Inspace Rocketry Preliminary Design Report

Introduction

This report outlines our preliminary design and development plan for the IN-SPACe Model Rocketry India Student Competition 2024-25, organized by the Astronautical Society of India with ISRO. We aim to launch a 1kg rocket to 1.2km altitude, safely ejecting and landing the payload. This competition offers hands-on rocketry experience and develops essential soft skills.

Mission Requirements

The IN-SPACe Model Rocketry India Student Competition 2024-25, organized by the Astronautical Society of India in association with ISRO, aims to provide a realistic experience for students and start-ups in designing and launching an amateur rocket. The key mission requirements are as follows:

- Payload: Design, develop, and launch a model rocket carrying a payload of 1kg mass.
- Altitude: Achieve an altitude of 1000m above the launch site.
- Recovery: Ensure the safe ejection of the payload and the safe landing of the rocket.

Design
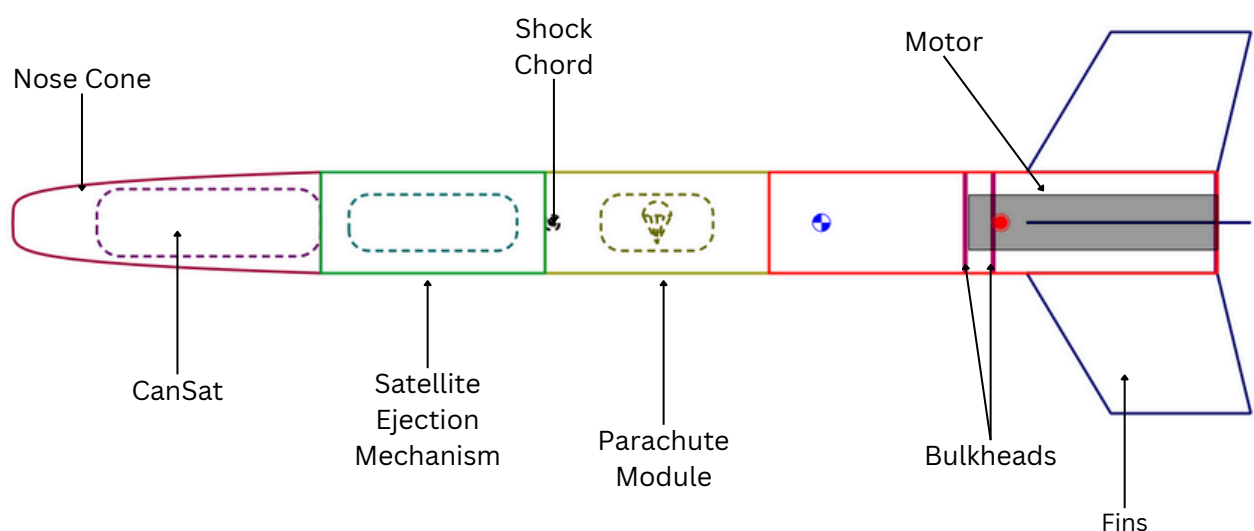
Rocket Components

- **Nose Cone:**
  - Material: Carbon Fiber
  - Thickness: 4mm
  - Base Diameter: 18cm
  - Length: 55cm
  - Payload: CanSat (16CM x 40CM)
  - NoseCone configuration: Power-Series (n=0.2)
  - Function: Opens the nose cone in two parts. Stores the Cansat till the ejection at the apogee.
- **Ejection Mechanism:**
  - Material: Carbon Fiber
  - Length: 40cm
  - Component: Electromagnetic Plunger and the Avionics system
  - Function: It pushes the Cansat out of the nose cone using an electromagnetic plunger.
- **Parachute Module:**
  - Material: Carbon Fiber
  - Length: 40cm
  - Parachute material: nylon (2-4m diameter)
  - Shroud Lines: Braided Nylon (3mm x 60cm)
 - Shock Chord: Elastic Braided chord (1-1.5 m)
- **Motor Bay:**
  - Material: Carbon Fiber
  - Length: 40cm
  - Function: it provides a solid support to the motor and the fins.
- **Fins Configuration**:
  - Number of Fins: 4
  - Root Chord: 34cm
  - Tip Chord: 25cm
  - Height: 25cm
  - Sweep Length: 15cm
  - Thickness: 3-5 mm

