Team Pinaka
Preliminary Design Review

Team ID: 2024-ASI-ROCKETRY-047

September 30, 2024

1. TEAM COMPOSITION AND MANAGEMENT

Team Name: Pinaka
Team Leader: Pranav MP
Institute: Lovely Professional University

Table 1: Team Details

Name	Discipline	Role	Academic Year
Mandeep Singh	Assistant Professor and Assistant Dean	Faculty Advisor	-
Ruhul Amin Choudhury	Innovation Officer	Mentor	-
Pranav MP	Aerospace Engineering	Aerodynamics	3rd Year
Vijay Mishra	Aerospace Engineering	Design	3rd Year
Shalu Yadav	Aerospace Engineering	Aerodynamics	3rd Year
Prajwal	Aerospace Engineering	Motor and Propellant	3rd Year
Ishu	Aerospace Engineering	Motor and Propellant	3rd Year
Bhanu Mahesh	Robotics Engineering	Avionics and Electronics	4rd Year
V Manish	Robotics Engineering	Avionics and Electronics	4rd Year
Nandish Panchal	Mechanical Engineering	Manufacturing	3rd Year

2. MISSION OVERVIEW AND COMPLIANCE

The **IN-SPACe Model Rocketry India. Student Competition 2024-25**, organized by the Astronautical Society of India. in association with ISRO, aims to provide students with hands-on experience in the design, development, and launch of amateur model rockets. The primary objective is to launch a rocket carrying a **1 kg payload** to an altitude of **1000 meters** and ensure the safe ejection and landing of the payload.

2.1 PRIMARY OBJECTIVES

i. To design a rocket having a height of less than 180cm.

ii. To design a rocket with a payload that can carry a CAN-Sized satellite of Diameter 0.15m and length 0.40m, with a weight of 1Kg +/-0.05Kg.

iii. To design a rocket that can deploy the payload at an altitude of 1000m +/- 100m.

iv. To design a rocket that can land safely after the deployment of the payload.

2.2 MISSION REQUIREMENT COMPLIANCE

Sr. No.	Requirement	Compliance
1	**Basic Rocket Requirements**	
1.1	The overall length of the rocket shall be less than 180cm.	Yes
1.2	The provision for Bulkhead / Integration of Motor Compartment should be made available in the Rocket body.	Yes
1.3	The teams shall design and bring their launch pads, and the launch angle shall be in the range of 80deg – 85deg.	Yes
1.4	All parts of the rocket must descend tethered together and must use parachute recovery.	Yes
1.5	The rockets must have only one stage that shall be powered only by commercially made model rocket motors, procured from Vendors identified by organizers.	Yes
1.6	The rocket motor capacity designed by teams cannot exceed 2800 Newton seconds of total impulse.	Yes
1.7	Motors must be retained in the rocket during flight and at ejection by a positive mechanical means and not retained simply by friction fit, but they must be removable post-flight.	Yes
1.8	The payload Separation mechanism shall be developed by the teams for activation at the desired altitude.	Yes
1.9	Any sharp edges on the container body shall be avoided as it can cause problems during the CANSAT ejection from the rocket.	Yes
1.10	The body of the rocket structure shall be painted with fluorescent colors i.e., pink, red, or orange.	Yes

1.11	The Amateur Model Rocket shall consist of the necessary sensors to provide the following mandatory Real-time datasets	Yes
1.12	The Amateur Model Rocket shall consist of necessary sensors to provide the following mandatory Real-time datasets: Position data, altitude, pressure, temperature, orientation data, power data & system status	Yes
1.13	The data shall be displayed in near real-time on the ground station User Interface/Software.	Yes
1.14	The Flight software system shall have provision to record the data and save it into an onboard SD card, in case of telemetry connection loss during flight.	Yes
2	**Payload Requirements**	
2.1	Rockets must contain and completely enclose in straight line configuration, a CAN-Sized satellite of Diameter 0.15m and length 0.40m, with a weight of 1Kg +/-0.05Kg.	Yes
2.2	The CANSAT (Payload) must be separated and deployed at the defined altitude (1000m +/- 100m).	Yes
2.3	The vehicle, including the Rocket body and the CANSAT shall return safely to the ground by means of safe landing, using a deployable parachute.	Yes
2.4	The CANSAT shall contain an altimeter and an accelerometer that will measure the altitude and acceleration levels reached by the vehicle.	Yes
2.5	Onboard Experiment Module (Optional) • The experiment should be designed to operate autonomously during the rocket's flight. • Teams must include a detailed proposal outlining their experiment, including objectives, methodology, expected outcomes, and any relevant calculations or simulations along with the PDR submission, with basic guidelines to be considered, given below. • Technical Specifications Safety Requirements	Yes

3	**Structural Requirements** Yes	
3.1	The vehicle structure shall be built to survive 15g of launch acceleration & 30g of shock. a. All the structural margins of the Model Rocket shall be substantiated by theoretical calculation and Finite Element Analysis (as applicable) in the PDR / CDR documentation. b. Tri- axis accelerometers shall be mounted on the vehicle to derive the Inertial loads (g levels), that shall be plotted and submitted to the Jury. c. The Motor shall have sufficient margins to withstand the propulsive loads. d. The design calculations shall also substantiate the structural loads experienced on the vehicle including the joints and fasteners, as the case may be.	Yes
3.2	Team number, email address and phone number must be placed on the structure in English, Hindi and the regional language of the launch state to aid in recovery.	Yes
4	**Avionics Systems**	
4.1	All electronics shall be enclosed and shielded from the environment. No electronics can be exposed except for sensors. There must be a structural enclosure.	Yes
4.2	Electronic circuit boards must be hard-mounted using proper mounts such as standoffs and screws. High-performance adhesives can also be used	Yes
4.3	Power Requirements The launcher ignition shall be carried out remotely, and accordingly, an external power switch with an Indicator light or sound shall be provided. Battery capacity to support up to 30 Minutes of wait in on the launch pad with additional time for flight operations, shall be ensured.	Yes

	The battery source may be alkaline, Ni-Cad, Ni-MH or Lithium ion. Lithium polymer batteries are prohibited. Lithium cells must be manufactured with a metal package similar to 18650 cells. An easily accessible battery compartment must be included allowing batteries to be installed or removed in less than a minute and not require total disassembly of the Rocket / CANSAT mounted on the rocket. Spring contacts shall not be used for making electrical connections to batteries. Care must be taken as the shock forces can cause momentary disconnects of power.	
4.4	On-board Communication Requirements The Rocket communications radio shall be the XBEE / Zigbee radio series 1/2/pro. The XBEE radios shall have their NETID/PANID set to the team number. The XBEE radio can operate in any mode as long as it does not interfere with other XBEE radios	Yes
4.5	Flight Software The flight software shall maintain and telemeter an indicator of the flight software state. An example set of states is 0 (BOOT), 1 (TEST_MODE), 2 (LAUNCH_PAD), 3 (ASCENT), 4 (CANSAT_DEPLOY), 5 (DESCENT), 6 (AEROBREAK_RELEASE), and 7 (IMPACT). In the event of a processor reset during the mission, the flight software shall be able to determine the correct state. The states shall be described in the review presentation by each team.	Yes
5	**Ground Station**	
5.1	Each team shall develop and use their own ground station. All telemetry shall be displayed in near real time during launch and descent. All telemetry shall be displayed in the international system of units i.e., SI system. Teams shall plot data in real time during the flight.	Yes

5.2	The ground station shall command the Model Rocket to start transmitting telemetry prior to launch. The rocket shall not transmit telemetry until commanded by the team.	Yes
5.3	The teams shall ensure to have separate channels for rocket and CANSAT, with an interference test to be demonstrated to the Jury to avoid any overlapping between both.	Yes
5.4	The teams can issue the telemetry command, only post the on-site inspection and clearance by the Jury members. A Pre-set checklist for clearance shall be made available for the teams, basis which the jury shall inspect and clear the vehicle for launch on the pad	Yes
5.5	The ground control station antenna shall be elevated from ground level to ensure adequate coverage and range.	Yes
5.6	Stability of the ground station must be ensured.	Yes
5.7	The ground station shall be able to command the rocket on parameters like barometric altitude, accelerometer readings etc, including zero-setting at the launch pad	Yes
5.8	The ground station shall generate .csv files of all sensor data as specified in the Telemetry Requirements section	Yes
5.9	Telemetry shall include mission time with one second or better resolution.	Yes
5.10	In case of processor reset the mission clock/time stamp & system state shall be maintained.	Yes
5.11	Teams shall plot each telemetry data field in real-time during flight.	Yes
5.12	The ground station shall include one laptop computer with a minimum of two hours of battery operation, XBEE radio and a hand-held antenna.	Yes
5.13	The ground station must be portable so the team can be positioned at the ground station operation site along the flight line and if required the team can also move to a different location, in case of distant landing location, in order to locate the projectile.	Yes
6	**Telemetry**	

