Flight Readiness Review

Team ID : 2022ASI-049
Team Name : Team Kalpana

TESTS

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Mission Summary

Main Objectives

1. Design the cansat having weight of 0.700 kg (+/- 0.050), with dimensions not more than 0.125m diameter and 0.310m height.
2. The cansat will be launched to an altitude of 800 to 900 m from the ground level.
3. The cansat shall contain a total of 2 descent control mechanisms to be used at two different stages while descent.
4. For the first mechanism the cansat shall deploy 1st parachute immediately after ejection from rocket.
5. For it the descent rate shall be 20 m/s (+/- 5 m/s) .
6. For the second mechanism the cansat shall deploy 2nd parachute at an altitude of 500m (+/- 10 m).
7. For it the descent rate of the cansat decreases from 20 to (1-3) m/s.
8. For the entire time cansat shall stabilize using Mechanical Gyro control.

Optional Objectives

1. Novel descent control and Innovative materials.
2. Additional innovative sensor and communication system.
3. Provision of video capture from separation till final touchdown.
4. Innovative recovery techniques viz. HAM radio/ advance beacon.
5. Innovative quality and Reliability analysis methodologies.

External objectives

1. Now more people are aware of the Cansat competition in our country.
2. India is organising cansat for first time so we are trying to get an esteemed position in Cansat India 2023.
3. We wish to get experience, knowledge and make a student satellite and successfully launch it.

GUI DESCRIPTION (1/4)

