fSection 1: Introduction

Title* *Give your submission a catchy title that describes the idea and gets people interested.*

- Sights Beneath Zenith: Advancing Rocket Design for Optimal Performance and Recovery

Short description *Provide a brief description of your idea. Be clear and concise.*

- Our rocket design focuses on optimized structure, efficient payload and precision engineering to ensure reliable flight and mission success.

How did you hear about this challenge?

- We discovered this competition by researching contests that aligned well with the focus and goals of our project.

Section 2: Application Information

Formal University Name* *ONLY enter your FULL FORMAL SCHOOL'S NAME.*

- Atilim University

University City/Province and Country* *Ex: Cincinnati, Ohio, USA*

- Golbasi, Ankara, Turkey

Mailing Address for Awards* *This is the address we'll use for mailing awards*

- Kizilcasar Neighborhood, Misakimilli Street, No:79/5 Golbasi, Ankara, Turkey

Team Name* *Enter your Rocketry team's name. ACRONYM and Full Name.*

- ZRT- ZENITH Rocket Team

Organization Type*

- **Club/Group**
  - Engineering Class
  - Senior Project
  - Grad Project
  - Other

Rocket/Project Name* *Name for this year's rocket Project*

- ZRT-02

Social Media Presence* *Web page URL, Facebook, Twitter, Instagram ... ESRA needs to have a clear understanding of the skills, experience and expertise of your rocketry team*

- https://www.instagram.com/zenithrocket/
- https://zenithrocketry.weebly.com

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Team Mentor(s) - Name, Organization, Cert Level, Email, Phone*

- Ray Clark, Tripoli, Level 3, 20895, raynichclark@gmail.com. +61466817011

REQUIRED Team Flyer of Record - Name, Organization, Cert Level, Email, Phone*

- Ray Clark, Tripoli, Level 3, 20895, raynichclark@gmail.com. +61466817011

Special Instructions

-

Category* *Select your participation category. The acronyms refer to the propulsion system.*
Note: New teams should start with the 10K - COTS category unless they have previous experience with more advanced rockets.

- **10k - COTS - All Propulsion Types**
  - 30k - COTS - All Propulsion Types
  - 10k - SRAD - Solid Motors
  - 30k - SRAD - Solid Motors
  - 30k - Multi-Stage
  - 45k - Multi-Stage (if available)
  - 10k - SRAD - Hybrid/Liquid & Other

○	30k - SRAD - Hybrid/Liquid & Other
○	Non-Competitive Demonstration Flight

Section 3: Team Demographic Data

Number of Undergraduate Team Members*

- 10

Number of Masters Team Members*

- 0

Number of PhD Team Members*

- 0

Number of Team Members who Identify as Men*

- 6

Number of Team Members who Identify as Women*

- 4

Number of Team Members Who Identify as non-binary*

- 0

Number of Veterans*

- 0

Number of Tripoli, NAR, CAR, UKRA Members and Certification Level*

- Tripoli, 10 Tripoli Members, Cert Level 0

Rocketry Experience* *Please describe your team's previous high-power rocketry experience. This includes things like local launches, regional rocketry competitions, and similar events. Also list experience with the type of propulsion system you intend to compete with. If you have individuals who have experience (but not with the team), be sure to list that as well.*

- The ZENITH Rocket Team was established in 2023 by a group of students from various academic disciplines. Their first competition was the 2023-2024 Teknofest Rocket Competition in the Medium Altitude category. For this competition, the team designed and manufactured a rocket with a length of 2800 mm, a dry weight of 19,865 grams, and a maximum speed of 225 m/s, capable of reaching an altitude of 2606 meters. The Teknofest-approved AeroTech M1850 engine was selected for propulsion. In the Preliminary Design Report phase, the Zenith Rocket Team achieved a ranking of 39th in Turkey. Following this initial success, the team independently completed the rocket's production and conducted all the required tests within the specified timeframe. Despite being newly formed and having limited experience in the production process, the team members meticulously manufactured the rocket’s body, nose cone, and fins from composite materials, demonstrating remarkable dedication. Furthermore, the rocket was presented at the MUBAK (Engineering Sciences and Research Student Congress) held at our university and was subsequently featured in the MUBAK booklet following the event. Throughout the rocket manufacturing process, we gained experience in various technical, management and production areas. This includes information in technical drawing, tolerance analysis, preparing CAD and CAM files, and system engineering. We also observed several manufacturing techniques, such as CNC machining, lathe operations, and mold-making. In composite production, we utilized methods like wet lay-up and vacuum infusion, achieving high-quality, durable components. Additionally, we acquired valuable knowledge in PCB design and integration, as well as electronic components assembly methods. We further refined our skills in folding parachutes and shock cords, understanding the specifications of fasteners, and learning effective techniques for sensor and communication integrations. Furthermore, we built advanced capabilities in SolidWorks, Ansys Fluent, Ansys Structural, and OpenRocket, which have been instrumental in our design and simulation processes.

