TEKNOFEST 2022
ROCKET COMPETITION
Medium Altitude Category
Firing Readiness Report (FRR)
Presentation
EVAX

Open Rocket/Rocket Design Overview

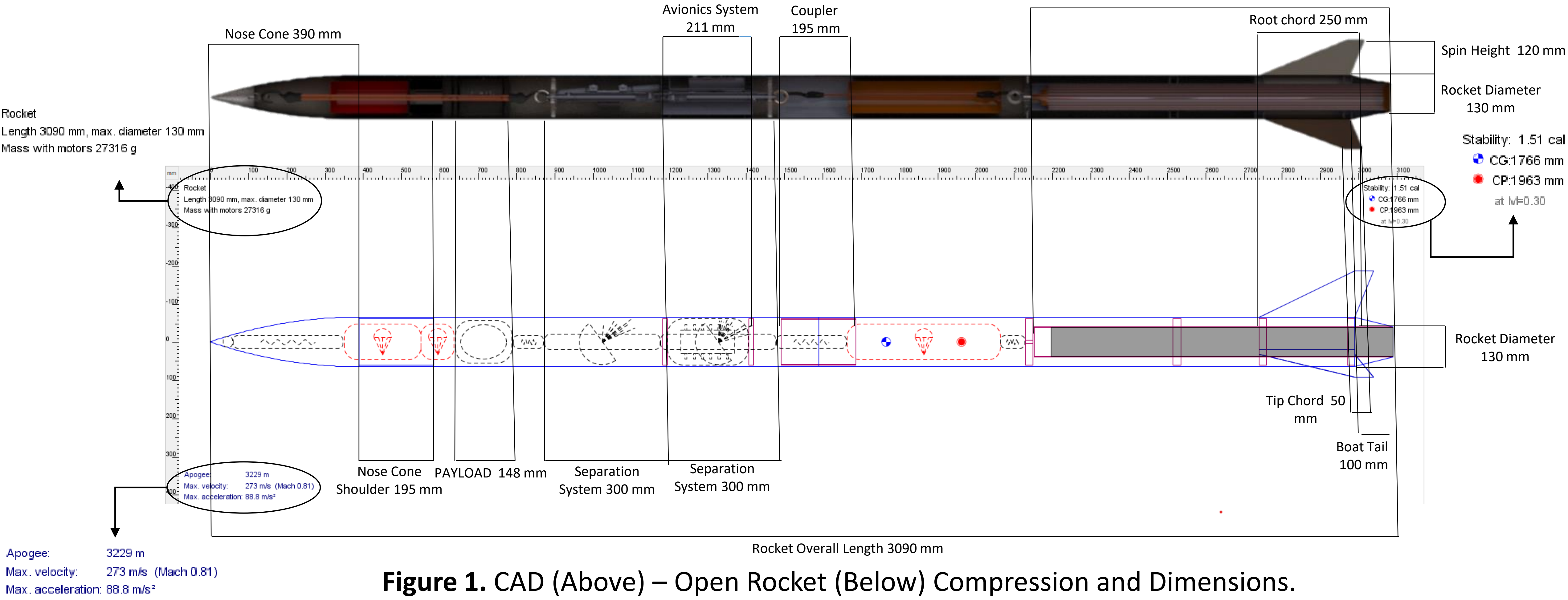

Figure 1. CAD (Above) – Open Rocket (Below) Compression and Dimensions.

Open Rocket/Rocket Design Overview

- Both the dimensions and design of the boat tail has changed as we increased its thickness to 4 mm and made the end of the boat tail straight to ease our manufacturing as it was hard to thread a curved surface and achieve a good engine retainer seal for our motor.
- The CO_2 activation system has also been changed from a servo motor to an electric valve as we faced some issues when testing that the servo motor would rarely fail to activate our separation but with the electric value it was granted.