Team Name, I.D & Logo

GUI Control Panel

GNSS Data

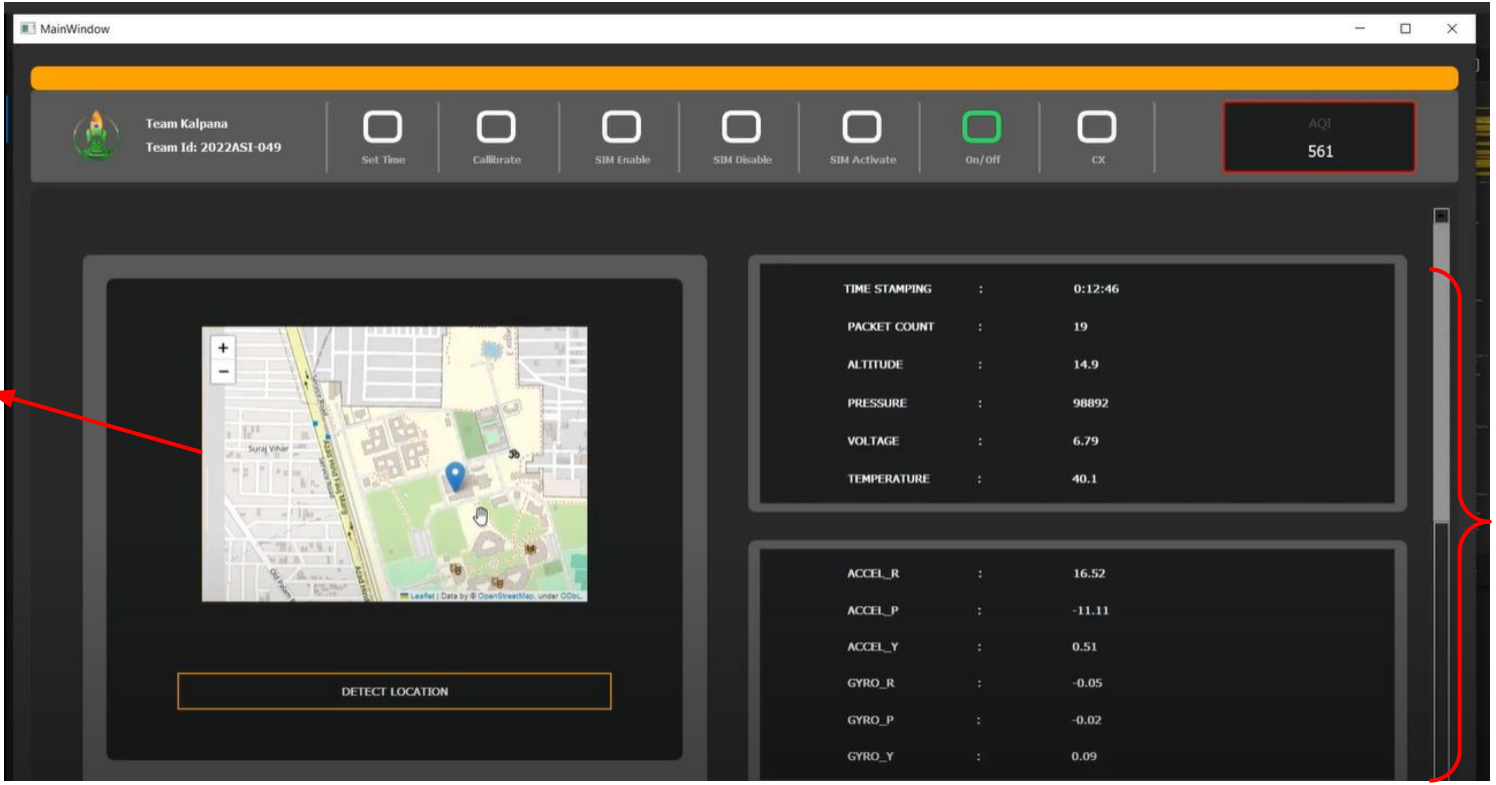
AQI Sensing

Graphs Plotting Sensor Data in Real Time

Software States

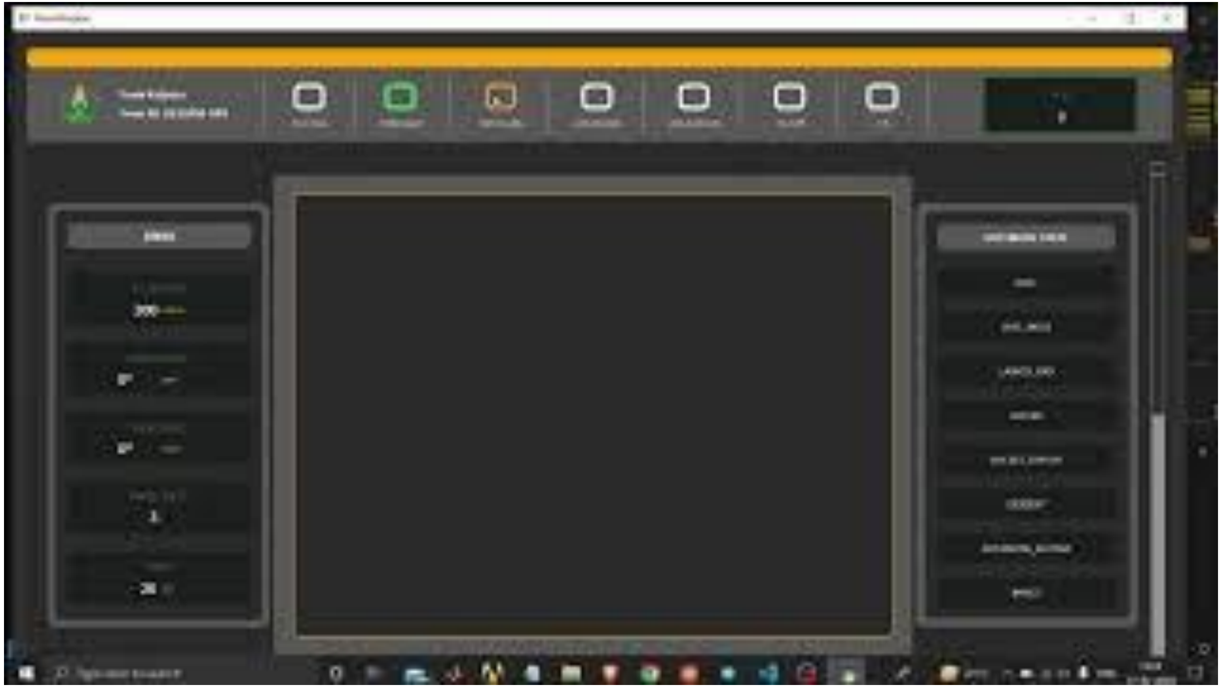
GUI DESCRIPTION (2/4)

Live Location Detection with Latitude and Longitude obtained from GNSS



Data Packet fields are updating in real time as shown

GUI DESCRIPTION (3/4)