- **Motor Configuration:**
  - Casing: Aluminum (3-5mm)
  - Motor Type: Solid Propellant
  - Nozzle: Converging-Diverging (CD) Nozzle
  - Motor length: 44cm
  - Motor diameter: 10cm
  - Fuel: Blue Thunder
  - Fuel: Aliminium (powdered) + hydroxyl-terminated polybutadiene (HTPB) [Binder]
  - Oxidizer: Ammonium Perchlorate
  - Igniter: Pyroigniter with black powder.
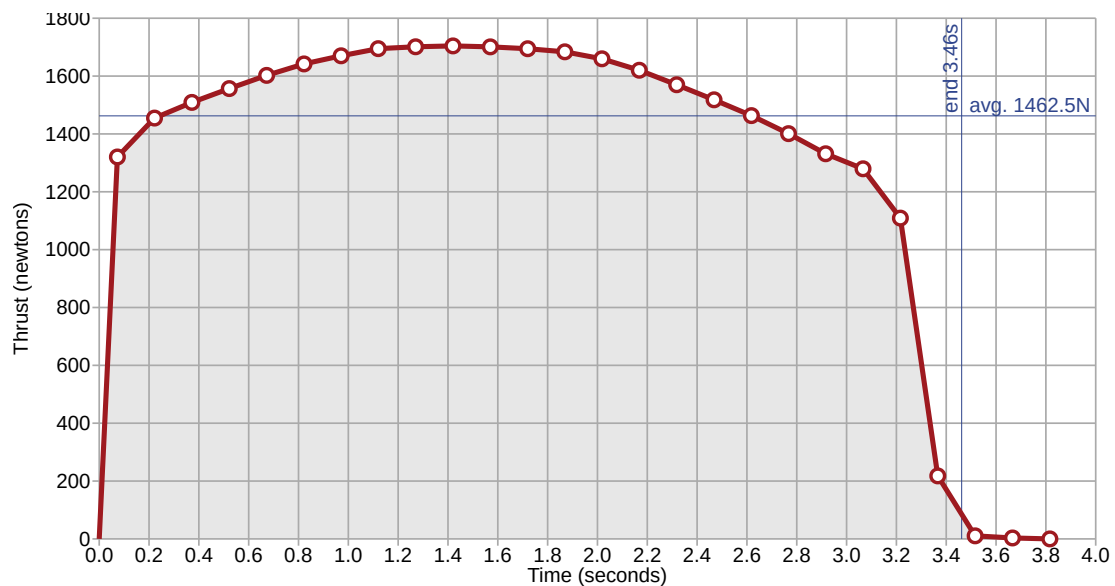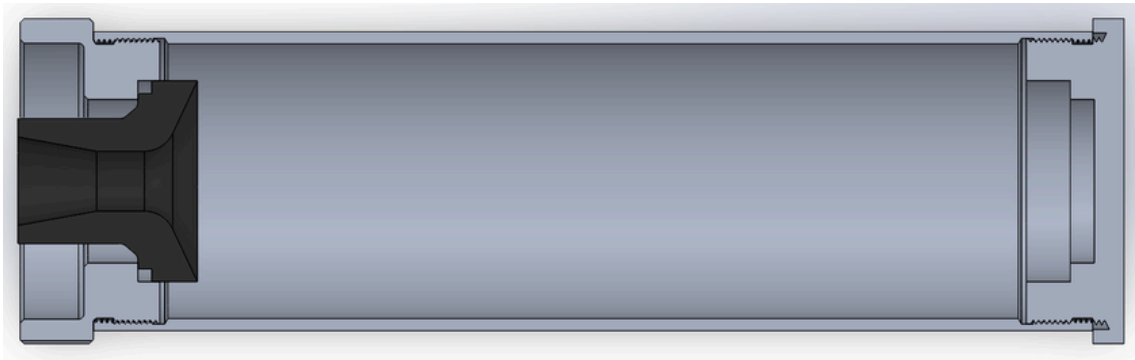
Motor type: L