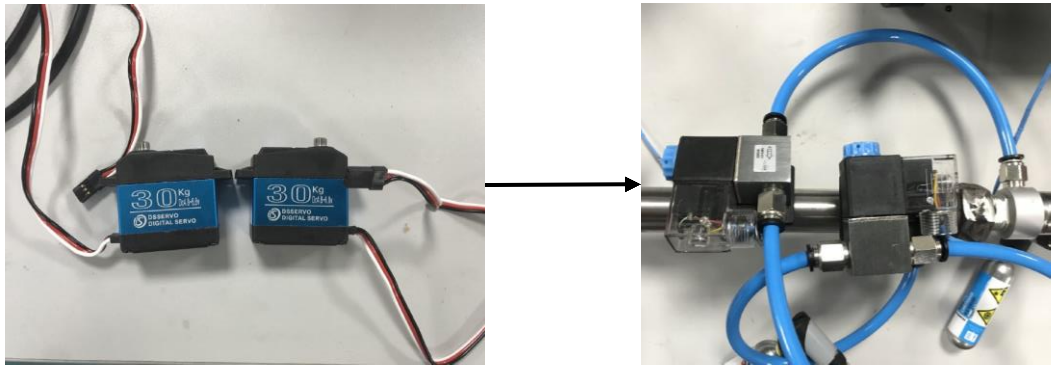

Figure 2. Old Servo motors (Left) – New Electric Values to be used in separation (Right).

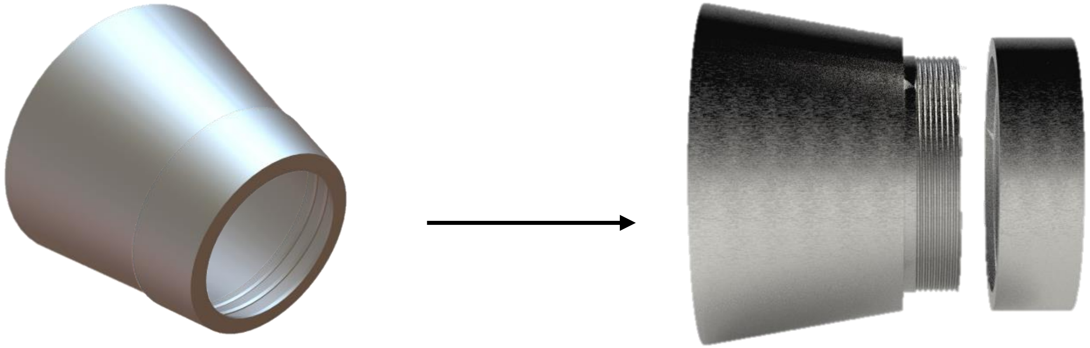

Figure 3. Old Boat-Tail Design (Left) – New Boat-Tail Design (Right).

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Static margin CP/CG Comparison/Simulation

Table 1. Design – Postproduction Values Comparison.

Data	Value in Design	Post Production Value	Difference (%)
Max Altitude	3394 m	3321 m	2.151
Max Speed	280 m/s	275 m/s	1.786
Maximum Acceleration	91.1 m/s^2	89.2 m/s^2	2.086
Ramp Output Speed	33.0 m/s	32.3 m/s	2.121
CP location (from the nose)	1.963 m	1.963 m	0
CG location (from the nose)	1.759m	1.766 m	0.398
Static margin (0.3 in Mach value)	1.57 cal	1.51 cal	3.822
Time to apogee	26.3 s	26.1 s	0.761