6.1	Upon powering up, the Rocket shall collect the required telemetry at a 1 Hz sample rate or better. The telemetry data shall be transmitted with ASCII comma-separated fields followed by a carriage return in the format as given in Annexure – 2	Yes
6.2	The received telemetry for the entire mission shall be saved on the ground station computer as a comma-separated value (.csv) file that will be examined by the Jury post the flight. Teams will provide the file to the Jury immediately after the launch operations via USB drive. The .csv file shall include headers specifying each field of data	Yes
6.3	The telemetry parameters display format with resolution along with the file naming shall be as per Annexure - 2.	Yes
7	**Descent and Recovery Requirements**	
7.1	The Rocket shall contain a minimum of one descent control mechanism (parachutes) to be used at different stages while descent. It is the responsibility of the teams to ensure that both the rocket and the CANSAT descent safely and securely.	Yes
7.2	The descent rate of the launcher body and payload bay shall be between 2 to 5 m/s (+/- 0.5 m/s). The descent rate should be measurable during the competition.	Yes
7.3	The descent control system shall not use any hazardous chemical-based explosive or pyrotechnic devices.	Yes
7.4	The descent control mechanism & all the attached components shall survive 30g of shock at the time of launch and separation.	Yes
7.5	All the electronic components shall be enclosed and shielded from the environment with the exception of sensors.	Yes
8	**Documentation Required**	
8.1	PDR Documentation with details as given in 6 DESIGN REVIEW DOCUMENTATION GUIDELINES	Yes
8.2	Participation in the One-Week short-term skill development model rocketry course	Yes
8.3	CDR Documentation	Yes

2.3 ROCKET CONFIGURATION

As described in the summary section, the purpose of the rocket is to reach 1 km +/- 100m and deploy the CANSAT at an altitude of 1000m. This will be accomplished with a 2800 Ns solid rocket motor and a 158 cm long, 140-170 cm Diameter airframe. The CANSAT will be contained within Payload Bay, which will be located just after the section of the nosecone. The avionics are below the Payload Bay followed by Parachute Bay which contains, the main parachute. The Motor Bay is below the Parachute Bay and contains the solid rocket motor. It is surrounded by four fins.

The overall rocket can be seen in Figure 1.

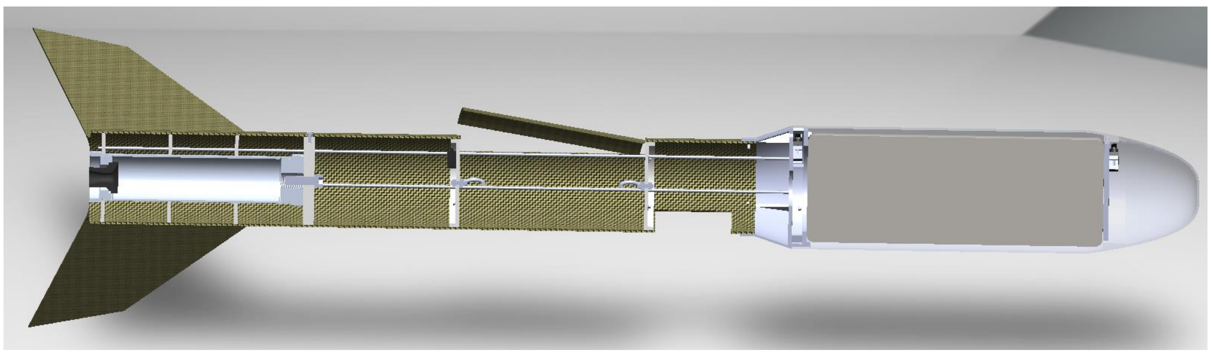


FIGURE 1: CROSS-SECTION VIEW OF OVERALL ASSEMBLY

Furthermore, the rocket budget summary (mass and dimensions) can be seen in Table 3-1.

TABLE 12: OVERALL COMPONENT LIST

System		Dimensions	Mass (g)
Nose Cone	Top Cap	17cm Dia. x 550cm length	451g +/- 15g
	CANSAT	15cm Dia. x 40cm length	1000g +/- 50g
Main Body	Airframe-Body	13cm x 90cm	2524g +/- 60g
	Avionics/Comm/Electro.	114cm Dia. x 125cm length	530g +/- 20 g
	Transition Zone	130cm-170cm Dia. x length 5cm	480 +/- 20g
	Parachute Plates	12.6cm Dia. x 5mm	250g +- 20g
	Centering rings and thrust plate	12.6cm Dia. x 5mm	180g +/- 20g
	Fins	4 Nos.	1000g
Accessories	Nuts and bolts	M4-12 7 Nos. Bolt, M3-12 8 Nos. Bolt, M6-12 2 Nos. bolts, M6 Eye bolts 2 nos., M5x5 6 Nos., M12-40	370g

		1 Nos., M2.5-12 4 Nos. M4 x56 Hex Nut	
Propulsion	Rocket Motor	28.9cm length x 7.5cm Dia.	3000g
Recovery	Parachute	21.6 m2	1304g +/- 10g
SUBTOTAL			10989 g

2.4 MAJOR COMPONENTS

The airframe is comprised of the following components:

- Body Tube (Payload Tube and Systems Tube)
- Nose Cone
- Fins
- Electronics Bay
- Motor Bay
- Parachute Bay

Each of these will be described in detail below.

The body tube is a carbon fiber laminate tube. The laminate is a woven carbon fiber fabric and epoxy matrix. Carbon fiber was chosen as the material for the primary structure due to its high strength-to-weight ratio, toughness, and ease of manufacture to customized shapes and dimensions. For fabrication and transportation reasons, it would be difficult to make the entire tube in one segment. As a result, the Airframe is split into 2 big segments, the upper part of the airframe is the Payload Bay and the lower body is the Body tube, as seen in Figure 2. The bottom tube has an outer Diameter of 13cm and an inner diameter of 12.6cm. The length of the tube is 90cm. There are 2 bulkheads of 12.6cm Diameter 5mm thickness, and 8mm of reinforcement, bolted to the body with M3-12 nut-bot. There is a thrust plate of 15mm thickness and 12.6cm Diameter, bolted to the body frame with 5 M5-12 nut bolts. There are 3 centering rings of 12.6cm Diameter, inner Diameter of 75mm, and thickness of 5 mm.

There are two cut-outs in the body, one for Parachute Bay with dimensions 250mm, and the other for Electronics Bay slider with dimensions 103mm length and 70deg of 130mm Diameter.

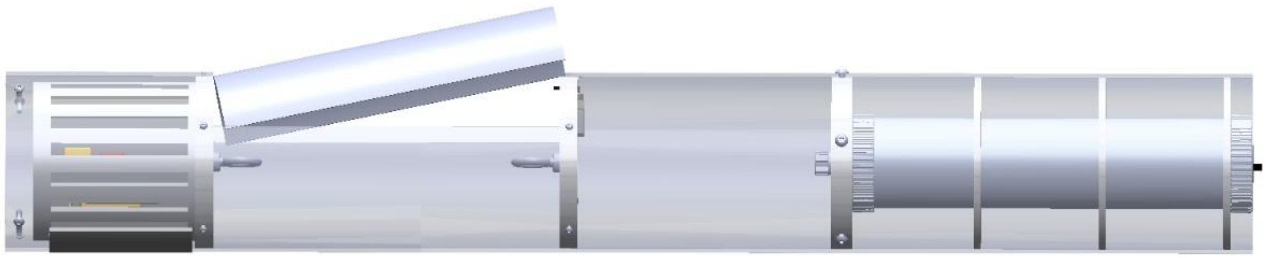


FIGURE 2 2: BOTTOM BODY SECTION

The nose cone is a carbon fiber tube, just like the body tube. The top cone shape is a power series of n=0.3 with a length of 15cm and a diameter of 17cm. the rest of the tube has a diameter of 17cm throughout. The Nose tube has a cutout of 75deg with a length of 42cm. The nose tube is also the Payload Bay that hosts the CANSAT and the ejection mechanism plate. The ejection mechanism on the ejection mechanism plate contains two servo motors that lock the hooks in the payload bay door. The payload bay door has 4 hooks that are locked to the main body by 4 servo motors. It is connected to the main body using a thin rubber.

The nose cone is connected to the Transition Cone which helps to reduce the diameter of the body to 13cm as a body tube. The length of the transition zone is 50mm. It also contains two servo motors that lock the hooks at the bottom of the payload bay door.

The locked payload bay door is attached to stretched strings that are wrapped around the body. Once the hinge is released, the payload bay door opens automatically to the maximum range of motion. Additionally, the CANSAT is also loaded with stretched strings. Hence, as soon as the door opens, the CANSAT is ejected.