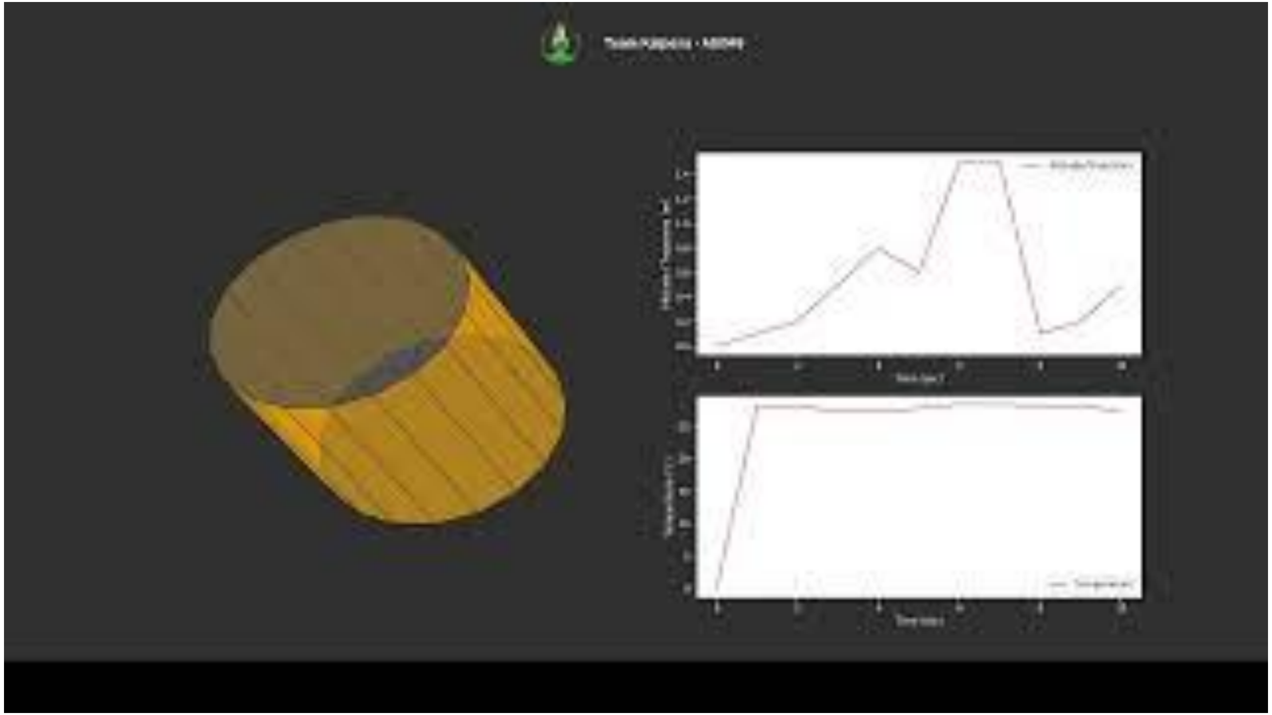


Click Picture to view GUI recording

GUI recording describing all the functionalities, features and modes of Operation of CanSat.

Telemetry is plotted in real time on receiving through XBEE

GUI DESCRIPTION (4/4)



Click Picture to view GUI recording

1. Developed a new GUI screen specifically for visualizing the orientation of the CanSat using gyro values obtained from the MPU sensor.

2. Integrated real-time data processing to interpret gyro readings and translate them into graphical representation of CanSat orientation.

3. Implemented Trajectory animation and variation of temperature according to the time and Trajectory.

GUI FUNCTIONALITIES

GUI Commands	FUNCTIONALITY
Set Time (s)	This Command is used to set the teensy’s RTC to 00:00:00 timestamp.
Calibrate (c)	• Once the "Calibrate" button turns blue, it indicates that the CanSat has acknowledged its readiness to accept commands. • This button activates sensor calibration, establishing the current position of the CanSat as the reference altitude. • Once this process is completed, the "Calibrate" button will turn green.
Sim Enable (e)	This command will enable the simulation mode.
Sim Disable (d)	• This button deactivates the simulation mode, causing the "Sim Enable" and "Sim Activate" buttons to turn red. • When re-enabled, these buttons will return to their original green color.
Sim Activate (a)	• In the Simulation Activate state, the Ground Control Station (GCS) will transmit pressure values to the CanSat at a rate of 1Hz. • The CanSat will then generate altitude values and data packets based on these synthetic pressure values. • The software state will be designated as "Simulation Mode" (‘1’ in the corresponding data packet field).
On/Off (x)	This command enables/disables telemetry, with green and red colors indicating the respective state.
CX	This command activates the plotting of the Canvas, allowing us to begin capturing data from sensors.
Reset (r)	• This command performs a hard reset of the entire CanSat. • It proves useful in cases of system errors or GUI hang-ups.

ADDED VALUE PROPOSITIONS(1/2)

On board charging facility for power bus - mitigating the requirement to constantly remove and install batteries.
Center of Mass and Reaction wheel of mechanical gyro system is **closer to the gimbals** - reducing Inertia, and increasing control authority thus, increasing the stability of the system.
We have **Separate** Microcontroller unit and Inertial measurement Unit **for gimbals** that offer accurate and critical servo control by utilising **Kalman filter and PID control**.
Our CANSAT is **stable** along **all 3- axes** with the help of mechanical gyro system.
We have features for **live location**, **AQI** and also have an **on board camera** to record footage during descent.
We have used light weight **shock absorber foam** to allow the CanSat to endure shock on impact.
A gui screen for **3D modeling (visualisation)** of the CanSat from the values of our rotation sensor.
We have a second GUI screen that will plot the **trajectory of the CanSat** during its flight .

