Netaji Subhas University of Technology

CanSat 2019

Post Flight Review (PFR)

#3279

K.A.L.A.M.

Kinetic Autogyro Landing Aerospace Mission

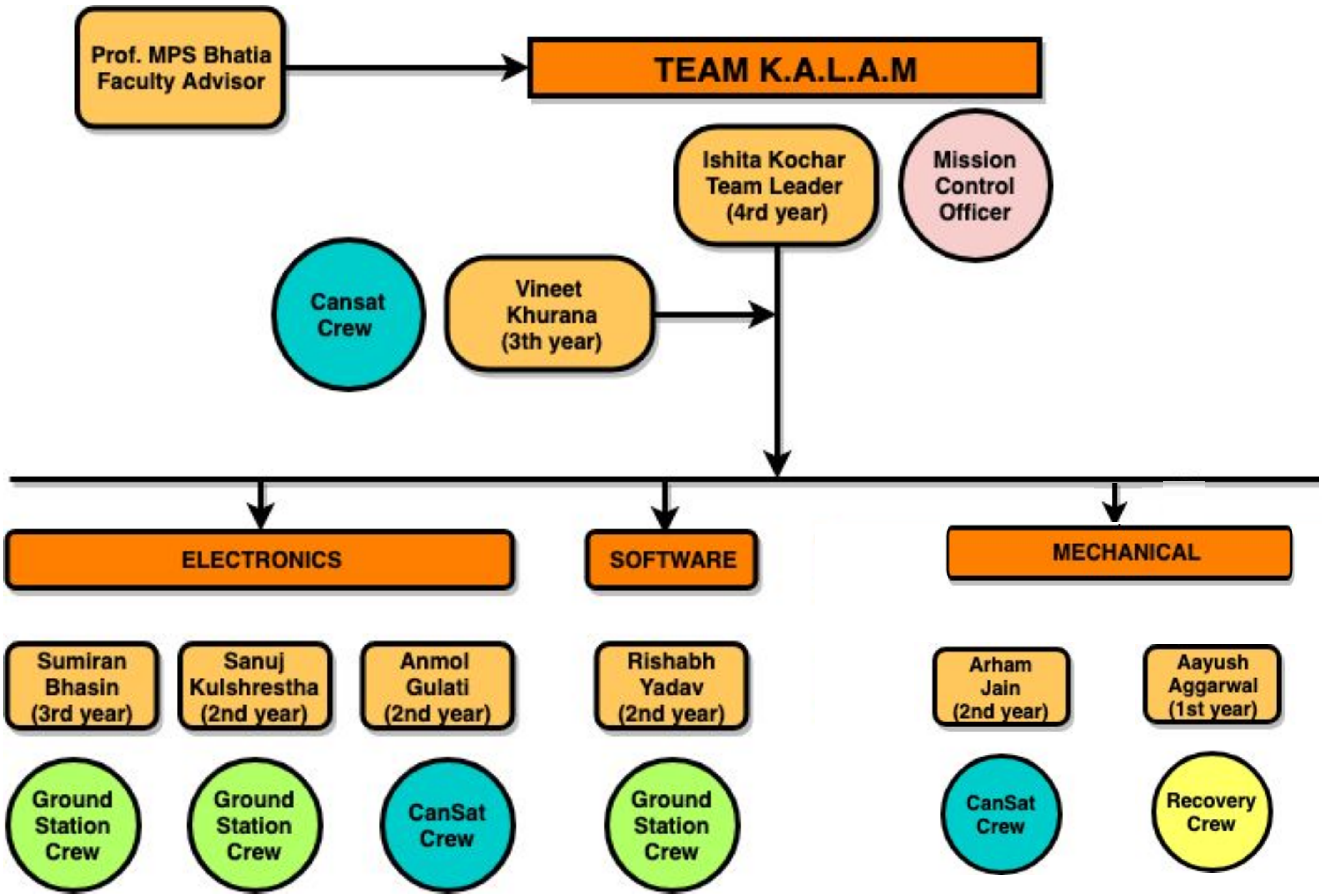
Introduction

ISHITA KOCHAR

Presentation Outline

S. no.	SECTION	PRESENTER	SLIDE NUMBER
1.	Introduction	Ishita Kochar	2-4
2.	Systems Overview	Arham Jain	5-11
3.	Concept of operations and sequence of events	Sumiran Bhasin	12-19
4.	Flight data analysis	Vineet Khurana	20-32
5.	Failure analysis	Sanuj Kulshrestha	33-36
6.	Lessons learned	Anmol Gulati	37-40

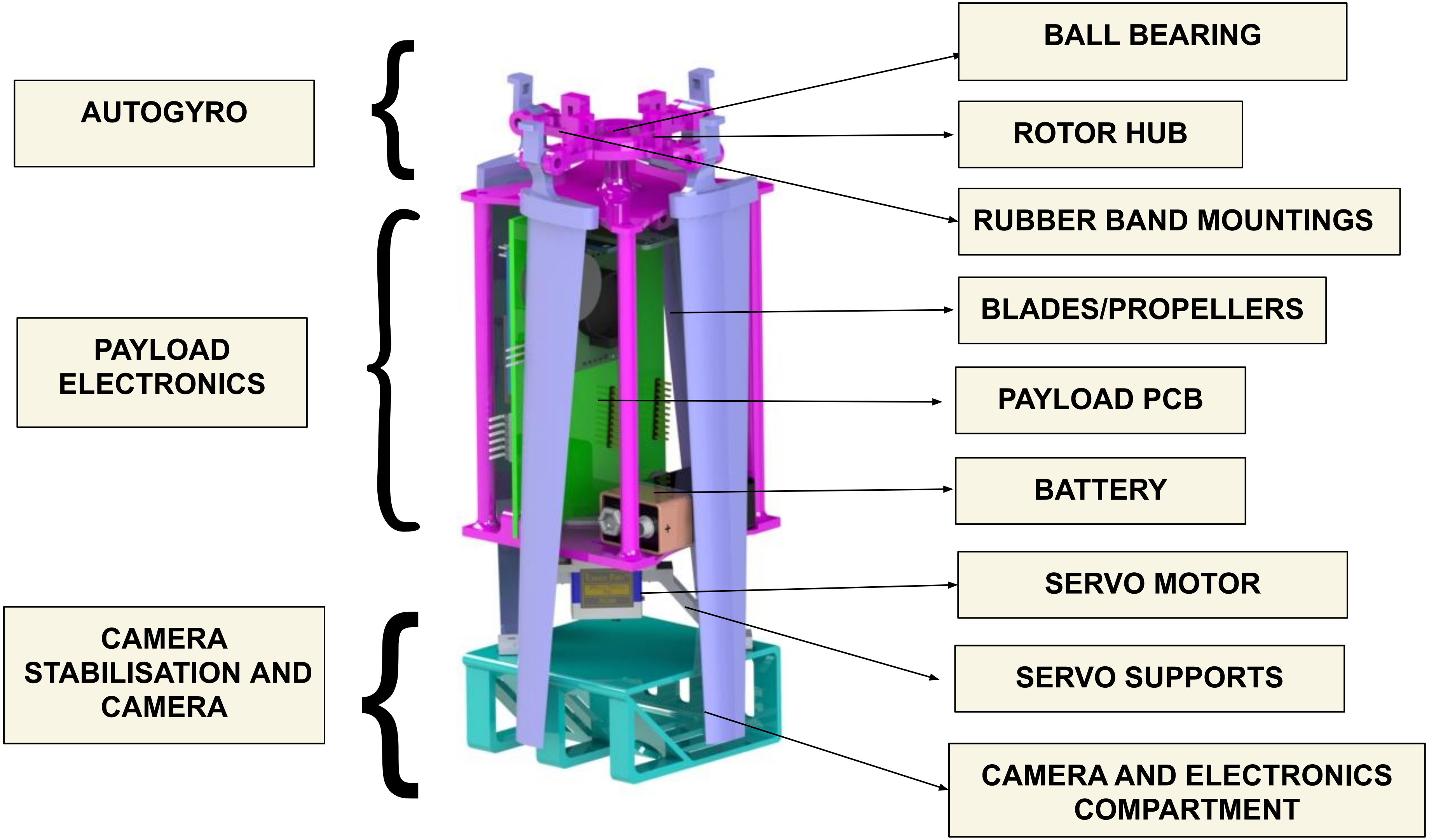
Team Organization



Systems Overview

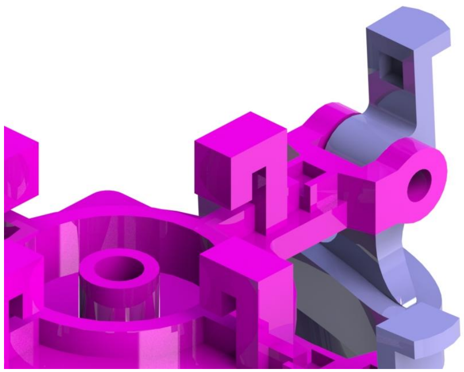
ARHAM JAIN

Payload Design Description



Payload Design Description

The payload starts to deploy after the container opening mechanism occurs.