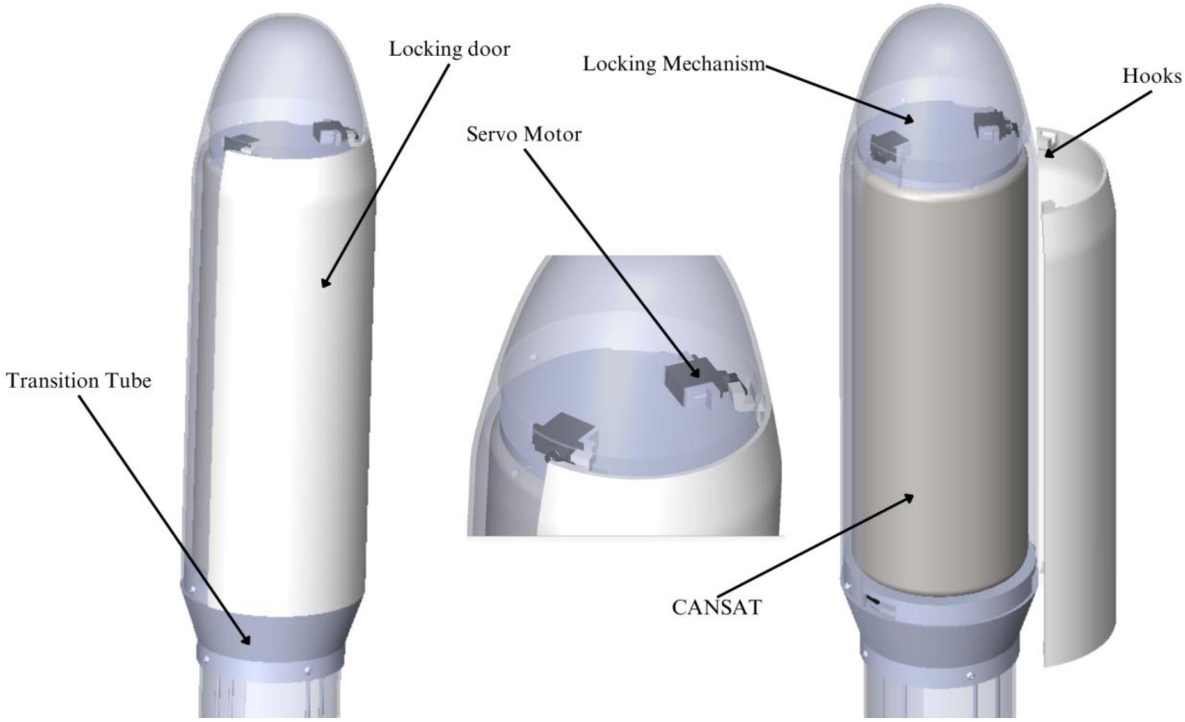


FIGURE 5: NOSE CONE AND PAYLOAD BAY

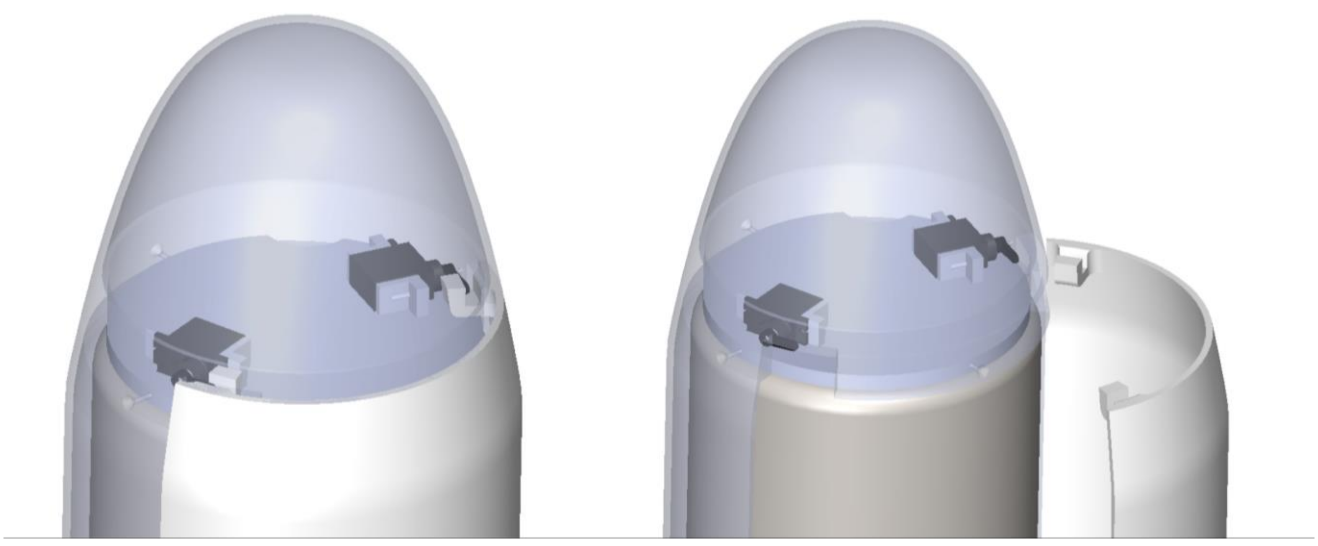


FIGURE 5: P A Y L O A D LOCKING MECHANISM – I. LOCKED, II. UNLOCKED

Four fins were chosen with the dimensions shown in Figure 6 for rocket stability reasons. The fins are made of carbon fiber to maximize stiffness with minimum mass. The fins are in position and angle relative to the rocket using fillets and it is joined to the body tube using direct epoxy bonds. The fins will be cut in shape and then carbon fiber sheets will be used to make fillets to blend the fins with the rocket body.

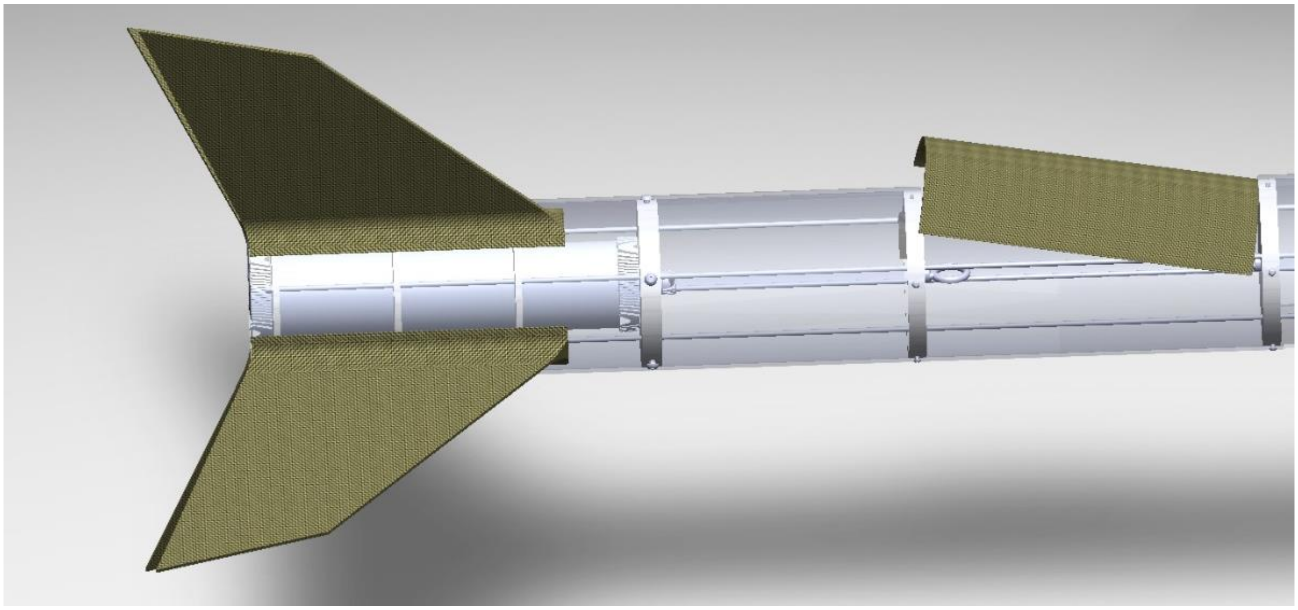


FIGURE 6: FINS ALONG WITH PARACHUTE BAY

The motor mount will consist of a commercial motor bolted with the 15mm thick thrust plate using an M12-40 Bolt. Additionally, there will be three 5mm thick centering rings in total, each located at an equal spacing from the thrust plate to the end of the motor tube. All of the bulkheads and centering rings will be made up of PEEK material using additive manufacturing. The thrust plate is mounted on the body tube using 5 M5-12 bolts. The motor is 85mm in diameter and 289mm in length. The mounting system can be seen below in Figure 7.

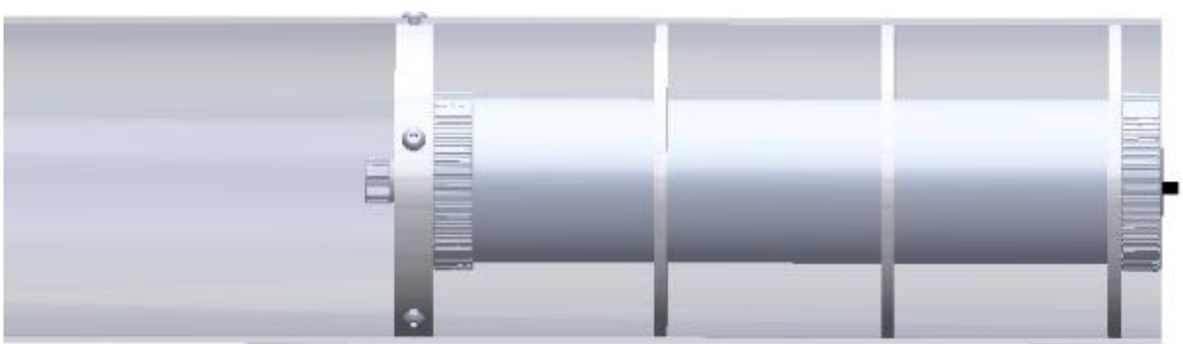


FIGURE 7: MOTOR BAY ALONG WITH THE MOTOR

The parachute bay contains two bulkheads that are connected to the body tube using two eyebolts on respective sides. Bulkhead provides the strength against the high g-stresses during parachute ejection. The parachute is connected to 8 shroud lines that join to a single mainshock chord. It is then connected to the two eyebolts on each side. These eye bolts proved sturdiness and support to the payload bay and distributed the stress equally in all axes of the airframe. the payload tube has a door that is connected to the main body using a hinge mechanism and is locked on the other side using a servo motor. The payload bay is stuffed by compressing the parachute and chord lines into the compartment, and the door is locked.

