Jericho Rocket: A Community-Driven Endeavor in Indian Amateur Rocketry

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Abstract: ***This technical report details the 2023 Annual Rocket Launch organized by Rocketry India, an amateur rocketry club. It covers the development and challenges of building a model rocket, including the flight computer, payloads, and rocket motor. The report highlights the importance of community involvement and the educational value of hands-on experience in rocketry. It concludes with reflections on the launch's success and future aspirations for the club. The purpose of this article is to document the technical aspects and community experience of the 2023 Annual Rocket Launch by Rocketry India, emphasizing the educational and collaborative efforts involved in amateur rocketry. This article is significant as it showcases the practical applications of amateur rocketry, the collaborative nature of such projects, and their potential to foster a community of enthusiasts and learners in India.***

Keywords: Amateur Rocketry, Model Rockets, Flight Computer, Rocket Propulsion, Community Involvement

1.Disclaimer

The rocketry project outlined in this report involves inherent risks associated with the handling of materials, manufacturing processes, and launch activities. It is imperative to acknowledge that rocketry, by nature, demands a comprehensive understanding of safety protocols and adherence to guidelines.

Certain specific manufacturing methods, which pose potential risks or require specialized expertise, have been intentionally omitted from this report. This exclusion is intentional and aims to prevent replication of these procedures without proper guidance and oversight.

Readers and enthusiasts engaging in rocketry activities are strongly urged to prioritize safety, adhere to local regulations, and seek professional advice when implementing manufacturing techniques or conducting launches. The omission of certain details in this report serves as a precautionary measure to encourage responsible and informed engagement with rocketry endeavors. It is essential to approach such projects with diligence, expertise, and a commitment to minimizing potential hazards.

Intro: Rocketry India, where our passion for space exploration and rocketry unites us in a vibrant community of enthusiasts, engineers, and dreamers. Our server is dedicated to fostering knowledge, collaboration, and innovation in the fascinating world of rocketry.

As of December 2023, our server is populated with 260+enthusiasts

Mission: At Rocketry India, our mission is clear: to provide a platform that nurtures curiosity and fosters innovation in rocketry. We're here to share insights, exchange ideas, and embark on exciting projects that propel our love for space to new heights, in order to jump start rocketry in India.

What sets us apart?

1) Weekly webinars
2) Build projects together
3) Annual Rocket Launch
4) Knowledge sharing
5) No other model rocketry community in India other than Rocketry-India discord server.

Vision:

1) To perhaps have this event as a butterfly effect towards jump starting model rocketry in India.
2) If the event goes successful and feedback is great, perhaps this can be an yearly recurring event.
3) Perhaps even turn this into India's first amateur model rocketry club, similar to Tripolli or NAR in the US.

About the event:

1) To host a mega event where all volunteering members of the server come together and build an advanced high powered rocket.
2) Participation can be done remotely as well, i. e. design and software work won't require physical presence unlike assembly process, which does.
3) Current goal is to reach 1 km apogee minimum, with member payloads, which in total should not be any more than 250 grams.
4) The event will be non profitable.
5) To host a variety of workshops to teach members the fundamentals they need to know, in case they don't know but still want to contribute.
6) Collaborating with companies in India to help us accomplish this event, with their guidance and expertise on organising such mass events, and also with material procurement.