Rocket Subsystems

Mechanical Views and Details

Recovery System Mechanical Appearance

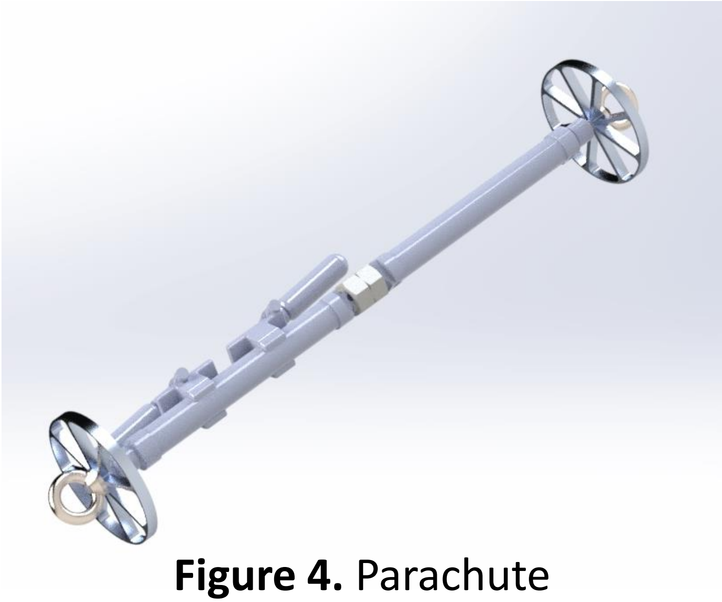

Figure 4. Parachute Opening System 3D View (CAD).

Figure 5. Integrated undelivered Parachute Opening System

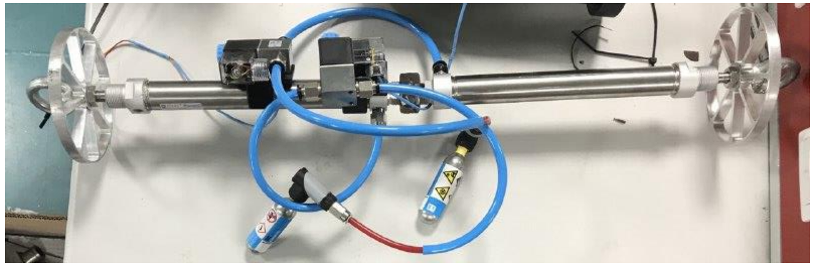

Figure 6. Produced Parachute Opening System.

Recovery System Mechanical Appearance

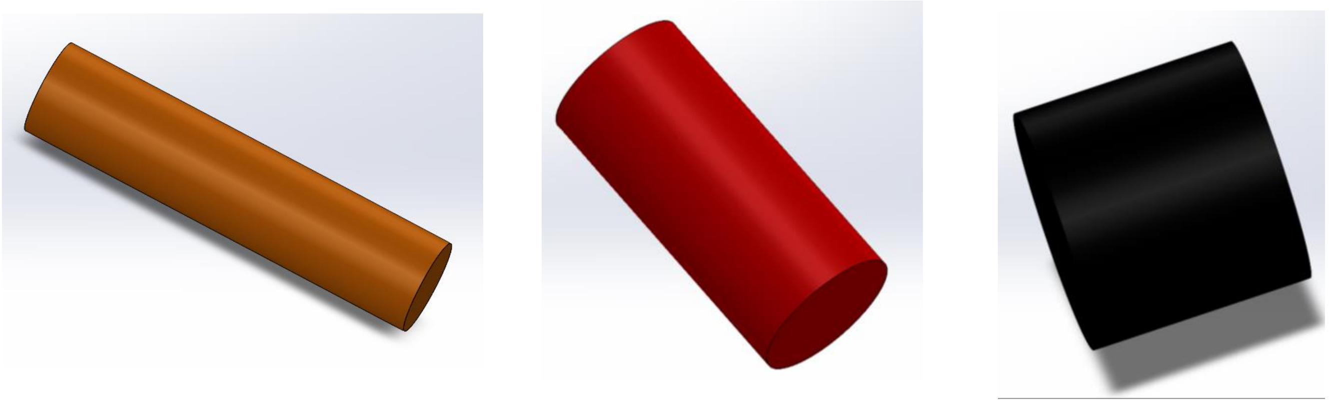

Figure 7. Parachute Sections 3D View (CAD).

