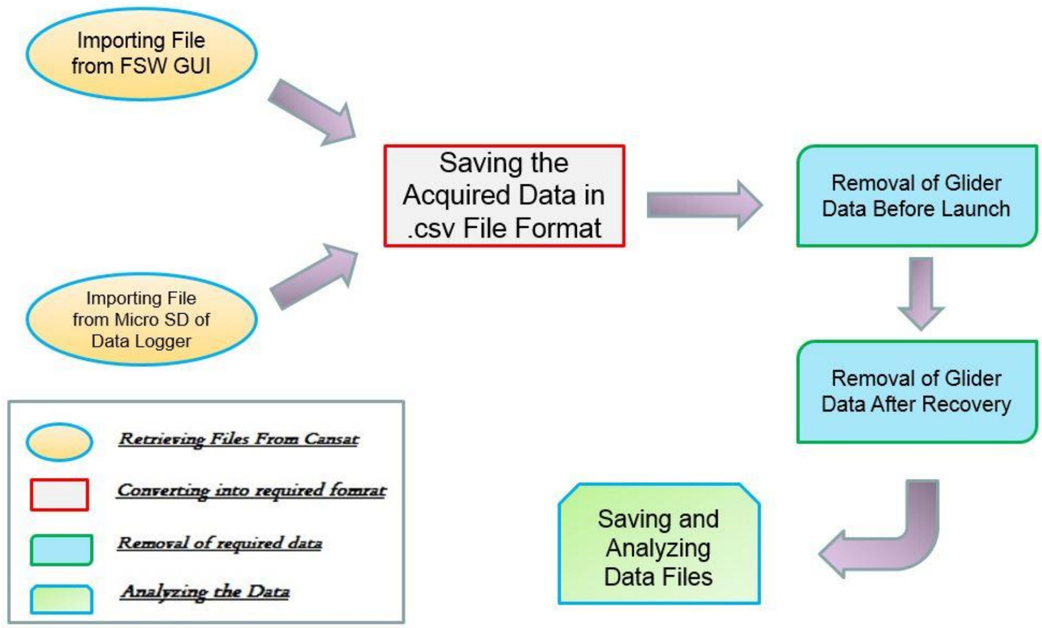


Fig 04: Ground Station Procedure

Chap 06: Physical Layout

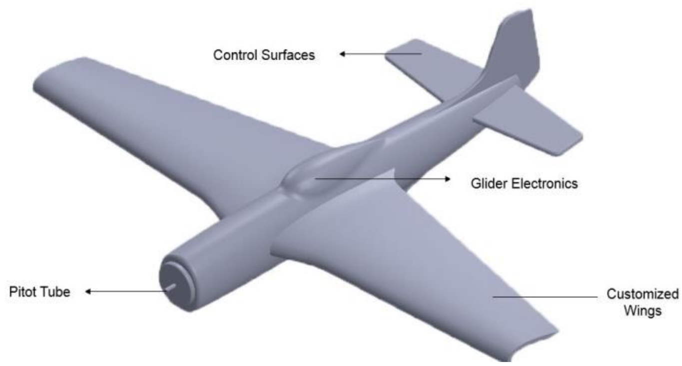


Fig 05: Physical Layout 01

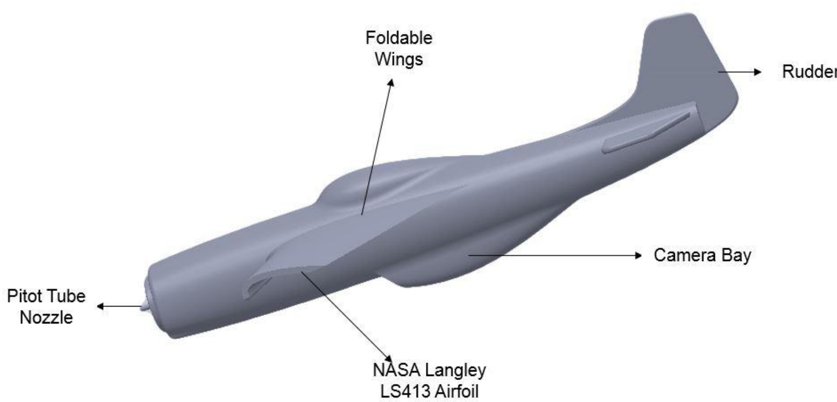


Fig 06: Physical Layout 02

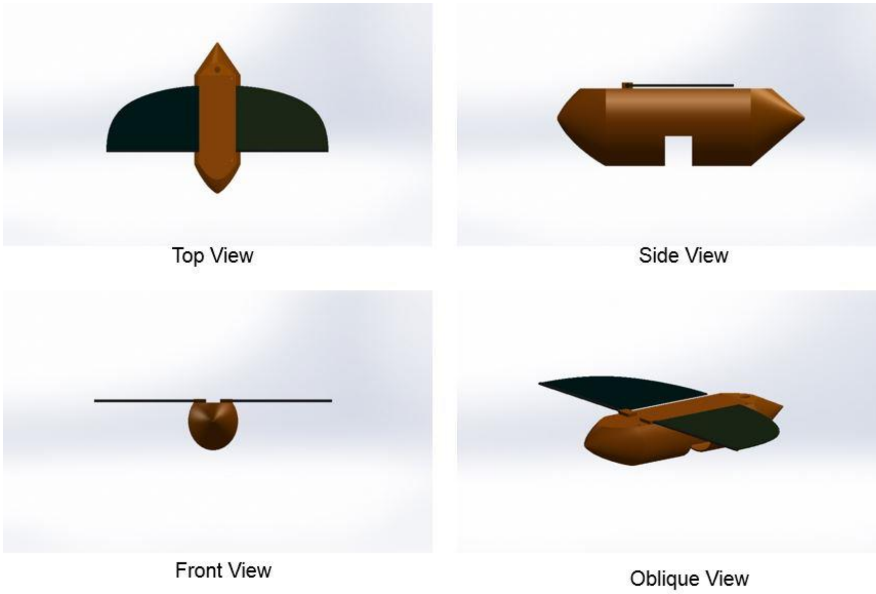


Fig 07: Engineering Views of Glider Model

Fig 08: Final Re-Entry Container

Fig 09: Final Glider Model 01

Fig 10: Final Glider Model 02

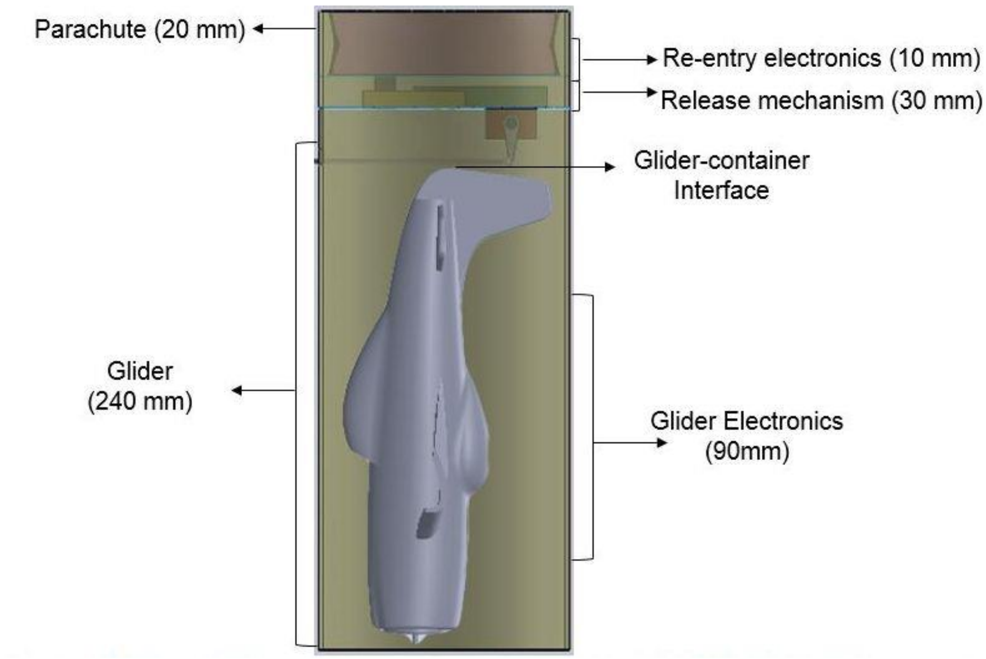


Fig 11: Glider Placement in Re-Entry Container

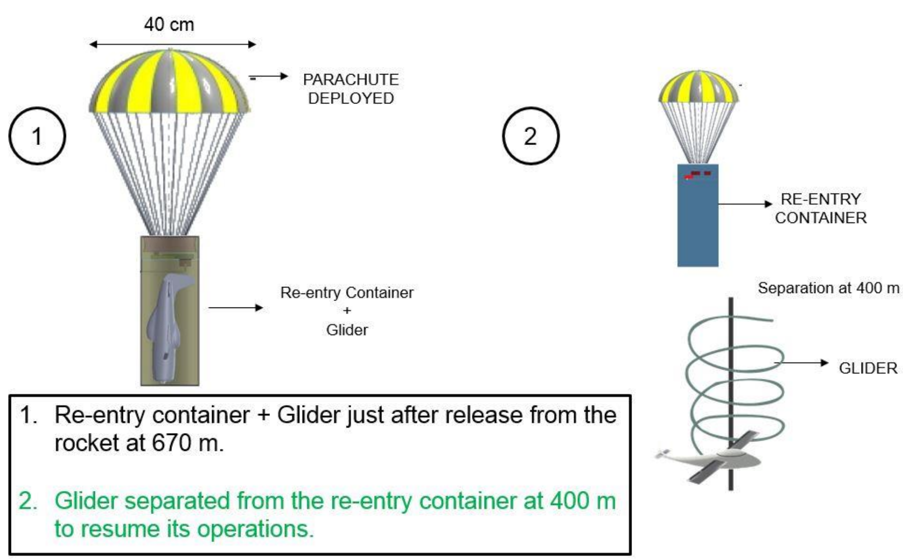


Fig 12: Glider Deployment

6.1: Launch Vehicle Compatibility

- The structure was designed strictly keeping in mind, the size and weight restrictions.
- Re-entry container was placed upside down in the rocket payload section.
- For verification of launch vehicle compatibility, the dimensions were tested in dummy rockets, a day prior to the launch day by making sure that the re-entry container slides in a container of dimensions: 310x125 mm.
- Maximum Diameter of Re-Entry container was 120 mm which is 5 mm less than the rocket's payload section, hence no components protruded outside the re-entry container which facilitated smooth deployment.
- Height of the re-entry container was 300 mm. This was well under the given limit of 310 mm, ensuring that CanSat did not protrude out of the payload section.

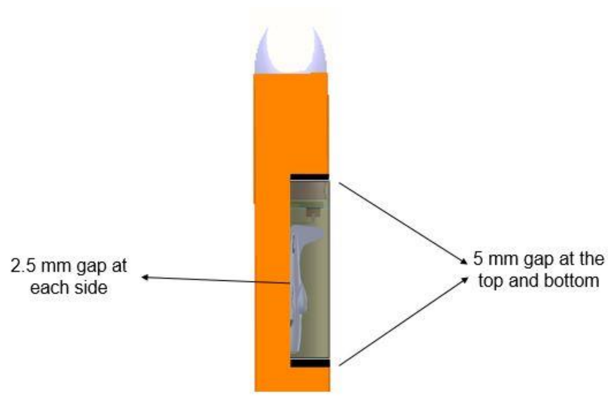


Fig 13: Glider Alignment in Re-entry Container

Chap 07: Mechanical Subsystem

7.1: Mechanical Subsystem Overview

a. Re-entry Container:

- Structure is to be made of Carbon Fiber which will provide strength and will be lighter in weight.
- Descent Control Mechanism: Consists of a hemispherical parachute of radius 20 cm with a spill hole at its center so the velocity above 450 m will become less than 14 m/s.
- Electronics: Electronics in the re-entry container include a BMP 085, and a servo motor for the release mechanism.
- The glider system is connected to the re-entry container with a rod controlled by a servo motor.

b. Glider:

- Structure: Consists of a Glider is made of using 3-D Printing Technology. The electronics are enclosed in a inside the fuselage of the glider with opening at the bottom part to place the camera. The Pitot Tube is placed in the nose of the glider. Foldable Wings are used in the glider to save space.
- Descent Control Mechanism: Consists of wings designed using NASA Langley LS413 Airfoil and fixed at different angle of attack. The rudder is fully deflected in direction of rotation which provides us the required circular preset. The descent is maintained to get a Erect spin.
- Electronics: Electronics in the glider include BMP085, temp. sensor LM35, voltage monitor, accelerometer, Pitot tube, GPS, Camera and XBEE radio.

c. <u>Container-Payload Interface</u>:

- The container and glider system are interfaced with a rod mechanism which is controlled by servo motor.
- The rod is attached to the glider through a D-Shaped hole and one end is connected to the servo motor.
- At an altitude above 400m the servo motor will rotate and pull the rod out of the glider.
- Due to its weight and the effect of gravity, the glider will be released.
- After separation the wings will unfold and it will start gliding in a circular preset pattern.
- Clearance of 2.5mm is provided between Glider and the Container to ensure smooth separation

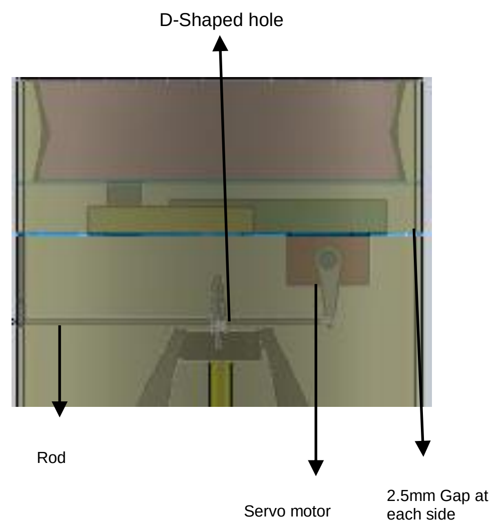


Fig 14: Release Mechanism

7.2: Structure Survivability

a. **Mounting Method**: All electronic components are hard mounted with the Glider frame using screws, hot glue and standoffs. No electronics are exposed to the outside atmosphere except for the sensors. The glider structure and electronics will support 15 g acceleration and will survive 30Gs of Shock.

b. **Enclosures**: A removable structural coating made of high quality sponge is being used to protect the electronic components during impact. A thin film of polythene covers the electronic circuits and sensors.

c. **Connections**: All electrical connections are verified and secured using insulation tapes.