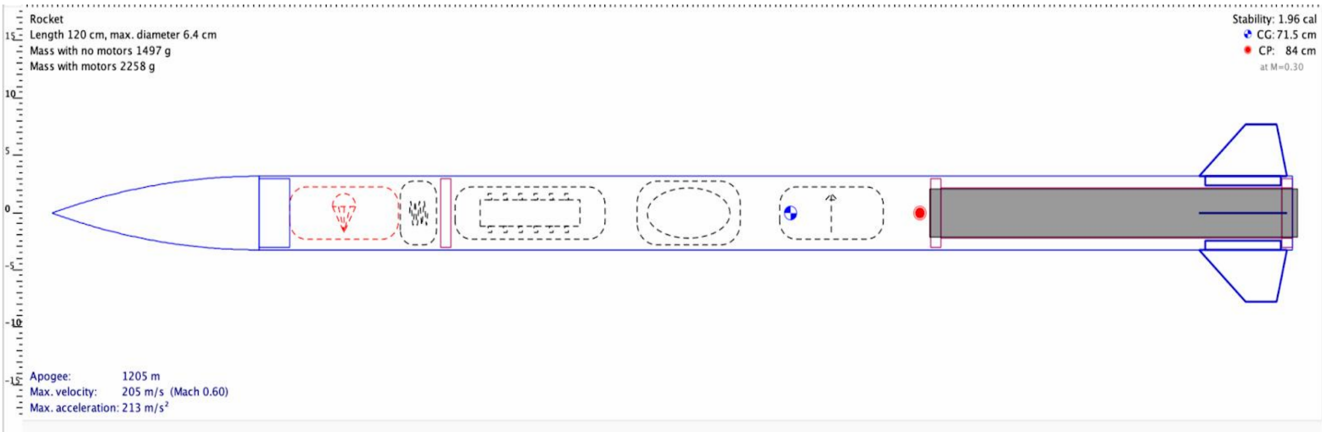
Our USP is that this is a community of all types of student enthusiasts, industry people, working professionals etc. who have come together to launch a rocket. No one has done this before, and the fact that an online community is doing this is very special to itself.

About the rocket:

1) Launching on I class KNDX rocket motor
2) Going up to 1 km altitude and recovering back to land by smooth descent assisted by a parachute inside the rocket.
3) As per latest simulations the rocket will attain speed 0.6 times the speed of sound (0.6 MACH)
4) Rocket will have onboard cameras and sophisticated integrated circuits.
5) Rocket will stand tall at 1 metre + height

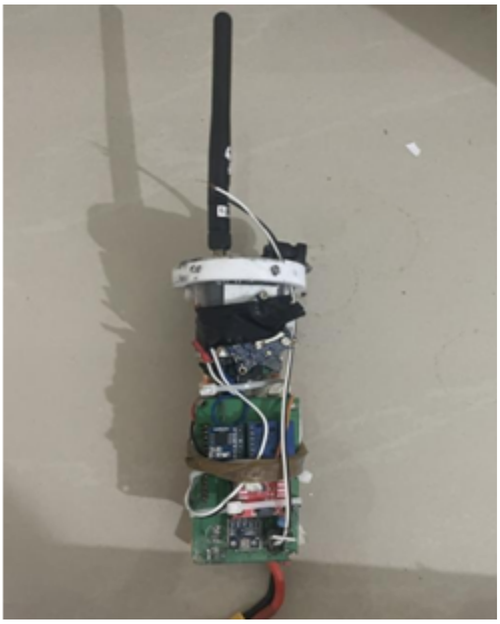
The project is sponsored by pcbway, although it was such a small amount we could not use it in a meaningful manner, but their name had brought us a lot of attention and hence why we thank them, this project was entirely supported by crowdfunds set up on Ketto online crowdfunding platform. (Raised 50000 INR), it was all non-profiting and each donation or payload fee went directly into building the rocket.

2.Open Rocket design



The design above represents the blueprint of the rocket, so to speak. It includes the flight computer and the payloads in the midsection of the airframe. At the aft section of the rocket is where the rocket motor is located, and near the forward section, the parachute assembly, along with the nosecone, can be seen. All these components collectively constitute the rocket's weight and contribute to its stability. We chose to maintain our stability above 1.5 and below 3 CAL to mitigate weather cocking. This design wasn't the initial iteration, as it underwent multiple revisions before any CAD work commenced.

2.1 Flight Computer



Disassembled condition, post flight

The Jericho flight computer served a very basic but crucial role of detecting launch, recovering the rocket safely at apogee, detecting its landing, and throughout this progression recording data and saving onboard rocket POV footage.

Modules onboard:

1) LSM6DSO-inertial measurement unit
2) BMP180-altimeter
3) SD card & flash chip module – data logging
4) Runcam Split 3 nano-Rocket POV footage
5) VTX module-sending live FPV footage on ground

The state transition logic on our flight computer was dominated by the altimeter, and coupled with dual redundancies that were based off the IMU sensor and hardcoded timer, in case every other previous redundancy fails. Its crucial role was to safely recover the rocket on its own, which it perfectly did by ejecting a parachute at apogee via a pyro charge. Its passive job was to keep saving data on its storage space, which was again done perfectly by the flight computer.