VISA Status for International Teams *Numerous international teams each year cannot attend the event in the US due to VISA request delays. Is your team concerned about securing VISAs to travel to the US? Explain your concerns*

- We are optimistic that we will get the VISA without any problems. One of our members has an R B1-B2 America VISA.

Section 4: STEM Outreach

Describe any activities that your team leads or participates in that helps your local community with Science, Technology, Engineering or Math enrichment.

STEM Outreach Events* *If you perform any STEM related outreach events, please place a brief description here. STEM stands for Science, Technology, Engineering, and Mathematics.*

- As the Zenith Rocket Team, we officially presented and published our Teknofest Rocket Project at the Atilim University Engineering Sciences and Research Student Congress (MUBAK) with the aim of inspiring a rocket science culture within our university, where we were invited to present and let our project to be published on the Atilim University website. Additionally, each team member has pursued individual STEM projects as part of our outreach efforts, hoping to influence more students to engage in rocket science and related STEM fields.
  The projects and experiences pointed out have provided us, as the Zenith Rocket Team, with valuable achievements and experiences in STEM fields. In Workshops and Hands-On Activities, our team members have developed skills through projects like the "Medium-Altitude Rocket Design Project," " Analyzing of the Effect of Airfoil and Fuselage Configuration on UAV Performance Optimization in Subsonic Flight Regime Using Various Parameters," "Emotional State Prediction Using EEG Brainwave Data," "External Aerodynamic Analysis Of Blended Wing Body By Using Different Open-Source Mesh Generators And Solvers," TUBITAK 2209-B and TAI Lift Up-supported projects. In addition, one of our team members is currently a certified Model Aircraft Instructor. In terms of public demonstrations and science fairs, we have participated in events such as the International Efficiency Challenge - electric car competition and the Teknofest vertical landing rocket competition. In School visits and presentations, our team members served as guide students. One of our team members contributed to the UTED International Technician Journal's editorial team, sharing educative articles on aviation. In the mentoring program, we demonstrated leadership by mentoring others as volunteer mentors in the third season of the Rider Robot League. In Competitions and Challenges, our team members displayed our diverse competencies in STEM through activities such as becoming a finalist in the TUBITAK 48th High School Research Projects Ankara Regional Competition in Coding. These achievements highlight our team members' strong capabilities in both theoretical knowledge and practical applications across multiple STEM disciplines.
  Each project has been individually documented, underscoring our commitment to advancing STEM fields and sharing our research with the engineering community.

Section 5: Rocket Information

Overall rocket parameters
FOR ALL NUMERIC FIELDS DO NOT INCLUDE UNITS in the field, use the units identified in the help.
All numerical values use a maximum of 2 decimal places.

Which rocket components are planned to be commercially purchased?* *Please list planned commercial components and materials. e.g., Nose Cone - fiberglass with an aluminum tip*

- **Recovery System:** Black Powder, Electric Igniters, Shock Chords, Carabiner, Parachutes, Swivel, Commercial Flight Computer.
- **Propulsion system:** AeroTech M2500T-PS RMS-98/10240
- **Miscellaneous:** Fireproof Fabric, Eyebolt, Fasteners, Angle Brackets.
- **Avionics:** Easy-Mini Dual Deployment Altimeter, RRC3 Sport Altimeter, Featherweight GPS Tracker.
- **Payload:** Nema-17 200 Step Motor.

Which rocket components are planned to be student fabricated?* *Please list planned student fabricated components and materials.*
e.g., Airframe - Carbon Fiber layup on an aluminum mandrel
e.g., Electronics Sled - 3D printed with XXX filament

- **Nose Cone -** Carbon Fiber layup on an MDF board mold (using resin and epoxy, followed by vacuum bagging and oven curing). Including the nose cone tip made of Aluminum 7075-T6 in CNC Cutting.

•	**Fins -** Carbon Fiber layup over a cleaned glass surface (using resin and epoxy, followed by vacuum bagging and oven curing).
•	**Upper and lower body -** Fiberglass wrapping technique over an aluminum tube profile (using resin and epoxy, followed by vacuum bagging and oven curing).
•	**Electronics Sled -** Polyethylene PE1000
•	**Aluminum Turning Operation -** Bulkheads, motor blocks, centering rings, upper and lower covers of avionics, hot gas generator tubes. Angle Brackets
•	**Nose Cone Tip** - CNC machining using G code from Aluminum.