Chap 08: Descent Control

8.1: Descent Control Overview

- Descent control system consisted of a parachute of radius 20 cm for re-entry container with a spill hole of 6.5 cm to provide stability.
- For the Glider, wings were fixed at different angle of attack and full rudder in direction of rotation.
- Parachute was folded such that it will occupy not more than 1.5 cm of space above the re-entry container.
- At the time of separation, Glider was released automatically and appropriate designing of the glider, enabled it to glide in a circular pattern.
- A customized NASA Langley LS413 Airfoil was used to ensure that it glides in a preset circular pattern.
- At approx. 400m, a servo motor was used to separate Glider from re-entry container.

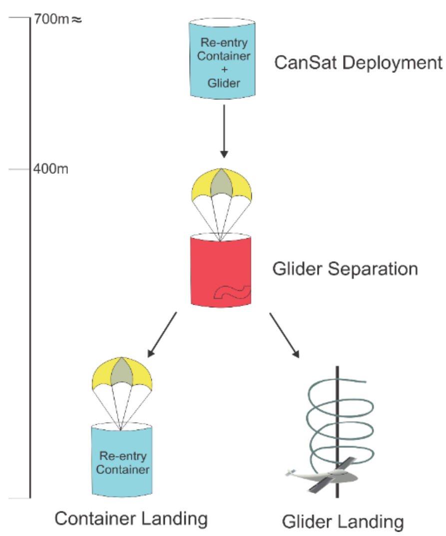


Fig 15: Glider Deployment Strategy

8.2: Descent Rate Estimation

a. Re-Entry container

- A parachute will be used to control the descent rate of the re-entry container

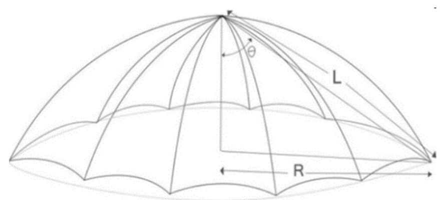


Fig. 16: Parachute Schematics

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

- To get the required drag and vertical velocity, radius of the parachute can be calculated as follows :

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

Where,

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

After rearranging the equation and finding the velocity:

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

The Descent rate of the re-entry container comes out to be 14 m/s which is within the range to protect the re-entry container from a violent drop and incur any damage.

b. <u>Glider</u>

- By Applying Basic laws of kinematics

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

Where,
s=89 m
t=12 s

- *Velocity of Glider = 7.41m/s*
- *The Distance of the Location where glider landed was measured from the launch site and was determined to be 234m.*
- *The above, lies well within the range of 1000m Diameter Requirement.*

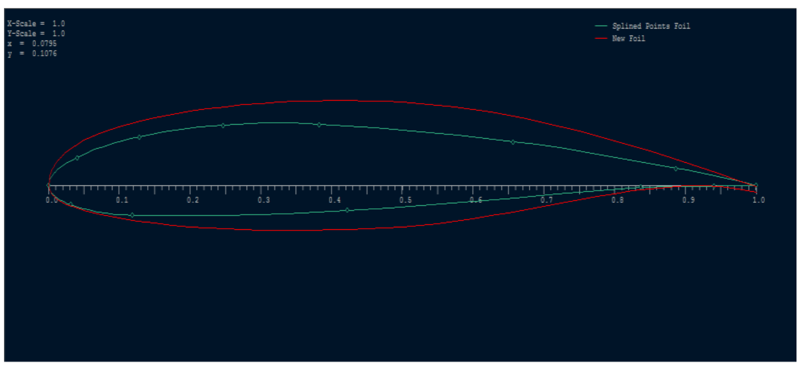


Fig 17: NASA LANGLEY LS413 Airfoil

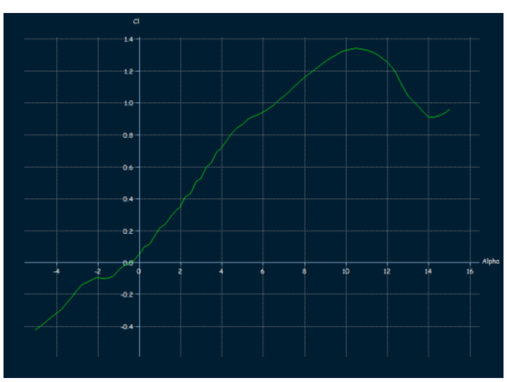


Fig 18: C_L Vs α graph

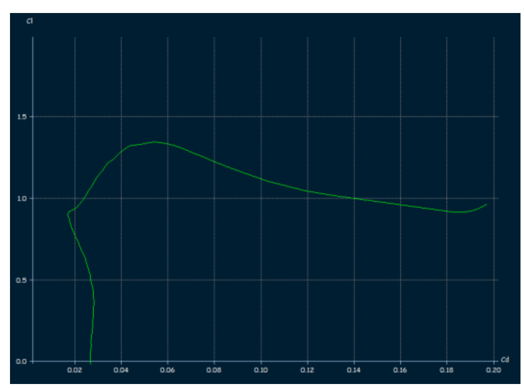


Fig 19: C_L Vs C_D graph

The airfoil was analyzed using XFLR5 software and following data was noted

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

Table 02: NASA LANGLEY LS413 Data

Chap 09: Sensor Subsystem

9.1: Sensor Subsystem Overview

a. Re-Entry Container Sensors:

- Altitude Sensor: Based on the altitude readings of this sensor, the separation mechanism is activated. BMP180 is used as the altitude sensor as it consumes very less power (5µA at 1 sample / sec).
- Separation Mechanism: Servo Motor is employed to implement the push-rod mechanism to separate the Glider from the Re-Entry Container.

b. Glider Sensors:

- Altitude and Pressure Sensor: The sensor used here is BMP180 as it has a wide range of barometric pressure and altitude.
- Temperature Sensor: LM35 is used as the temperature sensor. Low power consumption and wide range (-55^{o}C to 150^{o}C).
- Battery Voltage Sensor: A voltage-divider circuit is used through the ADC port.
- Pitot tube Sensor: It is used to sense the air flow velocity. MPXV7002-GC6U is used as the Pitot tube sensor. It provides a 0.5-4.5 V output.
- GPS Sensor: GPS sensor is used to get the co-ordinates, speed and altitude of the glider. It is also used to check the number of satellites tracked. The GPS sensor used here is UBlox Neo6mv2.
- Camera: Serial TTL Camera VC0706 processor is used for image capturing, in response to the received signal from the ground station.

