Netaji Subhas Institute of Technology
CanSat 2018
Post Flight Review (PFR)

#2426

Team Kalpana-1

June 10, 2018

Introduction

NAKUL AGGARWAL

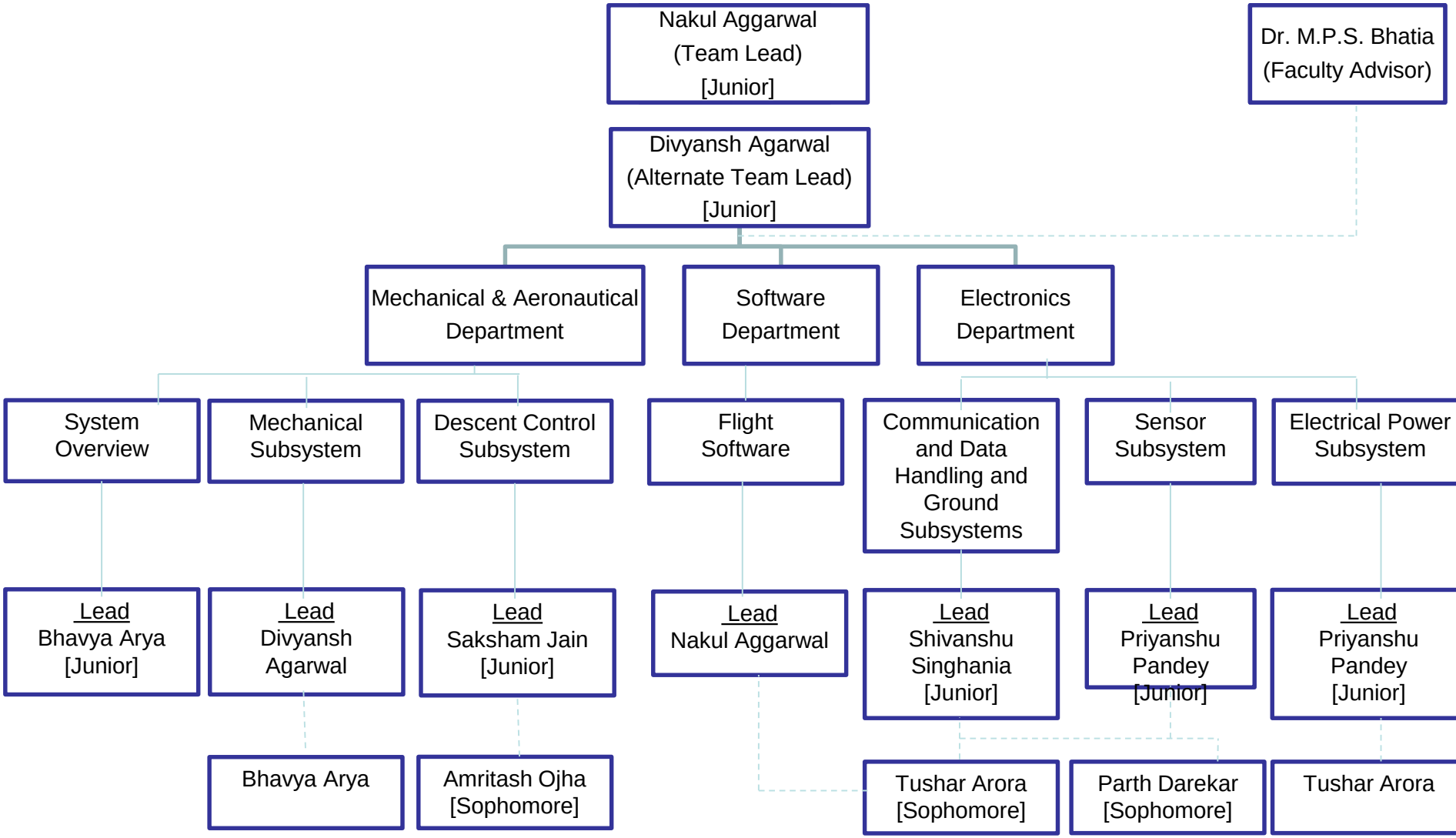
Presentation Outline

- **Introduction**
  - Presentation Outline
  - Team Organization
- **Systems Overview**
  - Mission Summary
  - Cansat Design Overview
  - Cost of Cansat <$1000
  - Physical Layout
- **Concept of Operations and Sequence of Events**
  - Planned and Actual CONOPS
  - Planned and Actual SOE

Presentation Outline

- **Flight Data Analysis**
  - Heatshield separation altitude
  - Payload pressure sensor data plot
  - Payload altitude plot
  - Payload temperature sensor plot
  - Payload GPS plot
  - Payload battery power plot
  - Tilt Sensor plot
  - Wind sensor Data
  - Camera Video
- **Failure Analysis**
  - Identification of failures, root causes, corrective actions
- **Lessons Learned**
  - Discussion of what worked and what didn't
  - Conclusions

Team Organization



Systems Overview

BHAVYA ARYA

Mission Summary

General Objectives

- To design and fabricate an Aero-braking Atmospheric Entry Probe (CanSat).
- The CanSat travels through the planetary atmosphere sampling the atmospheric composition during flight.
- CanSat consists of two important parts: Probe and Aero-braking Heat Shield.
- The probe shall hold a large hen's egg and protect it from damage from launch until landing

Mechanical Objectives

- The mass of the CanSat should be 500g with a tolerance of +/-10g and the cylindrical envelope dimensions should be less than 310 mm x 120 mm.
- The probe shall accommodate a large hen’s egg with a mass ranging from 54 grams to 68 grams and a diameter of up to 50mm and length up to 70mm
- The heat shield must protect the probe in stowed configuration and maintain stability along nadir direction.

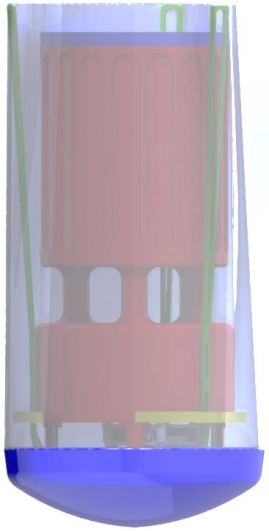
Mechanical Objectives (Cont.)

- The heat shield must be deployed between 675m - 725 m maintaining speed between 10m/s - 30m/ s afterwards till 300 m.
- At 300 m, the heat shield should be removed and parachute is to be deployed. Parachute must reduce the speed of probe to 5m/s

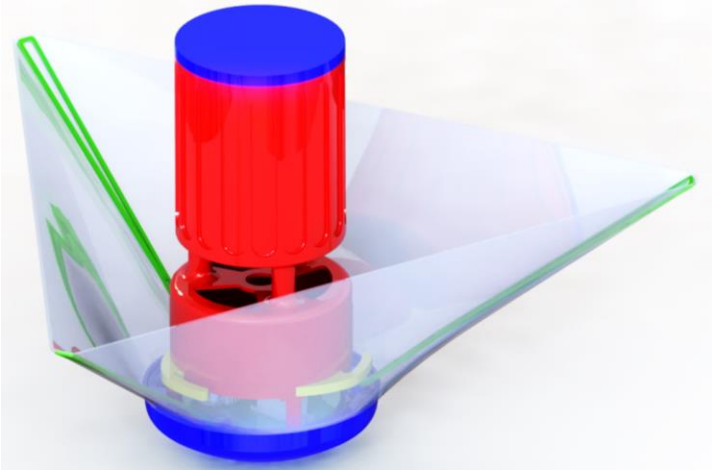
Electrical Objectives

- Telemetry of air pressure, atmospheric air temperature, altitude, voltage, GPS positions, tilt sensor reading , mission time, flight software state, should be collected and transmitted to the GCS at 1 Hz.
- All electronic components shall be enclosed and shielded from the environment with the exception of sensors.
- The probe must have easily accessible power switch and a power indicator.
- Probe should contain an audio beacon.

Cansat Design Overview



Stowed Configuration



Deployed Configuration

Heat Shield Release with parachute deployment

Cansat Design Overview (Components Summary)

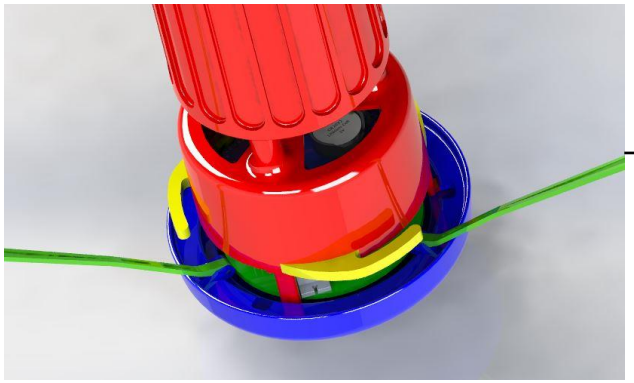
Electronics-

1. BMP180
2. ADXL345 Tilt Sensor
3. UBLOX NEO 6M GPS Sensor
4. DS3231 RTC
5. XBEE Pro S2C
6. 2.4 GHz Patch Antenna
7. Voltage Sensor-Resistor
8. Switch
9. Audio Beacon-PiezoBuzzer
10. PCB
11. 9V Lithium Ion Battery 1.2 Ah
12. 7.74 V Lithium Ion Battery 2.8 Ah
13. Heat Sink
14. Regulator
15. Micro-Servo 9g Motors x 2

Mechanical-

1. Nylon PA-2200 Capsule
2. Ribs
3. Taffeta Nylon Flare Membrane
4. Gears x 2
5. Rotor with flanges
6. Egg Compartment
7. Ethylene Sheet for Battery Compartment
8. Tarc-20 Parchute
9. Philips Screws
10. Silicon Glue and Epoxy
11. Nylon 12 Probe

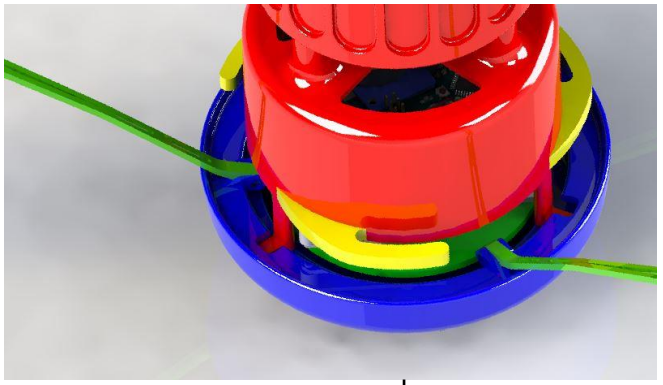
Cansat Design Overview (Heat Shield Release Mechanism)