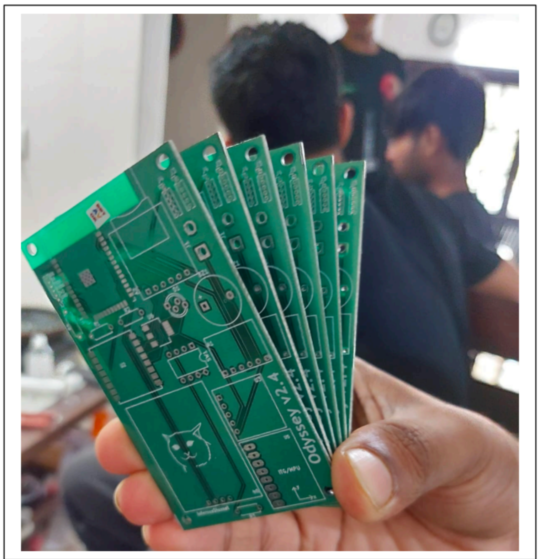
2.2 Payloads

Commencer V1

By -: Gautham machina (High school student) Sold spot for 3000 rupees

Commencer V1, an altimeter based on the rp2040 and sx1278 lora. It's capable transmitting a 433mhz radio signal for over 5km for long distance telemetry and can be used with a directional antenna to easily find the location of the rocket for recovery.

2.3 OdysseyFC Drone Flight Computer



OdysseyFC Drone Flight Computer

By -: Ayushman Kar (CSE IOT, VIT Vellore) Sold Spot for 5000 rupees

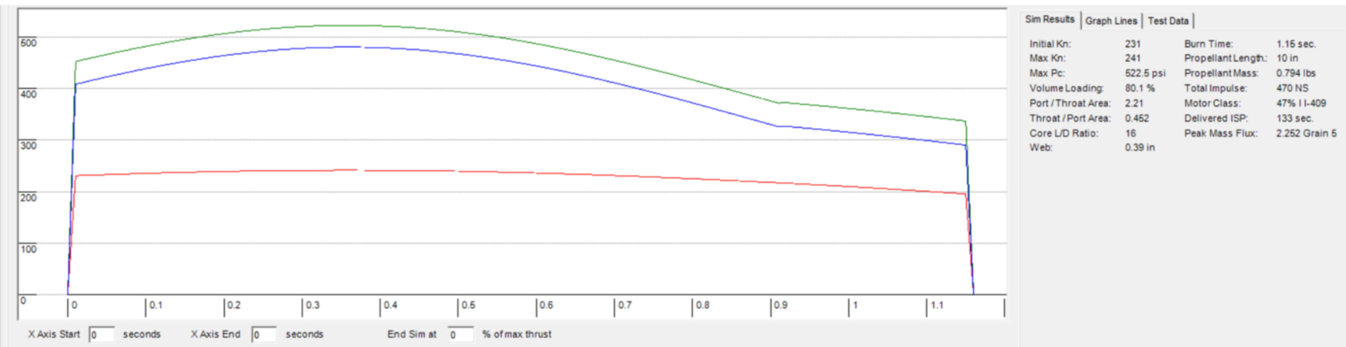
- Pioneering the design and development of an innovative drone flight controller in India, aimed at achieving affordability without compromising robustness or versatility. Significantly reducing costs in comparison to international counterparts, this project introduces a cost-effective solution to the drone technology landscape.
- The flight controller integrates a comprehensive suite of sensors, including IMU, Barometer, GPS, RF, Ultrasonic Sensor, and other sensors, conducting sensor fusion to gather diverse and accurate data. Designed to match the features and capabilities of high-end commercial solutions in the global market, the flight controller ensures robust performance in various applications.
- Demonstrating a commitment to technological innovation, this project contributes to the localization of drone technology by providing an affordable, feature-rich flight controller developed in India.