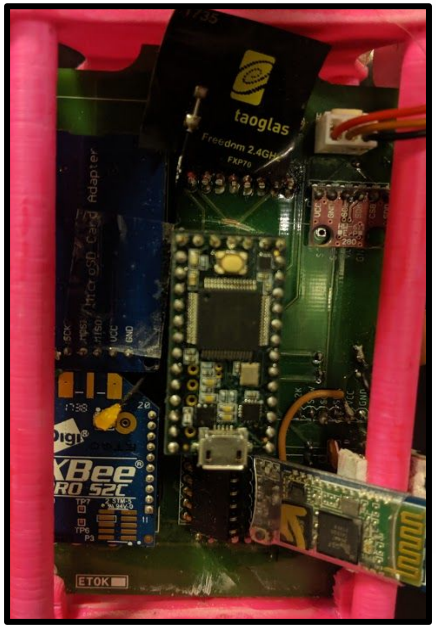


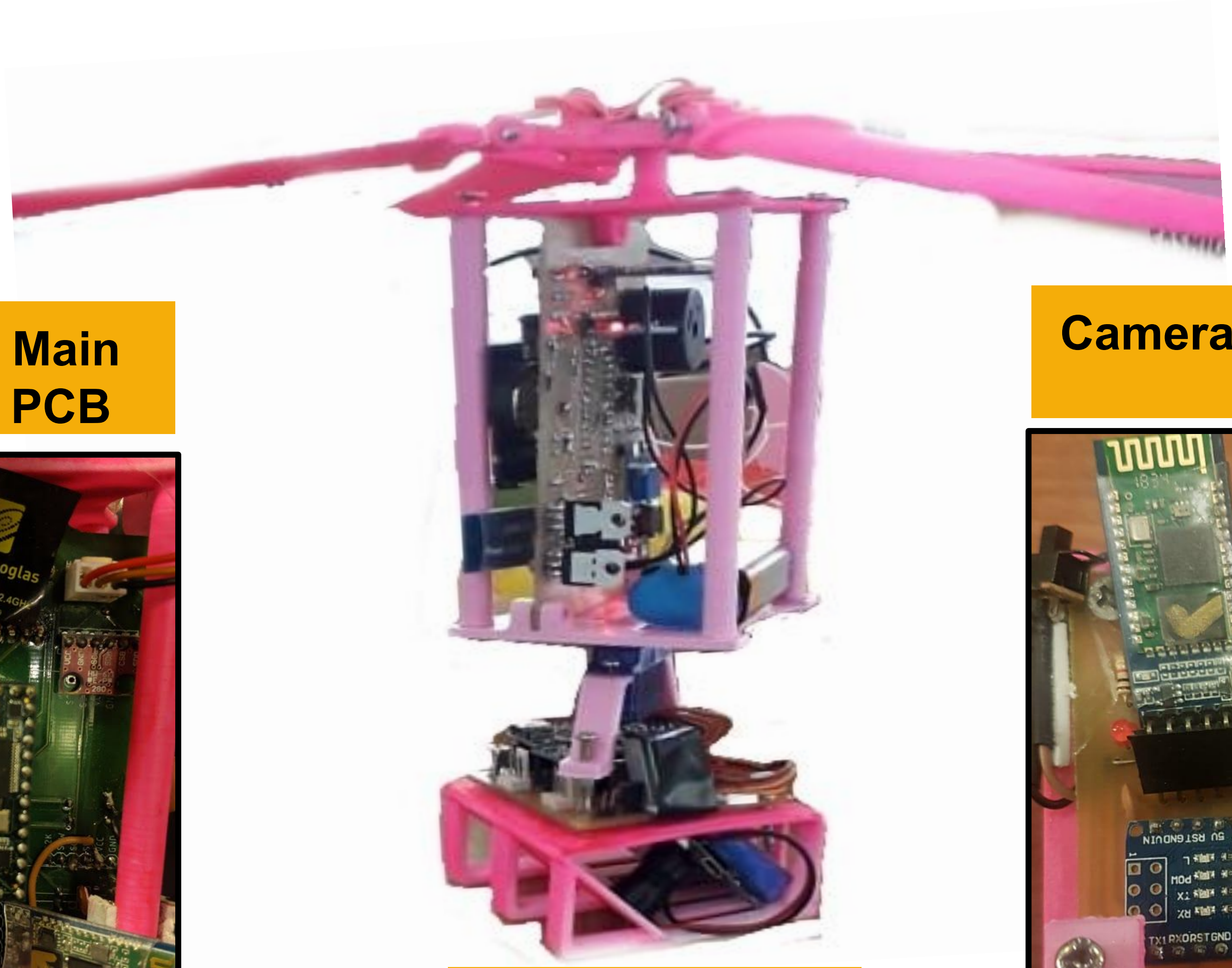
The rubber band mounted here pull the blades open as soon as payload is deployed.

The payload is fully deployed and the autogyro starts functioning.