Chap 10: Communication and Data Handling Subsystem

10.1: CDH Overview

a. Micro-Controller(s)

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

b. Interfaced Devices:

- Pressure and Altitude Sensor: Using the BMP180 sensor, would enable simultaneous recording and analysis of pressure and altitude measurements.
- Temperature Sensor: LM35 is an easy to interface, easy to program sensor with wide range of temperature sensing (-55ºC to 150ºC).
- Voltage Measurement: Voltage-Divider Circuit is employed to measure the battery voltage.
- Pitot tube: Pitot Tube MPXV7002 sensor uses the ADC port
- GPS Device: Ublox Neo6-MV2
- Camera: Serial TTL Camera VC0706 processor

c. Radio Communication:

- The **XBEE S2B Pro Radio** is configured using AT Mode. Ground Station being Coordinator AT & Glider X-bee as Router AT. The X-Bee Modules transfer data at a rate of 250Kbps.
- Indoor transmission and Receiving Range is 90m and the RF Line-of-Site-range is **3200m**.
- **XBEE Radio Module** is interfaced to Arduino Uno via USART Communication.
- Though Omni-directional, Antenna for Glider will be facing downward for ease in transmission.

Modes in USART with XBEE PRO S2B	
Data Bits	8
Baud Rate	9600
Flow Control	None
Parity Counter	None
Transmission Mode	Asynchronous
Stop Bits	1
UART Receiver	On
UART Transmitter	On

Table 03: USART Modes For Xbee Pro S2B

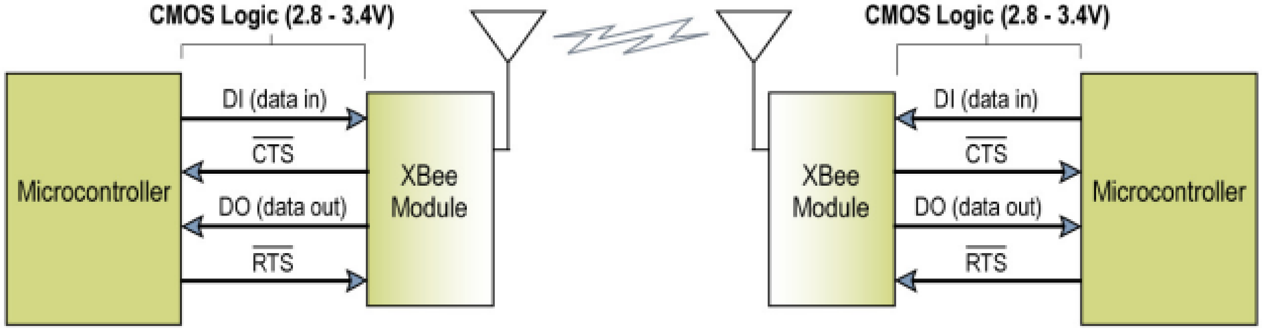


Fig 20: Radio Configuration

d. <u>Telemetry Format</u>:

<TEAMID>,<MISSIONTIME>,<PACKETCOUNT>,<ALTSENSOR>,<PRESSURE>,<SPEED>,<TEMP>, <VOLTAGE>,<GPS LATITUDE>,<GPS LONGITUDE>,<GPSALTITUDE>,<GPSSATNUM>, <GPSSPEED>,<COMMANDTIME>, <COMMAND COUNT>,[<BONUS>]

Chap 11: Electrical Power Subsystem

11.1: EPS Overview

a. Re-Entry Container:

- A 9V DC Alkaline Battery were employed for powering the Separation Mechanism.
- For constant supply of voltage and current some buck/booster circuits are used.

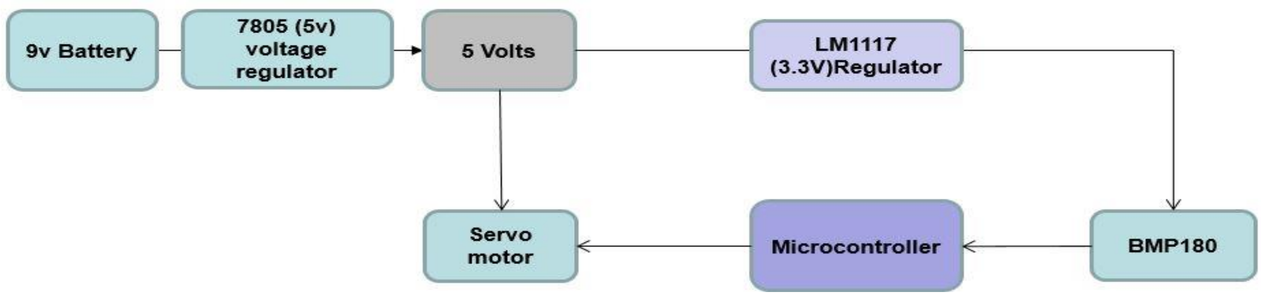


Fig 21: Re-entry Container Circuit Block Diagram

Component	Requirement
9V Alkaline Battery	It is used as a power source of the re-entry container.
Regulator	Installed so as to stabilize the voltage used by the microcontroller and other components.
Microcontroller	The Controller on which the code resides to interface and drive the Servo Motor, for separation of Glider.
Servo motor	Shift-Rod Mechanism for Separation of Glider.
BMP180	For successful altitude-measured release

Table 04: Component-Requirement Table for Re-Entry Container

b. <u>Glider:</u>

- The volt regulator needs to provide a little bit more current than it actually can handle, for interfacing Xbee alongside the Microcontroller.
- A current booster circuit shall be associated in the circuit to meet the current requirements.

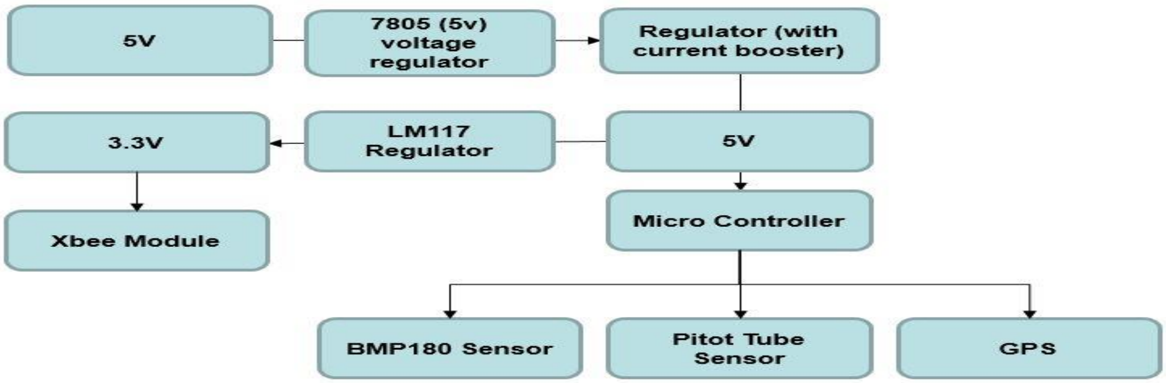


Fig 22: Glider Circuit Block Diagram

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

Table 05: Component-Requirement Table for Glider

11.2: Power Budget

a. Re-Entry Container

Device	Avg. Power Consumption	Voltage	Current	Time
Microcontroller	0.11 mW	3V to 5V	28 mA	100%
XBee	63 mW	3.3V to 5V	12 to 18 mA	100%
Pressure Sensor	2.5 mW	5V	1 mA	100%
SD Card	0.3 mW	5V	1 mA	100%