- **Payload -** Sensor and GPS Card, ESP32-CAM module.
- **Avionic –** Logger Avionic Card.

Total Vehicle Length (meters)* *Vehicle length from nose tip to aft end when ready for launch. Numbers ONLY*

- 2.97

Airframe Diameter (mm)* *Airframe diameter. Numbers ONLY*

- 154

Fin-Span (mm)* *The measurement from fin root cord to tip cord. Numbers ONLY*

- 80

Vehicle Weight Only (kilograms)* *All vehicles, recovery, electronics, and propulsion structures do not include propellants or payload. Numbers ONLY*

- 19.35

Propellent Weight (kilograms)* *All propellants ONLY (solid/liquid/gaseous) including any pressurizing gases. Numbers ONLY*

- 4.66

Payload Weight (kilograms)* *Must be at least 2 kgs per IREC Rules. Numbers ONLY*

- 3.5

Total Liftoff Weight (kilograms)* *Vehicle weight + propellant weight + payload weight. Numbers ONLY*

- 27.51

Number of stages* *Add additional comments below if using more than 1 stage.*

•	1
○	2

Rocket Information - Additional Comments *Add additional comments here regarding rocket construction and rationale for material selection.*
(optional)

- For the outer body of our rocket, we selected carbon fiber for the fins and nose cone (excluding the nose tip) due to its exceptional strength-to-weight ratio, which allows the rocket to withstand extreme forces during launch while remaining lightweight. This feature enables higher altitudes and greater stability, crucial for competitive performance at IREC. Carbon fiber is also resistant to bending and flexible, making it ideal for parts that require both strength and minimal deformation under stress. Additionally, its natural resistance to corrosion and fatigue reduces maintenance needs and enhances durability compared to traditional aerospace metals, which are valuable under repeated high-stress conditions.
  For the upper and lower body sections housing our avionics and payload communication modules, we selected fiberglass with S-glass fibers with plain weave paths due to its high tensile strength and durability. We have also compared S-Glass with E-Glass, where the difference in tensile strength and modulus of elasticity equates to roughly a 24-35% increase in strength for S-glass, depending on specific manufacturing variations. The higher strength of S-glass, along with its superior resistance to impact and fatigue, makes it a preferred choice for high-performance applications,

especially in aerospace and defense industries where structural demands are intense. For the fins of our rocket, we opted for a trapezoidal fin set design, chosen for its aerodynamic properties that optimize stability and minimize drag. The trapezoidal shape provides a larger surface area at the base, improving stability while maintaining a streamlined form at the tip to reduce aerodynamic drag. This design choice is crucial for maintaining control during the high-speed phases of the rocket's flight, where stability is a key factor in achieving maximum altitude and ensuring safe recovery. Aside from that we have chosen our thickness as 7.5mm to obtain the required structural strength and flutter conditions of the fins. We selected the Von Kármán Hack Series nose cone shape due to its superior drag performance in transonic and low supersonic ranges, according to the comparison of drag characteristics of various nose cone shapes in the transonic to low-mach regions graph published on rocketry forum. The Von Kármán profile ranks "1" at Mach 1 and maintains low drag up to Mach 2, making it ideal for our high-speed, altitude-focused rocket which was processed using CNC machining and G-code export. Additionally, we strategically placed three pressure holes along the rocket body according to aerodynamic guidelines to ensure accurate altitude and speed measurements during flight. These design choices optimize stability, reduce drag, and enhance overall performance for IREC competition. For our rocket's construction, we use a 15cm diameter aluminum tube profile as the base for fiberglass wrapping. The step-by-step process is as follows: Firstly, we clean the tube surface so that we can apply epoxy resin to secure the fiberglass. Next, we apply the wax to an aluminum profile then we cut the fiberglass to sizes, ensuring it covers the length of the tube with tolerance. After these steps are completed, we wrap fiberglass cloth over the aluminum tube profile for the outer body. Layers are added as needed to achieve the desired strength and thickness. For the fins, we use a clean glass surface, applying a release agent to prevent sticking. We then perform the fiberglass layup, layering and applying resin, allowing it to cure fully. For the nose cone, we create an MDF mold and apply fiberglass layers using the wet-layup technique, carefully shaping it over the mold with resin. In all the steps we are using necessary vacuuming elements for composite manufacturing. After all layups are completed, we cure the components in furnace with required time and oven to ensure durability. After trimming the extras, we finally polish and paint each part to achieve a smooth, aerodynamic surfaces. The final thickness will reach to 2mm.