At the 600m altitude, the servo motor is released, and the payload bay is forcefully open, thus ejecting the parachute.

The mechanism can be visualized in figure 8.

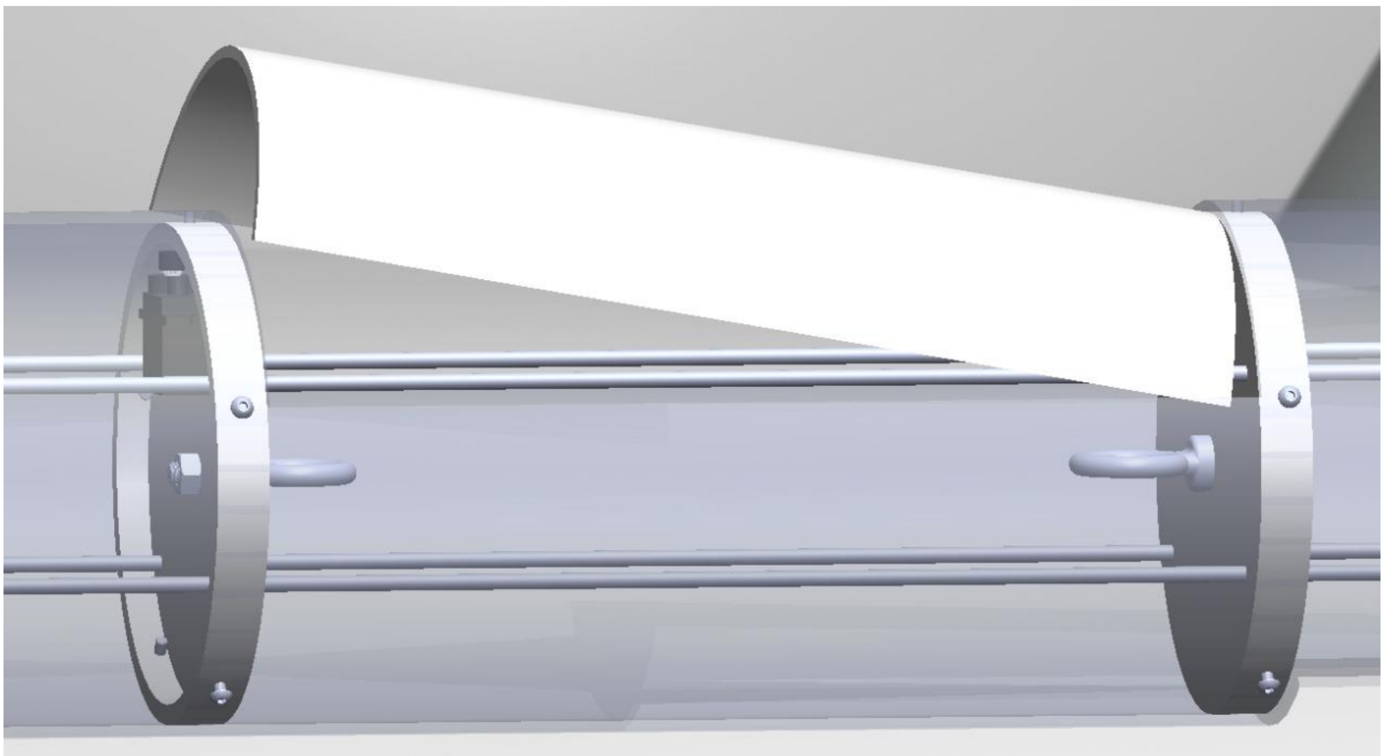


FIGURE 8: UNLOCKED PARACHUTE BAY

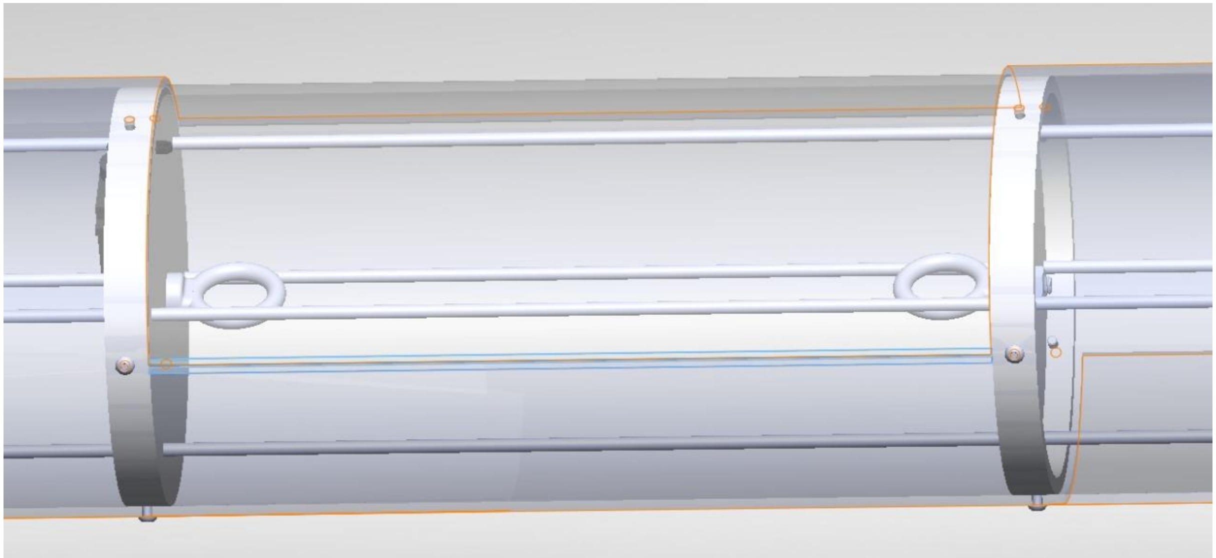


FIGURE 9: LOCKED PARACHUTE BAY

The avionics bay contains all the electronics including the microcontroller, sensors, power, and communication module. The avionics are placed on two parallel vertical plates inside a cylindrical cage. The cavity inside the avionics bay in the body has a 70deg x 103mm long cavity that helps to slide the electronics out of the body tube. A separate cavity is provided in the bulkhead to facilitate the sliding of the components plate.