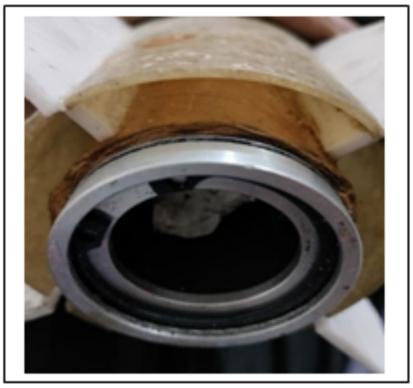
2.4 Rocket Motor

Our motor was built upon the already characterised KNDX propellant by Mr. Richard Nakka. The team managed to cast high efficiency grains (90-96%) compared against the provided KNDX density by Nakka himself.

The propulsion team spent two sleepless nights at casting a total of 5 grains for our I409 rocket motor. During which we quickly found out that working with KNDX is hard, as it melts quickly and also hardens in No time. It's brittle due to its quick hardening nature as well. Making it harder to work with as handling it not carefully can cause it to chip, making the grains hugely unusable. But the team managed to pull off High efficiency grains and deliver the motor in time for launch.

3.BurnSim Simulation





Our choice for motor hardware was Aluminum 6061 T6 grade due to its high material tensile strength, lightweight nature, and cost-effectiveness. This material is widely used in the aerospace industry for its versatility. However, procuring the material posed challenges as most vendors were reluctant to sell smaller quantities. We were consistently informed that their Minimum Order Quantity (MOQ) ranged from 100-300 kgs of material.

After extensive efforts, contacting various vendors online, we fortunately identified a couple willing to provide at least the entire ingot if not the rounded tube. We finalized the deal and promptly proceeded with machine lathing the ingot into specific engineering drawings for all components,

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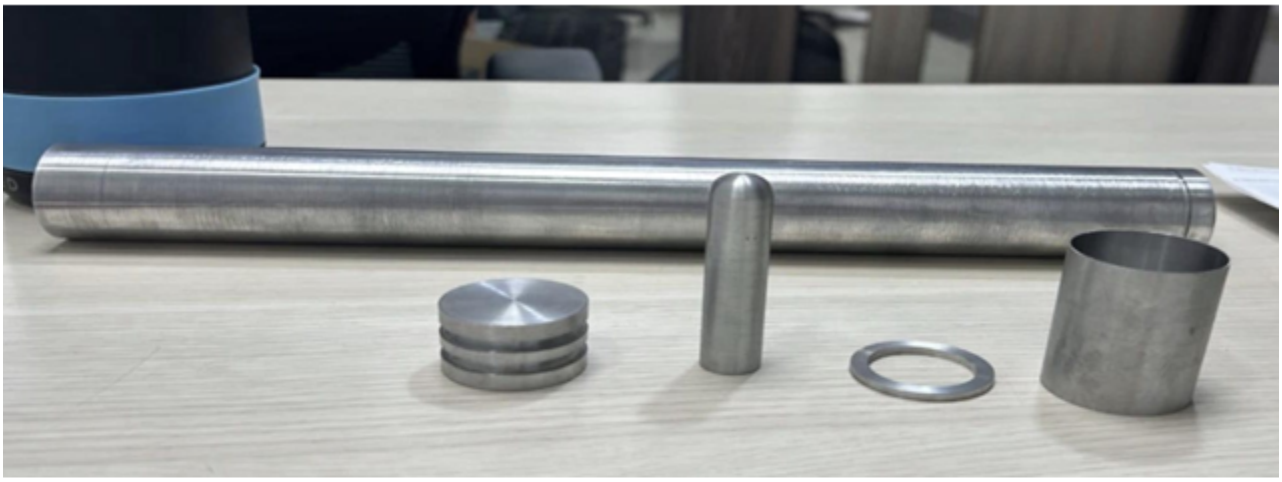
including the motor casing (combustion chamber), bulkhead, nozzle washer, grain casters, and cores.

Our nozzles were machined from isostatic 0.95 g/cm3 density graphite due to its high temperature tolerance and very low coefficient of throat erosion, making it reusable. The entire rocket motor is designed to be a reloadable hardware, allowing for the creation of new grains, loading them, placing the bulkhead, nozzle, snap rings, and other components for subsequent launches. Although for a one-time use project like this, fiberglass-wound casings and phenolic nozzles could have sufficed, we opted for reloadable hardware to showcase advancements and possibilities within amateur rocketry.