ADDED VALUE PROPOSITIONS(2/2)

A **hard reset signal button** is developed to make the reset of cansat systems more robust instead of constant power switching.
The **averaged altitude values** transmitted via telemetry serve as inputs for determining the software state, aiming to mitigate miscalculations or misreadings.
If the **BMP280 sensor malfunctions** or ceases to function for any reason, our CanSat will rely on alternative functionalities based on **real-time clock (RTC) timestamps**.
To **expedite** the process of acquiring a **fix** with the GNSS system, we've integrated an FXP 830 patch **antenna**.

Light-weight shock absorbing foam

VACUUM TEST

Purpose:
Vacuum test is conducted to simulate the low pressure condition experienced at high altitudes (850m - 950m) and to check how GUI responds to different pressure condition and altitude variations and ascent failures.

Setup:

- For vacuum test, we connected vacuum cleaner with a self-made vacuum chamber that housed the cansat
- A gasket installed to make the vacuum chamber air tight
- Pressure valve was used to adjust the pressure manually.

Results:

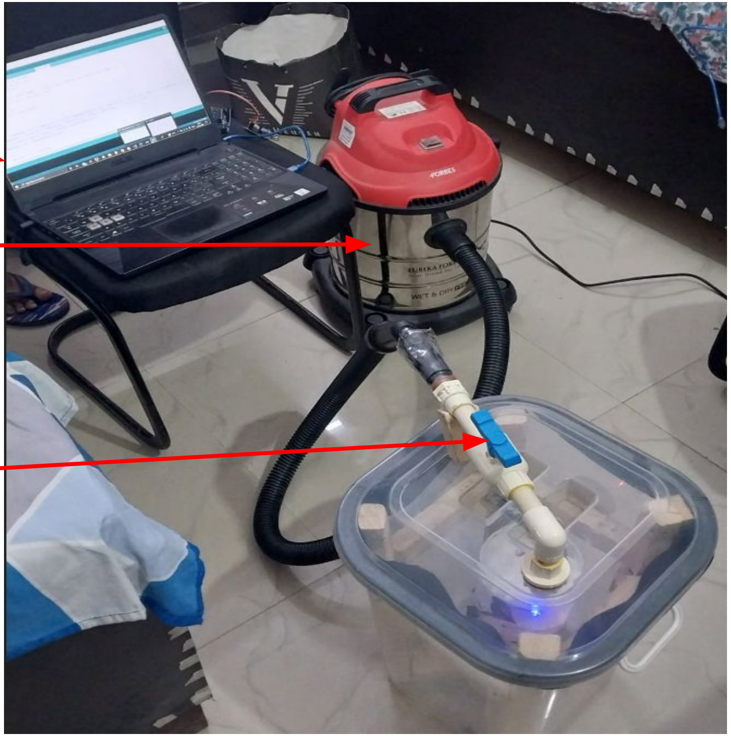
- Our GUI is handling pressure variations and ascent failures by releasing the parachute even if its does not reach the required altitude accurately and calibrating the altitude readings appropriately.
- Software state is also varying accurately with change in pressure.
- All expected mission operations are taking place according to their corresponding software state
- The GUI is responding well to all edge cases (if the CanSat deploys before reaching the apogee)

VACUUM TEST SETUP

GUI
Real-Time
Readings

Vacuum Cleaner

Pressure Valve



Vacuum
Chamber

VACUUM CHAMBER & PRESSURE TESTING

Click Picture to view Vacuum and Pressure testing video

Indicator	Function	Description
Blue LED	EPS is Operational	When CanSat is turned on for Flight (SW state = Test Mode) & Simulation Mode (SW state = Launch Pad).
Red LED Blinking	Camera Recording started	At 900m, CanSat is released camera starts recording & GYRO stabilization becomes active. (SW state = Deployment)
Buzzer Beeps	Impact on Ground	When CanSat hits the ground (altitude < 2m) Buzzer beeps and GYRO stabilization becomes inactive. Camera also stops recording. (SW state = Impact)