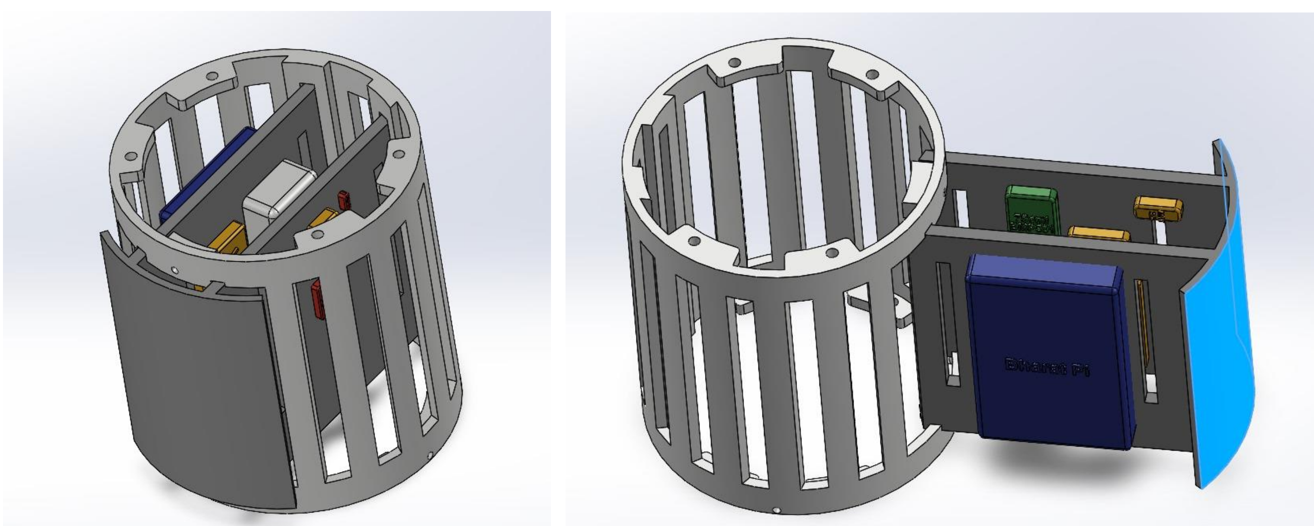


FIGURE 10: SLIDING MECHANISM OF ELECTRONICS BAY

3. Avionics

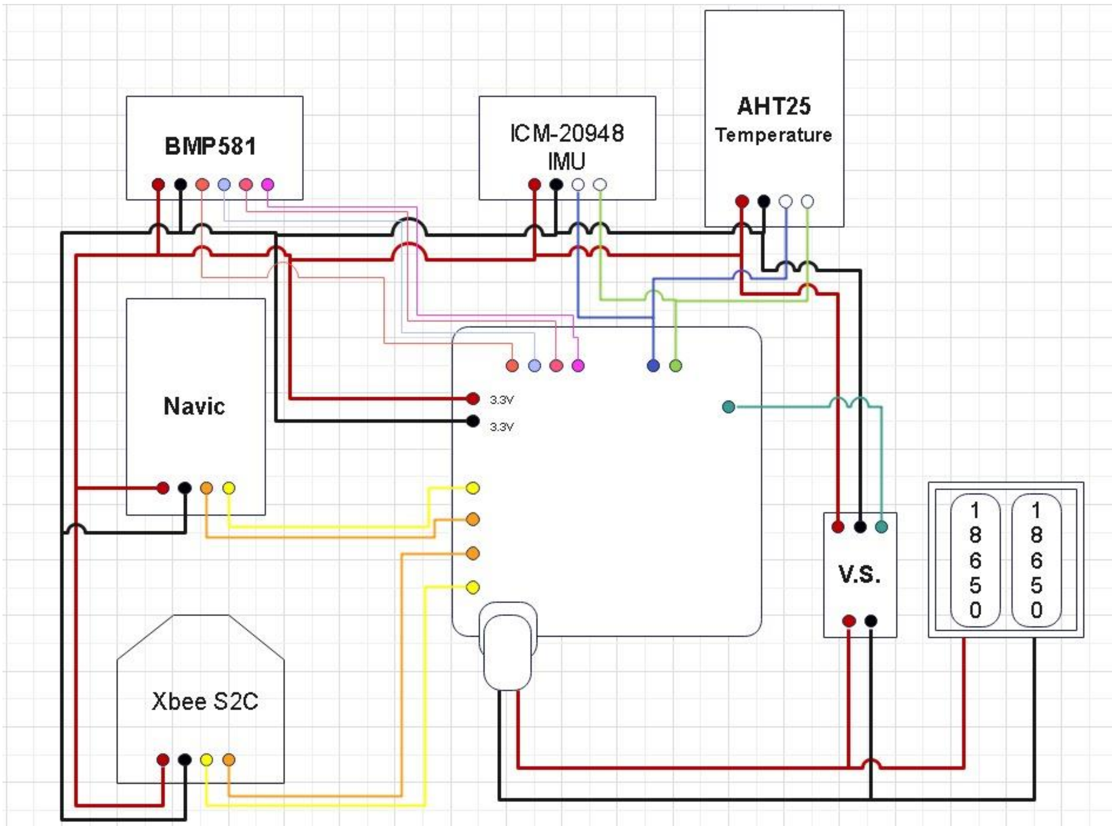


FIGURE 11: FLIGHT COMPUTER OVERVIEW

The purpose of the rocket avionics is to control parachute deployment while collecting rocket flight data and relaying it to the ground station.

Rocket Flight data includes:

- State Variables:
  - Altitude
  - Maximum Altitude
  - Velocity
  - Acceleration
- Flight State:
  - On Pad
  - Thrust
  - Coast
  - Apogee
  - Descent

- Drogue parachute Deployment
- Main parachute Deployment*Supply*

3.1 Power Supply

Samsung 18650-25R 2500Mah (8C) Li-Ion Battery

- Brand: SAMSUNG
- Model: INR 18650 Lithium Battery
- Battery Capacity: 2500mAh
- Nominal Voltage: 3.7V
- Rechargeable: Yes
- Charging time; Standard charge 3hours/100mA deadline
- Quick charge: 1hours/100mA deadline (25 °C)

3.2 SENSORS

1. **7Semi BMP581 Barometric Pressure & Altitude Sensor Breakout**

The 7Semi BMP581 Barometric Pressure & Altitude Sensor Breakout provides ultra-precise pressure and temperature measurements with I2C and SPI connectivity, low power modes, and customizable performance for your sensing projects.

Exceptional Accuracy & Resolution:

- Pressure accuracy of ±0.5hPa across the sensing range.
- Resolution down to 1/64Pa, offering precise barometric and altitude data.

Low Power Consumption:

- Deep Standby mode consumes just 1.5µA, ideal for power-sensitive applications.
- Normal operating mode draws only 260µA during measurements.

Wide Sensing Range & High Data Rates:

- Pressure sensing range of 30 to 125kPa.
- Output data rates up to 622Hz for fast, real-time data processing.

Programmable Features for Customization:

- Configurable oversampling, FIFO buffer, and low pass filtering for tailored performance.

- Includes 6-bytes of non-volatile memory for user-specific data.

FIGURE 13: BMP-581

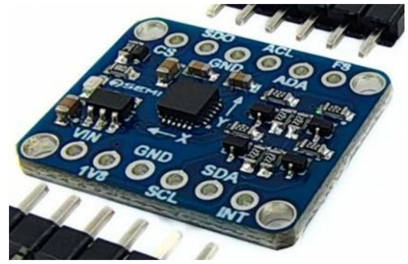


FIGURE 14: ICM-20948 IMU

2. 7Semi ICM-20948 9DoF IMU Breakout

The 7Semi ICM-20948 9DoF IMU Breakout board offers state-of-the-art motion tracking capabilities with the world's lowest-power 9-axis MEMS Motion Tracking device. Ideal for smartphones, tablets, and wearable sensors, this breakout board features a Digital Motion Processor (DMP) that enhances performance by offloading computation from sensors, ensuring optimal efficiency.

Key Features:

- Comprehensive 9-Axis Motion Tracking: Triple-axis gyroscope, accelerometer, and magnetometer with multiple programmable ranges.
- Efficient Digital Motion Processor (DMP): Offloads computation to ensure smooth and accurate motion tracking.
- Versatile Communication Interfaces: Supports I2C and SPI, with up to 7 MHz for SPI communication.
- Wide Supply Voltage Range: Operates efficiently between 1.95 V to 3.6 V.
- Compact and User-Friendly Design: Breakout board with 0.1"-spaced pins for easy breadboard use, and clearly labeled I2C/SPI pins for seamless integration.

3. NavIC (Navigation with India Constellation)

NavIC is a satellite-based positioning system designed for regional navigation, offering high accuracy within India. and nearby regions. It helps in tracking the rocket's real-time GPS coordinates and ensuring precise positioning. It can also support recovery operations by locating the rocket after it lands.

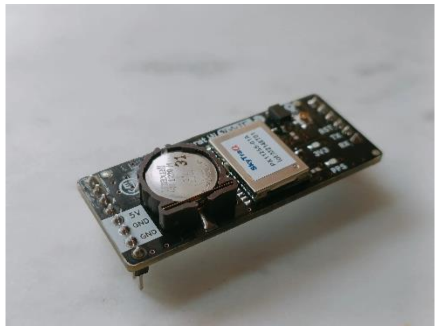


FIGURE 15: NAVIC MODULE

Datasheet - https://bharatpi.net/wp-content/uploads/2024/04/Bharat-Pi-NavIC-Module-Datasheet.pdf

- Type: Regional satellite navigation system by InDia.
- Coverage: InDia. and up to 1,500 km around the InDia.n mainland
- Position Accuracy: Typically 5-10 meters
- Signal Frequency: L5 (1.17645 GHz) and S-band (2.492028 GHz)
- Applications: Agriculture, disaster management, vehicle tracking, and navigation.

4. IRNSS/GPS/GLONASS L1 & L5 Antenna for NavIC GPS Tracker

IRNSS/GPS/GLONASS Antenna with RG174 Cable (L-3Mtr) and SMA (M) St. Connector. L1 + L5 band suitable for NavIC/IRNSS GPS trackers. Quick latching and magnetic mount for ease of use.

FIGURE 16: NAVIC ANTENNA

5. Voltage Detection Sensor Module 25V

The Voltage Detection Sensor Module 25V allows you to use the Analog input of a microcontroller to monitor voltages much higher than it capable of sensing.

Features:

- Voltage Detection Range (V): 0.02445 to 25
- Dimensions: 28*14*13 MM
- Weight: 5 g

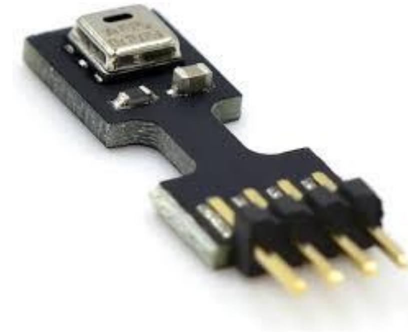


FIGURE 17: VOLTAGE DETECTION SENSO

FIGURE 18: ITEMPERATURE SENSOR

6. Temperature Sensor

The AHT25 Integrated temperature and humidity sensor is equipped with a newly designed ASIC dedicated chip, an improved MEMS semiconductor capacitive humidity sensor element, and a standard temperature sensor element, and its performance has reached the industry’s advanced level. The improved new generation temperature and humidity sensor AHT25 has a more stable performance in harsh environments and can maintain good accuracy in a larger measurement range.