Table 06: Power Budget - Re-Entry Container Electronics

b. Glider

Device	Avg. Power Consumption	Voltage	Current	Time
Microcontroller	0.11 mW	3 - 5V	28 mA	100%
Regulator	0.1 mW	3.4 - 4.5 V	92% eff.	100%
XBee	63 mW	3.3 - 5V	12-18 mA	100%
Pressure Sensor	2.5 mW	5V	22.7 mA	100%
SD Card	0.3 mW	5V	1 mA	100%
Camera	60mW	2.5 to 3.0V	20 mA	100%

Table 07: Power Budget - Glider Electronics

Chap 12: Flight Software Design

12.1: FSW Overview

- A procedural programming approach is followed to simplify Glider Telemetry Operational protocols.
- Basic FSW architecture details the programming paradigm to be employed to run on the hardware
- The Structured Code gathers data and runs on a loop of 1Hz per second.
- Programming Languages : Arduino , C/C++
- Development Environment : Arduino IDE

- FSW Tasks
  - Receive and plot air pressure, altitude, air temperature, speed, GPS data and battery voltage.
  - Transmit all real time flight telemetry at a 1 Hz rate.
  - Maintain packet counts transmitted and save the data on system in a .CSV file.
  - Capture image of ground when told and store for later retrieval.

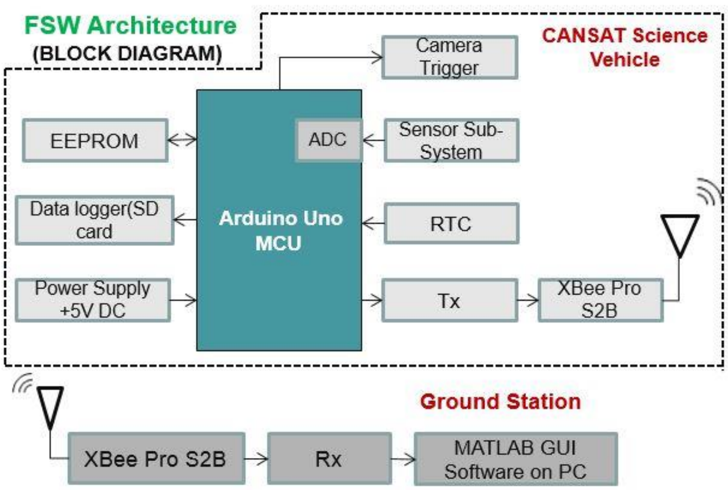


Fig 23: Flight Software Architecture Block Diagram

➢ Flight Software State Diagram

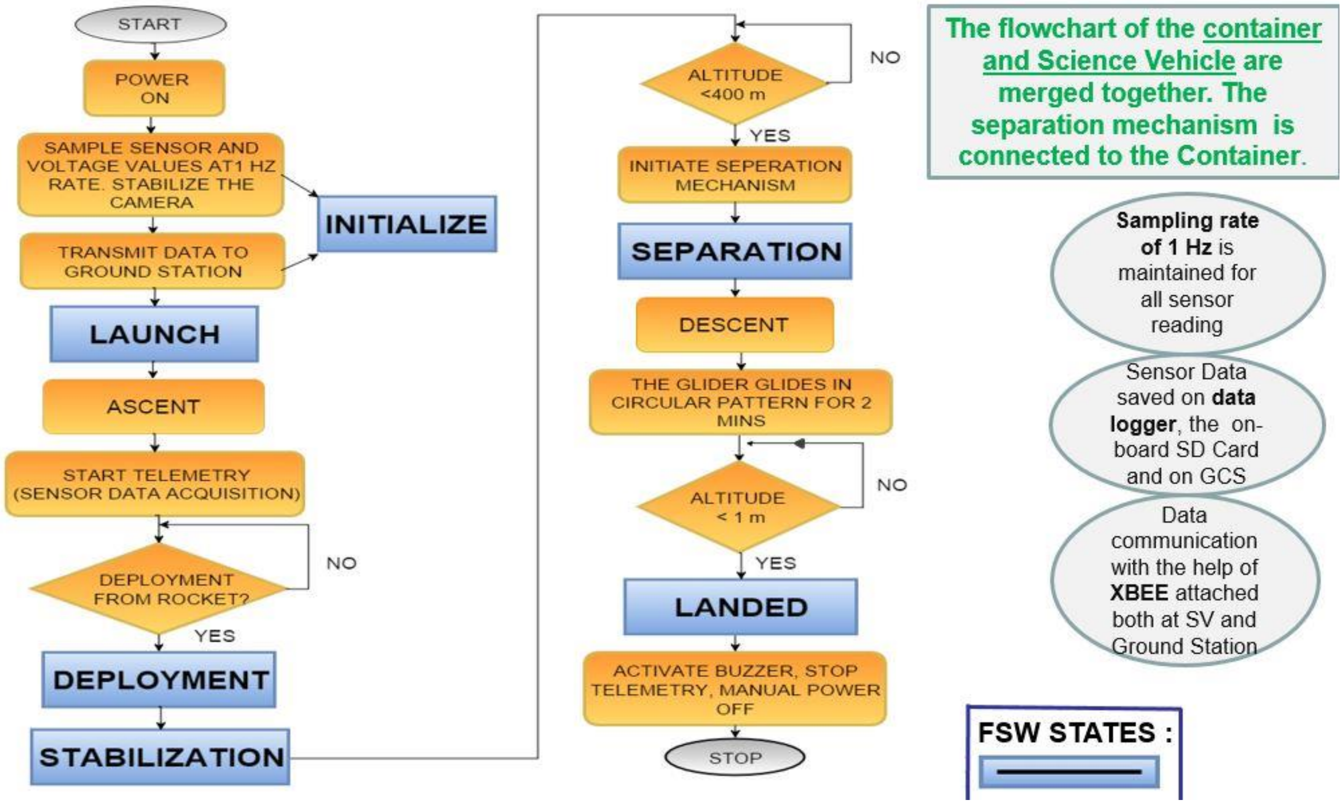
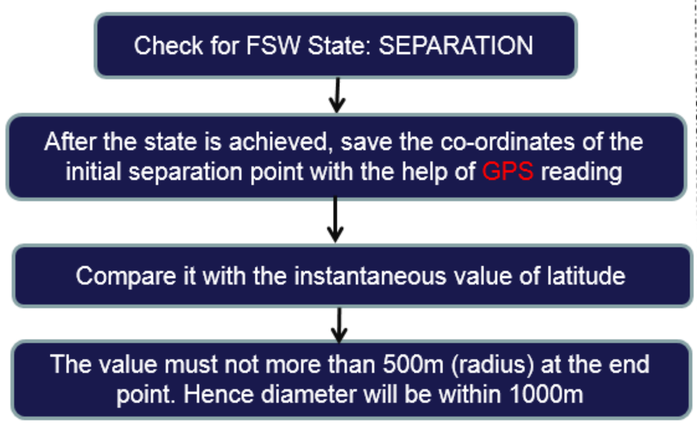


Fig 24: Flight Software State Diagram

FSW PLAN



Latitude, 1^0 = 110.574km

For 500m change in GPS value occurs at 3rd decimal point.