Ensuring safety is paramount, general rule of thumb is to have a safety factor of 5 or above for the combustion chamber. Our safety factor was calculated to be 7, considering the dimensions of our motor hardware and the material's ultimate tensile strength. These casings can withstand pressures up to 2000 psi. To enhance project safety, our motor simulations and grain configurations were designed to ensure the peak pressure did not exceed 800 psi.

We took additional precautions by using silicon-based O-rings, employing two on each end of the tube, and reinforcing the bulkhead with epoxy on top of the O-ring's sealing and snap ring's locking. These extensive safety measures were implemented to guarantee that, under any circumstances, there would not be a catastrophic failure (CATO).



4.Rocket Integration

The originally scheduled launch date of December 25th, within the 5 am – 7 am window, encountered last-minute changes and challenges, resulting in a delayed launch window from 7 am – 10 am. The integration process faced several challenges, each meticulously addressed:

1) Fiberglass Airframe: Opting for a Fiberglass airframe due to its strength and lightweight properties, the team invested significant effort in finishing through sanding and multiple epoxy layer applications.
2) 3D Printed Structural Components: The nose cone, fins, and other internal structural components were 3D printed using PETG material, ensuring both precision and durability.
3) Through-Wall Fins Methodology: Implementing through-wall fins methodology involved attaching fins in a robust manner. A 3mm thick cardboard tube encased the rocket motor inside the airframe. Fins, passing through a cutout in the fiberglass airframe, were epoxy-filleted onto the cardboard tube. Precision cutouts on the airframe and the use of a 3D printed fin jig ensured alignment. Outer epoxy fillets were applied between the fins and the curved surface area of the airframe enhanced sturdiness and alignment.
4) Flight Computer Debugging: The main flight computer faced an unexpected malfunction three hours before launch. Extensive debugging on the ESP32 WROOM module, including bootloader replacement and voltage regulator checks, was conducted. Ultimately, the entire breakout board was replaced with a different model of the ESP32 chipset. Rigorous testing validated its launch and recovery capabilities.
5) Parachute Design: The parachute design featured 8 shroud lines and a flat-braided shock cord to prevent tangling during recovery. Utilizing ripstop nylon material, commonly used for its rip-stopping properties, enhanced the parachute's durability. Pyro charges were strategically employed to eject the parachute on apogee, safeguarding it with walding paper against burn damage.
6) Final Integration: With all components prepared and validated, the team proceeded with the final integration. A distinctive decal was added atop the rocket's body, providing a visual identity for the meticulously assembled rocket.

Despite the encountered challenges, the integration process showcased the team's resilience, problem-solving skills, and commitment to ensuring the rocket's readiness for launch.