Payload Design Description

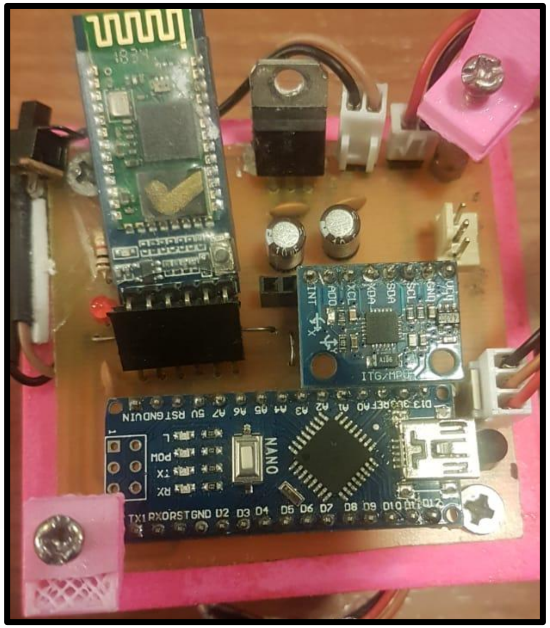
Payload Main Section PCB



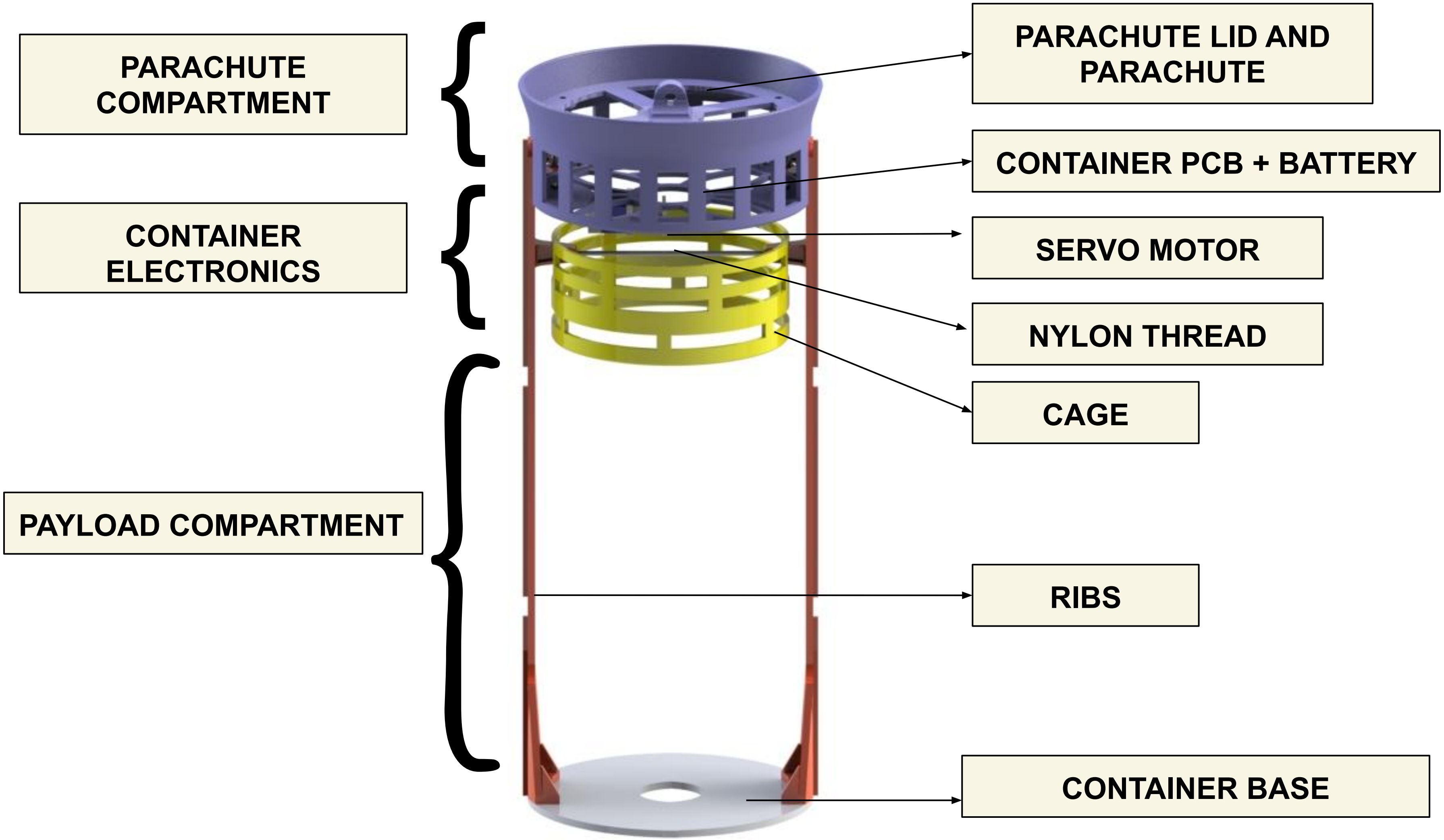


Payload Mechanical

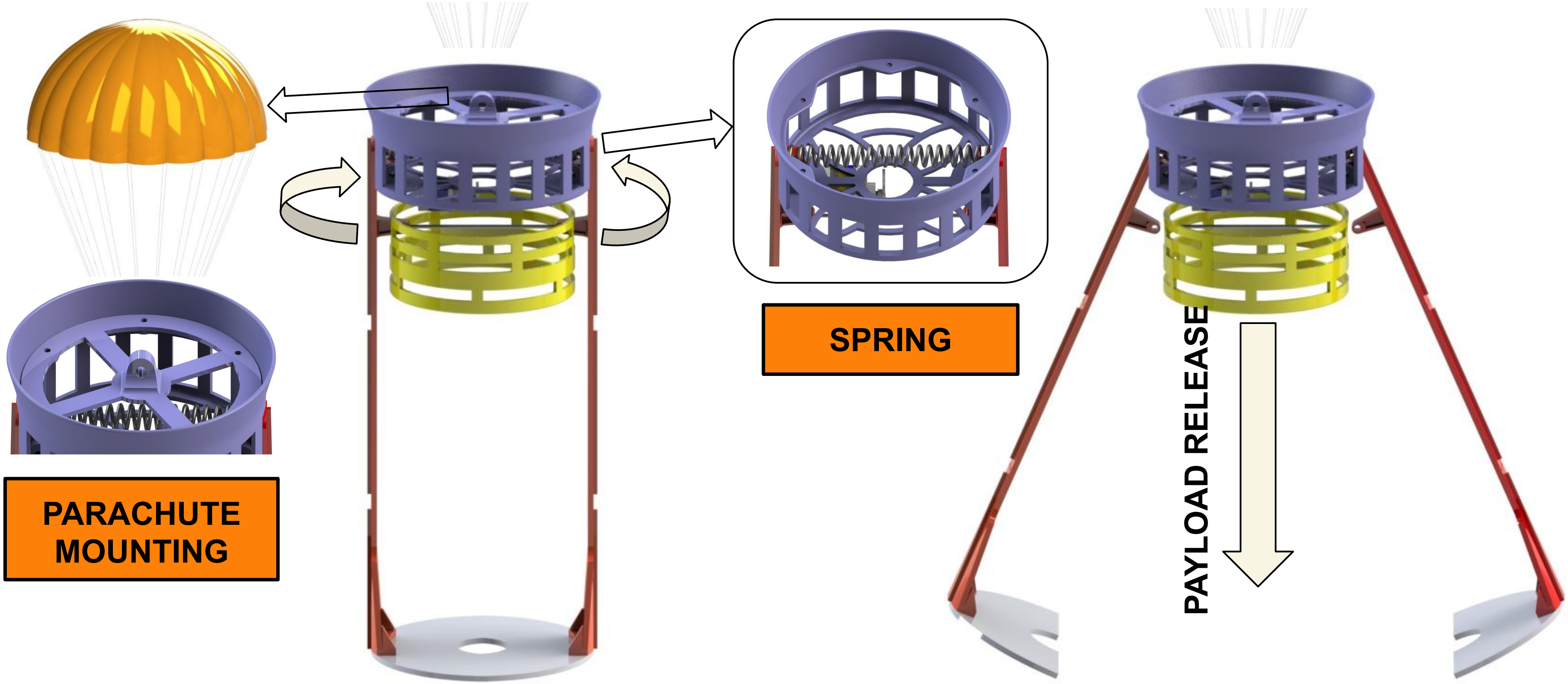
Camera Stabilization



Container Design Description



Container Design Description

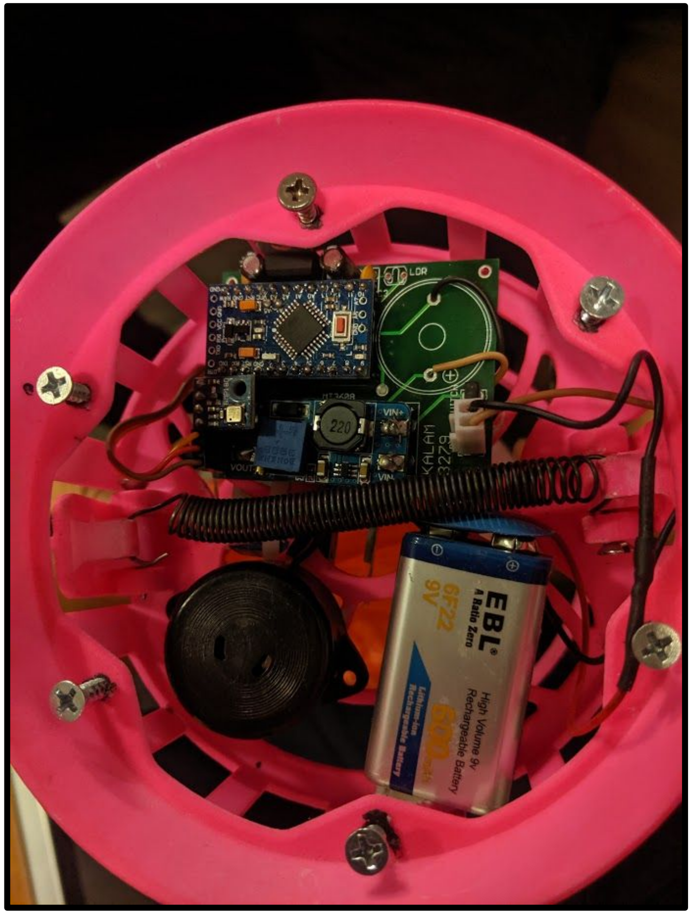


The container is kept stowed with the help of nylon thread, while the spring is trying to pull open the side supports.

The servo motor cuts the thread at 450m altitude, which leads to the spring to pull open the side supports. The payload which was kept stowed with the cage, slides down to get deployed.

Container Design Description

CANSAT



CONTAINER PCB

Concept of Operations and Sequence of Events

Sumiran Bhasin

Comparison of planned and actual Con-Ops (1/2)

Planned Con-OPS	Actual Con-Ops	Team's Remarks
• Payload integrity and Mechanical system integrity checks	**Achieved**	-
• Communication and GCS checks .	**Achieved**	-
• The software will be checked.	**Achieved**	-
• CanSat is switched ON, and telemetry starts.	**Achieved**	-
• CanSat integrated in the launch rocket.	**Achieved**	-
• CanSat released at apex at an altitude of around 700m.	**Achieved**	-
• Sensors start to collect data	**Achieved**	-
• The parachute of CanSat deploys right after the release.	**Achieved**	-
• The CanSat descents under parachute with velocity of 20 ± 5 m/s upto 450 m.	**Partially Achieved**	CanSat descents under parachute with velocity 14.7 m/s. (2% error from the prescribed lower limit)
• At the altitude of 450m, the servo motor cuts the nylon thread.	**Partially Achieved**	We expected servo cutting to take 1 second.

Comparison of planned and actual Con-Ops (2/2)

Planned Con-OPS	Actual Con-Ops	Teams' Remarks
• The stretched/stressed spring gets compressed and pulls the container ribs open.	**Achieved**	-
• The stowed autogyro blades are deployed and start rotating.	**Partially Achieved**	Auto-gyro blades stuck with hall sensor that stopped its rotation.
• The payload descent under autogyro with velocity of 10m/s.	**Partially Achieved**	Payload descent with velocity of 13.75 m/s.
• The audio beacon on both container and payload starts after landing.	**Not Achieved**	-
• The telemetry transmission stops	**Achieved**	-
• The last GPS location of payload is used to narrow down the location.	**Achieved**	-
• The .csv file is copied to the thumb drive and handed over..	**Achieved**	-
• PFR preparations are started.	**Achieved**	-

Comparison of planned and actual SOE (1/5)

1.) ARRIVALS

ARRIVAL	
Planned SOE	**Actual SOE**
• Arrival on the launch site.	• Arrived at 8 am
• Ground station is set up including antenna assembly and ground station settings.	• Setup at the launch time around 2:05 pm
• Initial start-up of the program is done and GCS is configured.	• Verified prior to the launch at 2:05 pm
• Communication with GCS is confirmed.	• Verified prior to the launch at 2:05 pm

Comparison of planned and actual SOE (2/5)

2.) PRE-LAUNCH CHECKS

PRE-LAUNCH CHECKS	
Planned SOE	**Actual SOE**
• All PCB connections are verified	• All PCB connections are verified around 9:30 am
• Working of sensors and the triggers are verified	• Working of sensors and the triggers are verified 10:00 am
• CanSat is checked for any physical damage.	• CanSat is checked for any physical damage. 11:30 am
• Safety control	• Safety control
• Weight check	• It was done around 11:55 pm
• Environmental test have been successful	• Environmental tests have been successful

Comparison of planned and actual SOE (3/5)

3.) INTEGRATION AND LAUNCH

INTEGRATION AND LAUNCH	
Planned SOE	**Actual SOE**
• Parachute is folded and placed into its designated compartment	• Successfully folded and placed parachute in its designated compartment at 2:06 pm
• The payload is secured into the container	• Verified securing of payload into the container at 2:06 pm
• The CanSat electronics are switched ON.	• The CanSat electronics are switched ON at the launch time around 2:00 pm
• The CanSat assembly is fitted into the rocket.	• The CanSat assembly is fitted into the rocket around 2:06 pm
• Launch	• Launch successful at around 2:13 pm

Comparison of planned and actual SOE (4/5)

4.) RECOVERY

RECOVERY	
Planned SOE	**Actual SOE**
• Container and payload are retrieved by the crew.	• Container and payload are retrieved by the crew at 2:40pm
• The last GPS location of the payload helps to narrow down the area.	• Thanks to the GPS coordinates
• The active audio beacon and bright pink color also aid in recovery.	• Audio beacon didn't work
• Both are inspected for any damage.	• Container was found broken