Deployed Configuration

Stage 1

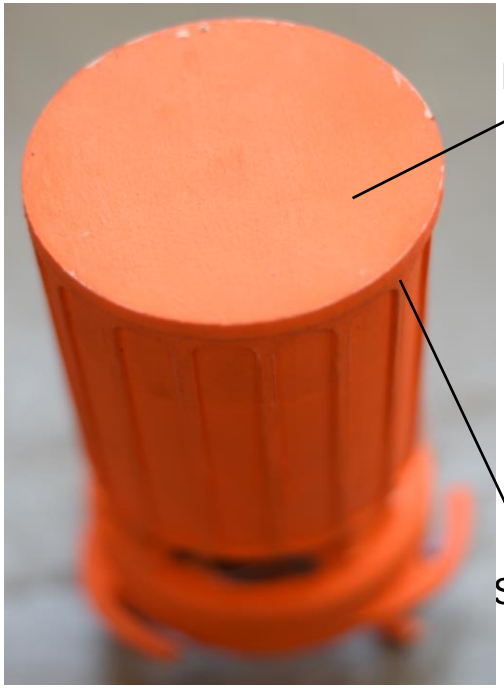
After deployment, further rotation of capsule by servo aligns the L-hooks and cavity in the capsule surface



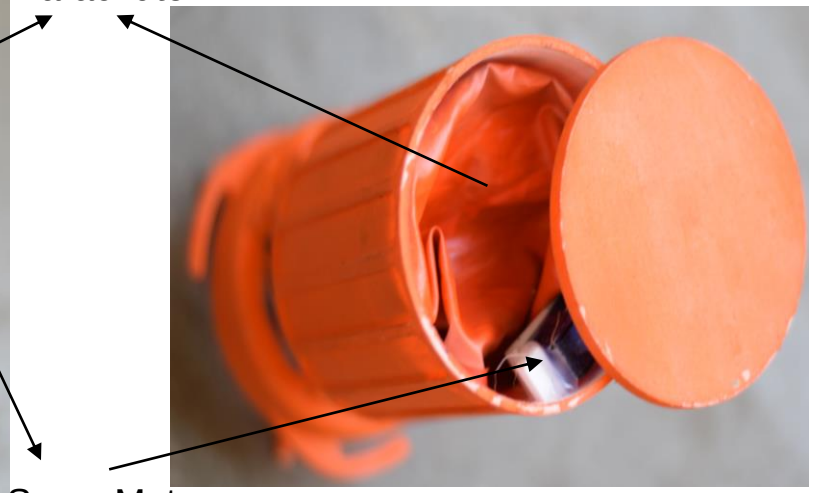
Stage 2

Due to upward force from parachute, the probe attains a relative velocity in the opposite direction which separates the Probe and heat shield.

Cansat Design Overview (Probe Parachute Release Mechanism)



Stowed Configuration



Lid rotates

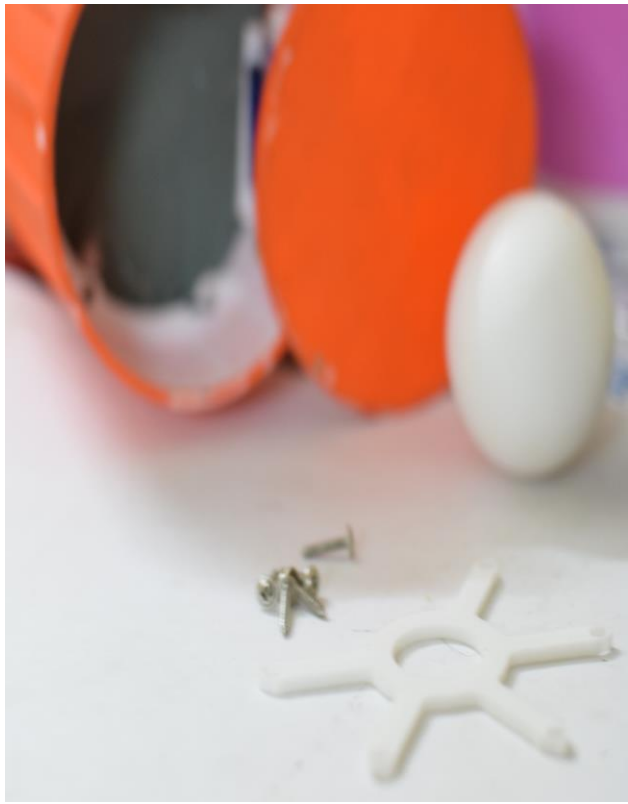
Deployment of parachute

Mechanism

- The lid hinged on the top of the parachute module is held in closed position via the help of a servo motor
- At 300m, BMP180 will sense this altitude and direct the servo to rotate and open the lid.

Cansat Design Overview

Strategy for insertion and removal of egg without complete disassembly



CanSat Budget – Hardware (Electrical)

Part		Model	Quantity	Total Cost ($)	Determination
Microcontroller		Arduino Nano	1	$5.85	Actual
Sensors	Air Pressure	BMP180	1	$4.8	Actual
	Temperature				
Tilt Sensor		ADXL345	1	$4.75	Actual
Camera Sensor		Adafruit TTL Serial Camera	1	$40	Actual
GPS Sensor		UBLOX NEO-6M	1	$15.13	Actual
Power Voltage Sensor		Voltage Divider Circuit	1	$1	Actual
XBEE Radio		XBEE Pro S2C	1	$41.61	Actual
CanSat Antenna		FXP70 Freedom (Patch Antenna)	1	$4.52	Actual
Audio Beacon		Mini Piezo Buzzer	1	$1	Actual
Battery		Custom Designed Lithium 9V Battery	2	$30	Actual
Servo Motor		Micro Servo (9g)	2	$6.96	Actual
SD Card		SanDisk Class 10	1	$9.42	Actual
SD Card Module		Arduino SD Card Module	1	$4.7	Actual
RTC		DS 3231	1	$5.97	Actual
Voltage Regulator		LM 7805(5V)	1	$2.5	Actual
Total				**$206.41**	

CanSat Budget – Hardware (Electrical-Ground Station)

Part	Model	Quantity	Total Cost ($)	Determination
Ground Station Antenna	Yagi Antenna	1	$46.04	Actual
Communication Module	XBEE Pro S2C	1	$41.61	Actual
Base Circuit Boards	PCB	1	$10	Actual
Others			$20	Estimate
Total			**$117.65**	

CanSat Budget – Hardware (Mechanical)

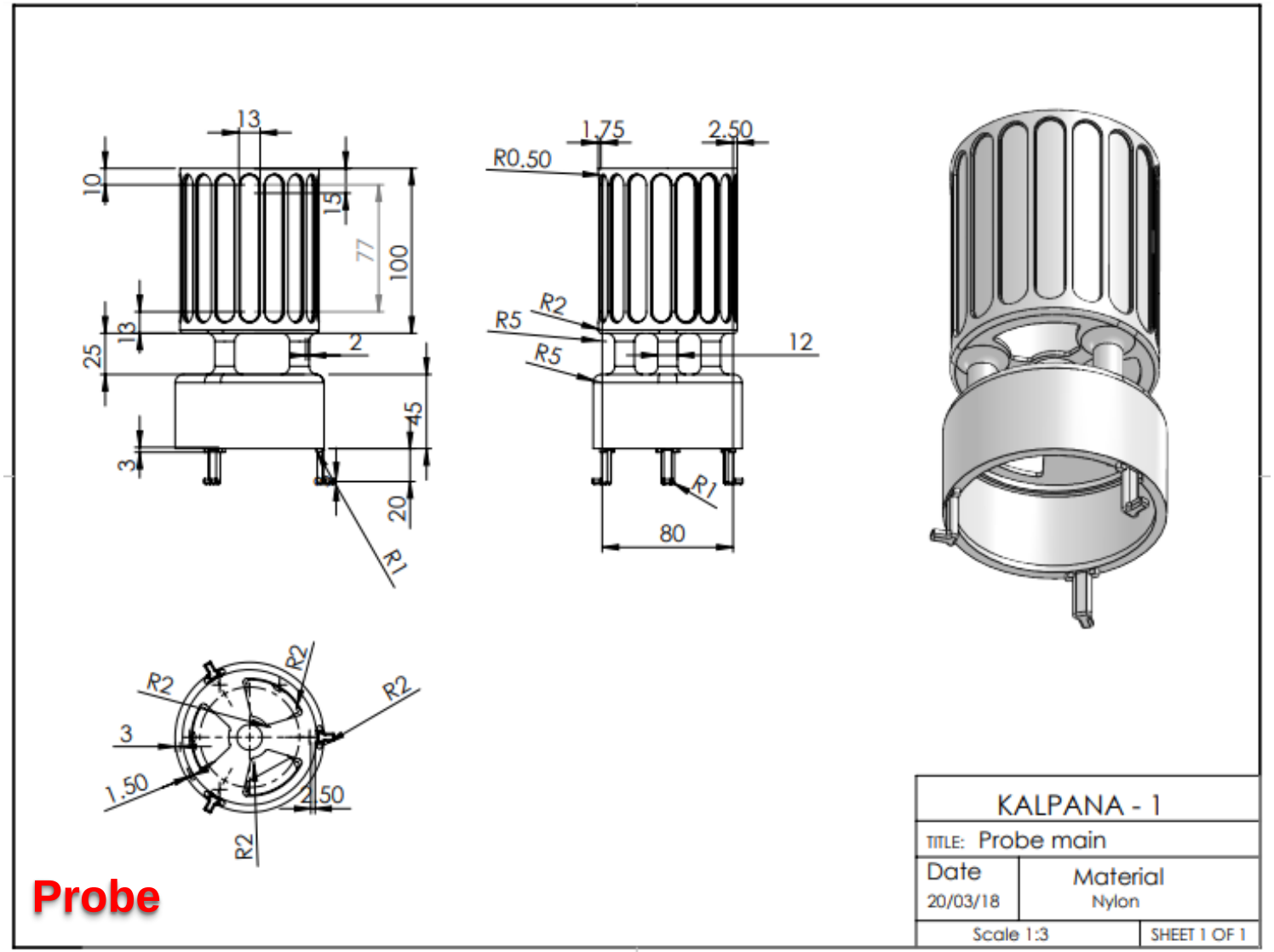
Part	Model	Quantity	Total Cost ($)	Determination
Probe				
Container Body+Lid	3D printed Nylon PA-2200	1	$80	Estimated
Parachute	Fruity Chutes TARC-18	1	$38	Actual
Rotor	3D printed Nylon PA-2200	1	$30	Estimated
Heat Shield				
Flexible Capsule/Nose	3D printed Nylon PA-2200	1	$50	Estimated
Flare Membrane	Tafetta Nylon Cloth	1 m^2	$80	Estimated
Ribs	3D printed Nylon PA-2200	6	$20	Estimated
Gearing Systems	3D printed Nylon PA-2200	1	$30	Estimated
Miscellaneous				
Hinges, Lid, Torsional Springs, Hooks, Adhesives etc.	N.A.	N.A.	$50	Estimated
			Total=$378	