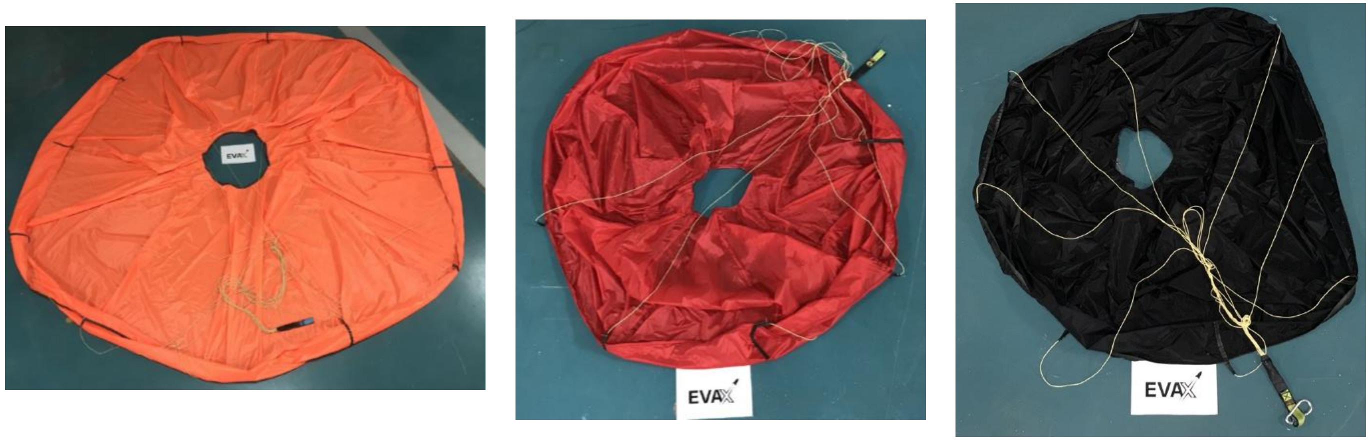

Figure 8. Parachutes Separate Images

Figure 10. Integrated Parachutes.

Parachute Opening System test

- This test has been made and done in Altinbas University Mahmutbey campus. We setup the rocket fully assembled with all the components inside and placed data into our avionics to activate the 1st separation and then the 2nd with a bit of delay. The CO_2 placed inside is brand new as it will be in the competition. The CO_2 will be activated using electric values that will grab its relevant signals from the avionics system. Once it is activated it will be released into the piston system its attached to pushing the nose cone then the main body.

- Parachute Opening System test youtube link: https://www.youtube.com/watch?v=z1FemW0khzE

Parachute Tests

- To check if the parachutes would open, we placed highly relative masses to each parachute and then threw them out of a window from a high floor. For the functionality of the parachutes we had members pull the parachutes from different sides at the same time to see if the material would be affected or not.

- Parachute Tests Youtube Link: https://www.youtube.com/watch?v=vdok_coJ_sg

Payload Mechanical Appearance

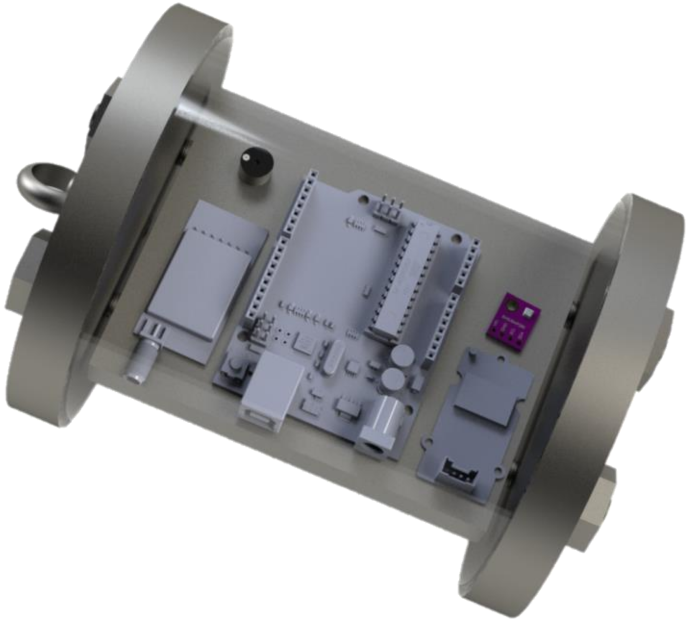

Figure 11. Payload 3D View (CHAD).