5.Visuals and Data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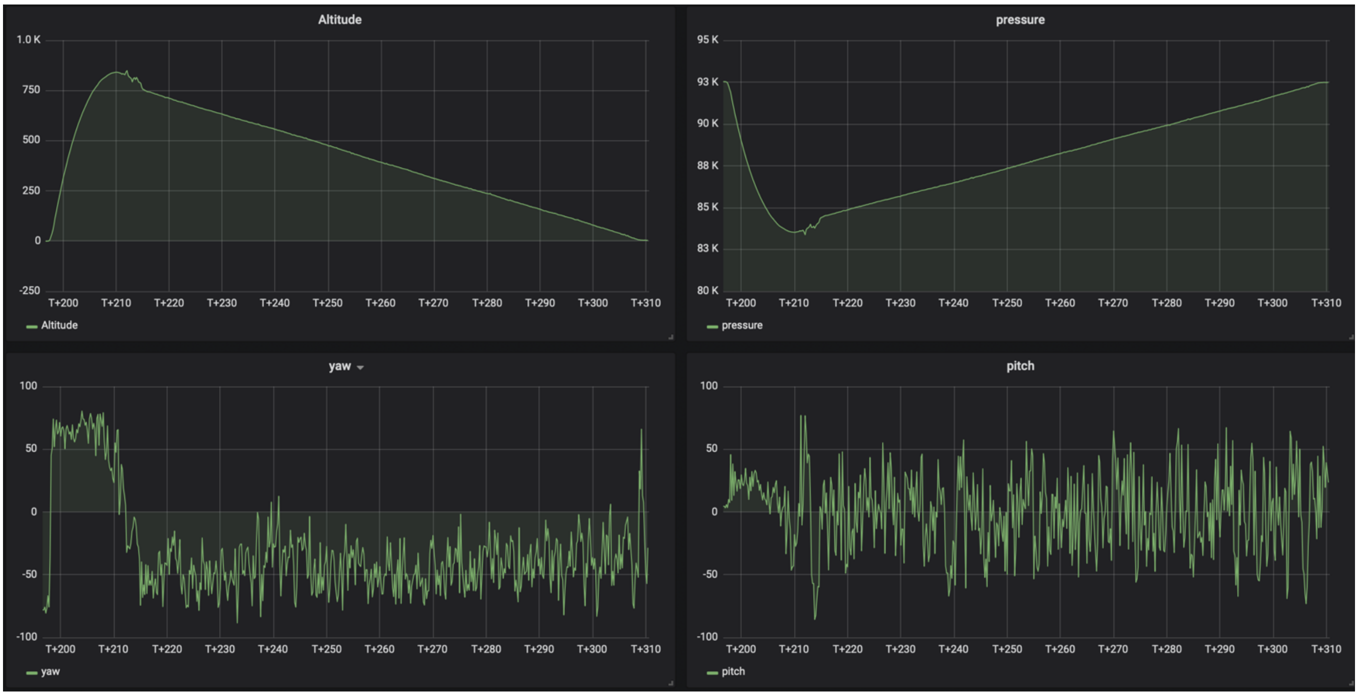
JERICHO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