CanSat Budget – Hardware (Total)

System	Cost($)
Electrical	$206.41
Mechanical	$378
Ground Station Costs	$117.65
Total Cost	$802.06

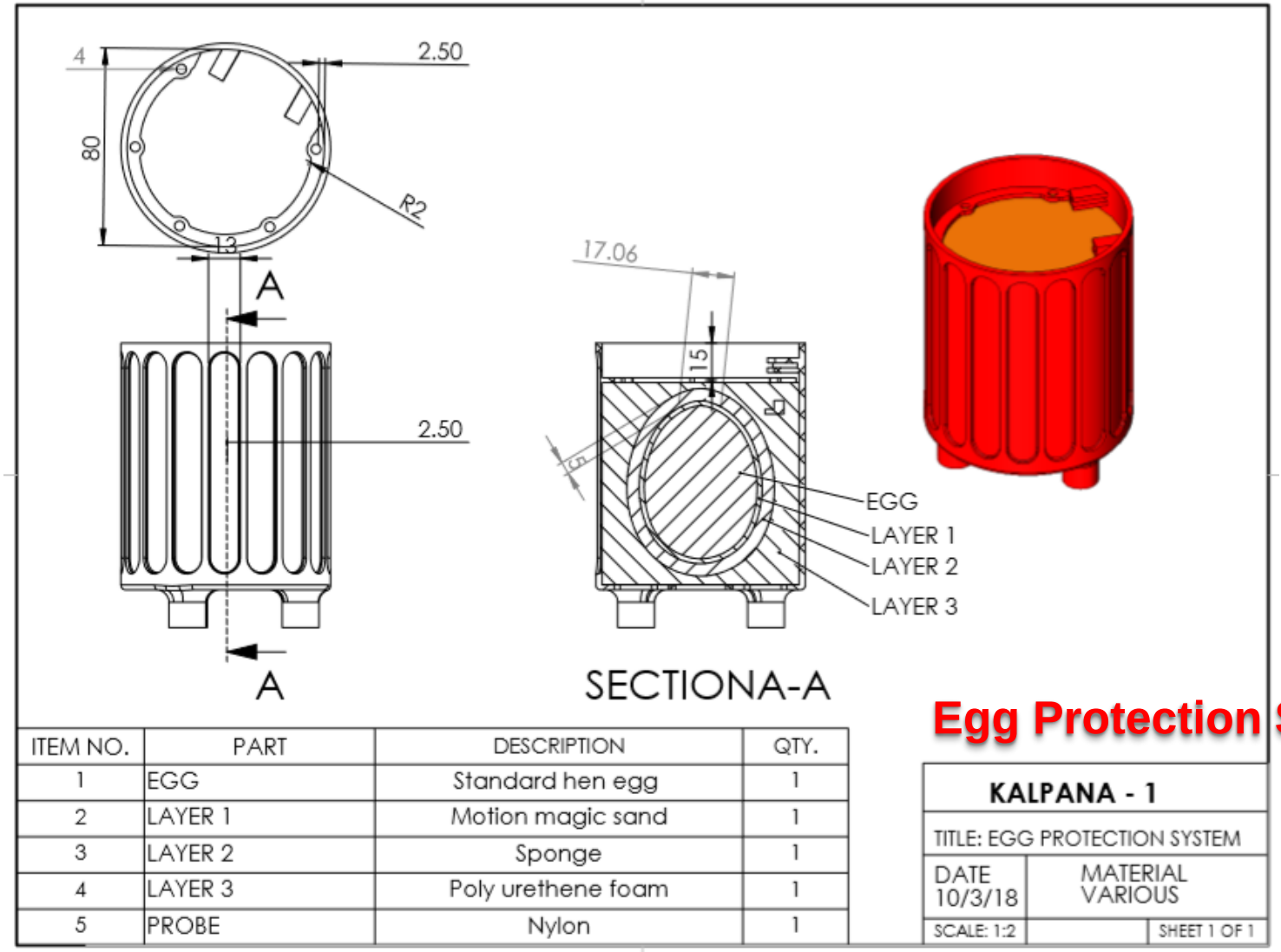
Total Cost is well within the CanSat guidelines of $1000

Cansat Physical Layout (Probe)



Probe

Cansat Physical Layout (Egg Protection System)

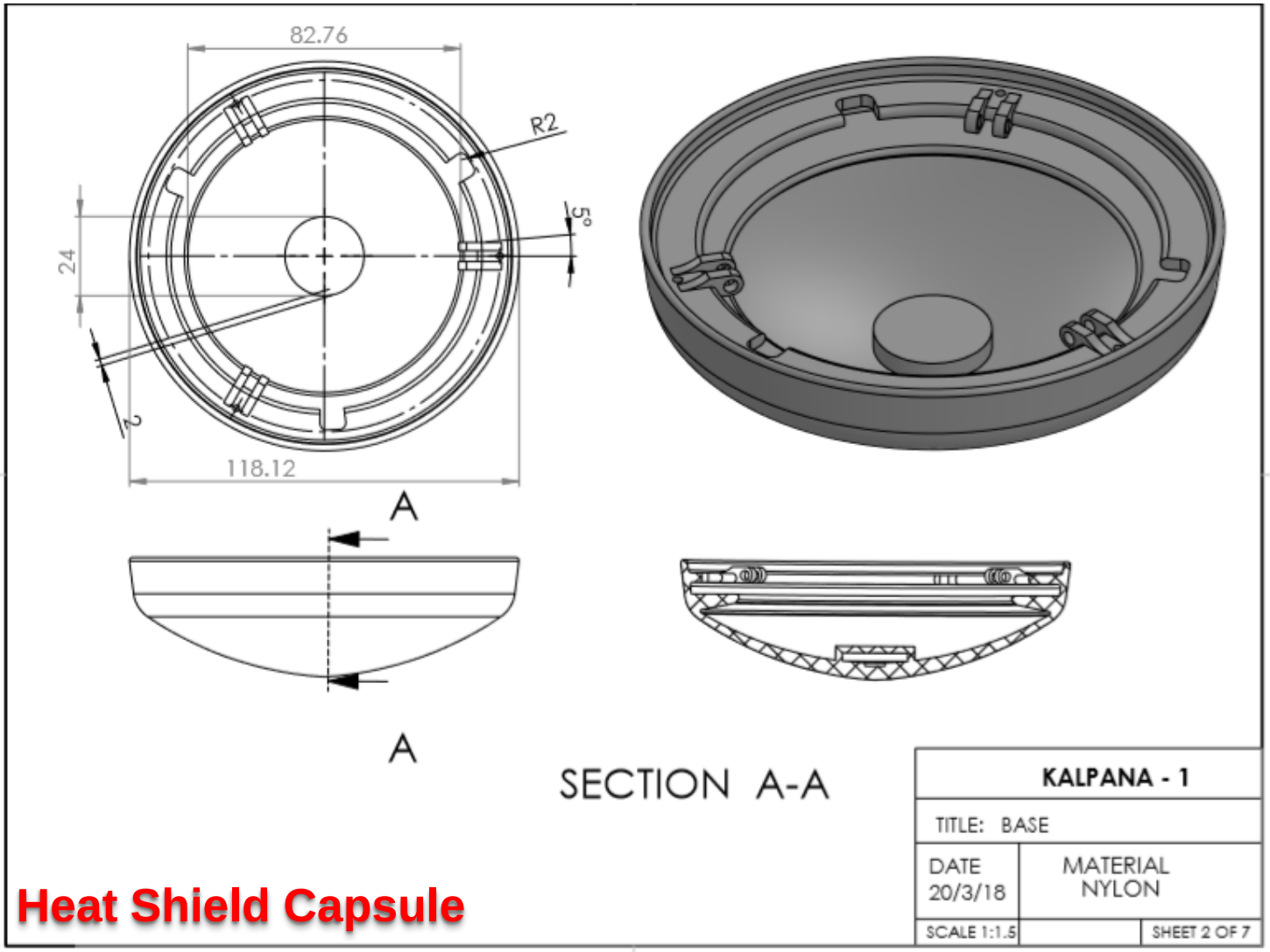


ITEM NO.	PART	DESCRIPTION	QTY.
1	EGG	Standard hen egg	1
2	LAYER 1	Motion magic sand	1
3	LAYER 2	Sponge	1
4	LAYER 3	Poly urethene foam	1
5	PROBE	Nylon	1