- Digital output, I²C interface
- Quick response and strong anti-interference ability

7. DS3231 Real Time Clock

- Supports 2.2 to 5.5 V for the Real-Time Clock (RTC).
- Equipped with a fast 400kHz I2C interface.
- It's an extremely accurate I2C real-time clock (RTC).
- It has an inbuilt temperature-compensated crystal oscillator (TCXO) and crystal.
- Capable of tracking seconds, minutes, hours, day, date, month, and year.
- Features a built-in 32Kbit EEPROM and a 10-bit temp
- Temperature sensor with 0.25°C resolution.

FIGURE 19: RTC

FIGURE 20: MINI BUCK CONVERTER

8. 7Semi 3.3 V 2A Mini Buck Converter Breakout - AP61201

The 7Semi 3.3V 2A Mini Buck Converter Breakout features the AP61201, offering efficient power conversion with a 2.3V to 5.5V input range, 3.3V output, and 2A continuous current. Ideal for reliable and stable electronic projects.

3.3 MICROCONTREOLLER UNIT

Bharat Pi Node Wi-Fi with ESP32, SD Card: Quad-core ARM Cortex-A72 (64-bit)

- **ESP32 Bit microcontroller – ESP32 Wroom**
- Memory – 4MB
- Storage – SD Card slot supports up to 64GB
- Reverse polarity protection – (Onboard fuse)
- USB Type-C connector

FIGURE 21: BHARAT PI

FIGURE 22: xBEE PRO

3.3 COMMUNICATION

Zigbee XBee Module S2C

Zigbee is a low-power wireless communication protocol, useful for real-time telemetry in the rocket. It can transmit sensor data such as altitude, temperature, and position back to a ground station. Its mesh network capability allows robust communication even in complex environments with obstacles.
https://www.mouser.com/datasheet/2/111/ds_xbee-3-zigbee-3-1288823.pdf?srsltid=AfmBOor4w-

LmduoaULaoqwj6U_CsMo1S1_4KRDPPBTNJZtvxSWnP_zEg –datasheet

- Frequency Range: 2.4 GHz (global), 868 MHz (Europe), and 915 MHz (North America)
- Data Rate: Up to 250 kbps
- Transmission Range: Typically, up to 100 meters indoors (depends on the environment).up to 2 miles in outdoors.
- Topology: Supports star, tree, and mesh network configurations
- Power Consumption: Low power consumption, ideal for battery-operated devices
- Protocol Standard: IEEE 802.15.4

4. Power Budget

4.1 Rocket Avionics:

- Battery Type: Two 18650 Lithium-ion cells (7.4V, 2500mAh) in series.
- Nominal Voltage: 7.4V
- Total Energy Storage: 18.5Wh

Energy Balance and Power Consumption:

Component	Voltage (V)	Current (mA)	Power(W)	Duration (MIN)	Energy(Wh)
XBee S2C Module	3.3V	65	0.215	30	0.1075
Bharat Pi Node (ESP32)	3.3V	180	0.6	30	0.3
BMP581 (Pressure Sensor)	3.3V	1.5	0.0045	30	0.00225
ICM-20948 (IMU)	3.3V	1.2	0.004	30	0.002
AHT25 (Temp & Humidity)	3.3V	0.09	0.0003	30	0.00015
NavIC GPS Module	3.3V	50	0.165	30	0.0825
SD Card (Data Logging)	3.3V	20	0.066	30	0.033
DS3231 RTC Module	3.3V	0.3	0.001	30	0.0005
Voltage Detection Sensor	3.3V	0.2	0.00066	30	0.00033

Power Conversion Losses	-		~0.1	30	~0.05

Total Power Consumption (30 min):
Total Power: 0.89176 W
Energy:
Energy = 0.89176 W × 0.5 hr = 0.446Wh
Energy=0.89176W×0.5hrs=0.446Wh

Battery Capacity and Safety Margin:
The onboard system consumes ~0.446 Wh during a 30-minute flight.
The 18650-battery pack provides 18.5Wh, so it offers a significant margin, ensuring sufficient power for the entire mission.

4.2 Ignition System

Components and Power Consumption:
Battery Setup:
- Igniter Battery: 9V alkaline battery (for igniter e-match).
- Control Battery: 5V power supply for microcontroller (using 18650 Li-ion).

Energy Balance and Power Consumption:

a. **Ignition System (Only operates briefly for ignition)**

Component	Voltage (V)	Current (mA)	Power(W)	Duration (MIN)	Energy(Wh)
E-match Igniter (Momentary)	9V	2	1.8	3	0.015

Total Ignition Power Consumption:

Power: 18 W (igniter is momentarily powered by a 9V battery for approximately 3 seconds).
Energy consumed:
Energy = 18 W × 3/3600 hours = 0.015 Wh
A standard 9V battery has a capacity of around 500mAh (4.5Wh), so it will easily handle the power requirements of the igniter.

b. **Control System (Arduino Nano and NRF24L01 for remote control)**

Component	Voltage (V)	Current (mA)	Power(W)	Duration (MIN)	Energy(Wh)
Arduino	5V	50	0.25	30	0.015

Nano					
NRF24L01 Module	3.3 V	12	0.04	30	0.02
Relay (Control Igniter)	5V	90	0.45	30	0.225

Total Control Power Consumption:
Power: ~0.74 W

Energy consumed:
Energy = 0.74 W × 0.5 hours = 0.37 Wh
Energy=0.74W×0.5hours=0.37Wh

The control system (Arduino + NRF24L01 + relay) consumes around 0.37 Wh during a 30-minute wait time.
A single 18650 battery (2500mAh, 3.7V) provides 9.25Wh, which is more than sufficient for the control system.

5. Ground Station

5.1 GROUND STATION FLOW CHART

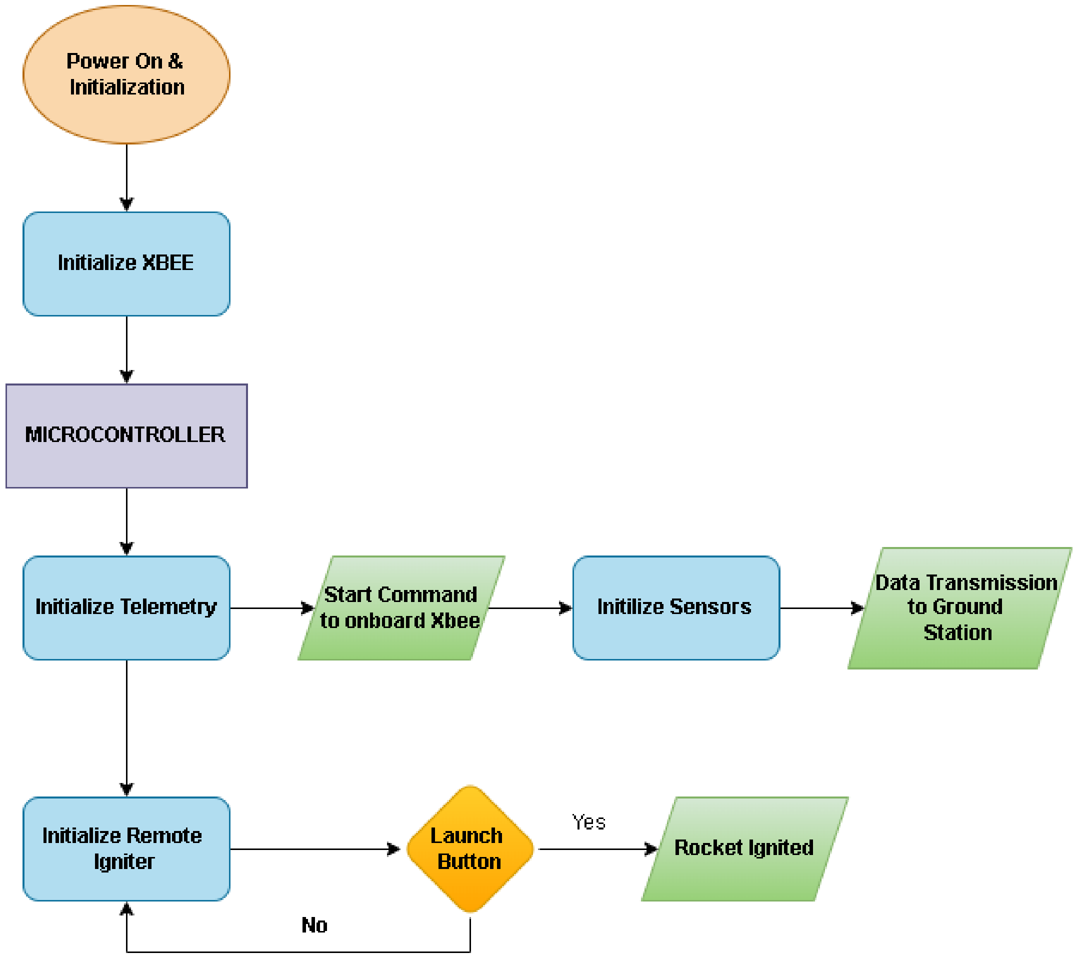


FIGURE 23 – GROUND SYSTEM OVERVIEW

5.2 GUI

The Graphical user interface uses the real-time data from XBee receiver to plot the graphs in real time. It contains various graphs to plots different parameters like acceleration, rotation, altitude, temperature, pressure, GPS and magnetic coordinates.