5.) ANALYSIS AND PFR

ANALYSIS AND PFR	
Planned SOE	**Actual SOE**
• The payload and camera SD card are acquired.	• Payload and camera section both recovered successfully.
• The received telemetry data and camera video are analyzed.	• Telemetry data plotted and analysed , camera video was not recorded
• Delivery of received data to jury	• Delivered successfully
• The data is utilized for mission assessment and PFR preparation.	• Mission assessment done
• Delivery of the PFR file to the Jury.	• Delivered

Flight Data Analysis

VINEET KHURANA

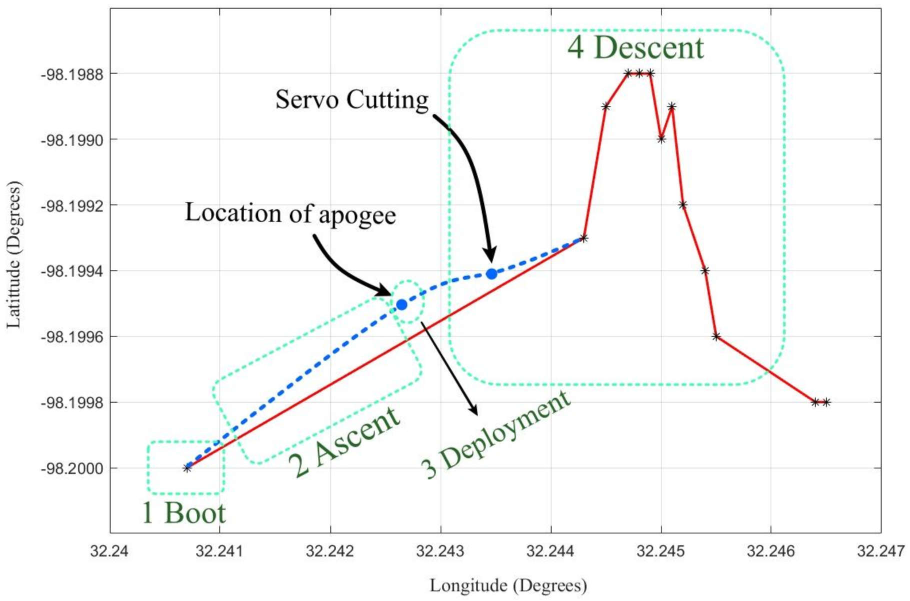
Container Separation Altitude

CANSAT released from the rocket at 771m.

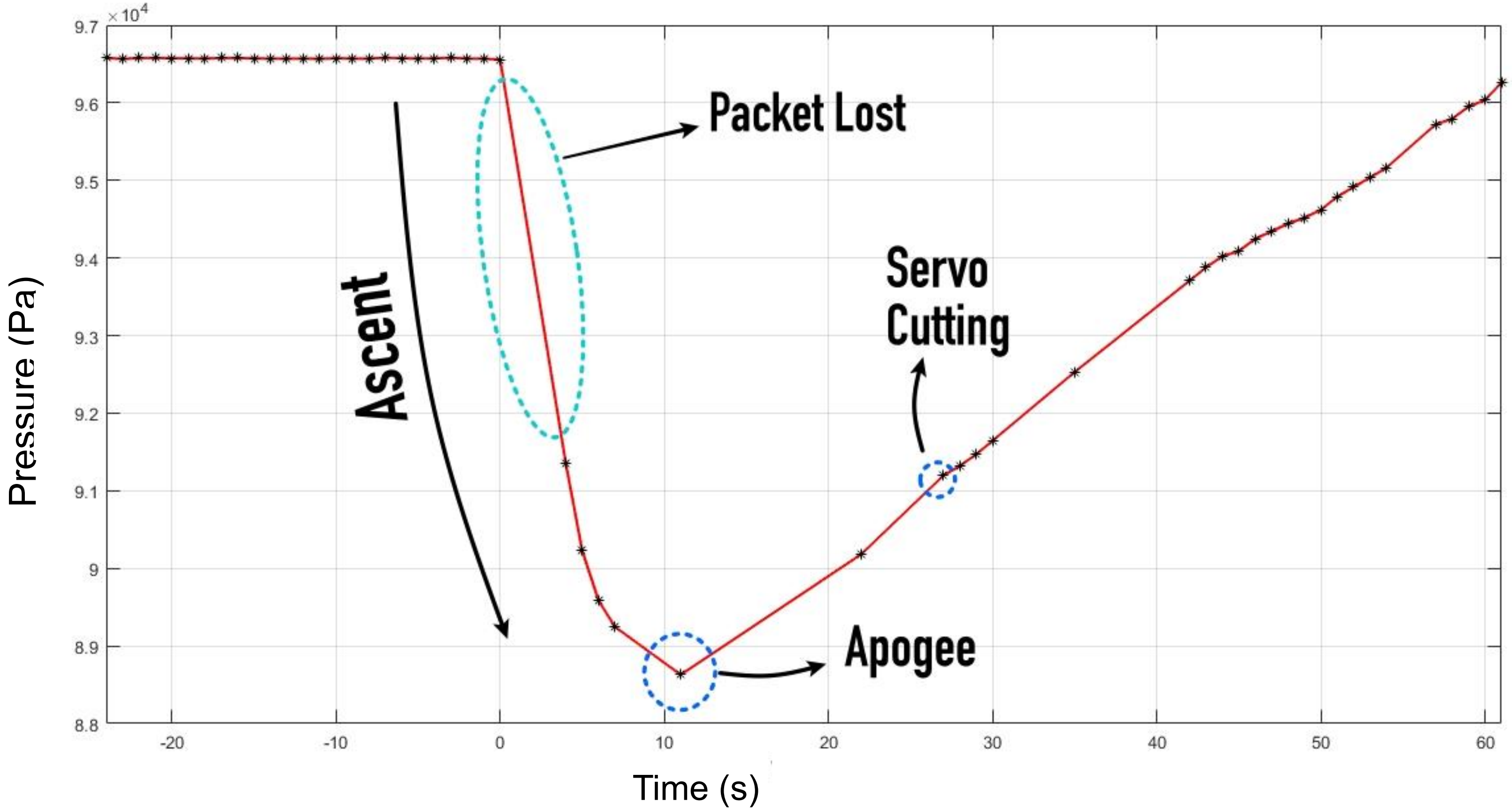
3279	806	779	567.79	90182.6	66.66	8.18	190725	-1	-1	-1	0	70	39	0	3	-1
3279	811	780	475.59	91194.9	66.25	8.27	190730	-1	-1	-1	6	-3	73	0	4	-1
3279	812	781	464.29	91319.6	66.16	8.19	190730	-1	-1	-1	6	-121	60	0	4	-1
3279	813	782	450.77	91468.9	66.1	8.27	190731	-1	-1	-1	6	-116	23	0	4	-1
3279	814	783	434.85	91645.1	66.04	8.32	190732	-1	-1	-1	8	-134	110	0	4	17
3279	819	784	355.24	92530.1	65.71	8.43	190738	-1	-1	-1	1	-50	49	0	4	-1
3279	826	785	250.3	93707.2	65.29	7.91	190746	-1	-1	-1	0	38	-22	0	4	-1
3279	827	786	235.16	93878.1	65.19	8.32	190746	-1	-1	-1	0	-31	-115	0	4	-1
3279	828	787	222.35	94022.8	65.22	8.44	190746	-1	-1	-1	6	159	79	0	4	-1
3279	829	788	216.56	94088.3	65.2	8.33	190748	32.2443	-98.1993	-1	6	115	72	0	4	-1

The actual altitude at which separation took place was measured to be 475 m. This can be verified as the software state changed from "3" to "4".

From the graph and the SD Card data we conclude that separation of payload from container took place at 475m as the software state changes from 3 to 4. We infer that software reset and loss of power for bluetooth and GPS occur due to turbulence faced during this separation.