Section 6: Propulsion System

Propulsion Type*

•	*Solid*
○	*Hybrid*
○	*Liquid*
○	*Combination (specify in comments)*
○	*Other (specify in comments)*

Propulsion Manufacturer* *Student built = SRAD, Commercial = COTS*
Combination implies a multi-stage or clustered design including both SRAD and COTS motor(s)/engine(s)
Specify in the discussion below if "combination" or "other."

○	*Student-built*
•	*Commercial*
○	*Combination*
○	*Other (add comment below)*

Propulsion Systems: (Stage: Manufacturer, Motor, Letter Class, Total Impulse)* *Please use a new line for each motor/engine.*
COTS Format - [Stage]: [Manufacturer], [Motor Designation], [Letter Class], [Total Impulse]
SRAD Format - [Stage]: [Motor/Engine Type], [Propellant mixture], [Letter Class], [Total Impulse] Examples: 1st Stage: AeroTech M2500T-PS RMS-98/10240

• 1st Stage: AeroTech M2500T-PS RMS-98/10240

Total Impulse of all Motors (Ns)* *IREC entries shall not exceed 40,960 Newton-seconds (Ns) until further notice. Numbers ONLY*

• 9573

Propulsion System Discussion *Use this field to discuss the rationale behind your motor/engine selection.*

- After evaluating the AeroTech M2500T-PS, AeroTech M2400T-PS, AeroTech M1845NT, and AeroTech M1850W motors, along with the necessary simulations, analyses, and reasons outlined below, we decided to proceed with the AeroTech M2500T-PS motor. According to values from the Thrustcurve.org, OpenRocket and results from literature research, this motor provides higher continuous thrust than the others, offering a powerful and stable profile during ascent. Its high-thrust-impulse value maximizes the rocket's flight performance, allowing us to achieve more efficient results. The AeroTech M2500T-PS also supplies the highest impulse required for the rocket to reach its target altitude compared to the other motors, with a total impulse of 9573 Ns. The M2500T-PS provides the highest average thrust of 2461 N, which is higher than the M2400T-PS's 2400 N, the M1850W's 1909.6 N, and the M1845NT's 1875 N. Its diameter of 98 mm and length of 751 mm fit the other parameters defined in the rocket's preliminary design perfectly, improving our overall stability and reaching altitude. The burn time of 3.88 seconds aligns ideally with our preliminary design and simulation results, playing an important role in achieving our targeted altitude. Additionally, the weight of the AeroTech M2500T-PS which is 8064g (launch mass) perfectly fitted with our design requirements, contributing to a balanced flight profile for the rocket.
  Taking all parameters into account, we conclude that the AeroTech M2500T-PS is the most suitable motor for our rocket's mission and performance objectives, making it the best choice to maximize our flight performance.

Section 7: Predicted/Simulated Flight Data and Analysis

The following stats should be calculated using rocket trajectory software (OpenRocket, Rocksim, RasAero...) or by hand.
Pro Tip: Reference the Barrowman Equations, know what they are, and how to use them.

Launch Rail* *Specify in the comment below if "other"*

- *ESRA Provided Rail*
- ○ *Team-provided*
- ○ *Other*

Rail Length (Meters)* *Write "5.7" if using ESRA provided rail. Numbers ONLY*

- 5.7

Liftoff Thrust-Weight Ratio* *5:1 thrust to weight ratio is the minimum for single-stage rockets.*
8:1 thrust to weight ratio for multi-stage rocket.
TTW requirements are in the Design, Test and Evaluation Guide.
Calculate using average thrust of the motor divided by takeoff weight (launch vehicle plus payload)

- 9.12

Launch Rail Departure Velocity (meters/second)* *30.5 mps is highly recommended. 15.25 mps is the absolute minimum. Anything less than 30.5 fps will need additional stability analysis.*

- 33.2

Minimum Static Margin During Boost* *Stability ratio between rail departure and burnout. Measured in Calibers. 1.5 is highly recommended minimum.*

- 1.57

Maximum Acceleration (G)* *Measured in G forces*

- 10.05

Maximum Velocity (meters/second)* *Measured in mps*

- 309

Target Apogee (feet AGL)* *Feet above ground level*

- *10,000 ft*
- ○ *30,000 ft*
- ○ *45,000 ft (Only multi-stage - if available)*
- ○ *Other (specify in comment below)*

Predicted Apogee (feet AGL)* *Feet above ground level.*
Note: Teams will receive a zero-flight performance score if their actual apogee differs from the competition target (10/30/45k feet) by over 30%.