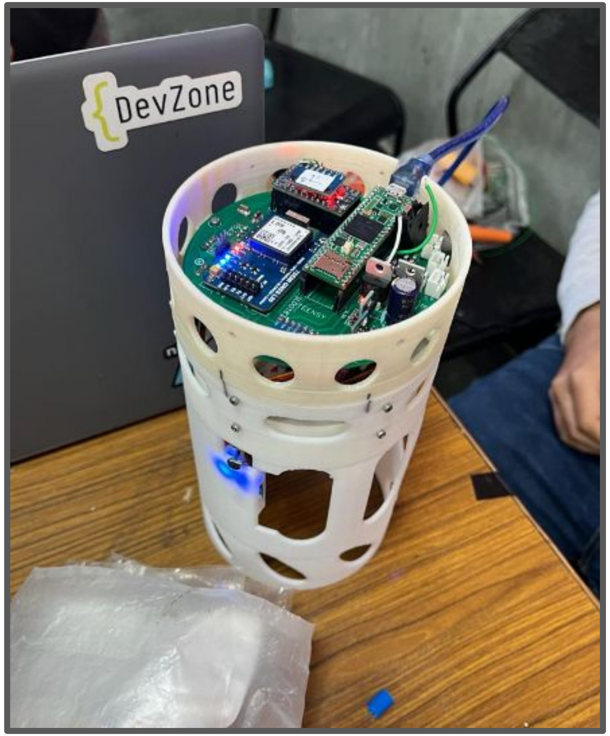
GUI RECORDING DURING VACUUM TEST

Graphs Plotting Telemetry in Real TIme.

Software States Changing according to altitude.

Click Picture to view GUI recording during vacuum test

ASSEMBLY FIT CHECK



The PCB and components are snugly fitted within their respective compartments.

HOUSING AND FIT CHECK (1/2)

Click Picture to view Housing and Fit Check Video

HOUSING AND FIT CHECK (2/2)

Click Picture to view Housing and Fit Check Video

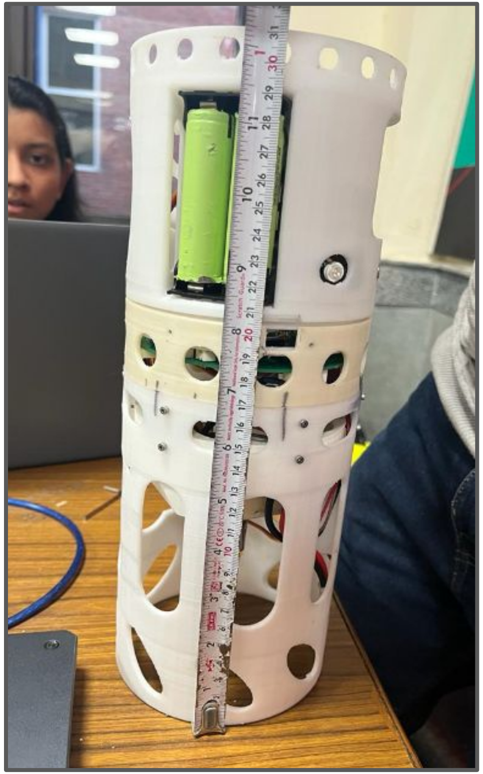
Secondary Parachute Deployment Mechanism.

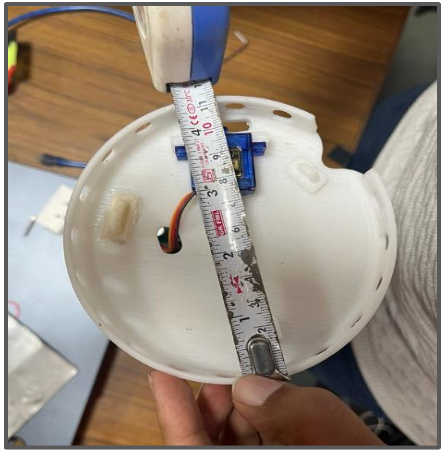
- **Descent to 500m:** As the CanSat descends to an altitude of 500 meters, the onboard system detects this threshold and triggers the deployment of the secondary parachute.
- **Parachute Deployment Mechanism:** A servo motor rotates a shaft that releases the lid covering the secondary parachute compartment. This action allows the parachute to deploy freely.
- **Speed Reduction:** The deployment of the secondary parachute, combined with its inflation, effectively reduces the speed of the CanSat descent to a targeted speed of 2 meters per second, with a tolerance of ±1 meter per second.
- **AeroBrake Release:** Achieving the desired descent speed, the AeroBrake SW state is achieved. This marks the successful completion of the descent phase, ensuring a controlled and safe landing of the CanSat payload.

CANSAT WEIGHT AND HEIGHT

CanSat is weighing not more than 0.75 Kg within limits as specified in Mission Guidelines