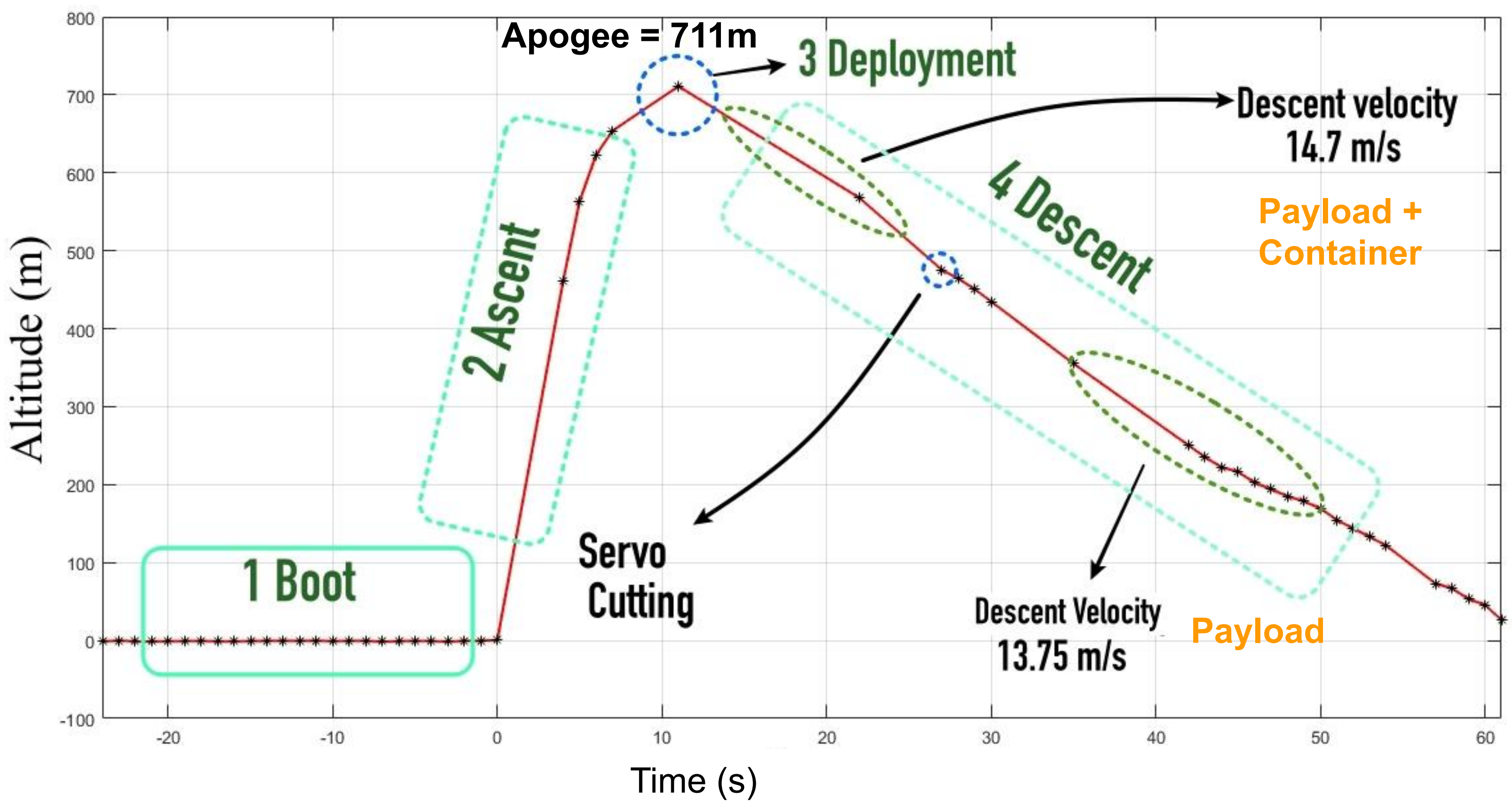


Payload pressure sensor data plot



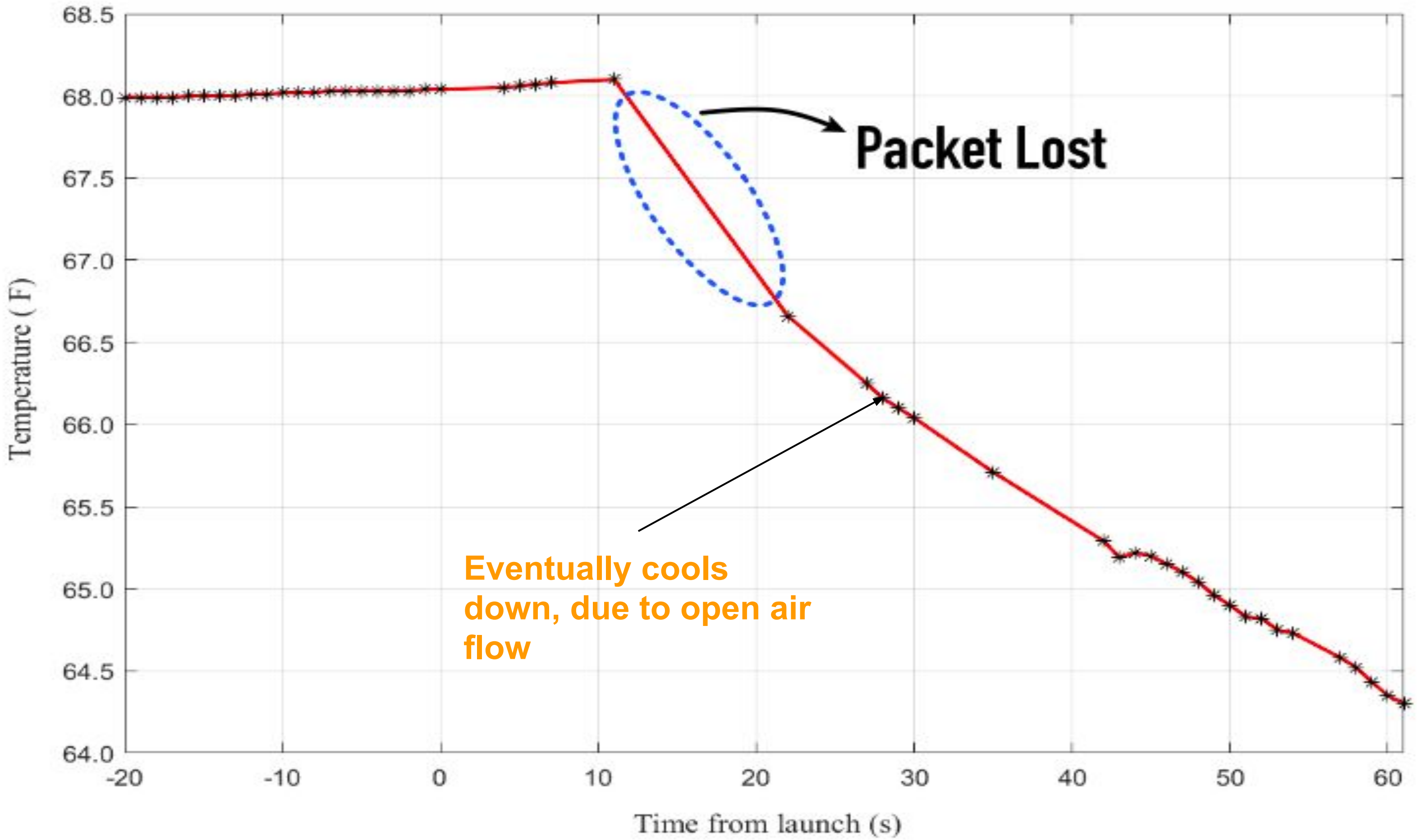
Pressure being inversely related to altitude dips during the ascent and increases while the CANSAT descends.

Payload altitude plot



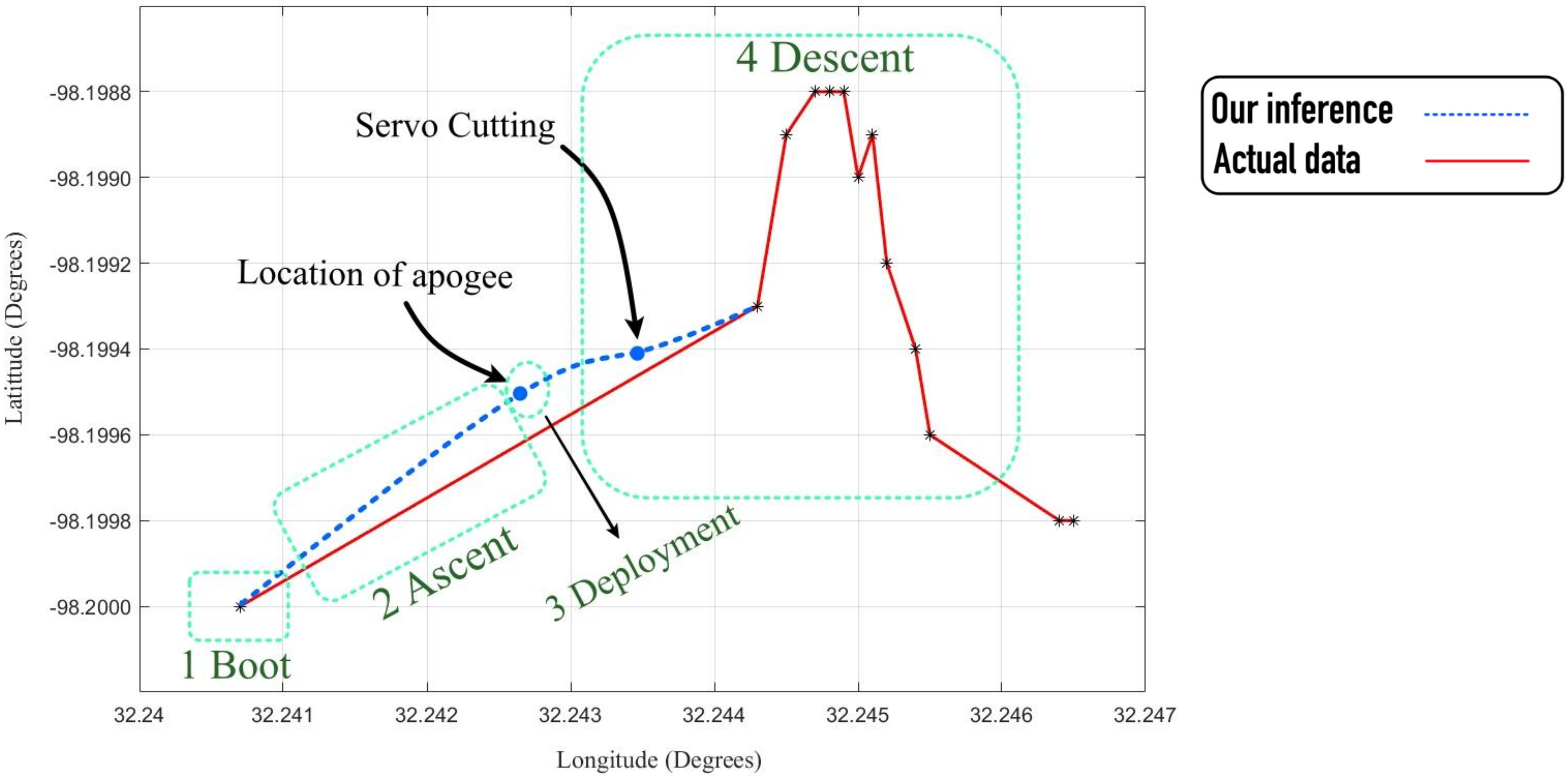
The shape of the curve clearly indicates that altitude sensing was satisfactory .