Egg Protection System

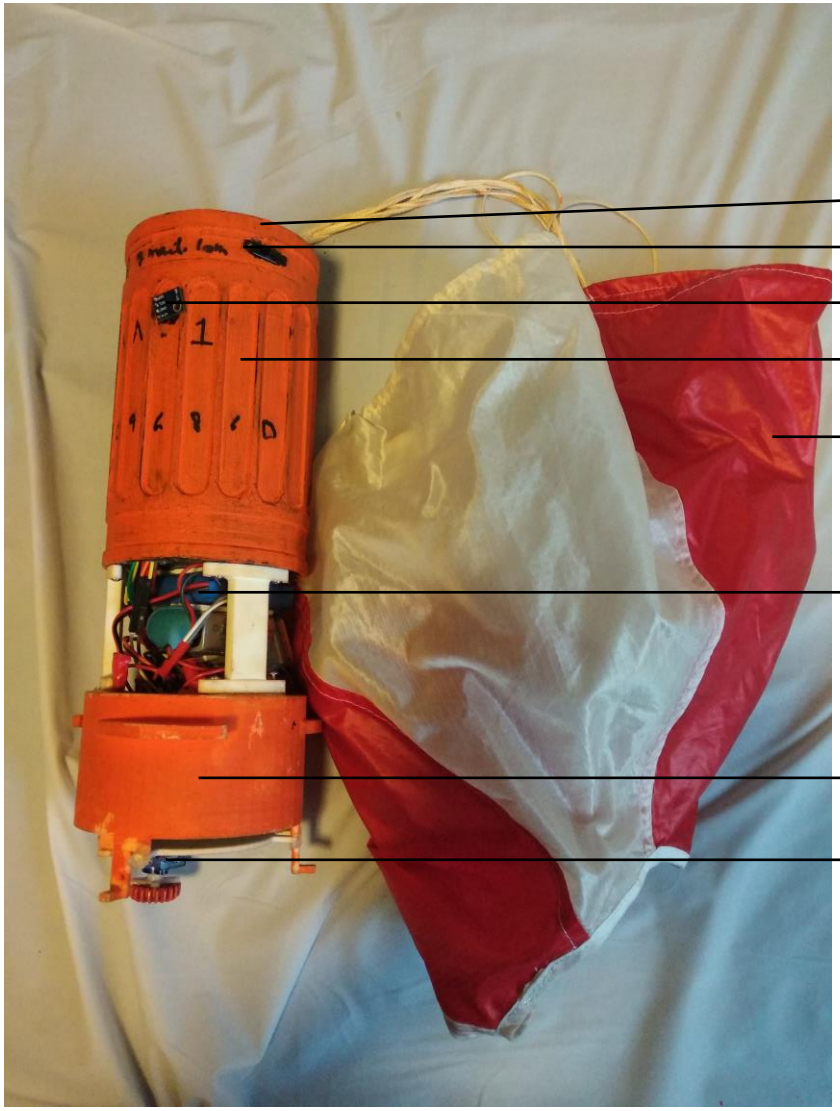
KALPANA - 1		
TITLE: EGG PROTECTION SYSTEM		
DATE 10/3/18	MATERIAL VARIOUS	
SCALE: 1:2		SHEET 1 OF 1

Cansat Physical Layout (Heat Shield)



Heat Shield Capsule

Cansat Physical Layout (Probe)



Parachute Compartment

Power Switch

BMP180

Egg Compartment

Parachute

Battery Compartment

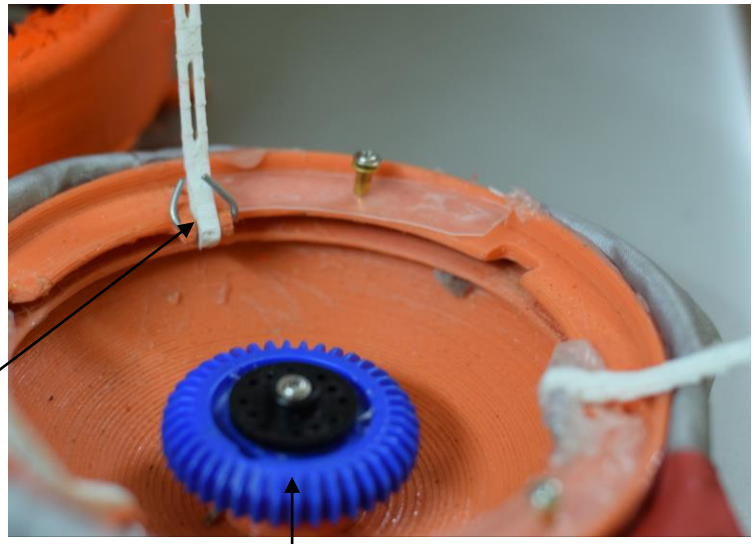
Electronics Compartment

SG90 Micro Servo 9g Motor

Cansat Physical Layout (Probe)

-

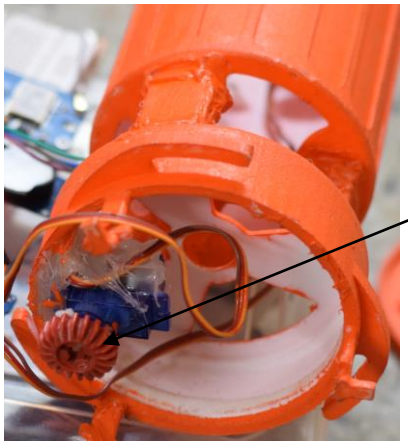
Hinges, Gears and Elastic Strands



Hinge

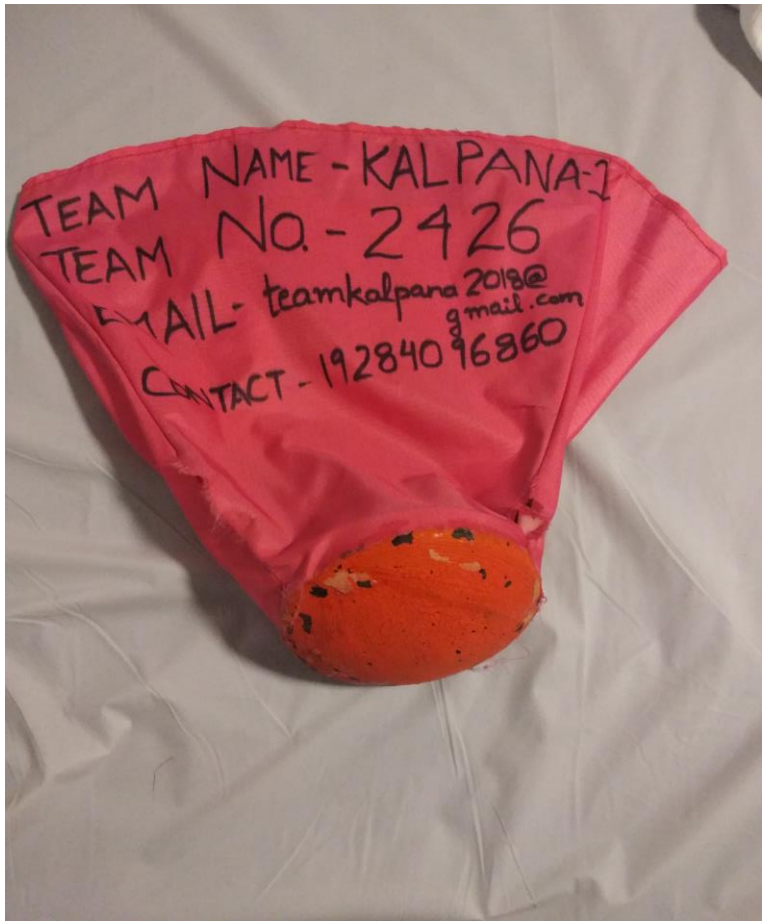
Driven gear

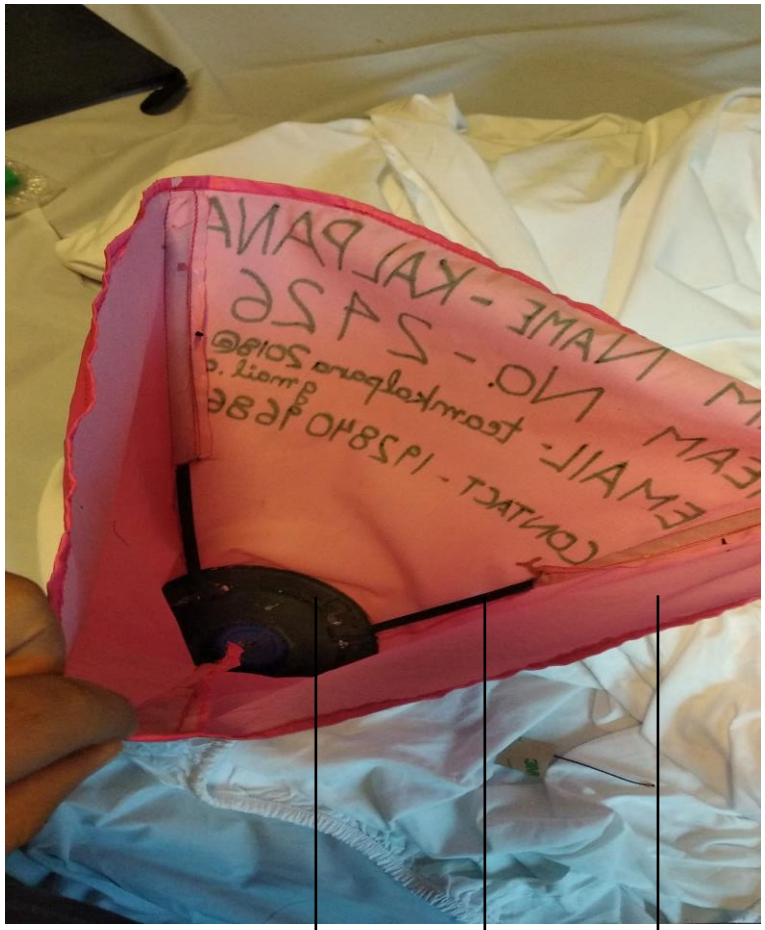
Elastic Strand



Driving gear (reduction ratio 1:4)

Cansat Physical Layout (Heat Shield)