Propellants Weight: ~2.5 kg

Total Weight: ~4.7 kg

Avg. Thrust: ~1,500.0 N

Max. Thrust: ~1,704.3 N

Total Impulse: ~5,089.3 Ns

Burn time: ~3.5s

Avionics

Sensor Type	Sensor Name	Source
Air Pressure and Temperature Sensor	MPL3115A2 - I2C	https://evelta.com/1893-mpl3115a2-i2c-barometric-pressure-altitude-temperature-sensor/
Accelerator, gyrometer and Magnetometer	ICM-20948	https://www.digikey.in/en/products/detail/tdk-invensense/ICM-20948/7062698
Positioning module	NavIC GPS	https://bharatpi.net/product/navic-gps/
Antenna Module	L1 & L5 Antenna for NavIC	https://bharatpi.net/product/irnss-l1-l5-antenna-for-navic-gps-tracker/
Transciever	XBEE Pro	https://www.digikey.in/en/products/detail/digi/XBP9B-DMWTB002/3863552
Microcontroller	Bharat Pi Node Wifi	https://bharatpi.net/product/bharat-pi-node-wifi/
Voltage controller	5v converter	-
Battery	6V Li-Ion Battery	-
Buzzer	SMTB-0927-TW-R	https://www.digikey.in/en/products/detail/pui-audio-inc/SMTB-0927-TW-R/13165907
Power switch	S101031SS03Q	https://www.digikey.in/en/products/detail/c-k/S101031SS03Q/2043289
SD Card	32GB	-

Flight profile timestamps
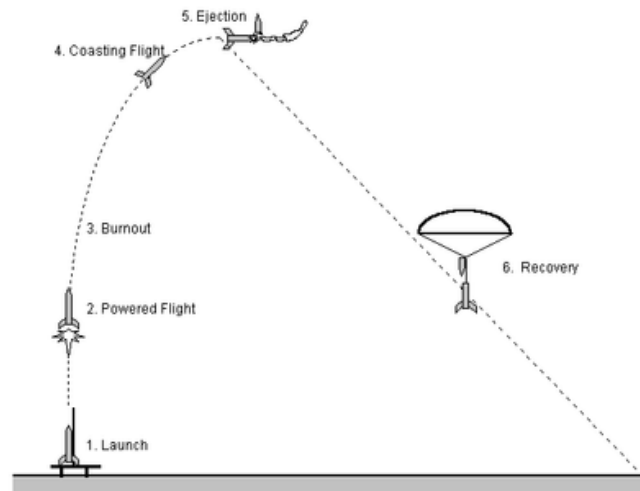
|	Function	Checks	Altitude	Time	Vel.
1	Connection with the ground station.	Radio and Video telemetry.	0m	t-60s	0
2	Ignition!	Axis calibration.	0m	t-3	0
3	Liftoff	IMU + BM confirmation.	0	t-0	0
4	motor burnout	IMU confirmation.	-	~3.5s	max.V
5	Fairing Separation	Fairing servo confirmation.	Apogee	~14s	~20 m/s
6	Cansat ejection	Solenoid Plunger activation. Light sensor Confirmation.	Apogee	~15.5s	~5m/s
7	Parachute Bay opening	Locking servo confirmation.	TBD	TBD	TBD
8	Parachute confirmation.	visual/camera confirmation	700m -> 0m	-	-
9	Landing	Buzzer Activation	0	∞	0

Simulations

Software: Openrocket

Total length of Rocket: 221cm

Aggregate Mass with motor: 15.082 kg

Max velocity: 245m/s (0.74 Mach)