Figure 12. Payload Postproduction.

Avionics – 1.SystemDetail

Table 2. Recovery Roles of Main Avionics Components.

Component	Product Name / Code / Type	Is Data Used in Recovery Algorithm?	The Function of the Data Used in the Recovery Algorithm
Processor	ATmega2560 Processor	- (It will be left blank for the processor)	-
Pressure Sensor	BME280 Pressure Sensor	Yes	After the altitude measurement with the pressure data obtained from the sensor is passed through the Kalman filter, the first separation is realized by falling below the max altitude. As a result of the data calculated with altitude descending below 550 meters, the second separation will be realized.
IMU Sensor	MPU6050 IMU Sensor	Yes	As a result of converting the gyroscope and acceleration data to the angle for the Z axis, the first separation will be achieved with the angle value obtained when the rocket reaches the maximum altitude.

Avionics – 1.System Detail

Table 3. Recovery Roles of Main Avionics Components.

Component	Product Name / Code / Type	Is Data Used in Recovery Algorithm?	The Function of the Data Used in the Recovery Algorithm
GPS Module	Grove - GPS (Air530) GPS Module	No	-
Communication Module	LoRa SX 1278 Telemetry Module	No	-
Buzzer	5V Buzzer	No	-
Antenna	TX433-JKD-20P 433 MHz Antenna	No	-
Battery	GP GP1604AU Alkaline Battery	No	-