Payload temperature sensor plot



As can be seen , the temperature does not vary much during the flight but slowly decreases

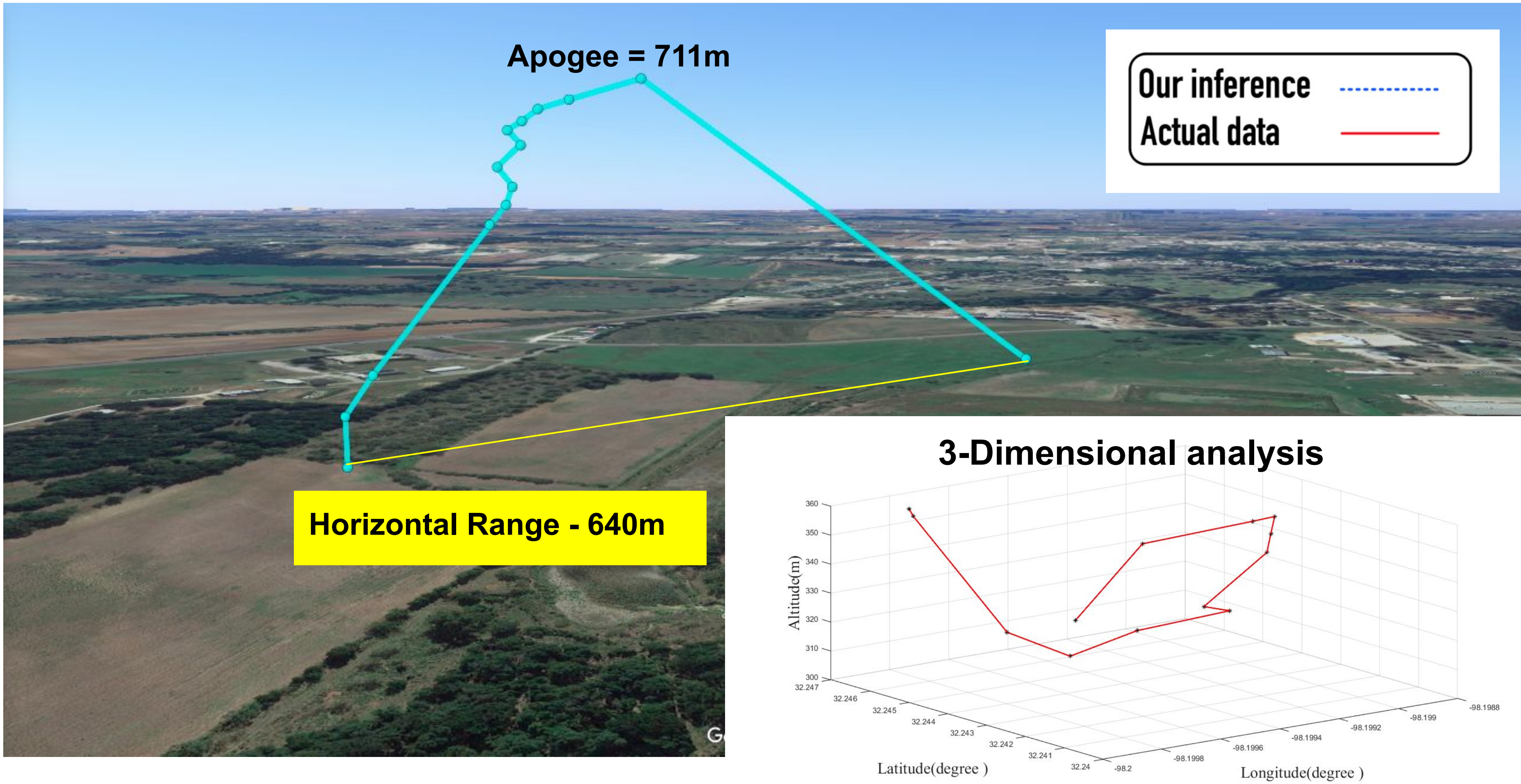
Payload GPS plot (1/2)



2 D interpolation of GPS data shows that although we missed some packets , the ones we received give us the trajectory fairly accurately . The last received packet was also close to the actual location.

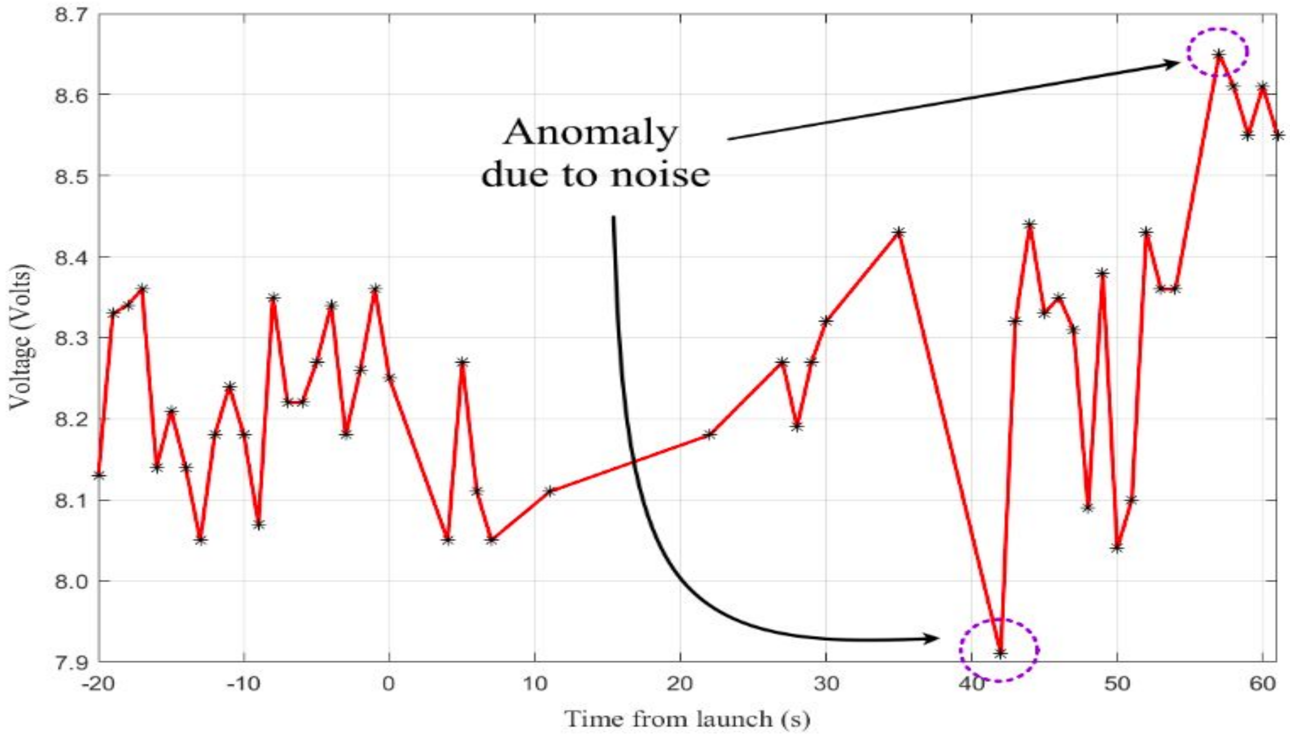
Payload GPS plot (2/2)