Altitude: 1481m
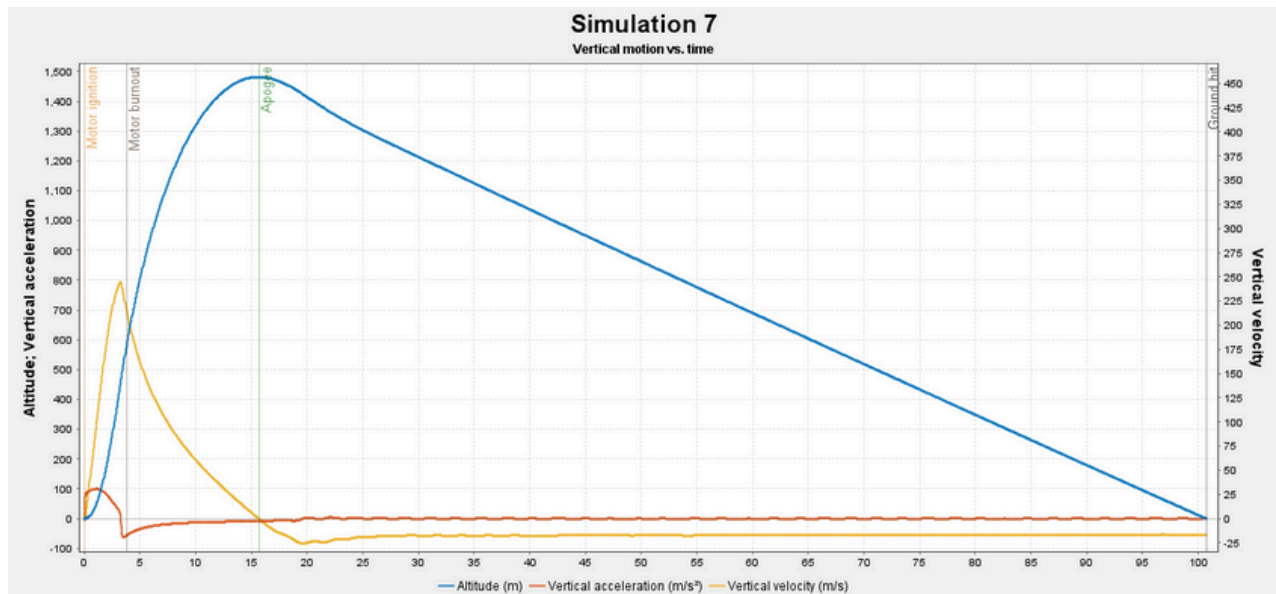
Software: Ansys

Boundary condition: 245m/s

Aggregate Mass with motor: 15.082 kg

Drag Force on whole body: 342.9868 N

Drag Force on each fin: 51.6696 N
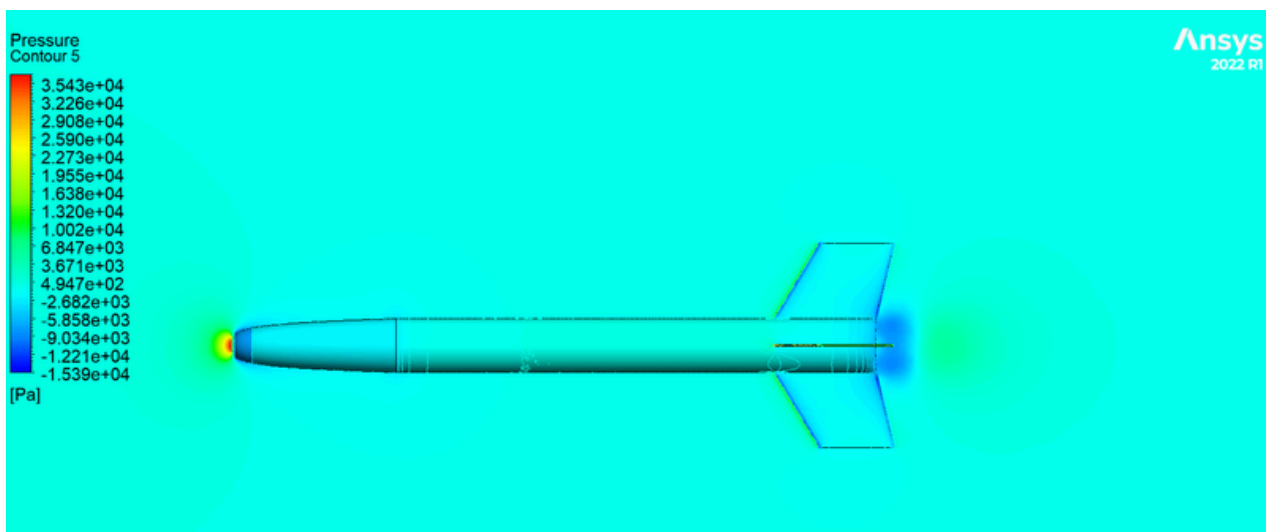
Drag Force on Nose Cone: 23.5234 N