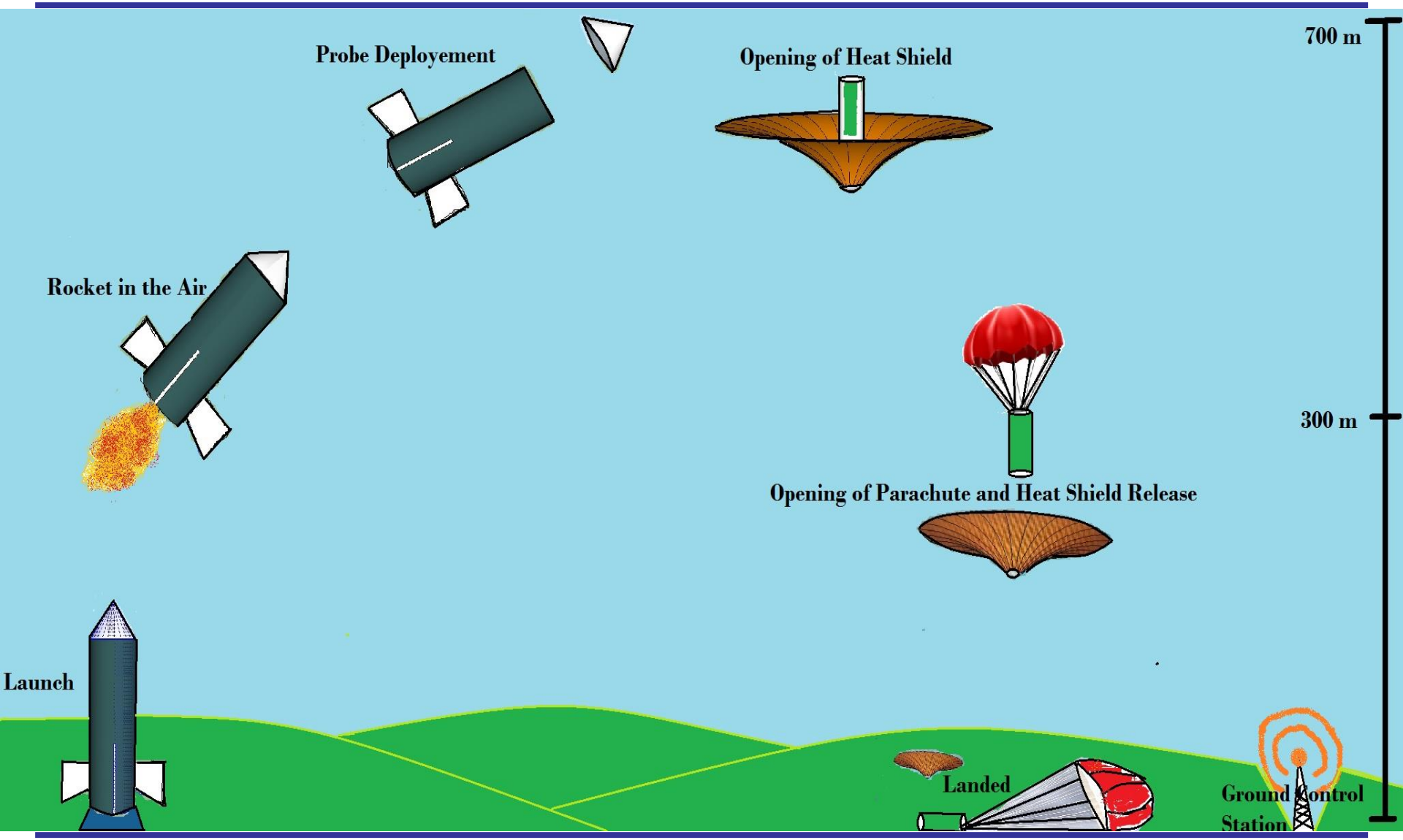




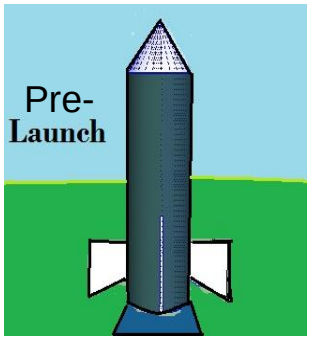
Concept of Operations and Sequence of Events

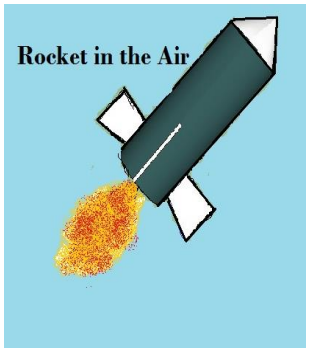
Nakul Aggarwal

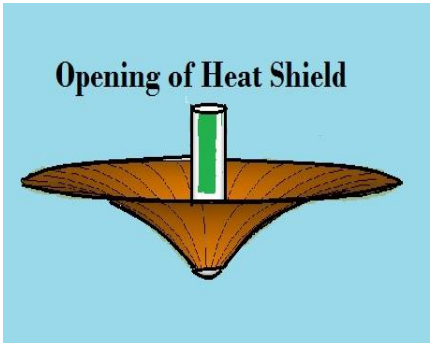
Planned CONOPS



Planned CONOPS







Pre-Launch

- Cansat Check
- Setup GCS
- Cansat is turned on
- Cansat is fitted into the rocket payload section
- Receive telemetry data

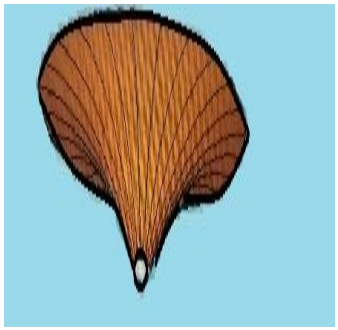
Launch

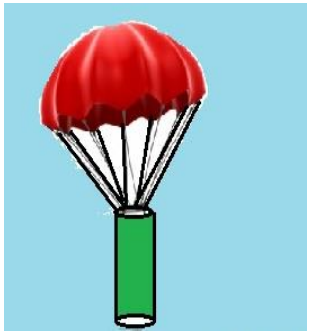
- Cansat transmits the telemetry data
- Plotted in real time in GUI

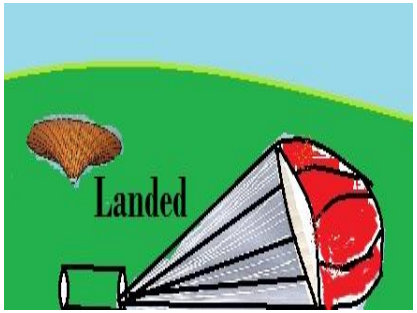
Cansat Deployment

- Cansat is separated from the rocket.
- Heat Shield is deployed at around 700m.
- Due to the deployment of heat shield, the speed of the Cansat reduces.

Planned CONOPS







Heat Shield release

At 300m, the heat shield separates using our servo-driven release mechanism and geared system.

Parachute Release

At 300m , the parachute releases from the lid using our servo-driven Release mechanism

Landing

- Probe lands
- Telemetry stops
- Audio beacon is turned on
- Retrieve probe and heat shield and extract data
- Retrieve Egg

Actual CONOPS

- **Heat Shield Release**

Heat shield release was successful and it got released mid-way. There was no physical Damage to the heat shield.

- **Egg Survival**

Egg survived with no cracks.

- **Parachute Release**

Parachute release was successful and due to its deployment, the egg also survived. There was no physical damage to the Cansat.

Planned SOE

1 Arrival

- Arrival at launch site (College Farm)
- Check In
- Set up Cansat
- Set up GCS

Cansat and Ground Station Crew

2 Pre-Launch Checks

- Perform Mass Check with and without egg and Fit Check
- Test the communication system
- Test the antenna with the XBEE radio
- Get Rocket
- Power On Cansat

Ground Station and CanSat Crew

3 Launch

- Insert Cansat into the rocket payload section
- Place the rocket onto the stand at the launch pad site
- Begin final checks using Mission Operations Manual
- The Mission Control Officer says yes for the launch after confirming with the Cansat and GCS Crew
- Record and save data during launch

Mission Control Officer

Planned SOE

4 Descent

- Telemetry transmission for ascent is received by the GCS
- Rocket separation and deployment of heat shield at 700m
- Telemetry transmission for descent begins
- Heat shield is released and parachute is deployed at 300m
- Camera captures the release of heat shield and subsequent descent
- Audio beacon activates just before landing
- Telemetry stops

5 Recovery

- Recovery crew goes into the field and accompanies the field judge as the scorecards are filled
- CanSat probe and heat shield are retrieved by the crew
- The parachute and heat shield are painted fluorescent orange to aid visibility
- The active audio beacon also helps in the recovery
- Both are inspected for any possible damage

Recovery Crew

6 Analysis + PFR

- The received telemetry data is analyzed
- The data is utilized for mission assessment and PFR preparation
- Data will be given to the judges
- The presentation is given on the following day

Entire Team

Actual SOE

- **Arrival**

Heat Shield was put in the correct position for its deployment and release using an initialization code

- **Pre-Launch Checks**

GCS, Cansat and Recovery Crew performed their operations successfully

- **Descent**

GCS Crew was able to collect telemetry only till the launch pad and no telemetry during the flight. Therefore, GCS Crew could plot the telemetry in real time only till the rocket was put in its stand at the launch pad