CanSat Assembly with Parachutes

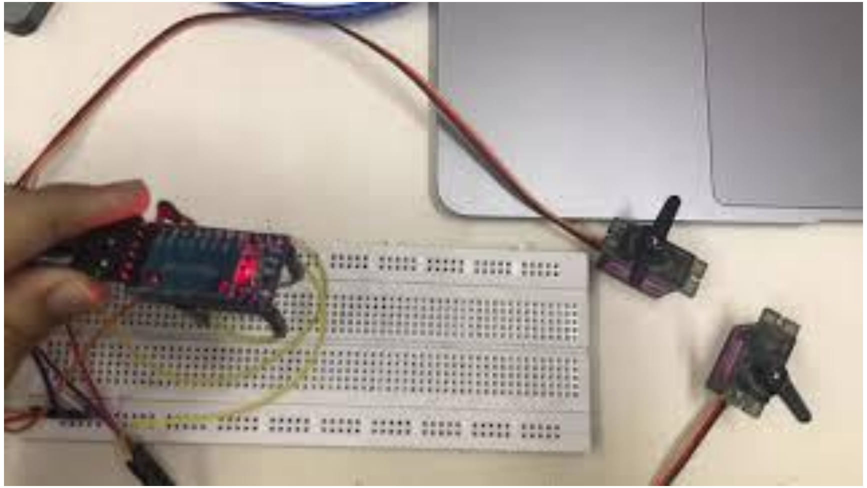


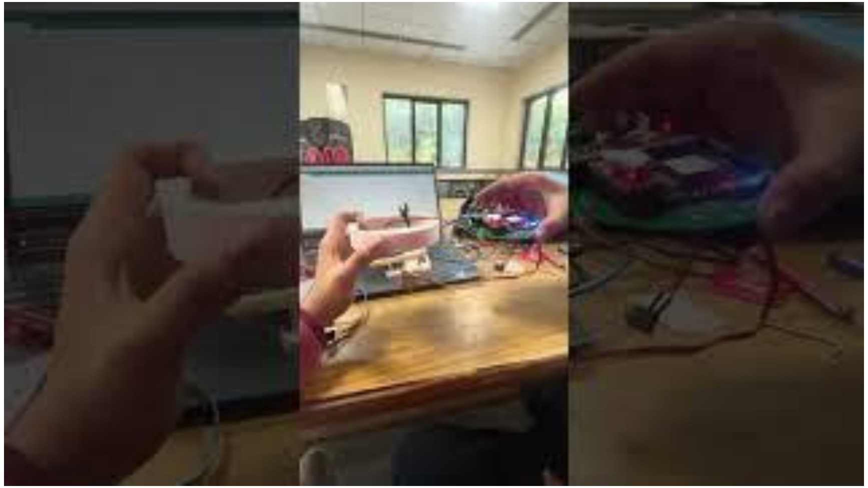


1. Diameter is 110mm complying with the guidelines of diameter being less than 125mm.
2. Length of CanSat is 310mm within the limits which is 310mm itself.

GIMBALS

Click Picture to view the Gimbals simulation Video

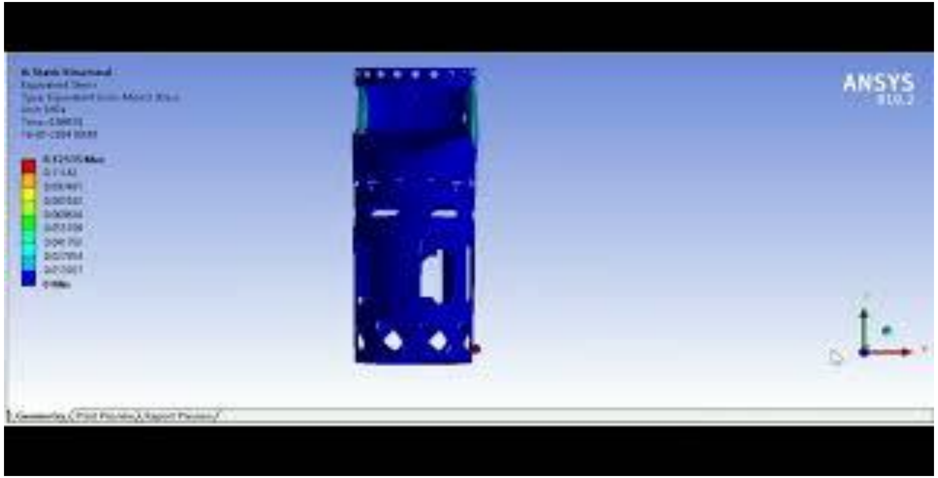




We have conducted testing on our gimbals and stabilization mechanism, and the results are promising. The gimbals are rotating accurately in alignment with the orientation of our CanSat, exhibiting minimal noise and errors.