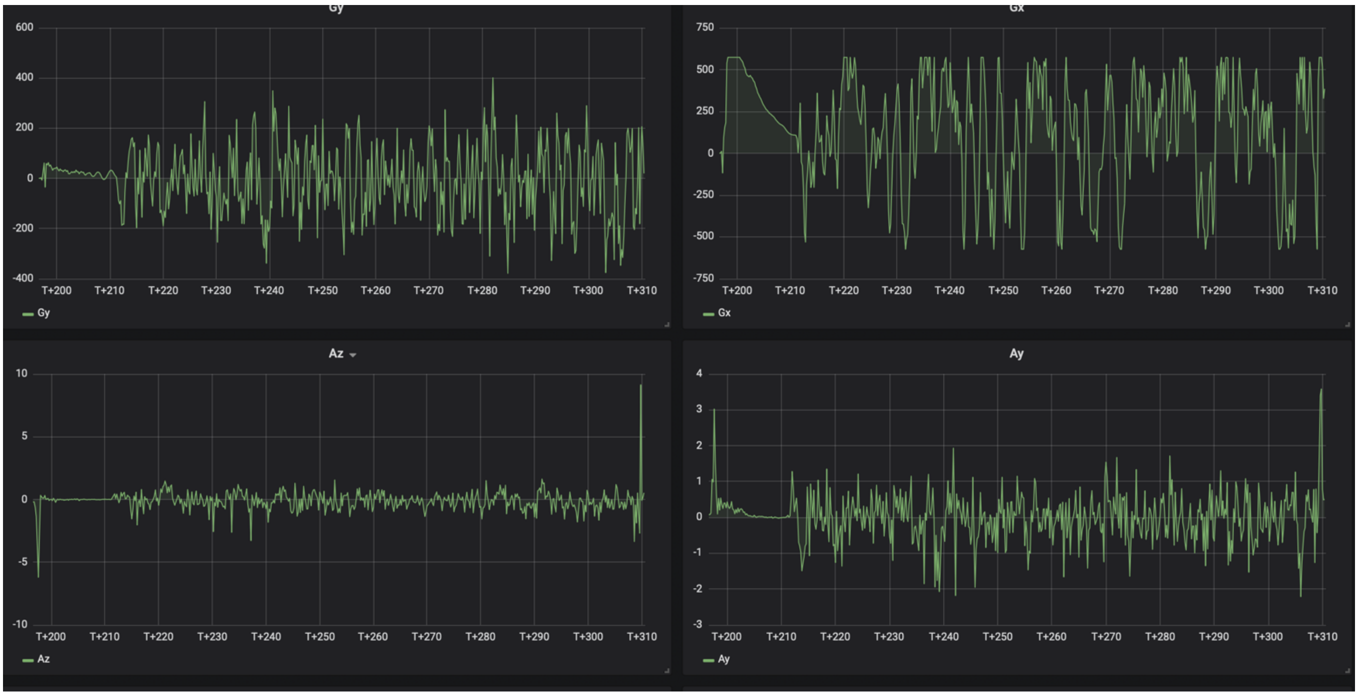
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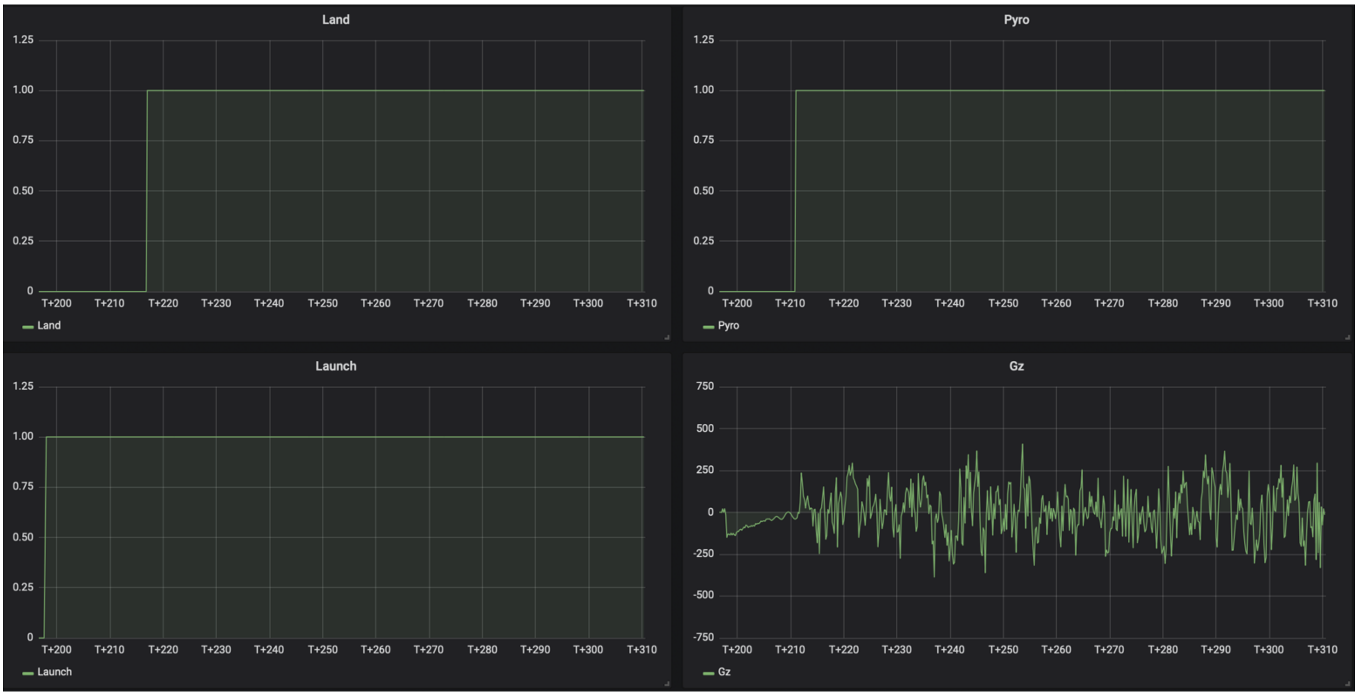