- **Recovery**

Successful Recovery of heat shield and probe

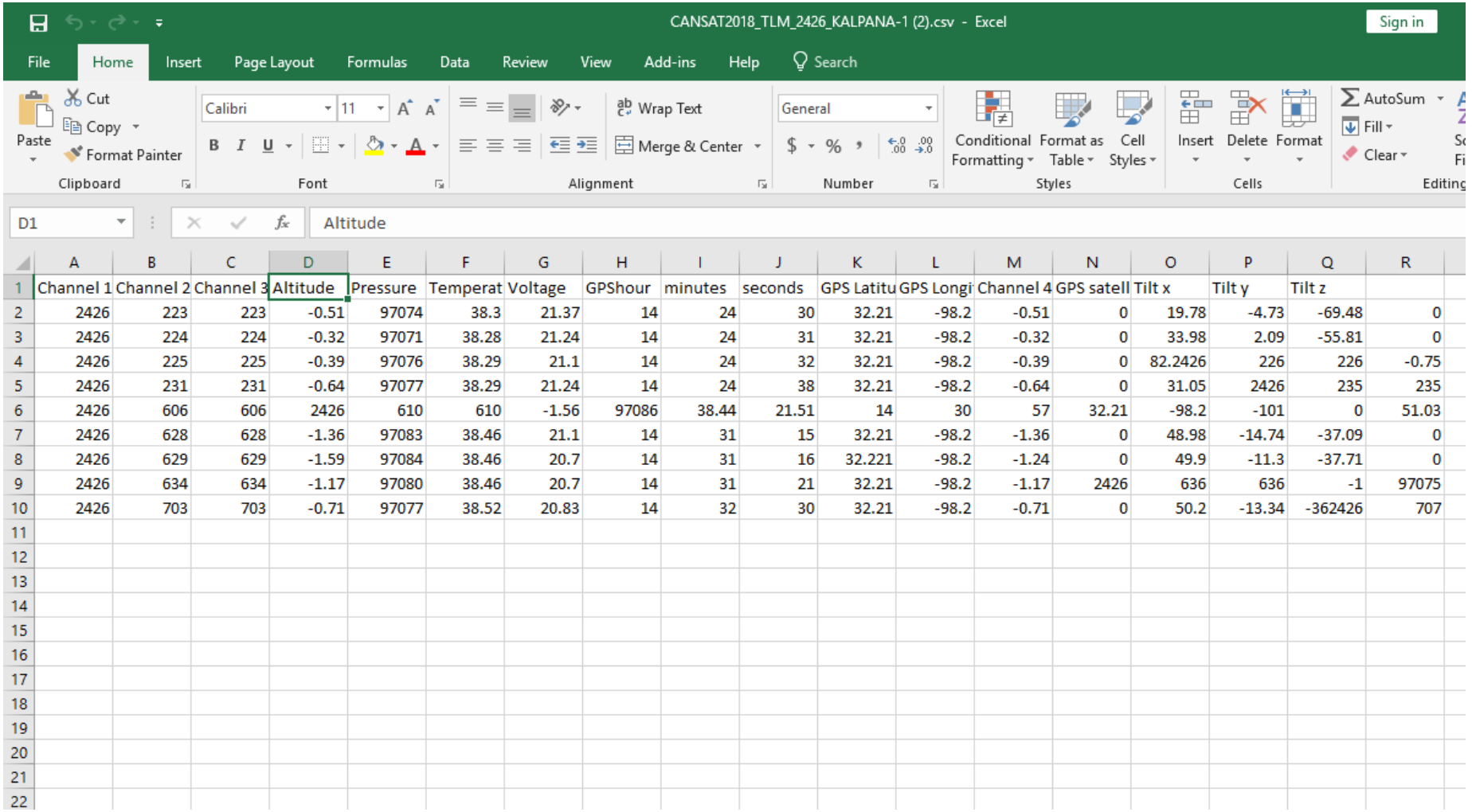
- **Data Retrieval**

Data was given to judges in a .csv file

Flight Data Analysis

Priyanshu Pandey

Telemetry Packets



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1	Channel 1	Channel 2	Channel 3	Altitude	Pressure	Temperat	Voltage	GPShour	minutes	seconds	GPS Latitu	GPS Longi	Channel 4	GPS satell	Tilt x	Tilt y	Tilt z	
2	2426	223	223	-0.51	97074	38.3	21.37	14	24	30	32.21	-98.2	-0.51	0	19.78	-4.73	-69.48	0
3	2426	224	224	-0.32	97071	38.28	21.24	14	24	31	32.21	-98.2	-0.32	0	33.98	2.09	-55.81	0
4	2426	225	225	-0.39	97076	38.29	21.1	14	24	32	32.21	-98.2	-0.39	0	82.2426	226	226	-0.75
5	2426	231	231	-0.64	97077	38.29	21.24	14	24	38	32.21	-98.2	-0.64	0	31.05	2426	235	235
6	2426	606	606	2426	610	610	-1.56	97086	38.44	21.51	14	30	57	32.21	-98.2	-101	0	51.03
7	2426	628	628	-1.36	97083	38.46	21.1	14	31	15	32.21	-98.2	-1.36	0	48.98	-14.74	-37.09	0
8	2426	629	629	-1.59	97084	38.46	20.7	14	31	16	32.221	-98.2	-1.24	0	49.9	-11.3	-37.71	0
9	2426	634	634	-1.17	97080	38.46	20.7	14	31	21	32.21	-98.2	-1.17	2426	636	636	-1	97075
10	2426	703	703	-0.71	97077	38.52	20.83	14	32	30	32.21	-98.2	-0.71	0	50.2	-13.34	-362426	707
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
21																		
22																		

We received 9 packets in total

Telemetry Packets (Saved in EEPROM of Arduino Nano)

COM3

```
2426,1,1,-0.33,97042,50.32,21.10,15:10:42,32.21,-98.20,-0.33,0,-8.56,-71.00,31.19,0
2426,2,2,0.60,97047,50.31,21.51,14:51:5,32.21,-98.20,0.60,0,-23.16,35.20,45.60,0
2426,3,3,0.35,97041,50.31,21.24,14:51:6,32.21,-98.20,0.35,0,-20.07,42.62,40.46,0
2426,4,4,-0.03,97046,50.32,21.24,14:51:7,32.21,-98.20,-0.03,0,-19.28,44.32,39.25,0
2426,5,5,1.19,97033,50.32,21.24,14:51:8,32.21,-98.20,1.19,0,-18.90,45.40,38.39,0
2426,6,6,-0.18,97041,50.33,21.37,14:51:9,32.21,-98.20,-0.18,0,-19.20,44.66,38.96,0
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2426,11,11,-2.76,97037,48.72,21.64,14:49:14,32.21,-98.20,-2.76,0,-17.17,46.76,38.04,0
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2426,16,16,-1.43,97044,47.83,21.37,14:47:56,32.21,-98.20,-1.43,0,-16.99,48.01,36.85,0
```

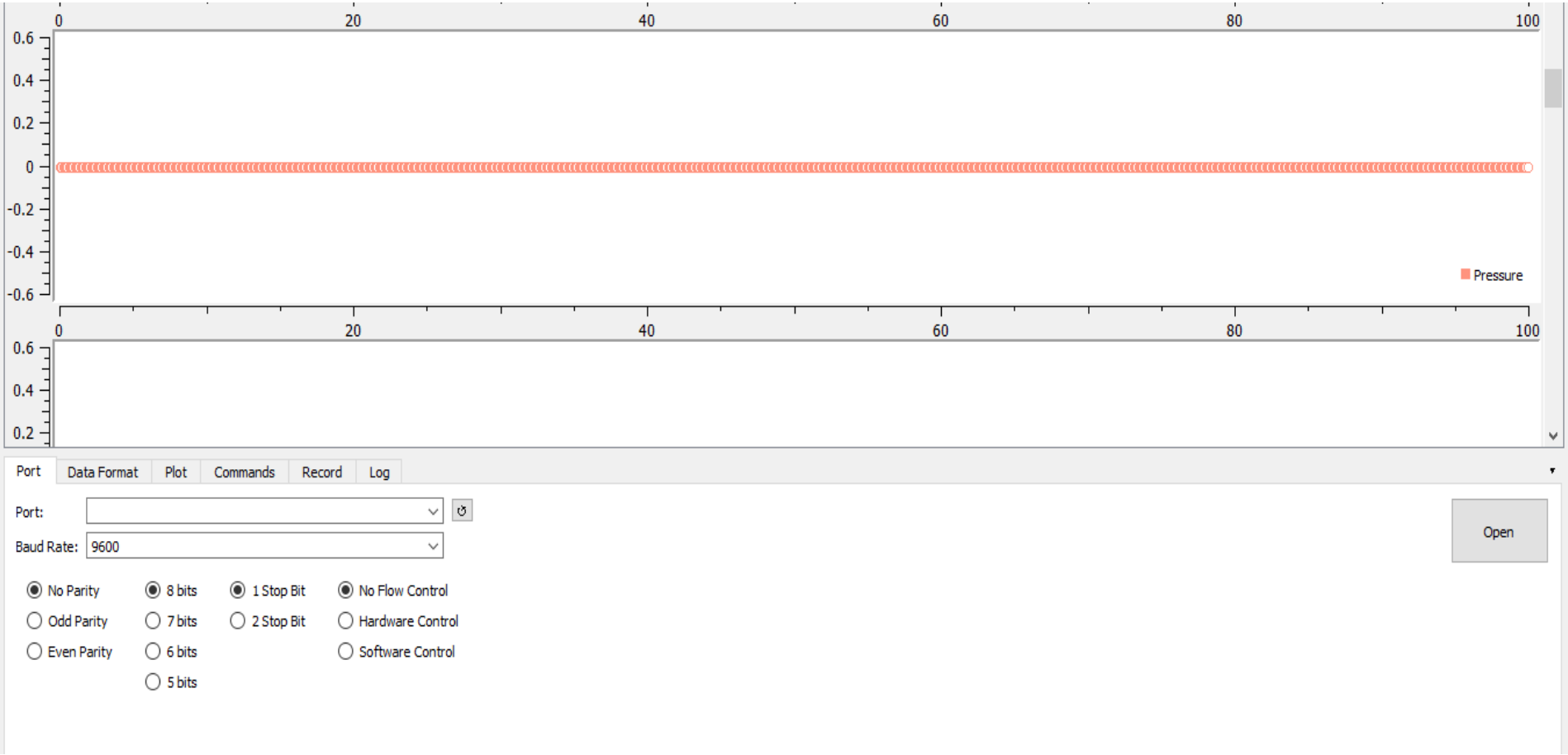
Heat Shield separation altitude

Due to no telemetry received, we cannot tell with accuracy at what height the heat shield got released. But on observation, it did get released around mid-way.