Avionics – 1.System Mechanical View

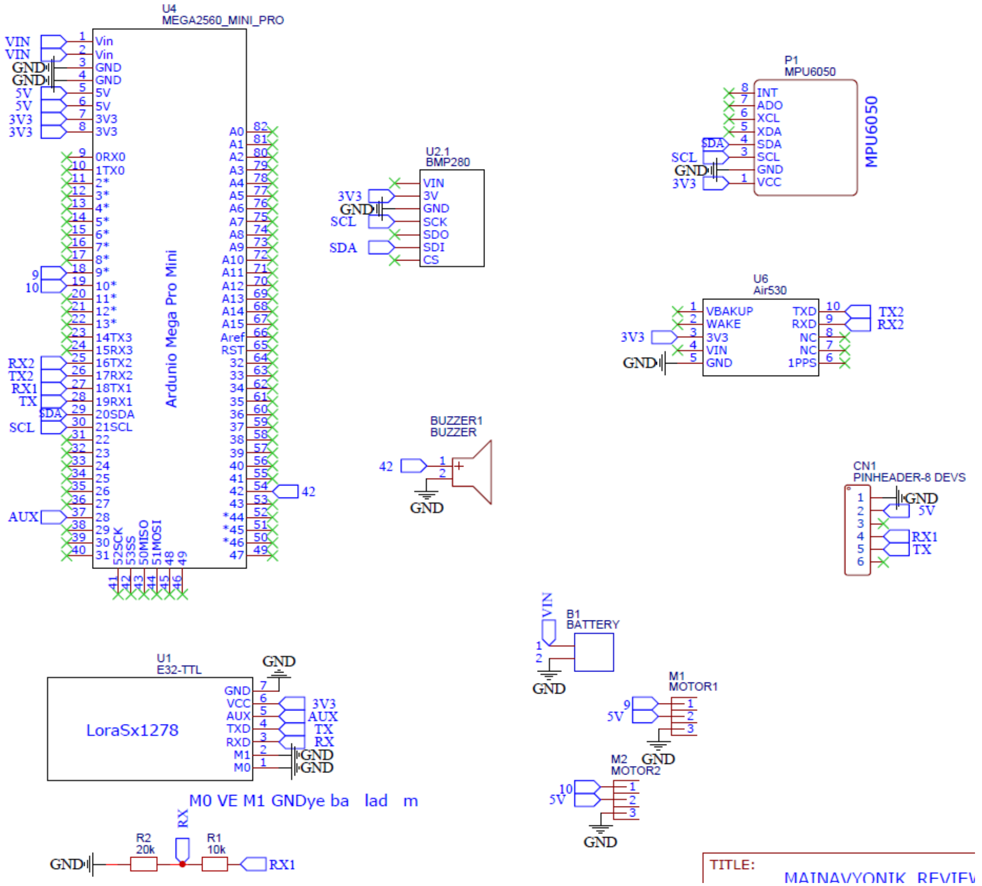

Figure 13. Avionic System Schematic

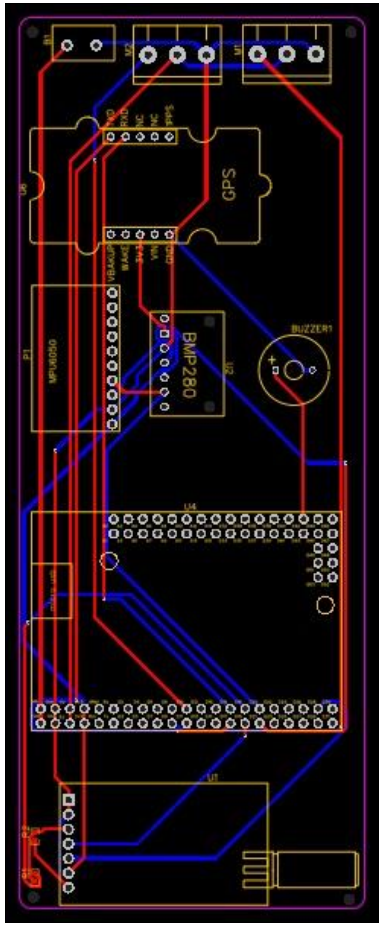

Figure 14. Produced Circuit Image

Figure 15. Generated Avionics System Image

Avionics – 1.System Mechanical View

Main Avionic Computer Seperation: BME280 pressure sensor that sends pressure values to Arduino Mega Pro Mini board with ATmega 2560 R3 processor; MPU6050 IMU sensor is used, which sends acceleration and gyro data. The pressure data from the BME280 pressure sensor is converted into altitude data and used for the first and second separation of the rocket after applying the Kalman filter. The gyro and acceleration values obtained from the MPU6050 sensor and the angle value in the Z axis will be found and used in the first separation of the rocket. The separations are realized as a result of pushing the pistons of the rocket by activating the electronic valves in the rocket, and the separation system trigger state value changes. The altitude, gyro, acceleration, angle and status values obtained from the BME280 sensor and MPU6050 sensor that will trigger the separation system are sent to the ground station with the LoRa SX 1278 telemetry module.

Main Avionic Computer Rescue: With the rocket flight, after the flight, Grove receives the altitude, latitude, and longitude data with the GPS (Air 530) module (The separation process will not be performed with the GPS data). The received data will be transferred to the ground station computer by sending the LoRa SX 1278 telemetry module to the LoRa SX 1278 module in the ground station. In line with the incoming data, the position of the rocket on the map is determined and the rescue operation is carried out. During the rescue, 5V Buzzer is used to make the rescue healthier in areas close to the rocket.

Main Avionic Computer Ground Station: The data sent from the LoRa SX 1278 module in the rocket comes to the Arduino Nano board with the LoRa SX 1278 module connected to the 12 dBi 433 Mhz DRFA-433Y antenna in the ground station. Incoming data is received from the ground station application created by EVA X Team via serial port. The received data is converted into hexadecimal format according to the UINT8 and FLOAT32 types in accordance with the Referee Ground Station application specified in ANNEX-8.

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Avionics – 2.System Detail

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Table 4. Recovery Roles of Main Avionics Components.