3-D GPS PLOTS



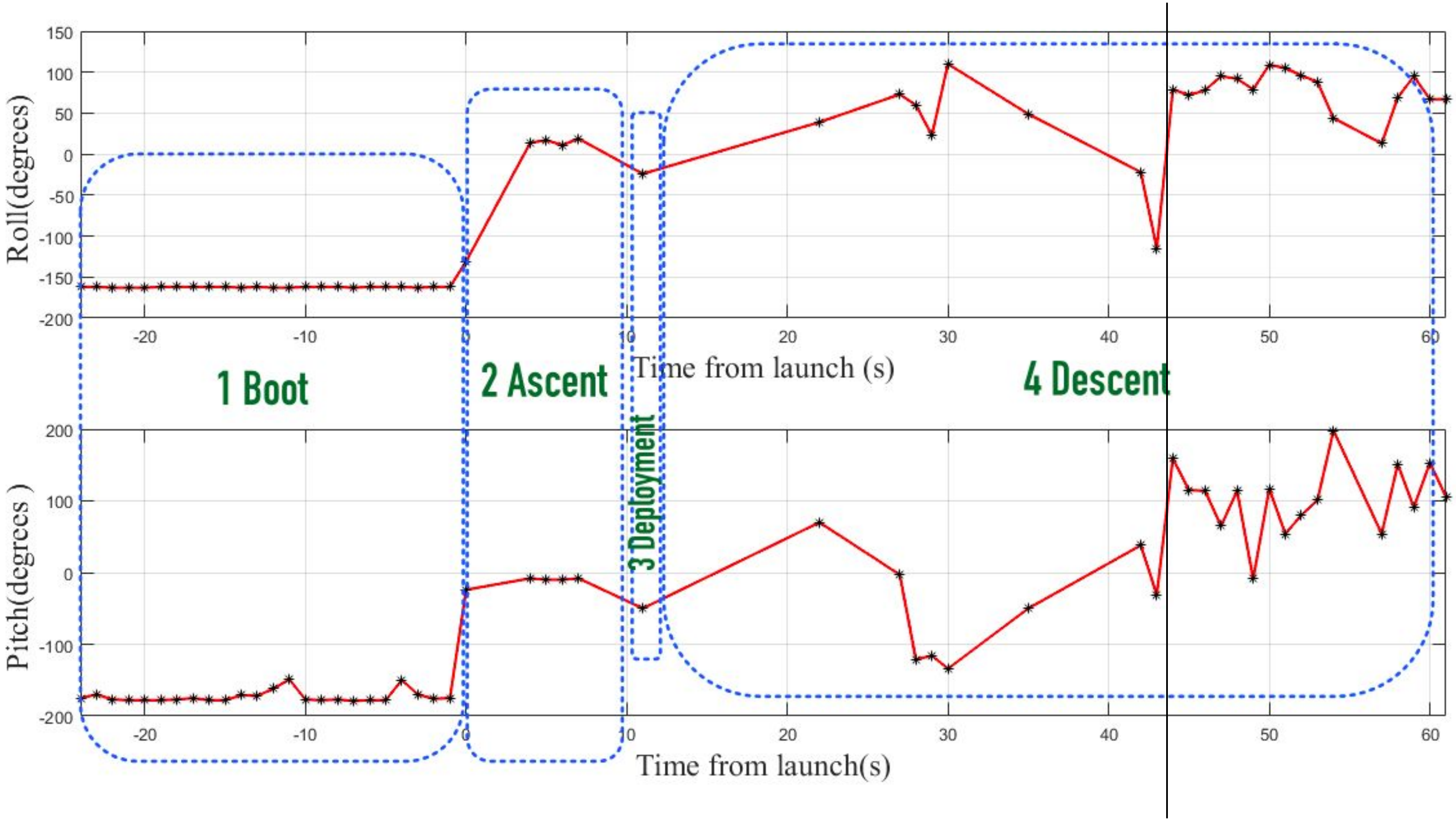
Payload battery power plot

Battery voltage almost remained constant because there was no high current drawing component.



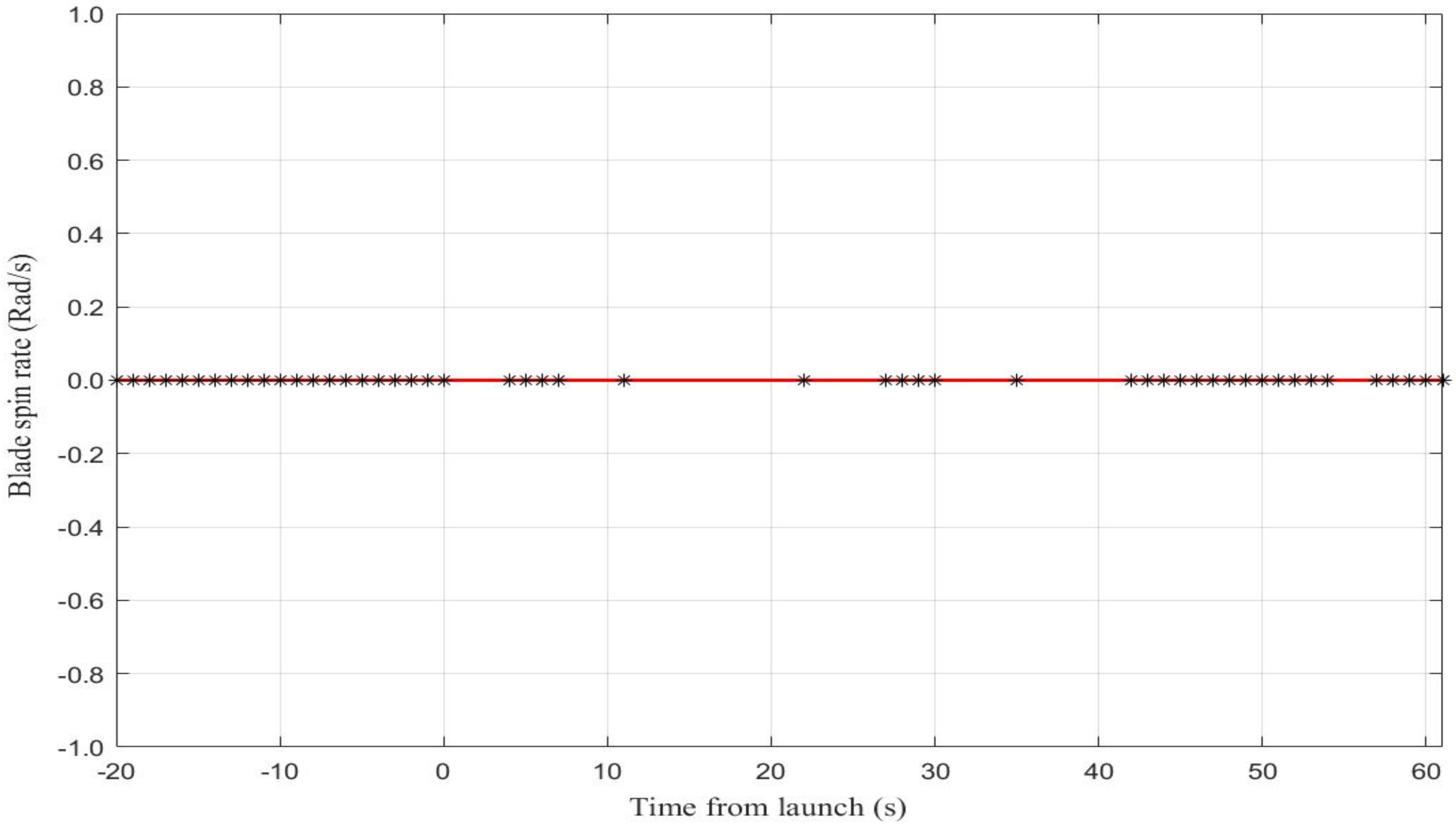
Bigger capacitors can be used to filter out these oscillations , however they were avoided due to weight constraints .

Tilt Sensor plot



An animation of the above plot shows that except for some initial turbulence , the roll and pitch move back and forth and the payload falls in the nadir direction .

Auto-gyro blade spin rate plot



Our Auto-Gyro blade spin is zero because one of the blade was stuck in container and its mounting then broke off and the rotation of rotor was also hindered by the loose wires of the hall sensor.

Camera Video (1/3)

BONUS PARTIALLY ACHIEVED

Our camera didn't record anything in the SD card during flight though our stabilization system worked.

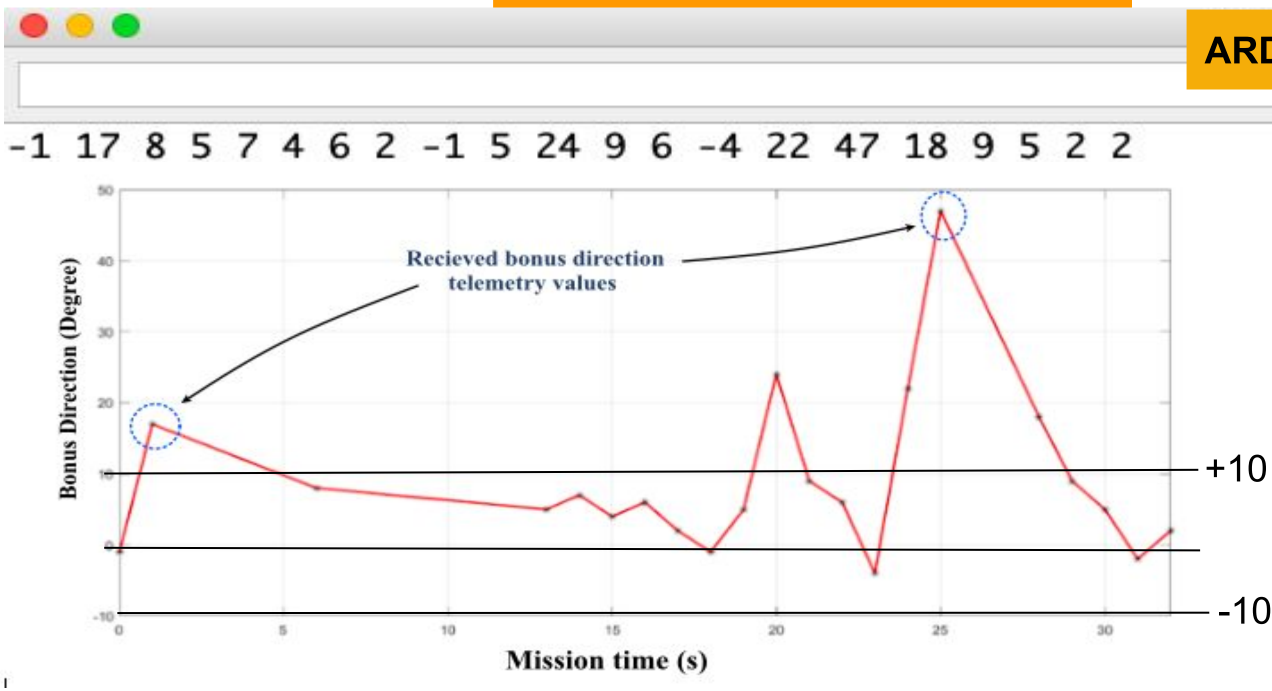
This was unexpected because camera stabilization system worked well and camera SD Card recorded video too during testing (images on left) and that's why we invested 130g weight (Current weight = 628) more by developing stabilization system in the cansat.

After the flight we found the wire that switches on/off the camera was broken. Reasons could be the jerks faced during take off or deployment.