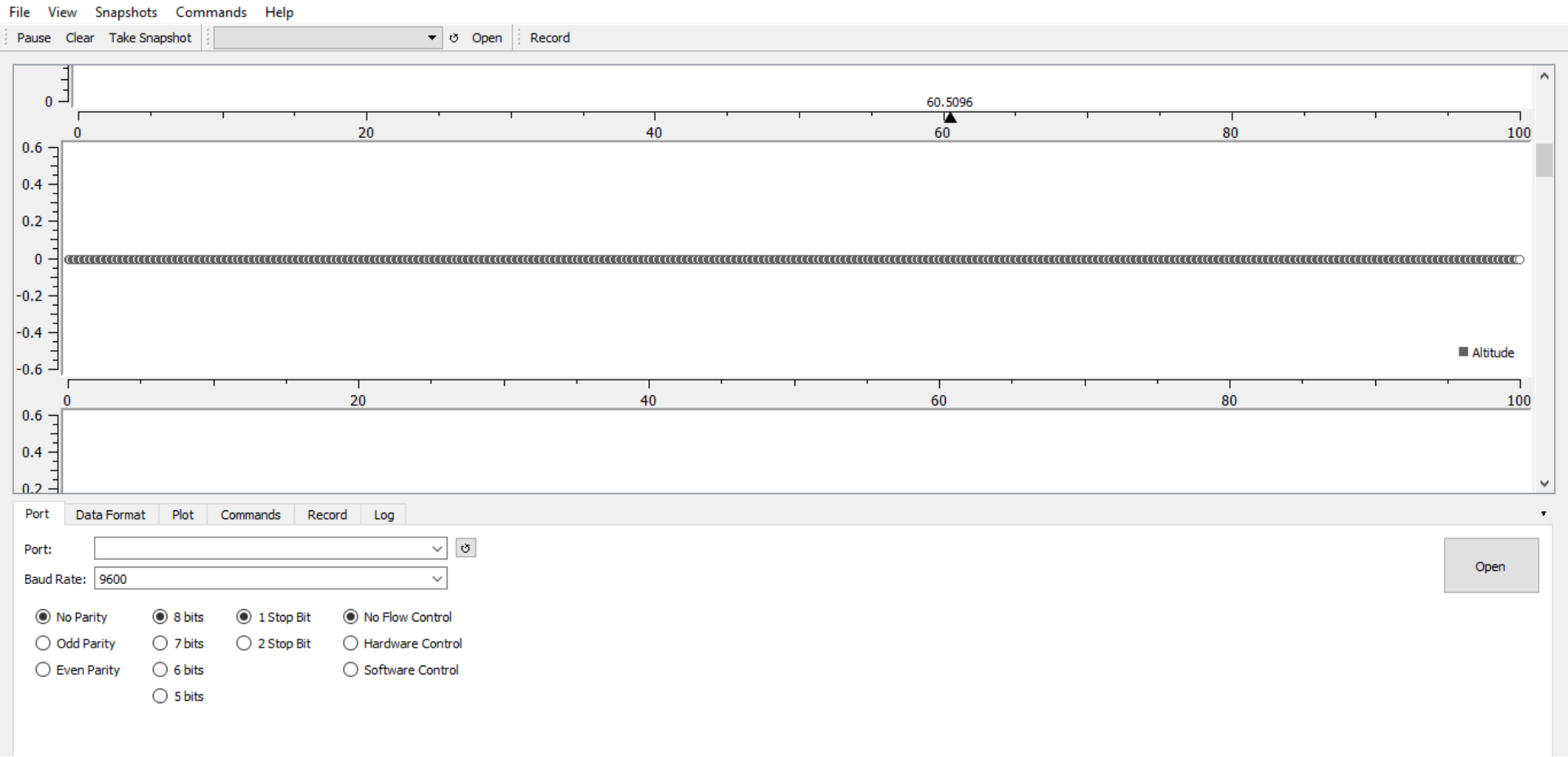
```
if (a > amax)
  amax = a;
if (amax >= 651 && a <= 630)
{
  deploy();
  In1.STATE = 1;
}
if (amax >= 651 && a <= 300)
{
  releaze();
  In1.STATE = 2;
}
if (amax >= 651 && a <= 5)
{
  buz = 1500;
  In1.STATE = 3;
}
```

Payload Pressure Sensor Data Plot

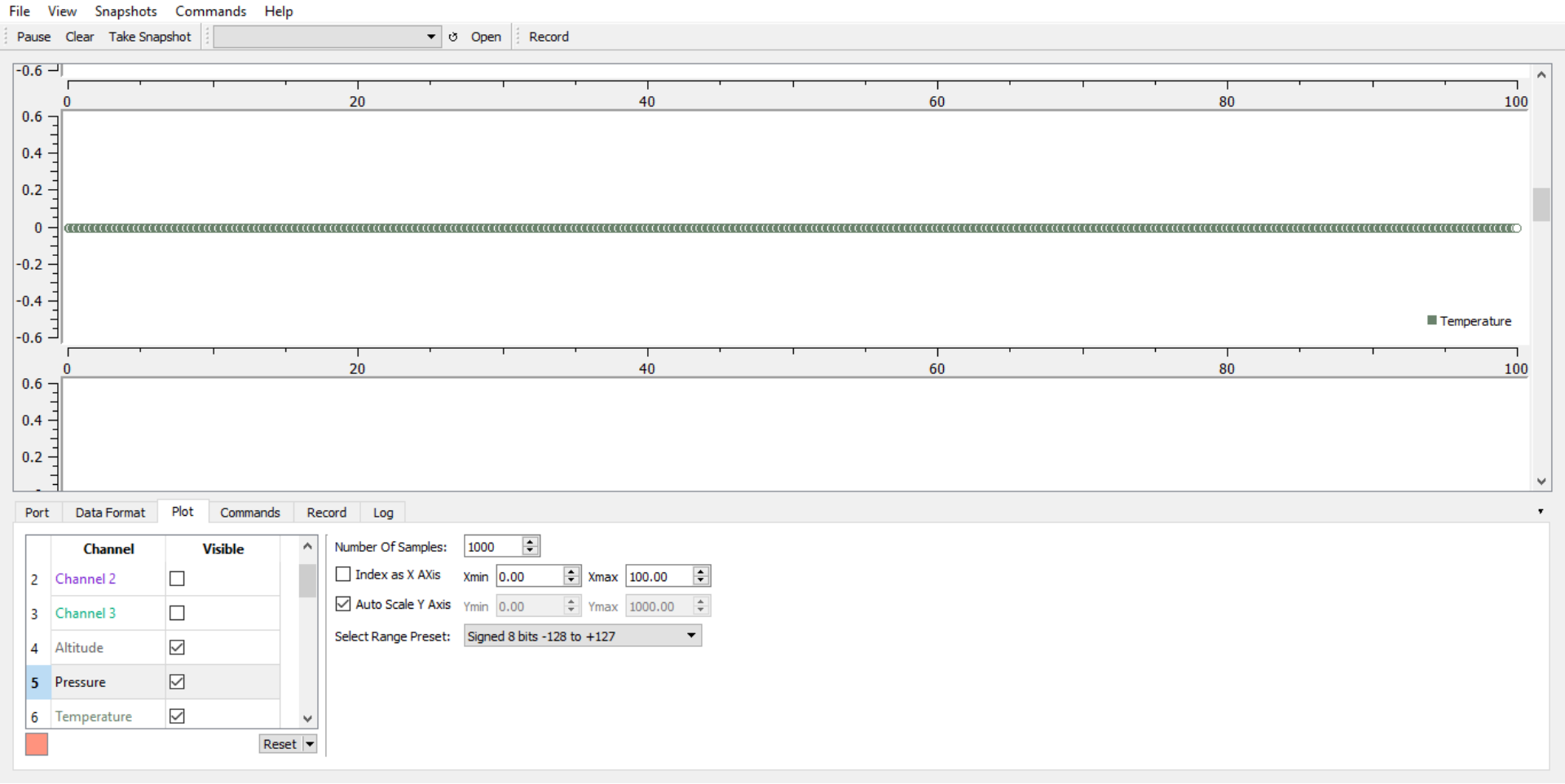
We received real time plotting for the 9 packets but after that no telemetry occurred. We showed the field judge real time plotting for these 9 data points and after that we cleared the session and started real time plotting fresh but forgot to save the screenshots of the previous real time plotted data.



