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PIONEERING UTM'S ENTRY INTO THE 2025 INTERNATIONAL ROCKET ENGINEERING COMPETITION (IREC)

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ABSTRACT

Rimau-1 is Universiti Teknologi Malaysia's (UTM) first high-powered rocket developed for the 2025 International Rocket Engineering Competition (IREC) under the 10k Commercial Off-The-Shelf (COTS) category. This project highlights UTM's maiden venture into competitive rocketry, involving a student-led team responsible for the design, fabrication, simulation, and testing of the rocket. Rimau-1 was engineered to reach an apogee of 10,000 feet using an Aerotech M2500T motor, and integrated a vibration-dampening payload experiment. This paper outlines the technical methodology, structural innovations, simulation results, and key outcomes from the project, showcasing UTM's entry into the international rocketry community through IREC 2025.

KEYWORD

Rocket engineering, IREC, UTM, COTS, Rimau-1, vibration payload, student aerospace project

LIFTOFF BEGINS HERE

The International Rocket Engineering Competition (IREC) is a globally recognized event that challenges university teams to develop high-powered rockets. In 2025, Universiti Teknologi Malaysia (UTM) participated for the first time with Rimau-1 in the 10k COTS category. This marked a significant milestone for UTM, demonstrating its commitment to advancing student aerospace innovation and practical engineering education.

Rimau-1 was led by a multidisciplinary student team supported by academic staff. The rocket was designed to achieve structural and aerodynamic stability, integrate recovery redundancy, and accommodate a research payload. The competition required the team to navigate design constraints, regulatory compliance, and systems engineering challenges under real-world conditions—providing an invaluable learning experience.

Figure 1: Rimau 1 rocket.

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Figure 2: UTM Rocketry Team.

Top Row from the left: Tahir Mazhar, Mohammed Sabri Mohammed Farah, Shivee Prakkaash Suriya Narhayhanen, Youssef Mohamed Fawzi Abdelaal Shahi, Ong Li Bin, Waali Ahmad Zargar, Arykummara Thava Kumar.
Bottom Row from the left: Brenden Huang Hong Quan, Julian Chee Yie Jian (mentor), Ts. Dr. Ahmad Humaizi Rozaini (), Umesh Devadas, Nik Muhammad Danish Nik Roslan, Raahull Kumaresan.

INNOVATION PIPELINE: FROM CONCEPT TO PROTOTYPE

The Rimau-1 launch vehicle utilized a modular structure combining G10 fiberglass and carbon fibre, a 4:1 tangent ogive nose cone, and trapezoidal fins. Simulations in OpenRocket and RasAero II informed design decisions regarding stability, apogee prediction, and aerodynamic performance. The Aerotech M2500T motor, delivering 2500 N average thrust, was chosen for propulsion due to its reliability, performance consistency, and compliance with 10k COTS category limits.

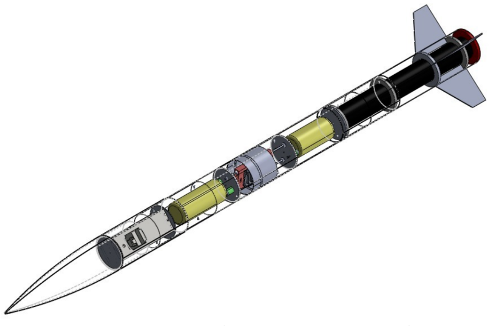

Figure 3: Rimau 1 internals structure and components.

The recovery system was designed using a dual-deployment configuration controlled by two commercial altimeters: the Featherweight Blue Raven (primary) and Altus Metrum EasyMini (redundant). The Blue Raven executed apogee detection using a 2-of-3 sensor logic combining barometric, gyroscopic, and velocity readings, ensuring fault-tolerant ejection control. The main parachute was deployed at 1500 feet via barometric triggers, while redundant circuits on the EasyMini added an additional layer of fail-safety with a programmed 5-second delay. This fully independent redundancy significantly reduced the risk of recovery system failure.