The program utilizes a combination of python and Qt along with communication and network module to deliver the best quality graphs at high speeds. It contains different tabs to display and send command to the System.

FIGURE 23 – GROUND STATION GUI

6. RECOVERY SYSTEM

At 600m altitude, the servo motor is power to unlock the parachute bay. Thus, the parachute ejection will take place.

Considering the constraints:

Mass of the rocket: ~11kg

Force required for descent = 11 * 9.82 = 108.2 N

On equating with drag force = D = ½ p $V^2S\ C_l$ = 108.2

Taking 0.8 as drag coefficient for parachutes, and descent velocity as 3m/s.

S = (2*108.2/(1.225*9*0.8)) = 24.54 m^2

Thus, diameter of parachute is ~4.5

Figure : PARACHUTE

7. Launch Pad

The launchpad has been designed for the safe and reliable launch of model rockets, adhering to competition guidelines. It is equipped with features that ensure stability, safety and precise orientation during launch. The structure is modular, portable and designed to be easily assembled.

Materials used for Launchpad

The construction of the launch pad consists of light but strong materials such as aluminum or stainless steel to provide strength and protection from the elements. This base structure offers a solid support base that bears the weight of the rocket and absorbs all the vibrations produced during the launch sequence.

Features:

- 200N capacity
- Folds for easy transportation
- Holes in feet for staking the pad to the ground
- Accepts launch rods and launch rails with more than 90% of the rocket's length.

- **Launch Rail and Rods**
  The launchpad utilizes a 200 cm launch rail to ensure a straight and stable ascent. The guide system supports the rocket during the critical initial phase of the launch, preventing any lateral movement and ensuring that the thrust vector remains aligned with the desired trajectory.
- **Rail Length:** 200cm to support acceleration.
- **Rail Angle Adjustability:** Adjustable between 0 degrees to 90 degrees for varying wind

conditions and required launch angles.

- **Locking Mechanism:** A robust locking mechanism is used to secure the rocket on the launch rail prior to ignition.

Safety Features

To ensure the safety of both the team and spectators, the launchpad design includes several key safety features:

Distance Control: The launchpad is equipped with remote ignition capabilities, allowing the team to control the launch from a safe distance (typically 5-10 meters).

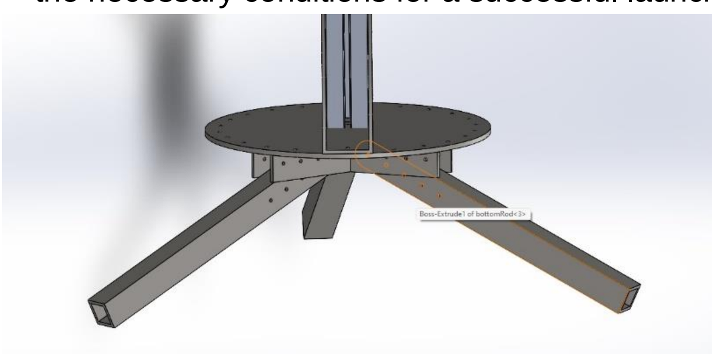
Grounding Rods: Grounding rods are included to protect against electrical discharge during ignition.

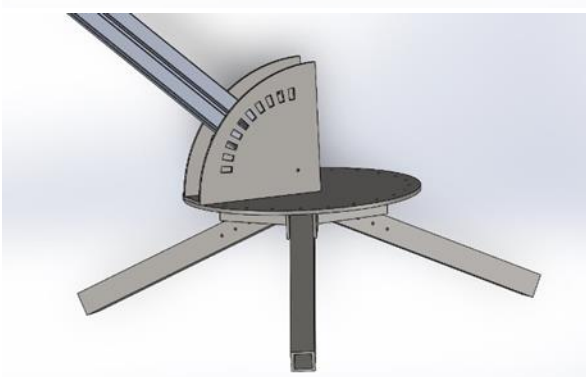
Stabilization Anchors: The base is equipped with heavy-duty anchors to ensure stability on uneven surfaces or windy conditions.

Safety Perimeter: A physical barrier or designated safe zone is established around the launchpad during operation.

Launchpad Stability and Adjustments

The launchpad has been designed for easy adjustment and secure placement in different terrain conditions. It includes adjustable legs or a tripod stand that can be levelled according to the terrain. This flexibility ensures that the rocket remains vertical, providing the necessary conditions for a successful launch.





Electrical Launch System (ELS)

The remote ignition system uses two NRF24L01 transceivers for wireless communication, with one acting as a transmitter and the other as a receiver, both controlled by Arduino Nano boards. When the "LAUNCH" command is sent from the ground via the transmitter, it is received by the NRF24L01 receiver near the rocket. The receiver, connected to an Arduino, activates a 5V relay module, which closes the circuit between a 9V battery and the pyro igniter. This triggers the ignition, allowing current to flow to the igniter, which heats up and initiates the rocket's launch. This system ensures a safe and reliable wireless ignition process, keeping the operator at a safe distance.

8. TEST MEASUREMENTS, VARIABLES, AND CONTROLS

8.1 For Electronics:

Testing and verification of the avionics occurs in three distinct phases: ground testing, on a test aircraft and lastly on the final rocket, thus enabling ground testing shall consist of validating the correct operation of all hardware and sensors in a non-critical environment.

Phase One – Ground Testing

During the ground testing phase, the avionics system will be validated in a controlled environment. Key components like the flight computer, NavIC/GPS, and sensors (IMU, barometric pressure, etc.) will be connected and tested for functionality. The telemetry system will be checked by sending mock data to a ground station, ensuring proper communication. All sensors will be tested under different conditions, like altitude simulation, to confirm they provide accurate data.

Phase Two – Drone Testing

The avionics system will be integrated into a commercial drone for flight testing. Initial flights will be manually controlled to verify the stability and communication between the flight computer and ground station. Autonomous flight testing will follow, where waypoints are uploaded to the system mid-flight to check navigation accuracy. Sensors, data logging, and telemetry performance will be monitored throughout.

Phase Three – Final Rocket Testing

In this final stage, the avionics will be tested with the CANSAT integrated into the rocket. The system will be checked for stability, proper deployment, and recovery after launch. The rocket’s propulsion system and control gains will be optimized for stable flight, while sensor performance and data logging capabilities will be verified. Final drop tests from an elevated platform will simulate deployment from the rocket and confirm system recovery.

8.2 For Mechanical Structure:

We will multiple testing for the whole rocket body-

1. Compression and tensile strength testing for the body: We will put the rocket body under load cell and test whether it will sustain under high loading and tension or not as well as tensile strength of body as well as calculate the young's modulus.