DROP TEST SIMULATIONS (1/2)

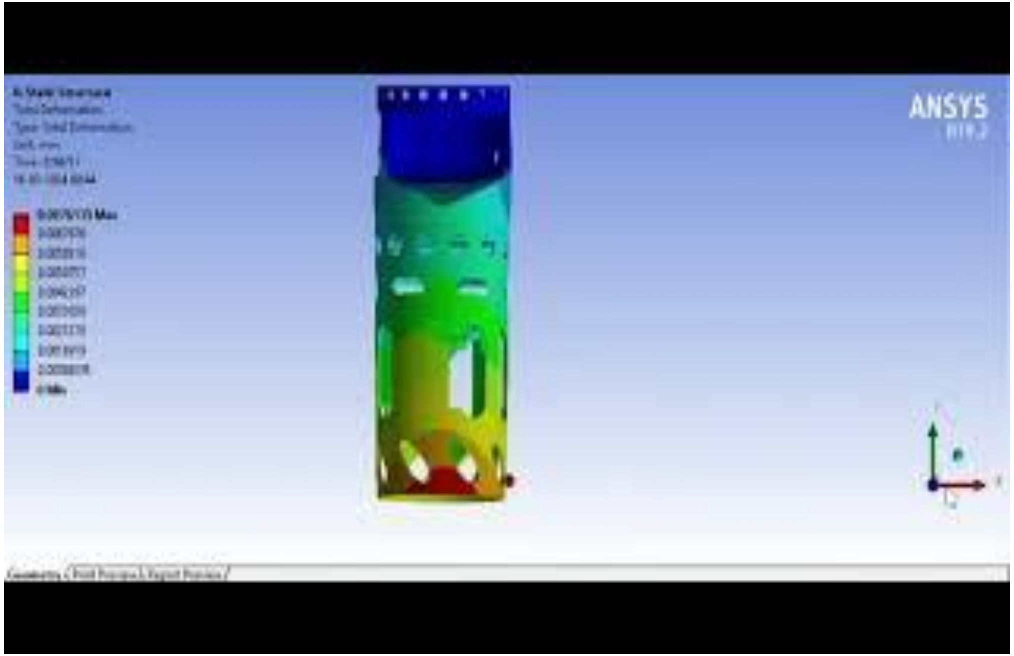
Click Picture to view the drop test simulation Video



Result:
The model will undergo a maximum stress of **0.12535MPa** on hitting the ground, while most of the region of Cansat is free of any stress generated.

- Cansat would be dropping at a speed of about 2 m/s when both aero brakes are deployed.
- When the Cansat impacted the earth, its speed would abruptly drop from 2 m/s to 0 m/s, decelerating by **2 m/s^2.**
- Cansat's weight = 0.75kg,
- So the impulse it would undergo is 0.75kg × 2m/s^2 per second = **1.5N/s.**
- We applied a force of 3N to the Cansat's bottom, taking into account its Factor of Safety of 2 ,we found the following results were also shown side by side in the video.

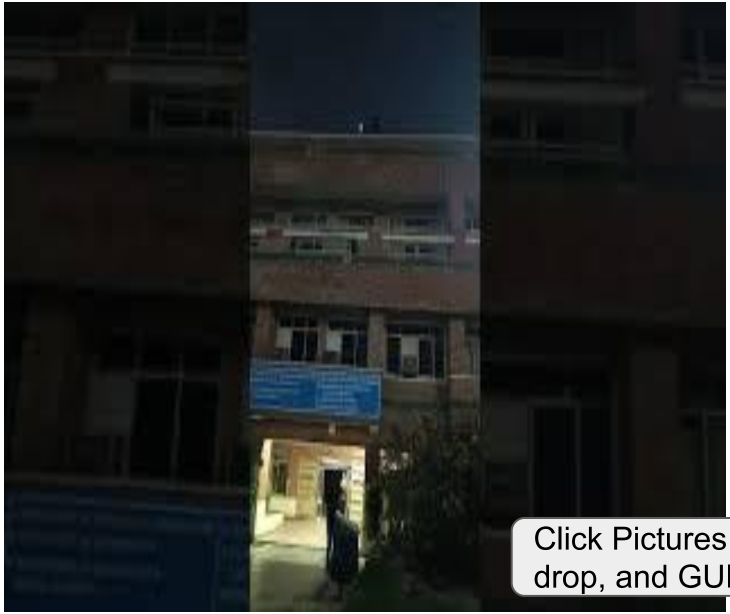
DROP TEST SIMULATIONS (2/2)



Click Picture to view the drop test simulation Video

- The entire deformation the Cansat will experience upon landing is depicted in this video.
- According to the simulation, the bottom most part is subjected to an impulse of 3N/s and deformation occurred in that region was observed to be 0.0076mm which is very minute considering the scale of the Cansat's dimensions. Thus, our Cansat would be able to tolerate the impulse it would experience on landing with both the aero brakes deployed.