- 10311

Simulation/Analysis Comments* *Use this field to provide more detail and methodology used to help justify your analysis.*

- In the preliminary design phase, we verified the rocket's dimensions and weight to ensure they met the specified altitude, speed, and stability requirements through simulations. The initial design was created using OpenRocket software, and adjustments were made to critical parameters to enhance performance and stability. After completing the necessary sizing and motor selection processes, we evaluated altitude, speed, acceleration, flight time, and stability values based on simulation results.
  To optimize the rocket's aerodynamic profile, we conducted analyses on various nose cone profiles and fin configurations. For the nose cone, we evaluated options that would minimize aerodynamic drag at different altitudes and speeds, ultimately selecting the Von Kármán Hack series profile. This profile offers optimal performance by reducing drag forces at high speeds while maintaining stability. After finalizing the primary sizing, we analyzed and compared rocket motors in the propulsion system to select the motor that would help achieve the target altitude. To ensure flight safety and reach the required fin flutter speed, modifications were made to parameters like the center of gravity (CG), center of pressure (CP), and fin design. Using the NACA TN 4197 method, we calculated a fin flutter speed of 506.14 m/s (at least 1.5 times the rocket's maximum speed), with a safety margin of 63.8%. During this analysis, parameters such as fin angle, thickness, and dimensions were adjusted to optimize altitude, stability, and speed. These calculations and iterations confirm that the design meets the specified requirements.
  By entering the weights and dimensions of all rocket components into the system, we conducted OpenRocket flight simulations under predetermined flight conditions. Data such as latitude, longitude, altitude, and wind direction were assumed based on reports from other teams, while wind speeds were tested at 0, 5, 10, 15, and 20 m/s. The launch rail length was set to 5.7 meters, and the inclination angle was entered according to specifications. After completing all sizing and component placements, final simulations were conducted. The vertical position-time graph, which allowed us to examine values like flight time, altitude, acceleration, and speed, helped us assess the operational concept of the design. The stability vs. time graph allowed us to observe minimum and maximum stability margin values throughout the flight. We analyzed the changes in the CG and CP positions during flight and assessed how these changes affected rocket stability. By observing how the rocket behaved at different altitudes and speeds, we evaluated the impact of CG and CP shifts on the stability margin. These results guided necessary design measures to maintain stability throughout the flight, particularly addressing CG shifts caused by fuel consumption. This analysis helped prevent issues such as over-stability or insufficient stability, ensuring stable flight. Our design achieved a minimum stability margin of 1.57, a maximum stability margin of 4.26, and a static stability value of 2.94 at 0.3 Mach. These values indicate that the rocket will fly stably without becoming over-stable. We plan to use CAD software for CG determination, validate the CP value using the Barrowman method via Excel, and compare it with OpenRocket results. Analytical solutions will be adapted and executed in Excel and MATLAB.
  In the next phase, we will conduct structural and CFD analyses for the nose cone, fins, and rocket body. Forces obtained from flow analysis will be transferred to structural analyses to examine deformations and von Mises stresses in the nose cone, fins, and body components. For structural components inside the body, tensile strength and deformation analyses will be performed, while structural strength tests will be conducted on motor centering rings and motor retainers. Shear stress analyses will be performed for fasteners, aiming to maintain a safety margin above 1.5 for all structural analyses. MATLAB Simulink will be used for trajectory and 6-DOF solutions, while structural and flow analyses will be conducted in Ansys Structural and Ansys Fluent.
  For the recovery system, we carried out detailed studies on shock loads at deployment, parachute simulations, and descent speed calculations to ensure safe and controlled landing. We conducted simulations and calculations to analyze the high shock loads at parachute deployment, ensuring it open safely without risk of tearing or detachment. Parachute simulations and analytical calculations were performed to test descent performance at various altitudes and speeds, allowing us to determine the optimal parachute size for the target descent speed. These calculations minimized the risk of structural damage by maintaining a safe descent speed, enhancing the safety of the recovery system.

Section 8: Team Provided Launch Systems

Are you bringing your own launch system?* *Are you planning to bring your own launch system to the competition? If so, describe the system you will be using along with why you need it.*

- None

Section 9: Payload Information

NOTE: To compete in the SDL Payload Challenge, you MUST follow the instructions on the Spaceport America Cup Documents and Forms Page. The information provided here is for ESRA purposes only.
See http://www.soundingrocket.org/sa-cup-documents--forms.html

Payload Description* *Please help us to help you by filling this box out as completely as possible. Identify whether the payload is functional or inert. Include a description of its purpose (if applicable) and its recovery scheme (if applicable). The more information we have the better we can help you.*