Camera Video (2/3)

EEPROM RECOVERED DATA

ARDUINO IDE SCREENSHOT

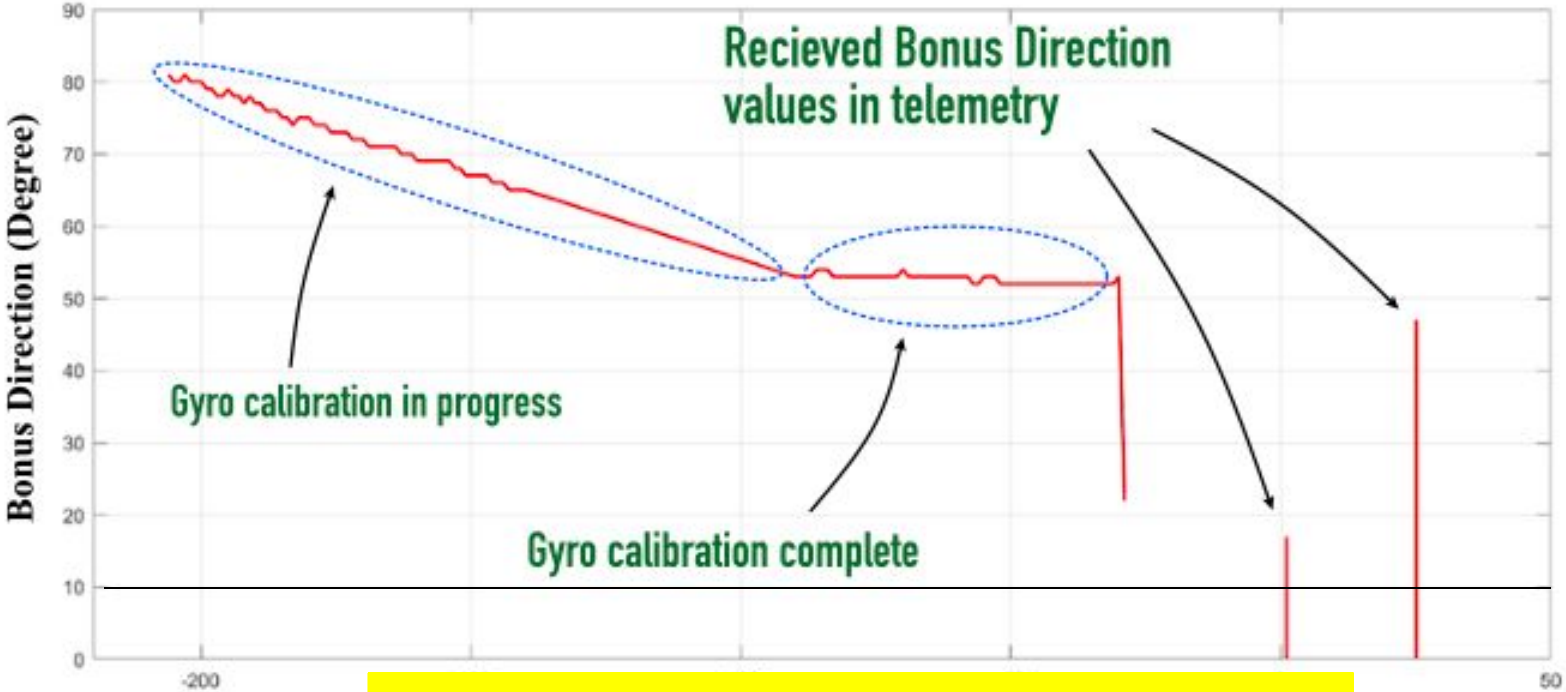


CAMERA STABILIZATION - **SUCCESS**

Most of the readings (70%) stored in the EEPROM range from -10 to 10 degree deviation. Thus, Camera Stabilization system was a major success.

Camera Video (3/3)

TELEMETRY RECEIVED DATA



BONUS TELEMETRY - **PARTIAL SUCCESS**

Due to an error in angular velocity the gyro will integrate to find the angle which results in the initial error.

Failure Analysis

SANUJ KULSHRESTHA

Identification of failures, root causes, corrective actions (1/3)

Failure	Root cause	Corrective action
Audio Beacon failure	Payload must have hit the ground and damaged the system before it could change to END state. As data sample rate is 1 Hz and and last stored altitude is 26m.	Better software alternative could've been designed for this problem and auto-gyro would have reduced the speed for current software to work
Failure of storing of Bonus video in SD Card	The camera switch on/off wire broke off and nothing was saved in the SD Card	Using firm headers to tighten the connection
CanSat weighed more than 500 grams	With an aim to complete the bonus objective , the entire camera subsystem's electronics and mechanical model were different and modular which caused an extra weight of about 130 gms	Entire payload could have one single battery reducing the weight and the mechanical model could have lost some of the weight.

Identification of failures, root causes, corrective actions (2/3)

Failure	Root cause	Corrective action
Blade stuck	Our spring was not stiff enough and it hence one of the payload blades struck in the container rib and one mounting broke off.	A better spring with stiffer spring constant could be used.
Container broken	The material wasn't sturdy enough and it struck the ground from its side supports	A better material could have been used such as carbon fibre but was avoided due to cost reasons.
Auto gyro failure	Because one of the blades was stuck in container and the mounting broke off , the payload fell off from the container leaving the blade above . The rotation of rotor was also hindered by the loose wires of the hall sensor.	More secure mounting of hall sensor and

Identification of failures, root causes, corrective actions (3/3)

Failure	Root cause	Corrective action
Received 496 packets. 87 Packets not received out of 583	For some time during launch, deployment and descent, due to power cut off ,teensy faced software reset due to which packets were not generated and transmitted	Better hardware connections and mounting of electronics may not have created this problem

Lessons Learned

ANMOL GULATI

Discussion of what worked and what didn't (1/2)

WHAT WORKED
Payload electronics and software worked successfully as expected.
Servo cutting mechanism worked.
Successful telemetry of 496 samples were received at a frequency of 1 Hz during the mission time of 549 seconds, thereby achieving a 87% success rate.
GPS coordinates were used to recover the payload.
Camera stabilization worked and the bonus direction was also telemetry to the ground station (partial).

Discussion of what worked and what didn't (2/2)

WHAT DID NOT WORK
The total mass of the CanSat was 628g. Bonus Camera Stabilization system increased the weight by 130g. A single battery could've been used in the payload system instead of heavy multiple batteries presently used.
The audio beacon could not turn on in the last 5m as the last recorded altitude by the sensor is 26m.
The container was found broken after the recovery.
Failure of bluetooth communication between upper payload and camera stabilization system at the deployment time failed us to store camera recording.
Auto-Gyro blades rotation was interfered by the placement of hall sensor and also one of the blade mounting broke because it was stuck in container.

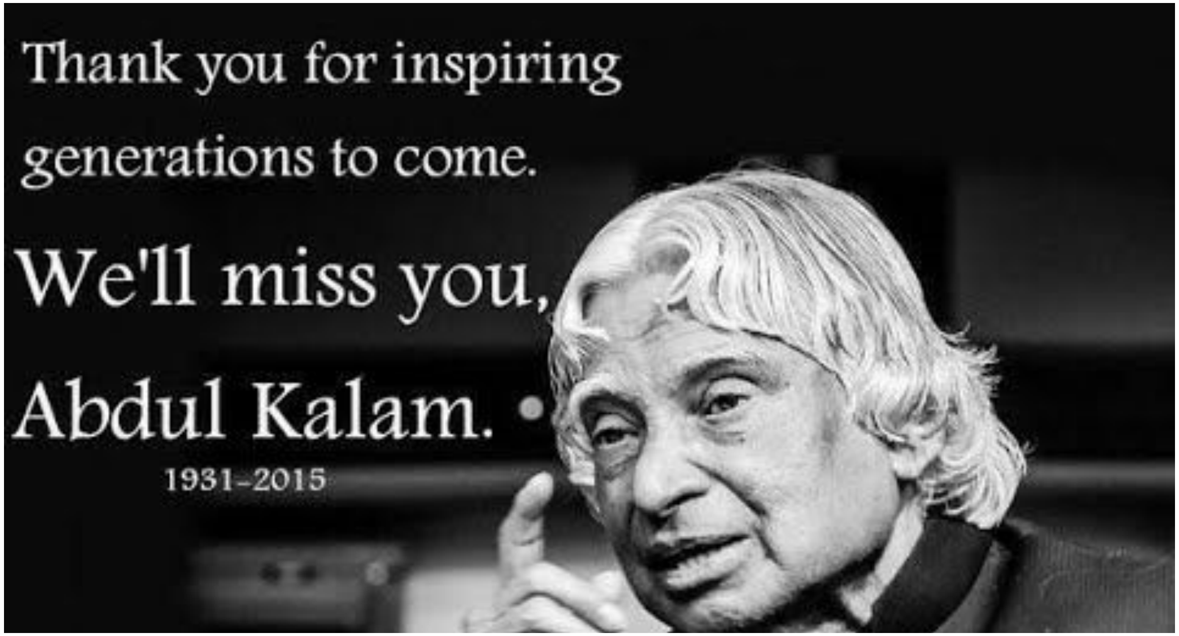
CONCLUSIONS

Successes:

- **Completed every subsystem requirement.**
- **Implemented but couldn't complete the bonus mission entirely but achieved the camera stabilization and telemetry of bonus direction (partial).**

Thanks to the organisers for their hospitality and generosity. It was truly a great experience.

We would also like to pay our respects to late Dr. Avul Pakir Jainulabdeen Abdul Kalam for being a constant source of motivation to us.



MISSILE MAN OF INDIA KNOWN FOR HIS PIONEER WORK IN THE DEVELOPMENT OF LAUNCH VEHICLE TECHNOLOGY