PARACHUTE TEST



Click Pictures to view the parachute drop, and GUI plot video

- The CanSat was dropped from our college building of **10.6 m** height. This was the calibrated height reading from our CanSat
- The parachute slowed the descent and the CanSat covered nearly 8m in 3 seconds; which complies with the aerobrake release requirement in the mission guidelines **- descent velocity of 1-3 m/s after 500m**

ANTENNA TEST (1/2)

- We tested a variety of antennae to mount on our CanSat (duck,patch,helix)
- The best efficiency was recorded with FXP 830 dipole antenna
- We have used a proven combination of nearly omnidirectional on board antenna and a directional Yagi GCS antenna

ANTENNA TEST (2/2)

- We tested the horizontal range on the longest continuous road of our college and were able to receive data packets with the CanSat up to 600m
- There were obstructions too including trees, cars, and barriers.
- In horizontal range with obstructions and higher likelihood of signal interference, we recorded loss of approx 2 in 10 packets.

MISSION RUNTIME

Power remaining in power bus post 3.5 Hours + Runtime

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	TEAM_ID	TIME_STAI	PACKET_C	ALTITUDE	PRESSURI	TEMP	VOLTAGE	GNSS_TIM	GNSS_LAT	GNSS_LOI	GNSS_ALT	GNSS_SAT	ACC_R	ACC_P	ACC_Y	GYRO_R	GYRO_P	GYRO_Y	FLIGHT_S(	TVOC	eCO2
2	<2022ASI-	0:00:00	0	8.8	97602	29.9	6.34	5:29:52	0	0	0		-0.02	10.06	0.98	-0.02	-0.02	0	0	0	0>
3																					
4	<2022ASI-	0:00:00	1	8.8	97602	29.9	6.34	5:29:53	0	0	0		-0.01	10.06	1	-0.02	0	-0.02	0	0	0>
5																					
6	<2022ASI-	0:00:01	2	8.6	97604	29.9	6.34	5:29:54	0	0	0		-0.04	10.08	0.96	-0.02	0	0	0	0	0>

Console log

```
<2022ASI-049,0:00:25,26,8.8,97264,28.2,7.46,5:30:20,0.0000,0.0000,0.0,,-0.01,10.06,0.98,-0.02,-
0.00,0.00,0,0,400>
<2022ASI-049,0:00:26,27,8.7,97266,28.2,7.46,5:30:21,0.0000,0.0000,0.0,,-0.01,10.01,1.00,-0.02,-
0.02,-0.00,0,0,400>
<2022ASI-049,0:00:27,28,8.8,97264,28.2,7.46,5:30:22,0.0000,0.0000,0.0,,-0.03,10.04,0.99,-0.02,-
0.02,-0.00,0,0,400>
```

initial voltage

18.7 % reduction in Voltage was observed

- The system was run for 3.5 hrs to verify the capability of our power bus
- Telemetry was relayed for 2 hrs and 3 minutes (to simulate Simulation mode at launchpad)
- Thereafter, the servo rotates (simulating parachute deployment), camera begins to record, and bldc motor switches on; these operations run for 10 mins (to simulate descent)
- The buzzer then beeps for 1hr (recovery)

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Key Learnings From This Competition

During this competition, in which we designed and will launch our own CanSat, our team gained invaluable insights across various domains of Mechanical, Electronics and Software departments. However, the most crucial aspect of our journey was the lessons we imbibed in teamwork. We learned to appreciate each other's perspectives, to respect diverse ideas, and to comprehend how our team members think. These experiences fostered a cohesive and collaborative environment, ultimately enhancing our collective performance.

MECHANICAL LEARNINGS

- Obtained practical understanding in mechanical design, from visualization to material selection and manufacturing.
- Learned about additive manufacturing (3D printing) and its varied settings and materials.
- Acquired knowledge about the functionality of mechanical gyro devices in real-life applications.
- Utilized simulation and CAE software for structural analysis to ensure strength and durability.
- Gained hands-on experience in designing and prototyping mechanical systems for aeronautical applications.
- Learned about aerospace parameters affecting parachute material selection for optimal flight.
- Faced technological hurdles during design and testing phases, focusing on minimizing CanSat weight and size to meet payload requirements and ensure reliable parachute deployment.

Key Learnings From This Competition

ELECTRONICS LEARNINGS

- Learned optimal sensor selection based on size, weight, and power consumption parameters.
- Mastered microcontroller selection based on adequate I/O pins and processing power.
- Acquired PCB design skills, ensuring avoidance of short circuits and circuit faults.
- Developed problem-solving proficiency in coding for microcontroller operations, ensuring comprehensive edge case coverage.
- Implemented integration of subsystems and conducted rigorous testing for CanSat integrity.

SOFTWARE LEARNINGS

- Utilized XBee module for efficient real-time data processing, enhancing dynamic information management.
- Created user-friendly interfaces with PyQt5, while gaining hands-on experience in sensor calibration for accurate data collection.
- Developed effective debugging techniques and integrated simulation functionality, ensuring software reliability.
- Implemented communication protocols for seamless data transmission and incorporated live location rendering for enhanced visualization.
- Worked closely with other departments, integrating hardware insights for cohesive project execution.