- Our mission is to develop a new payload system for finding habitable planets with sustainability, which will be test on earth, sustainability being the most critical attribute for this purpose. It achieves its objective by mounting four solar panels onto the payload, each with dimensions of 80x60 mm and specifications of 1.5 V, 0.65 W, and 430 mA. Panels will be mounted on the side surfaces of the cube and connected to a switch system. These panels safely charge six batteries, arranged in a three-series, two-parallel connection. Passive BMS is designed to prevent battery overheating by distributing excess power through resistors in case of overcharging. The charged batteries power our specially designed SRAD card. Switch system operates in conjunction with altitude data obtained from a pressure sensor. The system becomes active when the payload reaches an altitude of 100 meters from AGL. The switch system designed in order to open includes four leg driven by a stepper motor with specifications of Unipolar NEMA17 200 Step 34x42 mm 1.3A Step Motor-17HS3401. To evaluate habitability, we use humidity, temperature, and VOC (Volatile Organic Compound) sensor along with a pressure sensor for altitude data. VOC's are organic compounds with high vapor pressure at room temperature. Excessive amount of VOC's can cause serious health problems in humans when inhaled or absorbed through the skin. The BME680 sensor collects data on pressure, temperature, humidity, and VOC levels. Although these measurements could be obtained individually by different sensors, BME680 provides a compact solution with high-resolution readings. These sensor measurements are transmitted live to our custom ground station using the 433 MHz E32-433T30D LoRa RF module, operating in the 433 MHz band, enabling real-time data monitoring. Transmission to this band requires a HAM radio license. Additionally, we use the GY-NEO6MV2 GPS module to track the live position of our payload. To visually document the mission stages, we added a camera and SD card module to the payload. For this purpose, we selected the ESP32-CAM module as it houses both the OV2640 camera and an SD card slot. The total weight of our payload is 3.5 Kg. The payload will be inside the rocket until the apogee. It will be separated from the rocket by the recovery systems that will start at the apogee. The diameter values and fabric of the payload parachute in the recovery system were calculated and selected to ensure that the payload lands at a speed that is acceptable for the requirements. 3U cube with dimensions of 100mmx100mmx300mm will be used.

Section 10: Electronics

Electronics Description* *Describe all the electronics in your rocket. Include COTS and SRAD components and indicate the role of each component (primary or backup).*
-For altimeters include manufacturer and model. Teams are reminded of the requirement that at least one altimeter must be a COTS.
-For GPS or telemetry include manufacturer and model, along with whether a HAM license is required.

- Rocket includes three flight computers and one GPS. Two of these systems are COTS, while the other is an SRAD flight computer. The primary system selected from our COTS devices is the RRC3 Sport Altimeter produced by Missile Works. This altimeter features a 16MHz 16-bit MSP430 series MCU, 8Mbit SST flash memory, and an MSI NS5697 pressure sensor. The main reasons for choosing this altimeter are its capability to provide high-resolution pressure data (due to its 24-bit analog-to-digital converter) and its high availability in our country. The RRC3 Sport Altimeter operates with dual deployment, allowing it to open both the drogue and main parachutes in our recovery system. The secondary system utilized is the EasyMini Altimeter produced by Altus Metrum, which is also a COTS device. The EasyMini Altimeter contains an Arm Cortex M0 MCU, an NXPLCP11U24 chip, an MS5607 pressure sensor, and 1MB of SPI flash memory. This system operates in dual deployment mode and serves as a backup to the RRC3, providing an additional layer of safety for the deployment of the drogue and main parachutes. As the third system, an SRAD flight computer will be used. This SRAD system will not be involved in recovery phases; instead, it will detect the start of flight using data from its accelerometer and record the rocket's altitude and acceleration data. The PCB to be prepared for our SRAD system will be designed in the program called Altium Designer and sent to JLCPCB for production. Our team will handle the assembly of its components. Our COTS systems also record altitude data for the rocket. For GPS, we will use the Featherweight GPS Tracker produced by Featherweight Altimeters. Since Featherweight GPS operates on the 915MHz band, it does not require an HAM license. This GPS system will provide location tracking for the rocket during recovery. Each system has independent power sources. The two COTS flight computers and the SRAD system operate using pairs of serially connected batteries, while our COTS GPS system is powered by a single battery. All batteries are Li-Ion types packaged in metallic cylindrical enclosures. Batteries will be held in the commercial battery holders. Battery holders will be placed in a way it prevents acceleration forces to compress springs of battery holders. 22 AWG cables will be used to connect the necessary components. Paired cables will be in the form of twisted pairs and zip ties will be used where necessary. There is a Schurter rotary switch between each flight computer, GPS and their power source. The two COTS altimeters activate the recovery system independently.