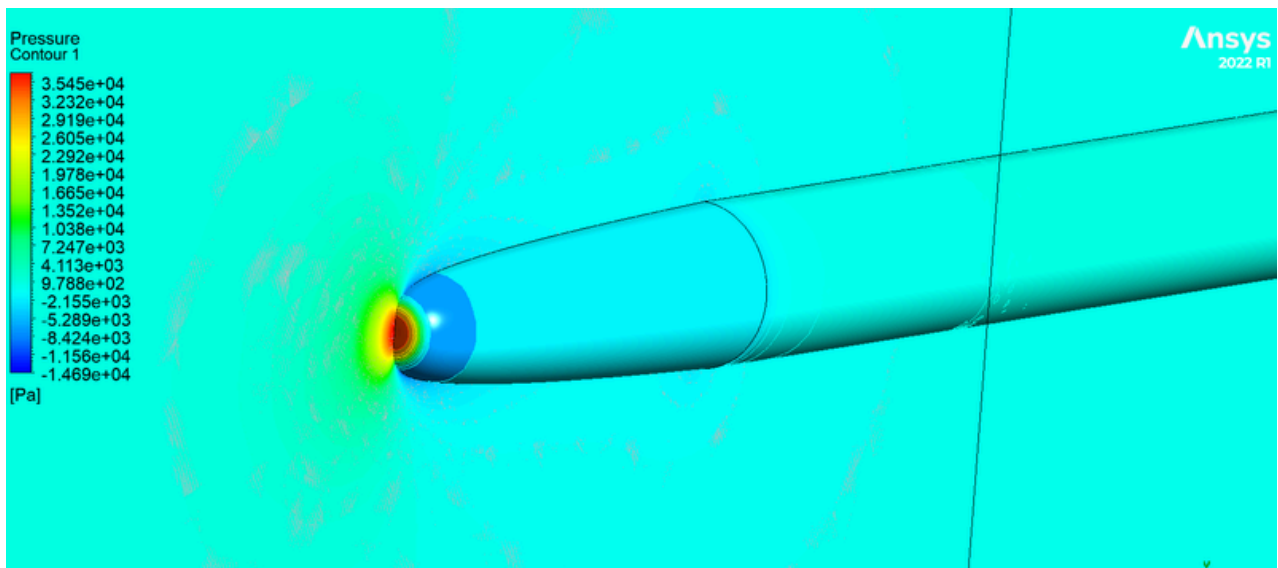*fig.1 pressure contour over whole body.*