Component	Product Name / Code / Type	Is Data Used in Recovery Algorithm?	The Function of the Data Used in the Recovery Algorithm
Processor	ATmega2560 Processor	- (It will be left blank for the processor)	-
Pressure Sensor	BMP180 Pressure Sensor	Yes	The pressure data obtained from the sensor will be converted to altitude data and passed through the Kalman filter. The first separation will be performed by calculating the obtained Kalman altitude value and the maximum altitude value of the rocket. After the rocket reaches 500 meters, the second separation will be carried out.
Pressure Sensor	BME280 Pressure Sensor	Yes	The pressure data obtained from the sensor will be converted into altitude data and passed through the Kalman filter, when it is determined that the Kalman altitude value obtained is over 3000 meters, the first separation will be performed, and when the value of 500 meters is determined, the second separation will be performed.

Avionics – 2.System Detail

Table 5. Recovery Roles of Main Avionics Components.

Component	Product Name / Code / Type	Is Data Used in Recovery Algorithm?	The Function of the Data Used in the Recovery Algorithm
Communication Module	DRF7020D27 Telemetry Module	No	-
GPS Module	GY-NEO 8M GPS Module	No	-
Buzzer	5V Buzzer	No	-
Antenna	TX433-JKD-20P 433 MHz Antenna	No	-
Battery	GP GP1604AU Alkaline Battery	No	-