Section 11: Recovery

Recovery Description*

Describe your recovery system; dual-deploy, size and style of chute, number of chutes, chute protection method, length of shock cord(s), and any other components of your recovery system.
Please fill this box out as completely as possible. Identify every independently recovered part of the launch vehicle and its recovery scheme. As appropriate, identify its associated recovery events, means of event triggering (e.g. barometric, magnetometer, other...), the redundancy of those event triggers, and the altitude those events should occur at.

- As soon as the assembled rocket is placed on the launch pad, the avionics system that will operate the rescue system is activated. After the rocket reaches the specified altitude, the avionics system comes into play and performs the separation process of the rocket. Two avionics components are used in the separation system. One is the RRC3 Sport Altimeter and the other is the EasyMini Altimeter. These altimeters will be backups of each other and will detect the apogee and send the first ignition signal. Upon ignition of a pre-measured amount of black powder through these fuses, the rocket body splits into two sections at the first separation time. At the other separation time, the two altimeters will continue to work as backups of each other and send the ignition signal for the separation. When the rocket reaches the required altitude for the second separation, the black powder in the pressurized area ignites upon fuse activation, causing an explosion and the rocket body splits into three sections. The black powder amount is set at 3 g for the first separation and 3.4 g for the second separation. Following the first separation, a drogue parachute deploys to control the speed of the split rocket body, while the main parachute, designated as the payload parachute, ensures the payload (CubeSat) safely reaches the ground. The payload descends independently from the rocket body and, utilizing the parachute, achieves a landing speed that is below the specified threshold of 11 m/s (36 ft/s). Simultaneously, the payload is tracked via a GPS sensor. The separated rocket body sections are connected to with a shock cord. At the altitude specified in the specifications, 1,500 ft (457 m), the main parachute opens and controls the speed of the rocket. In this way, the rocket reaches the ground at the required speed. The rocket uses two hot gas generators for the separation stages. Each of the three parachutes is specially designed according to its load-bearing capacity. Parachutes the number of cords and panels has been selected: 12 panels on the main parachute and 8 panels on both the primary (drogue) and payload parachutes. The parachute segments were selected as 12 panels for the main parachute and 8 panels for the primary (drogue) and payload parachutes. Fireproof protective fabric will be used to protect the parachutes. A shock cord protector will be used for the shock cords. The parachutes used in the recovery system have a circular geometry with a dome-shaped design. A circular gap, known as a "vent hole," is in the center of the dome to enhance stability. This vent hole, approximately 1/10th of the parachute's diameter, controls airflow, preventing excessive drag force that could compromise stability during descent. The length of each parachute cord is set to 1.75 times the parachute's inflated diameter. Durable 3 mm-thick polyester cords were chosen. The parachutes are made from Ripstop Nylon 40 D, a material with low air permeability and high tear resistance. In parachute design, a drag coefficient of 0.8 is assumed. An integral part of the recovery system shock cord, Perlon Flat licensed with a minimum strength of 15 kN and a weight of 34 grams was selected. To enhance the rocket and recovery system's safety, the shock cord length is set at three times the rocket length, measuring 4.5 m from the nose to the upper body, and 5.5 m from the upper to the lower body, totalling 10 m. The parachute colours are neon orange for the drogue parachute, neon green for the payload parachute, and neon red for the main parachute. The parachutes will be produced using specially ordered parachute fabric and ropes. Finally, the parachute diameters are calculated to meet target descent speeds: 1,25 m for the payload parachute, 0,85 m for the drogue parachute, and 3 m for the main parachute. M8 swivels and carabiners, with a tensile strength of 560 kg and 550 kg respectively, are used at the connection points between the parachute and shock cord. The parts of the main and drag parachutes connected to the shock cord are connected with a swivel and a carabiner. At the same time, the eyebolt in the payload is connected to the payload parachute with a swivel. The connecting elements used are made of cast steel. One end of the shock cord located in the upper body is connected to the nose eyebolt with a carabiner; the other end is connected to the eyebolt in the avionics capsule with a carabiner. For the shock cord in the lower body one end is connected to the lower eyebolt of the avionics capsule and the other end is connected to the bulkhead eyebolt, over the motor located in lower body, with a carabiner. Hence, three swivels, five eyebolts and five carabiners were used.

Planned Tests* *Please keep brief, use these headers in your response:*
Date Type Description Status Comments

1. Shock Cord Pull Test: January 2025, (To be done) Purpose: To test the shock cord's resilience against the forces it will encounter during descent.

2. Eyebolt Pull Test: January 2025, (To be done) Purpose: To verify that the eyebolt provides adequate strength at the attachment points.