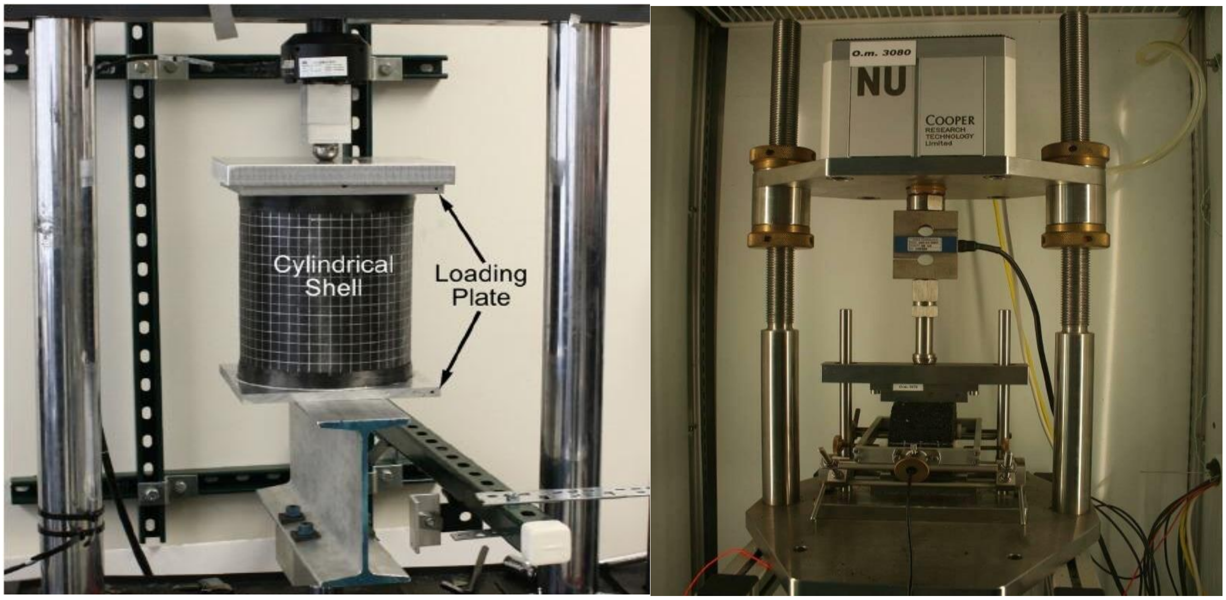


Figure: COMPRESSION TESTING & TENSILE TESTING

2. Shock testing: We will test our rocket for high G stress up to 30g minimum.

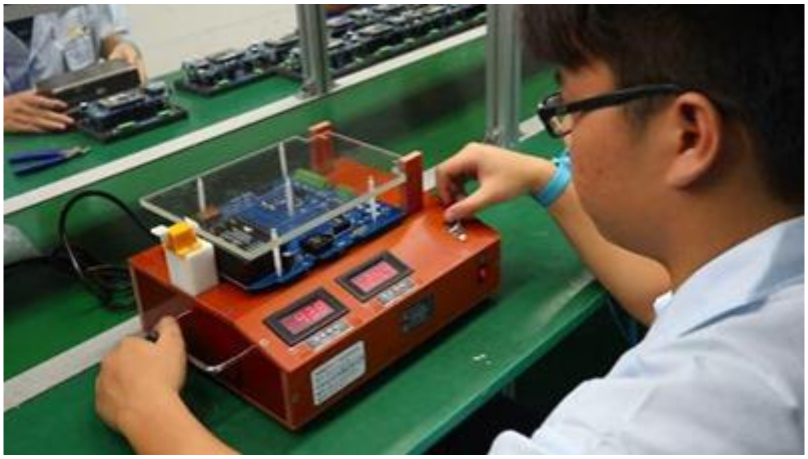


Figure: SHOCK TESTING

3. Heat Testing: It is to test the body whether we will be working properly at 60 degree temperature or not.

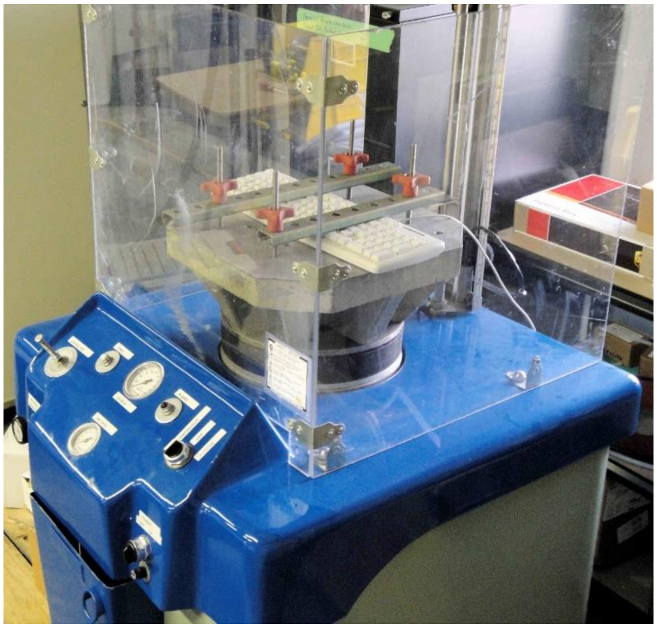


Figure: HEAT TESTING

8. ACTIVITY PLAN

8.1 BUDGET PLAN

The budget plan outlines the estimated costs involved in the design, construction, and testing of our model rocket for the upcoming competition. The goal of the project is to develop a fully functional rocket that adheres to the competition guidelines and reaches an altitude of 1,000 meters. Our approach includes detailed research on materials, propulsion systems, and essential components while maintaining cost-efficiency without compromising performance or safety.

The budget covers the following key areas:

1. **Materials**: This includes the procurement of carbon fibre, adhesives, parachute, motor and other structural components required for the rocket's body and systems.

2. **Testing and Validation**: Expenses related to launch tests, and any necessary recalibrations or adjustments to ensure the rocket meets the required performance parameters.

3. **Logistics and Miscellaneous**: Costs for transportation, team equipment, and other unforeseeable expenses during the preparation process.

This budget plan is designed to balance quality and efficiency, ensuring that we achieve the project goals within a manageable financial framework.

Budget source – Lovely Professional University

Estimated budget Amount – 1.5 Lakh Rupees

Pinaka Budget					
Subsystems	**Item Name**	**Description**	**Rate (₹)**	**Qty**	**Amount (₹)**
Airframe	Lower Body tube	IM Carbon Fiber,2.02 Kg, Dia - 13cm, Length - 95cm	1300	1	1300
	Upper Body tube	IMCF, 1.12 Kg, Dia - 17cm, Length - 40cm	1650	1	1650
	Nose Cone	IMCF, 0.34 kg, Dia - 17cm, Length - 15cm	400	1	400
	Fins	IMCF, 0.729 Kg , Area - 1 m^2	300	4	1200
	Bulkhead	PEEK , 0.118 Kg	408	1	408
	Centring Rings	PEEK, 0.051 Kg	1248	3	1248
	Transition tube	IMCF, 0.156 Kg	250	1	250
	Nut and Bolts	M4-12 x7 Bolt, M3-12 x8 Bolt, M6-12 x2, , 5xM5, M			200
	Eye Bolts	M6 Eye bolts	1500	2	3000
Avionics	Pressure & Altitude sensor	7Semi BMP581	800	1	800
	Motion Tracking Device	7Semi ICM-20948 9DoF IMU Breakout	900	1	900
	Telemetry Sensor	Zigbee XBee Module S2C	2000	2	4000
	Microcontroller	Bharat Pi Node Wi-Fi with ESP32	1100	1	1100
	Navigation Module	NavIC (Navigation with Indian Constellation)	1800	1	1800
	Antenna	IRNSS/GPS/GLONASS Antenna with RG174 Cable (L-	900	1	900
	Voltage Sensor	Voltage Detection Sensor Module 25V	20	1	20
	Temperature Sesnor	AHT25 Integrated temperature and humidity sens	150	1	150
	Transceiver Module	NRF24L01 2.4GHz PA+LNA SMA Wireless	140	2	280
	Chip	Nano CH340 Chip Board	189	2	378
	Relay	5V 1 channel without light bulb coupling relay	80	1	80
	Clock on board	DS3231 Real Time Clock	80	1	80
	Battery	Samsung 18650-25R 2500Mah (8C) Li-Ion Battery	418	1	418
	Converter	7Semi 3.3 V 2A Mini Buck Converter Breakout - AP6	92	1	92
	Buzzer		20	1	20
	LEDs		10	3	30
Launch System	Launcher	Ground Rocket Launcher	6000	1	6000
Recovery System	Parachute	Ripstop Nylon Sheet, Area 14 m^2	7000	1	7000
	Shock Chord	Braided Nylon, Length - 0.54 m	40	1	40
	Suspension Chords	Braided Nylon, Length - 0.504 m	40	8	320
Propulsion System	Rocket Motor	Aerotech K-680 P(Motor with required configuratio	20000	2	40000
Miscellaneous		Includes any other processing/ machining and other	6000		6000
Total					**80064**

TABLE 5-1: FUNDING SOURCES

8.2 TIMELINE

Month 1: October

1. **Parameter Iteration & Design Optimization**

Week 1-2: Review the initial rocket design and iterate key parameters such as dimensions, thrust, weight, and stability for enhanced performance.
Week 3-4: Conduct in-depth analyses using tools like OpenRocket or MATLAB to further refine the design. Optimize for height, stability, and thrust-to-weight ratio.

2. **Preliminary CFD Setup**

Week 4: Set up initial **CFD (Computational Fluid Dynamics)** simulations to analyze aerodynamics. Focus on optimizing the nozzle and body shape for reduced drag and improved flight efficiency.

Month 2: November

CFD & FEA Analysis

Week 1-3: Continue with **CFD** simulations to evaluate flow characteristics and identify areas of improvement. Begin **FEA (Finite Element Analysis)** for structural integrity checks, focusing on stress and load distribution during launch and flight.
Week 4: Analyze results from both CFD and FEA, and improve structural elements or aerodynamics based on findings.

Final Design Adjustments

Week 4: Make final adjustments to the design based on CFD and FEA feedback. This may include tweaking the fin size, body shape, or material selection to ensure the rocket can withstand forces and achieve optimal performance.

Month 3: December

Rocket Testing

Week 1-2: Prepare for the first ground-based tests of the rocket. Conduct simulations of the launch and flight to validate the adjusted parameters.
Week 3-4: Perform the initial **live launch tests**, evaluating thrust, stability, and height achieved.

Parachute Testing

Week 3-4: Begin testing the parachute system to ensure safe recovery of the rocket. Optimize deployment speed, canopy size, and material.

8. CONCLUSION

The team is developing an innovative model rocket system designed to accomplish various mission objectives, including search and rescue simulations, data collection, and other scientific tasks. This project represents a significant advancement in model rocketry, specifically tailored for the InSpace Model Rocket competition in India. The rocket is engineered to meet the competition's stringent requirements and will autonomously perform critical tasks, such as locating its landing position and gathering essential flight data as outlined by the mission parameters.

Drawing on their expertise in working with high-performance composite materials, the team is constructing the rocket using a robust yet lightweight carbon fiber layup. This ensures the vehicle has both the structural integrity to withstand launch conditions and the optimized weight needed for efficient flight performance. The design process includes addressing challenges related to the size, aerodynamic stability, and payload integration, ensuring the rocket operates reliably throughout all phases of the mission.

As the project progresses from design into the fabrication and testing stages, the team is committed to following a structured timeline to meet all competition deadlines. Detailed planning, combined with regular team meetings, ensures each milestone is completed on time. The team's dedication to excellence, alongside support from the broader aerospace community, positions them for success in the InSpace competition. With a solid foundation of technical expertise, meticulous planning, and a clear mission, the team is poised to demonstrate the effectiveness of their model rocket while contributing valuable insights to the field of model rocketry.