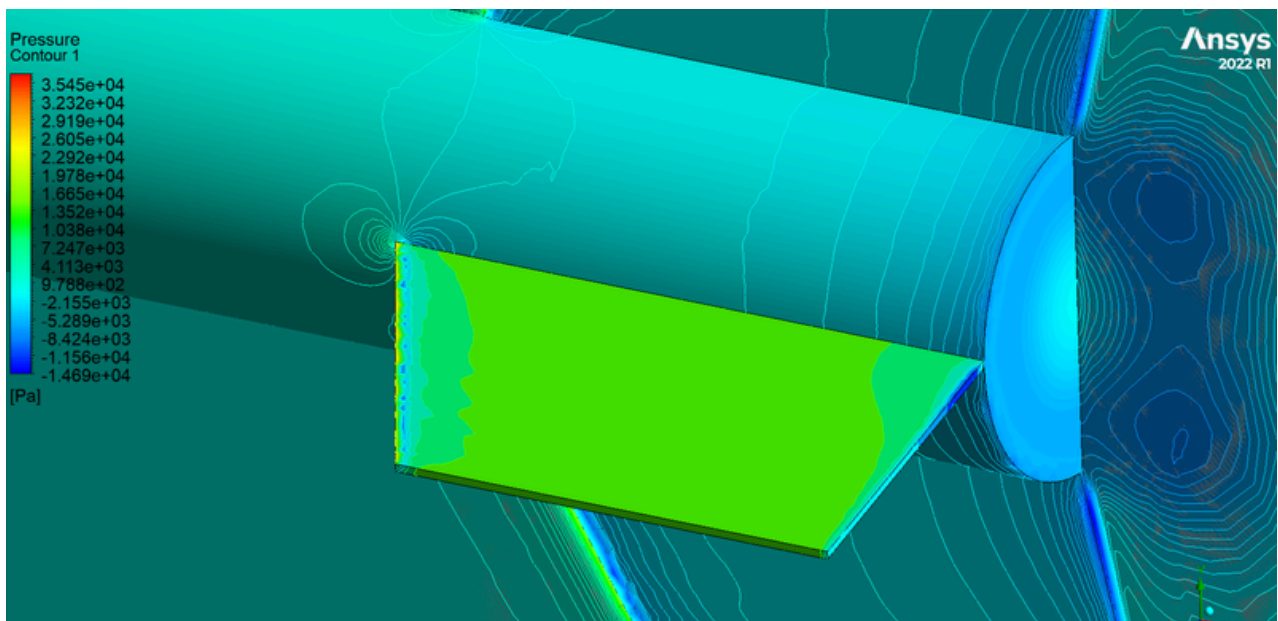*fig.2 pressure contour over nose cone.*
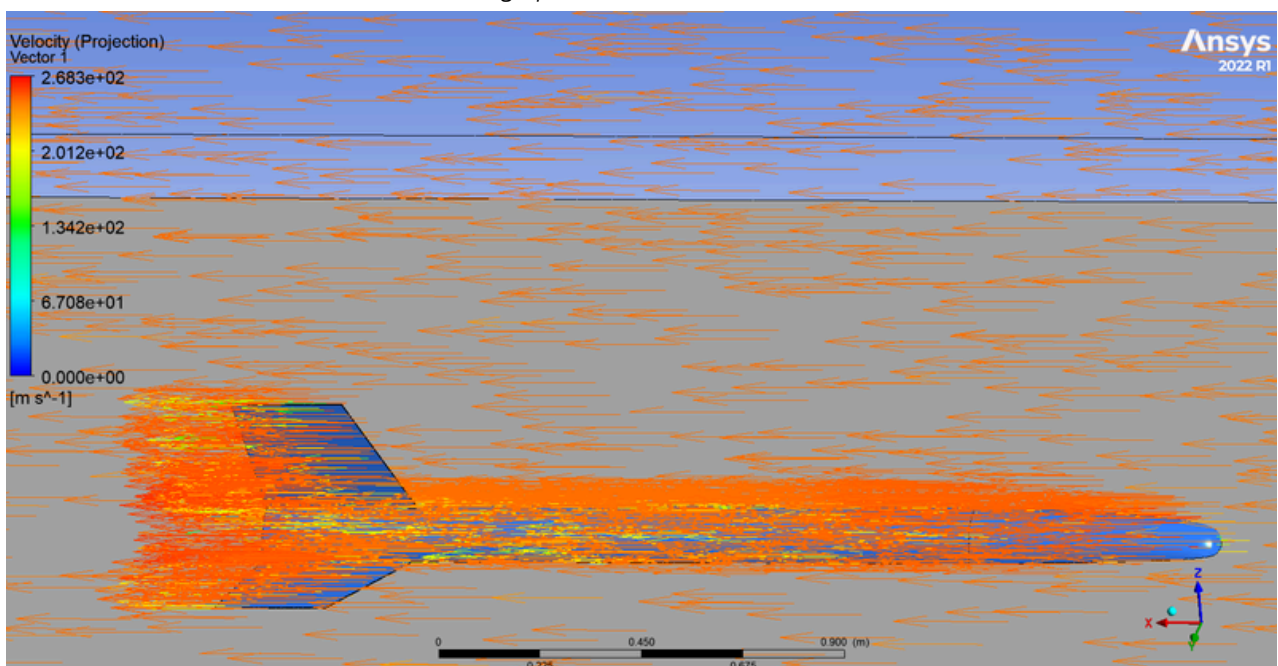