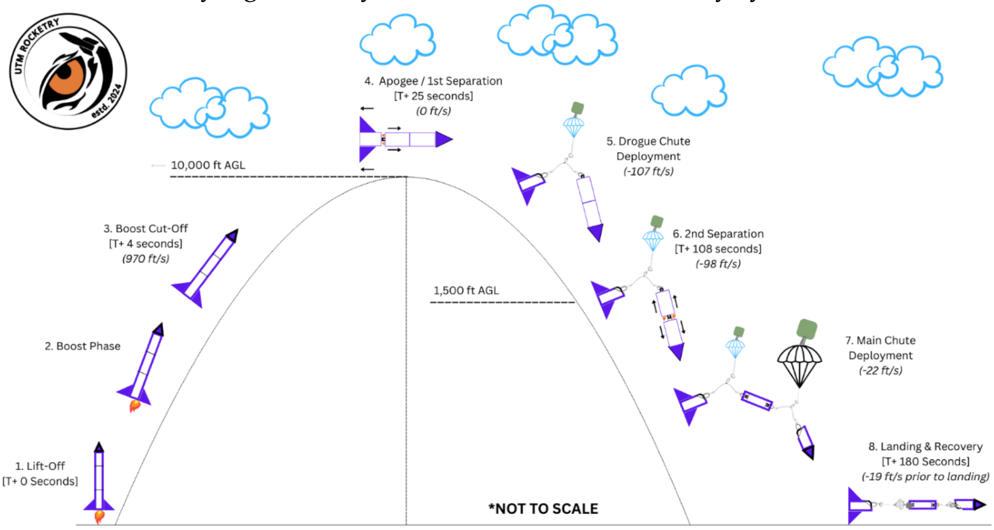

Figure 4: Flight profile infographic.

Rimau-1's avionics bay housed a self-contained electronics stack including the dual altimeters, telemetry modules, a GPS tracker, and power regulation circuitry. The telemetry setup enabled onboard data logging and post-flight retrieval. The avionics sled was custom-designed using PETG mounts and securely fixed onto a dual-threaded rod support system within the coupler. All ejection charge wiring was routed through bulkhead terminals to maintain clean cable management and reduce failure risk due to vibration.

A standout feature of the rocket was which experimental payload, which evaluated the vibration attenuation capabilities of thermoplastic polyurethane (TPU) compared to a rigid PETG baseline. The payload, housed in a 3U CubeSat-style casing, included a Raspberry Pi with two IMUs and a BME680 atmospheric sensor. Both TPU and PETG-mounted accelerometers recorded data in parallel, providing real-time insights into structural dynamics throughout the flight. This payload was fully enclosed in a non-ejecting compartment and recovered with the airframe.

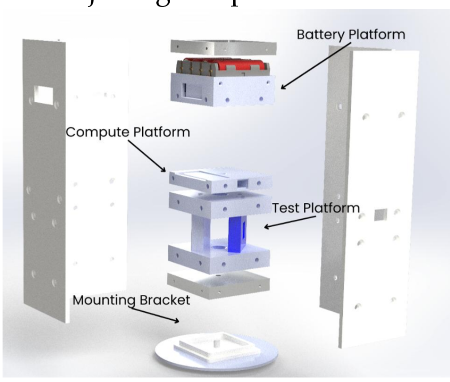

Figure 5: Payload Overview.

All components—including the airframe, thrust retention system, avionics mounts, and payload enclosures—were fabricated in-house by the student team. Materials were selected based on their mechanical properties, ease of fabrication, and performance under high dynamic loading. The integration of simulation-driven design, real-world fabrication, and system-level testing ensured a well-rounded and robust engineering workflow from concept to launch.

NOT JUST A FLIGHT — IT'S A BREAKTHROUGH BEYOND THE SKIES

Rimau-1 was successfully launched on June 12, 2025, achieving an altitude of 9,326 feet. The vehicle maintained stable flight and deployed both drogue and main parachutes as designed. Upon retrieval, the rocket was fully recovered with only minor structural damage—specifically, zipping along the body tube's shear pin connection area, a common post-flight occurrence in high-power rocketry recoveries.

A key highlight of the project was the in-house fabrication of the rocket's modular airframe. The main body tubes were fabricated using a mandrel-wrapped layup technique with fiberglass cloth and epoxy resin. A carefully prepared mandrel (6-inch diameter) was treated with mold release wax and layered with fiberglass cloth strips saturated with epoxy. Each layer was applied with precision to ensure uniform wall thickness and mechanical strength. After a 24–48 hour curing period, the tubes were demolded and post-processed through trimming, sanding, and surface finishing. The resulting tubes featured a 6.17-inch outer diameter with a wall thickness of 0.085 inches and demonstrated sufficient stiffness and impact resistance during both handling and launch phases.

This custom fabrication approach enabled the team to optimize the structure-to-weight ratio while ensuring compatibility with commercial motor hardware. During flight, the body tubes withstood peak thrust forces of up to 2891 N without structural compromise. The only notable deformation post-flight was the aforementioned zipping at the shear pin joints, which did not affect overall integrity and can be easily mitigated in future builds with reinforcement layers or improved shear pin seating.

The performance of the payload system was also satisfactory, successfully logging vibration data for TPU and PETG platforms. The structure's rigidity and effective vibration isolation ensured that the data collected was reliable and that sensitive electronics remained protected throughout the mission.

Figure 6: The historic liftoff of Rimau-1.

MILESTONE MOMENT

Rimau-1 marks Universiti Teknologi Malaysia's successful debut at the International Rocket Engineering Competition (IREC), demonstrating strong capabilities in design, systems integration, and recovery engineering. Achieving an altitude of 9,326 feet with full recovery and minor repair needs, the mission stands as a testament to UTM's potential in future rocketry competitions. The experience paves the way for more ambitious entries into SRAD and multistage categories, positioning UTM as a serious contender in global student aerospace challenges.

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