Summary			
Metric	Value	Units	Remark
Max Speed	176.9231	m/s	
Apogee	850.66	m	
Mach	0.536131		
Max Accel.	156.98	m/s^2	Sensor Value Capped

According to the data:

1) The time from launch till touchdown was 112.051 seconds.
2) And from parachute ejection to touchdown was 98.63seconds.
3) Time at apogee was 15.285 seconds.
4) The rocket pulled higher G's than 16g, we knew this would happen as it was reflected on our simulations as well. By taking an educated guess it must be under 20g. Due to the undersized capacity of our inertial measurement unit, the value is capped at 16g, which can be seen on the acceleration graph.

6.Launch summary

The open rocket design showcases a compilation of three payloads, one of which is our own flight computer, and the other two are paid bases. This design was not exactly followed in our rocket integration process due to the following reasons:

Firstly, initially, the payload sender was unable to complete and functionalize their payload by the launch hour. Consequently, the team considered sending it as dead weight. However, since the mass of the rocket had already increased due to a last-minute change to a larger battery to sufficiently supply power to the onboard camera and the flight computer, we all decided to remove it completely.

Due to this change, the rocket was lighter, but it also meant the stability changed. Overall, the rocket ended up being a bit too bottom-heavy, causing it to be less stable. To address this imbalance, we added about 100 grams of dead weight to the nose cone, almost equalising the recently lost weight from the payload. In the end, the rocket weighed around 2200 grams.

The conclusion and mutual agreement the team reached at the last moment were that the rocket would definitely not reach the 1 km altitude; it would fall just shy of that due to the above modifications affecting the rocket's stability.

The team conducted a thorough analysis post-flight, and we believe there were also a few other minor reasons why the rocket did not reach the 1 km mark, in addition to the reasons mentioned above: high winds, launch angle, ground evenness, and possible motor imperfections.

After further analysis, it can be said that the motor did not over-under perform, as the burn time matches the open motor simulation. In real life, the motor did, in fact, burn for around a second. Due to the Doppler Effect, it can be heard for longer, but visually it can be decoded and timed. Regardless, some imperfections definitely played a role in the rocket's performance.

Team

Ayushman kar, Upmanyu bhati, Syed Affan, Kunj sorathiya, Aujas mehta, Sachit Shastri, Parag jitwani, Harsh Katrodiya, Gautham machina, nikhil, Aviral bajpai, Sunny Gavali, Prabal rawat, Aarush jaiswal, Aaditya Rengarajan, Abhishek jaiswal.

7.Conclusion

The 2023 Annual Rocket Launch by Rocketry India successfully demonstrated the capabilities and enthusiasm of India's amateur rocketry community. Despite challenges, the team's collaboration and innovation led to a successful launch, laying the groundwork for future endeavors in this field. This event signifies a major step forward in establishing a vibrant rocketry community in India, with aspirations for higher altitude launches and greater technical advancements.

The agenda of this project was never to reach a specific altitude but rather to encourage people to participate in a project that would provide them with hands-on experience in real rocket building and the challenges faced. We also aimed to represent the Indian rocketeers' community through this project, and the Jericho team believes that the project surpassed this expectation, making it a 100 percent successful flight. We wish to collaborate with more people and organisations in the near future to keep doing these launches and fully establish a functioning and healthy rocketry club in India. The team also plans for a 3km launch in 2024!

References

[1] https://www.nakka-rocketry.net/dex.html

Author Profile

Syed Affan is pursuing his B. Tech in Electronics and Communications engineering at VIT Vellore, Tamil Nadu. During his school years author developed a keen interest in amateur rocketry. Being someone who learns better by building things and gaining knowledge along the way, he found himself facing a challenges due to the lack of materials available in India to create an advanced model rocket. However, his strong determination to pursue rocketry prevented this roadblock from deterring him. Author decided to make his own solid rocket motors, which were not commercially available off the shelf in India, unlike in the US. In the first year, "I encountered failures in developing rocket motors, spending time foolishly on trial and error". Realising that this approach wasn't suitable for rocketry, given its inherent risks, author took a break. During this break, he focused on studying safety and development aspects related to his pursuit. After this break, author successfully replicated Richard Nakka's R-candy solid rocket motor chemistry and achieved consistent results with each burn. Although sugar-based solid rocket motors may not be the most reliable or efficient propellants, they fulfilled his requirements at that scale and also suited the needs of many amateur rocket hobbyists on a similar path. Throughout this journey, author recognized the need for a community - A group of people in India who shared the same hobby and face similar challenges. Once the progress started, author posted on Instagram and YouTube, establishing connections with like-minded individuals who shared both interests and concerns about pursuing this hobby in India. The challenges included not only the lack of resources but also the absence of awareness regarding the inherent risks associated with the hobby. During +2, author created the Rocketry India Discord server to bring together people with a passion for amateur rocketry, facilitating the exchange of insights and knowledge. Organised weekly calls to explore new concepts and discuss their application in the hobby. Soon, when author ran out of ideas for new projects, inspiration struck. Author decided to collaborate with the people and connected with through the server and work on creating a rocket together, which is now known as the Jericho rocket.

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