3. Swivel Pull Test: January 2025, (To be done) Purpose: To assess the swivel's resistance to load while allowing rotation and flexibility.

4. Montaged Links Pull Test: January 2025, (To be done) Purpose: To ensure that the assembled link points provide a secure and durable connection.

5. Parachute Opening Test: March 2025, (To be done) Purpose: To verify that the parachutes deploy fully and without issues.

6. Black Powder Test For The First Deployment: March 2025, (To be done) Purpose: To confirm that the black powder for the first separation ignites correctly in the specified amount and timing.

7. Black Powder Test For The Second Deployment: March 2025, (To be done) Purpose: To ensure the black powder for the second separation ignites safely and effectively at the target altitude.

8. Battery Drain Test: March 2025, (To be done) Purpose: To verify that the batteries will operate the systems without any problems during the flight.

9. Primary Flight Computer Test: March 2025, (To be done) Purpose: To ensure that the primary flight computer ignites the e-matches at desired altitude values.

10. Secondary Flight Computer Test: March 2025, (To be done) Purpose: To ensure that the secondary flight computer ignites the e-matches at desired altitude values.

11. Logger Flight Computer Test: March 2025, (To be done) Purpose: To verify that the logger flight computer logs the desired altitude values to the SD card.

12. SRAD Payload System Test: April 2025, Purpose: To verify that the transmitter module is transmitting precise GPS, pressure, humidity, and temperature data to the ground station according to accuracy and range specifications.

Is your Team Leads logging into and following HeroX? *ESRA HIGHLY RECOMMENDS that ALL team members join HeroX and follow the Cup. A minimum of Team Student Leaders should be following HeroX.*

•	*Yes*
○	*No*

Any other pertinent information* *Treat this as your resume cover letter. On initial application, this box may be the deciding factor on your acceptance--focus on what's important. Keep within one page of text.*

International Rocketry Engineering Competition (IREC) Committee

Spaceport America Cup Organizing Team

Dear IREC Committee,

As a dedicated and innovative student-led rocketry team, we are happy to participate in the IREC 2025 America Cup competition. As the Zenith Rocket Team, we have achieved significant success by participating in the TEKNOFEST competition held in our country. Our purpose is to proudly represent ourselves and our country at IREC by contributing to the growth of rocketry. 2025 is the year that we want to bring our talents and expertise to the international arena. As the Zenith Rocket Team, we have developed ourselves in various fields including aerospace, mechanical, and electrical engineering. Our team is founded on the principles of interdisciplinary cooperation and a shared passion for excellence in aviation. Our participation in TEKNOFEST, one of Turkey's leading aviation competitions, allowed us to design, analyze and produce high-power rockets, where we have consistently demonstrated technical competence and innovation. The experiences we have gained have taught us valuable lessons in the design and development of rockets that meet comparable safety and performance standards for the IREC 2025 competition. The avionics and recovery mechanisms prepared us well for the competition. Our designs have previously achieved precise altitude targets and demonstrated reliability recovery systems theoretically. This experience positions us well for the ambitious goals we have set for IREC 2025. We plan to design and manufacture a high-performance rocket capable of reaching an altitude of 10,000 feet for the IREC 2025 competition. For our project, we chose advanced materials for high flight efficiency and an avionics system that includes real-time telemetry and GPS tracking systems to ensure accuracy and safety throughout the mission. We are focused on adhering to the highest engineering standards while ensuring that our design meets all competition requirements. For us, participating in the IREC 2025 America Cup will be an invaluable learning experience. It will allow us to further develop our technical capabilities and have experience in global rocketry. We are excited for the chance to compete with teams from around the world, learn from industry experts, and test our rocket in a real-world setting. We are confident that our team's technical expertise, combined with our passion for rocketry, will make us a worthy competitor at this prestigious event. We are excited about the possibility of representing our team and our country at IREC 2025 and contributing to the continued growth of aerospace technology. Thank you for considering our application. We look forward to the opportunity to exhibit our hard work, innovation, and determination worldwide.

Sincerely,

Zenith Rocket Team

Atilim University

https://zenithrocketry.weebly.com

Section 12: Previous IREC/ Spaceport America Cups

Has your team applied for past competitions?*

○	*Yes*
•	*No*

Previous Results/Outcomes* *Please provide a brief review for EACH year your team filled out an application. Be sure to include YEAR; STATUS - Participated, Accepted did not participate, Not selected; CATEGORY; FLIGHT RESULTS or reason for not participating; RECOVERY RESULTS; HIGH LEVEL FAILURE ANALYSIS if applicable; AWARDS.* ***New teams fill the field with NA.***

- NA