Pseudo Code

```
//Global variable
int a;
int glider_fsw_plan()
{
   if (fsw_state=="Separation")
{
   a = read_gps_lat();
}
else
   return 0;
}
void check_fsw_plan()
{
   if(fsw_state=="Landed")
   {
      //compute difference in latitude
      int dif = read_gps_lat() – a;
      dif = math.abs();
      if(dif > 0.001)
        //mission accomplished
      else
        //diameter exceeded 1000m.
   }
}
```

Fig 25: Flight Software Plan

Chap 13: Ground Control System

13.1: GCS Overview

- GCS uses the telemetry data to populate Real-Time graphs.
- Saves the received telemetry in a .csv file in the format.
- Sends command to capture picture.
- Receives the status of picture ‘Command Time’ and ‘Command Count’.
- Ground control system in which our computer will connect to a circuit having Arduino through UART Serial Communication Protocol using MAX232 IC as computer works on RS232 logic and Arduino on TTL logic.
- At ground station we will be using an XBee Pro S2B Module which will receive data of various sensors from the XBee Module on the Glider via antenna at the ground station.
- Data will be provided in Real-Time at the ground station.
- Arduino will receive and transmit signal via UART Serial Communication Protocol which will be received by serial port of the computer.

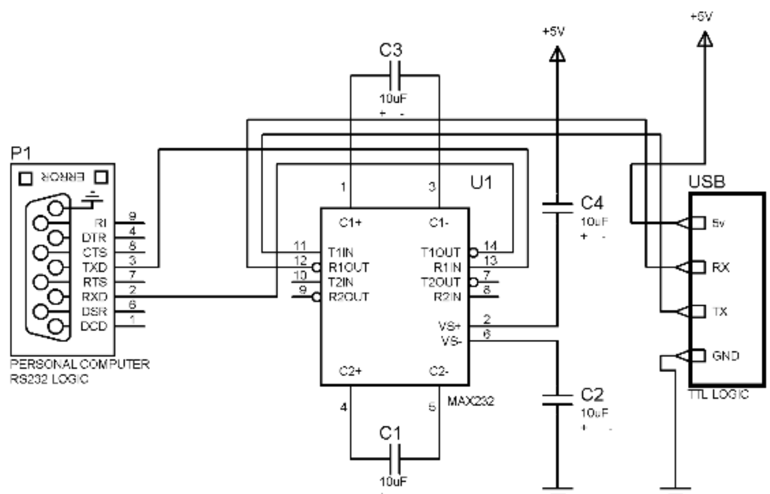


Fig 26: Ground Station Setup

13.2: GCS Antenna

Xbee Long Range Omni-Directional Dipole Antenna

- High Gain 9dBi & Field Pattern are utilized.
- Larger Dimension allows better reception.
- Higher Range Antenna : up to 3200m Open Ground
- Frequency same as that of Xbee Pro S2B
  (Specific for Xbee Radios)
- Being a RSPMA connector antenna, it stands to be portable
- The antenna is pointing upwards and will be kept on the ground station.
- The antenna will not be fixed but will be kept on a table so that it can be moved easily in case if the data is not being received.

Fig 27: XBee Omni-Directional Dipole Antenna

a. Antenna Distance Link Margin

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

Where:
R = 901 m
f = 2.4 GHz

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

13.3: GCS Software

- Real-time plotting design is done in the GUI which has been developed in MATLAB software using MATLAB GUIDE tools.
- The data will be stored in .csv file and then stored on the system in Real-Time using MATLAB Pre-defined Function for Auto-Generation of .csv files.
- Connection is established/reset using the Connection Settings.
- Push Button commands for Picture Clicking has been provided in 'Camera Controls Panel'.

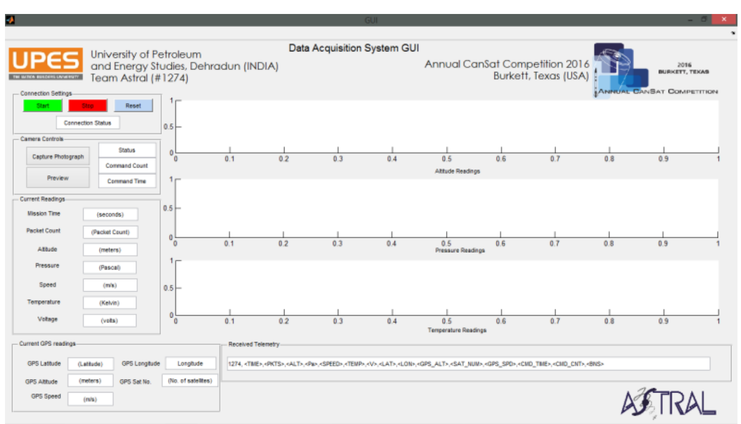


Fig 28: Graphical User Interface (GUI)

Chap 14: Integration and Testing

14.1: Mechanical Integration

A push rod controlled by a servo motor is used inside the container over which a string attached to the Glider is rounded. This holds the assembly intact, till GPS sends a signal to the microcontroller. At an altitude of 450m, after receiving the signal, the servo rotates and the pushrod moves. Thus the string which was previously hung upon it gets released along with the Glider detaching it from the Glider-container assembly.

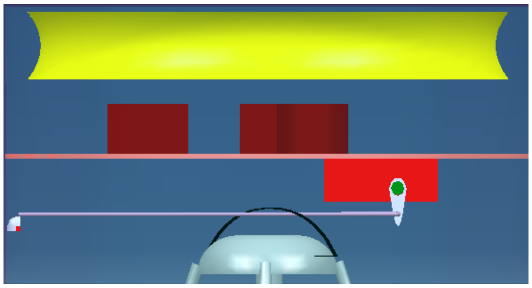


Fig 29: Release Mechanism

a. **Re-Entry Container**:

- The parachute will be placed in the topmost position inside the re-entry container.
- The electronics will be below the parachute along with the servo and the push rod assembly.
- The Glider shall be Fixed Just below this arrangement.

b. **Glider:**

- The electronics including the sensors and processors will be placed at the fuselage of the glider.
- The camera shall be fixed on the landing gear bay of the Glider.
- Electronics except for sensors will be enclosed and shielded from the environment.

14.2: Descent Control Test:

- The DCS of the container has been tested by dropping it from a height of about 50m. This verified the desired descent rate of 14 m/s at the calculated radius of the chute and spill hole. The descent rate of the container weighing 500 g on drop test was about 16.751 m/s.

- The DCS test for Glider weighing around 350 g, including dropping it from height of 89m and verifying the terminal velocity as derived. The objective of the test is to identify the appropriate diameter of the DCS which will result in the required terminal velocity and circular motion to ensure glide in a circular preset.

- Its survivability due to deployment to counter 30 Gs of shock force for both the DCS components.

14.3: Structure Survivability Tests:

- This involved dropping the Glider prototype from a height of approx.. 20m without its descent control system. An impact force sensor was planted at the bottom of the prototype in order to check the shock force which acts on the Glider structure.
- The Glider prototype sustains impact as tested by the Izod impact test.
- The structure is surviving 15 Gs of acceleration and 30 Gs of shock force as per the tests conducted.