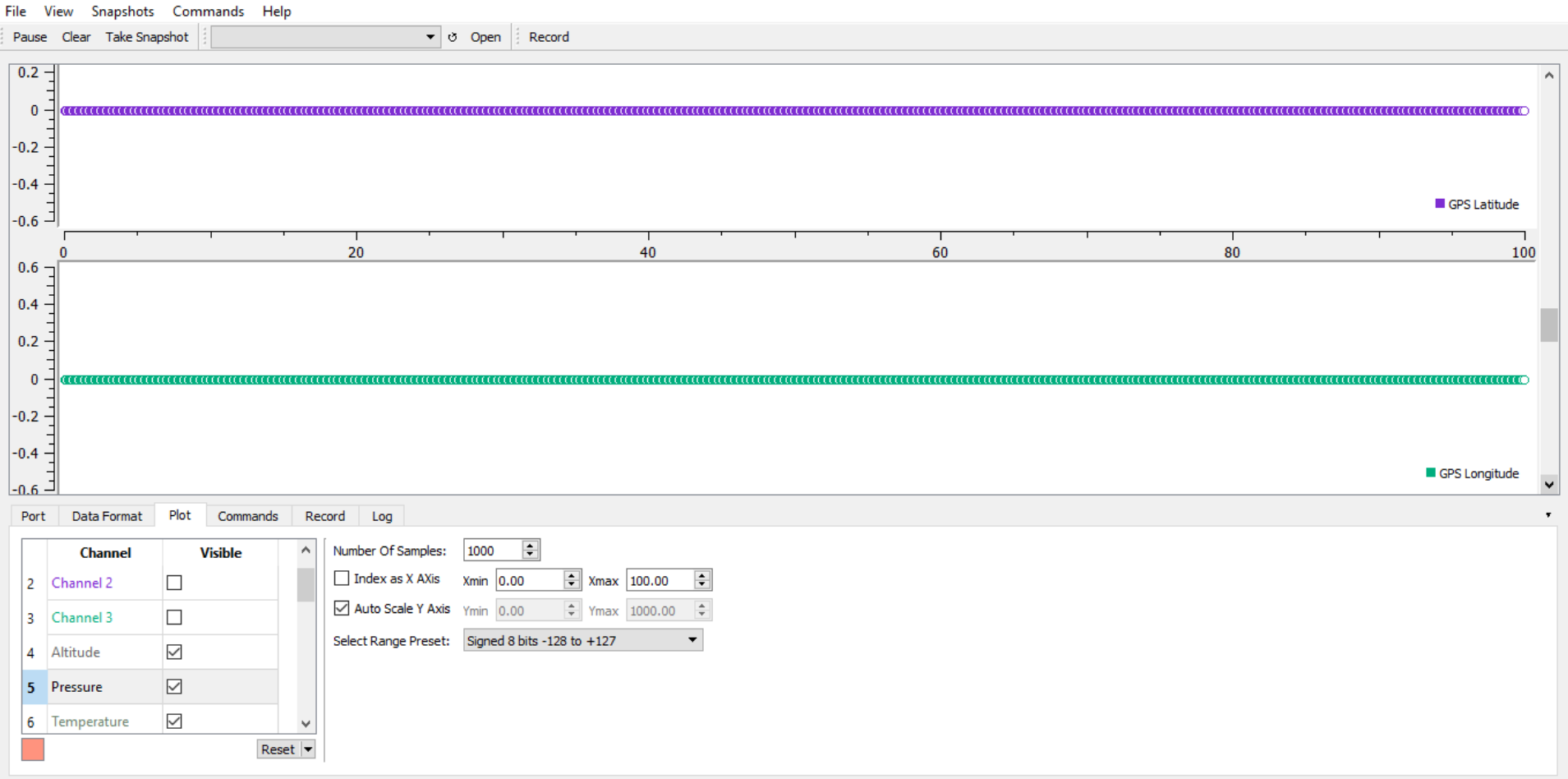
Payload Altitude Plot



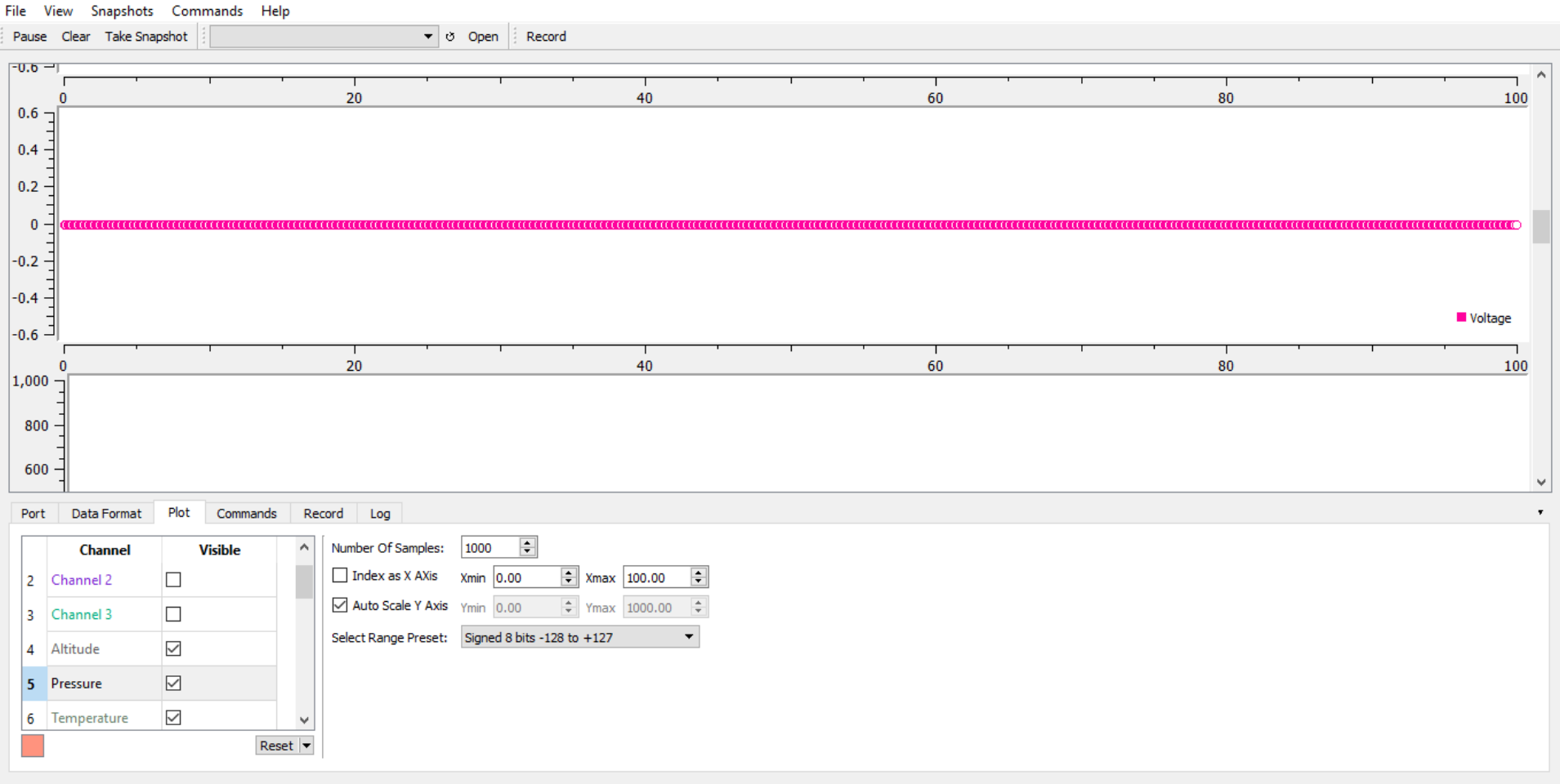
Payload Temperature Sensor Plot



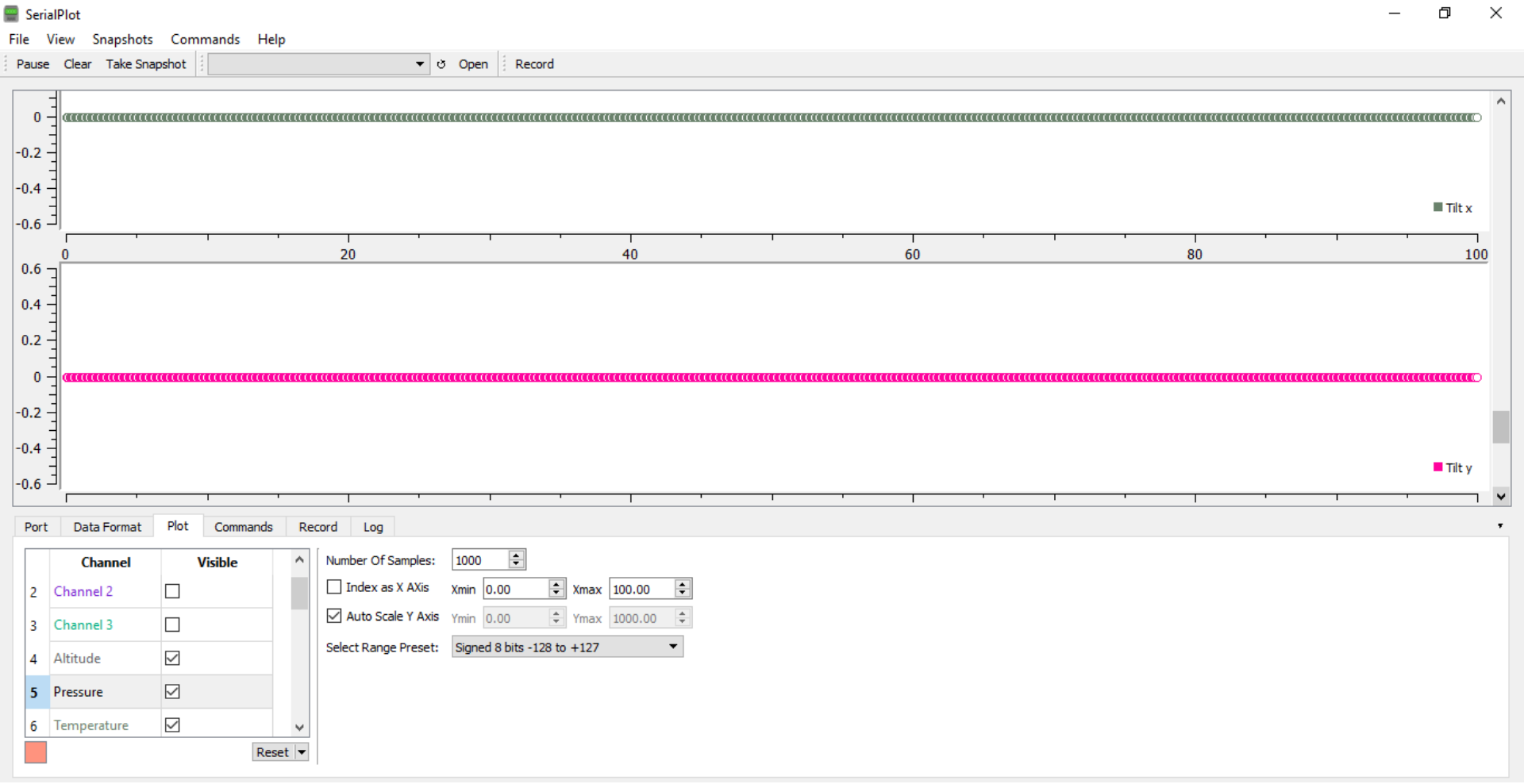
Payload GPS Plot



Payload Battery Power Plot



Tilt Sensor Plot



Wind Sensor Plot

We didn't attempt this bonus due to weight constraints

Camera Video

We couldn’t attempt this bonus due to latency caused in telemetry

Failure Analysis

Saksham Jain

Identification of Failures and Root Causes

Sr. No.	Failures	Root Cause
1.	No telemetry	The 2.4 GHz Yagi Antenna (13dbi) got stuck at the London Heathrow Airport and we didn't receive that baggage until 8th afternoon and the connectors inside it were missing. So, we received those packets using a 900 MHz Yagi antenna at the receiver side and 2.4 GHz Patch antenna at the transmitter side.
2.	During recovery, the audio beacon wasn't loud enough.	The audio beacon was muffled due to the Cansat's outside covering

Corrective Actions

Sr. No.	Failures	Corrective Actions
1.	No telemetry	Next time, we will take extra care and precaution while shipping things at the next competition site. We should have brought an extra Yagi antenna and instead shipped to USA directly. We should not have carried it with us. We should also have saved the data in an SD Card separately since EEPROM of Arduino Nano has very small memory space.
2.	The lid fell off.	The lid should have been mounted properly using the screw on top.
3.	During recovery, the audio beacon had a very faint voice.	Better choice of audio beacon which is loud enough.

Lessons Learned

Parth Hemant Darekar

What Worked

1. The Cansat passed all the environmental results and the fit check as well due to 10 mm tolerance along the height and 6 mm tolerance along the diameter.
2. The heat shield got deployed and released successfully.
3. The parachute deployed successfully, thus reducing the speed and swaying of the Cansat
4. The egg survived with no cracks.
5. A total of 9 packets were received at the ground station for which there was successful real-time plotting on the GUI
6. The heat shield did not break on landing
7. The probe had no physical damage and it was fully functional and could be used again for another flight.

What didn’t work

1. We only received the telemetry during pre-flight
2. Audio beacon wasn’t loud enough to help in the recovery process.
3. We couldn’t attempt the Camera bonus sensor as was planned earlier due to latency caused in the rest of the telemetry.

Conclusions

1. The launch was successful except only the telemetry
2. We were worried about the tumbing of the Cansat but it worked pretty well after the deployment of the parachute.
3. Huge amount of time and research was given to deployment and release phases and multiple prototypes were made which helped in the success of the launch.
4. We did not give much attention to the shipping and transportation which we will next time.
5. Since it was our first time to Cansat competition, we thank all the organizers and professors for helping us and imparting in-depth knowledge about the rocket and satellite launch.