fig.3 pressure contour over fin

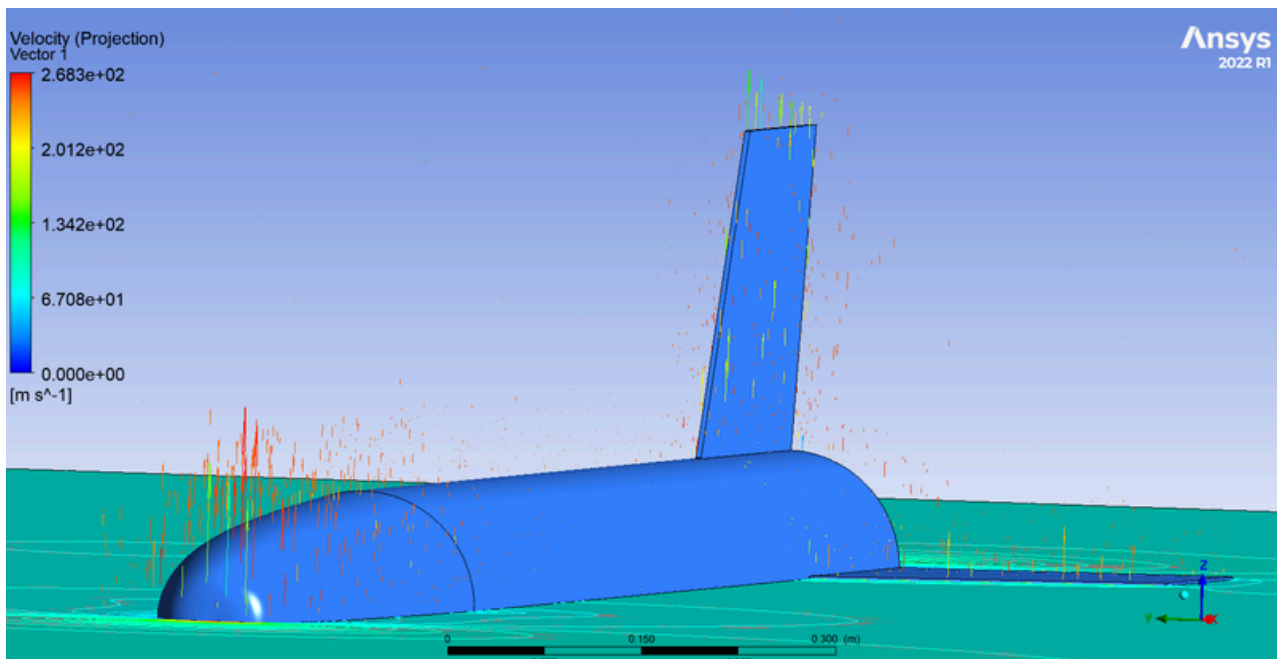*fig.4 vertical velocity components*

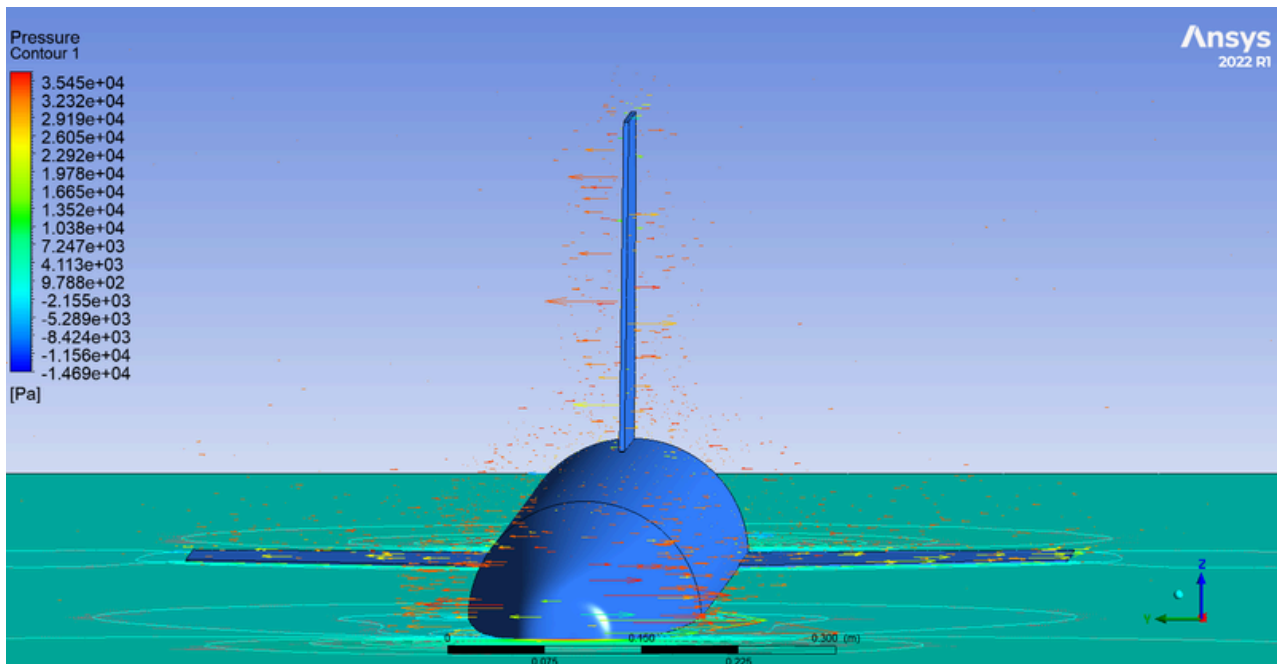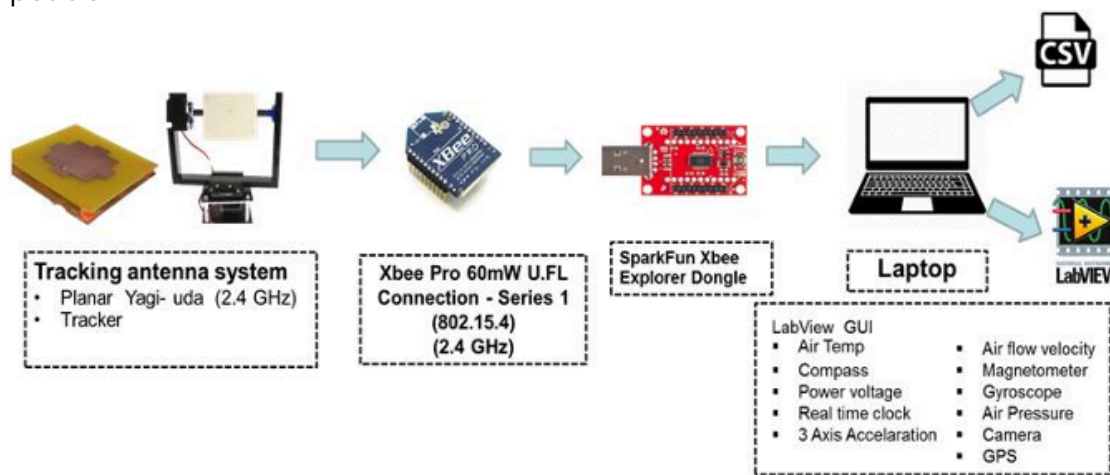*fig.5 lateral velocity components*

fig.6 longitudinal velocity components

Ground Station

Ground station is a very important part of the whole satellite system that receives data from the sensors in the Rocket. We also develop a tracking system to increase the efficiency of the operation. below shows the components of the ground station for this competition.

Timeline for the competition

S. No.	Activity	Start Date	End Date
1.	Registration	06-06-2024	30-06-2024
2.	Mission Requirements and PDR documentation Guidelines Release	01-07-2024	15-07-2024
3.	PDR Document Submission	16-07-2024	31-08-2024
4.	Preliminary Design Review Completion	01-09-2024	30-09-2024
5.	Hands-on Workshop	01-10-2024	30-10-2024
6.	Critical Design Review Submission	01-11-2024	30-11-2024
7.	CDR Evaluation	01-12-2024	31-12-2024
8.	Flight Readiness Review & Competition	01-04-2025	30-04-2025
9.	Post Flight Review and Results Declaration	After Completion of competition	

Conclusion

Team Valkyrie is committed to designing and building a high-performance rocket for the IN-SPACe Model Rocketry India Student Competition. Our goal is to achieve an altitude of 1.2 km with a 1 kg rocket using advanced materials and efficient propulsion systems. We look forward to further developing our design and conducting tests to ensure success in the competition.