14.4: Drop Tests

a. Re-entry Container

- The parachute attachment point didn't fail and was in a good shape.
- The Glider remained well-attached with the container.
- No visible damage to the Glider during the drop test, which gives us surety about the reliability of our mechanisms.

Fig 30: Re-entry Container (Experimental)

b. Glider

- A Scale model of the Glider was designed in Solidworks software
- Material of the Fuselage was selected as ABS and the Wings as Nylon.
- 30Gs of Shock and 15Gs of acceleration was applied

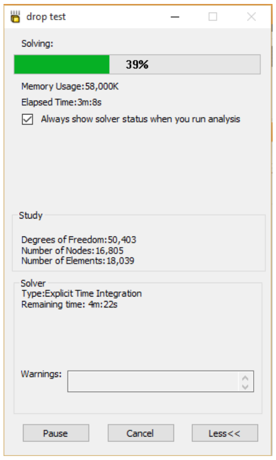


Fig 31: Glider (Software)

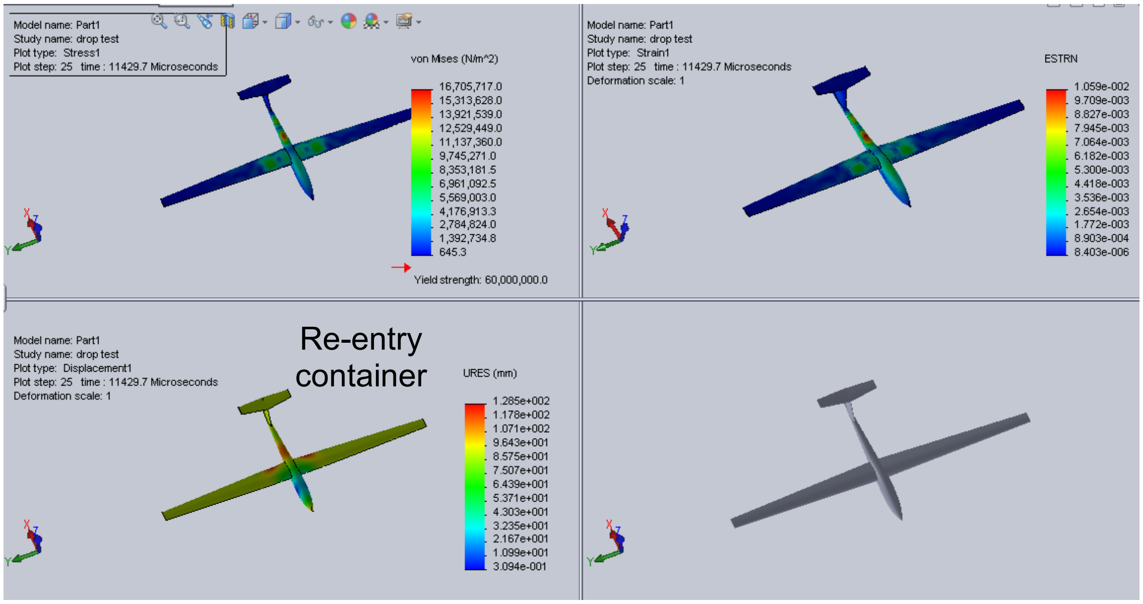


Fig 32: Stress, Displacement and Strain variation throughout the Glider

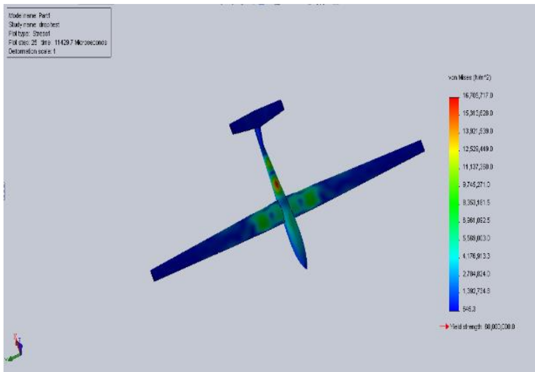


Fig 33: Stress Distribution in Glider

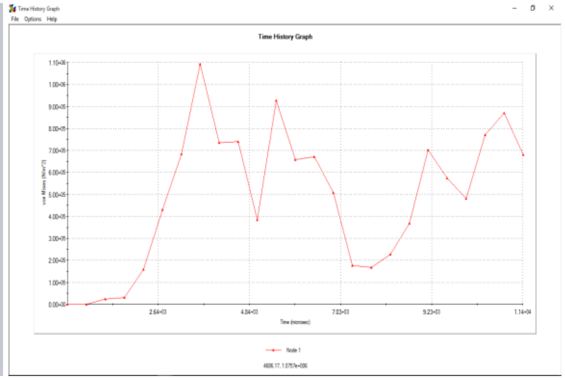


Fig 34: Time History Graph

14.5: Glider System-Container Release Mechanism Test:

- This involves releasing the Glider from the re-entry container with the help of a servo motor and a microcontroller by moving the pushrod and releasing the string attached with the Glider.
- A test on release mechanism for Glider weighing more than 350g will also be performed. The objective is to test if this structure can survive the shock of parachute deployment and so the Glider is not released due to the shock.

14.6: Electronics Integration

- Electronics components and sensors which include the microcontroller are mounted on the base board after calculating the operational ranges.
- Power Supplies are designed for 5V using 7805 voltage regulator and 3.3V using LM1117 voltage regulator.
- A current booster circuit (by using a transistor) with the regulator will be employed to meet the current requirements by the Xbee.
- Various tests are conducted in order to rectify the errors. Such as, test for proper power current supplied to XBee.
- Temperature, Pressure and Altitude sensors were tested using arduino interface and results were displayed on a 16x2 LCD.

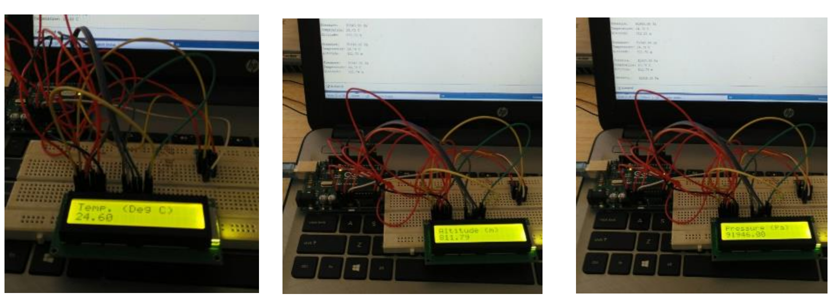


Fig 35: Temperature, Pressure and Altitude Testing

14.7: Micro Controller and Circuit Test

- Arduino Uno Microcontroller has been tested for serial communication for real-time data acquisition, using LM35, BMP180, Pitot Tube Sensor and GPS UBlox Neo6-MV2.

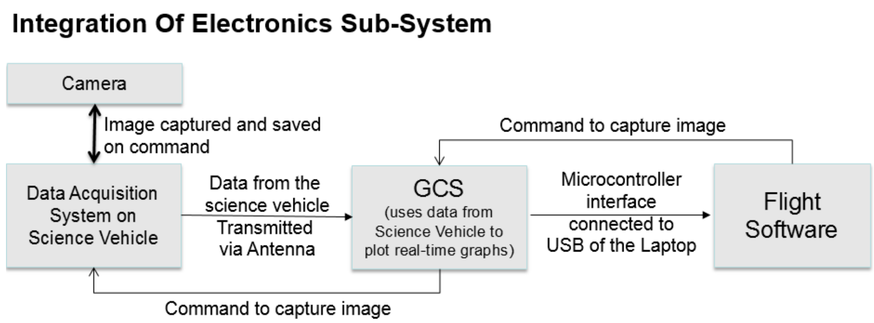


Fig 36: Electronics Integration

Chap 15: Management

15.1: Electronics Hardware

Component		Model	Quantity	Cost
Micro Controller		Arduino Uno	1	$ 35.00
Communication Module		Xbee Pro S2b	2	$ 140.00
Sensors	Temperature	LM35	1	$ 2.00
	Pressure	BMP 185	1	$ 25.00
	GPS	Ublox Neo6 MV2	1	$ 25.00
	Pitot Tube	Freescale MPXV7002	1	$ 24.95
Camera		Serial TTL Camera	1	$ 39.95
Antenna		X-Bee Pro S2B With Whip Antenna	1	$ 73.56
Battery		Alkaline,9V	3	$ 8.00
Circuit Base Boards		Zero Size PCB	2	$ 5.00
Misc.				$ 20.00
SUBTOTAL				$ 373.46

Fig 08: Electronics Hardware Details

15.2: Mechanical Hardware

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

Fig 09: Mechanical Hardware Details

15.3: External Costs

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

Fig 10: External Cost Details

Chap 16: TimeLine

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

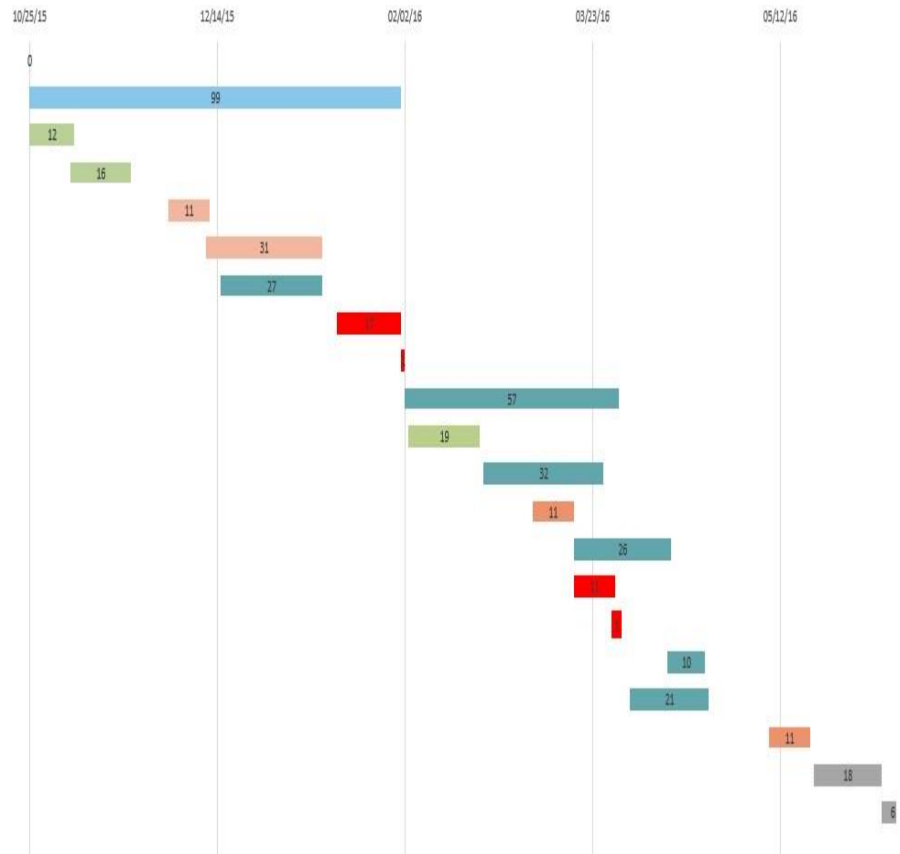


Fig 37: Gantt chart

Chap 17: Result

The Year 2016, witnessed Team Astral obtain the *4th International Rank and the 1st Rank in the Europe-Asia Pacific Region* not only surpassing the participating teams from the Indian Subcontinent but also gaining victory over those from the Asiatic region.

International Rankings

Team	College	Percentage (%)	Rank
Triton Cansat	University of California San Diego (USA)	91.81	1
Raven Knights	Carleton University (Canada)	89.76	2
Sky Dive	University of Alabama Huntsville (USA)	89.26	3
Astral	***University of Petroleum and Energy Studies (India)***	***86.48***	***4***
AGH Sky Divers	AGH University of Science and Technology (Poland)	85.22	5

Table 11: International Team Rankings

File Photo: Team Astral at Launch Ground, Abilene, Texas, USA
(Annual Cansat Competition, June 10 – June 12 2016)

Chap 18: Conclusion

Cansat competition serves as a platform to bring out the best of an engineer. The procedural lines in order to design, fabricate and launch the proposed model requires in depth study of each and every engineering domain. From documentation to designing to fabricating, it provides an all-round inter personal and ex-socio development of the individual as he/she is exposed to high-end technical knowledge as well as mannerism to present it before eminent personalities from The National Aeronautics and Space Administration (NASA), American Astronautical Society (AAS), Jet Propulsions Laboratory (JPL) and associated establishments.

The hard work, persistence, sheer dedication and team spirit of each and every individual in the Team was evident through the celebrated feat for Team Astral to carry the trophy back to India and decorate the College shelf with yet another achievement.

Team Astral proved its worth at the international level as those who have the potential not only to compete in a competition at that stature hosted by many of the space domain related institutions, but also emerge as a prominent rank holder to have their names mentioned in international records.

During the journey, Team Astral received comments of appreciation from the delegates of CANSAT from the Naval Research Laboratory (Washington D.C.) for reverting them with successful test results and flight demonstrations.

Appendix 01: Acronyms

• ADC	Analog to Digital Converter
• CMOS	Complementary Metal Oxide Semiconductor
• CONOP	Concept of Operations
• FAT	File Allocation Table
• FIFO	FIRST IN FIRST OUT
• GCS	Ground Control Station
• GUI	Graphical user interface
• HW	Hardware
• HWR	Hardware Review
• I/O	Input / Output
• LED	Light Emitting Diode
• MB	Mega byte
• MCU	Microcontroller Unit
• MECH	Mechanism
• MSR	Mechanical system requirement
• m/s	Meters per Second
• R	Normal Reaction Force
• SPI	Serial Peripheral Interface
• SSR	Sensor Subsystem Requirement
• TBD	To Be Determined
• TBR	To Be Resolved
• USART	Universal Asynchronous Receiver/ Transmitter
• mA	Milli Ampere
• µA	Micro Ampere
• dB	Decibel