Avionics – 2.System Mechanical View

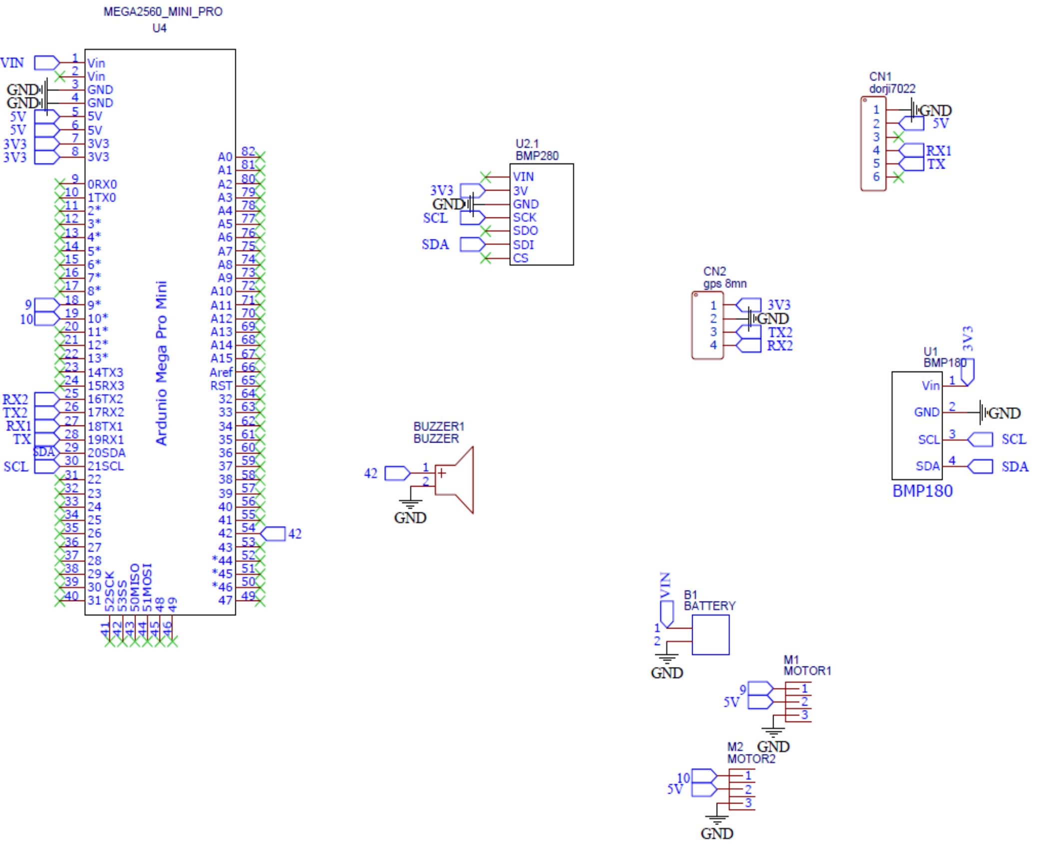

Figure 14. Avionic System Schematic

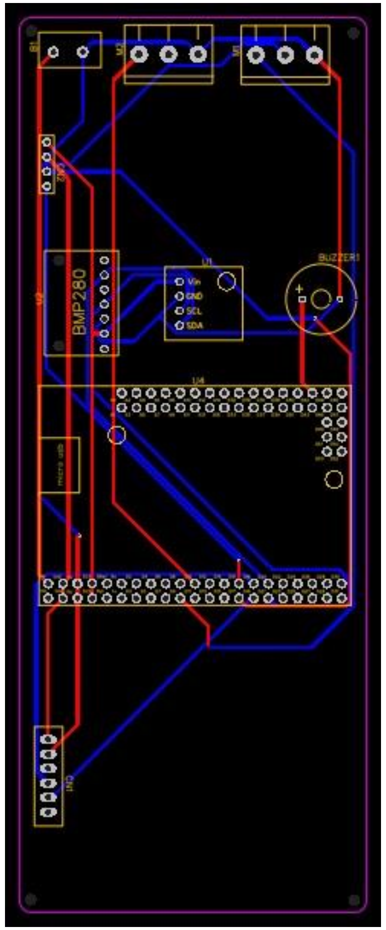

Figure 15. Produced Circuit Image

Figure 16. Generated Avionics System Image.

Avionics – 2.System Mechanical View

Backup Avionic Computer Seperation: There is a BME280 pressure sensor and BMP180 pressure sensor, which sends the pressure values to the Arduino Mega Pro Mini board working with the ATmega 2560 R3 processor. The pressure data from the BME280 pressure sensor is converted into altitude data with mathematical calculations (instantaneous sea level may vary) and used for the first and second separation of the rocket after applying the Kalman filter. The altitude value calculated from the BMP180 sensor is used in the first and second separation processes together with the Kalman filter. The separations are realized as a result of pushing the pistons of the rocket by activating the electronic valves in the rocket, and the separation system trigger state value changes. The BME280 sensor that will trigger the separation system, the altitude value from the BMP180 sensor, and the status value according to the separation process of the rocket are sent to the ground station with the DRF7020D27 telemetry module.

Backup Avionic Computer Rescue: From the rocket flight, the GY-NEO 8M receives the altitude, latitude, and longitude data with the GPS module (the separation will not be performed with the GPS data). The received data is sent to the DRF7020D27 module in the ground station with the DRF7020D27 telemetry module and transferred to the ground station computer. In line with the incoming data, the location of the rocket on the map is found and the rocket is recovered. During the rescue operations, 5V Buzzer is used for the rocket in order to provide a healthier recovery in close areas.

Backup Avionic Computer Ground Station: The data sent from the DRF7020D27 module in the rocket will be sent to the Arduino Nano board with the DRF7020D27 module connected to the 12 dBi 433 Mhz DRFA-433Y antenna in the ground station. Incoming data is sent to the ground station application created by EVA X Team via serial port. The sent data is converted into hexadecimal format according to UINT8 and FLOAT32 types in accordance with the Referee Ground Station application specified in ANNEX-8.

Avionics Tests

Algorithm Tests: It was observed that the separation was triggered by calculating the altitude with the pressure sensors of the avionic computers in the depressurized environment with the vacuum machine, and it was also observed that the vacuum bag was made 90 degrees perpendicular and the IMU sensor in the main avionics computer provided the separation with the angle value in the Z axis. It has been observed that when the main avionics computer realizes the separation status, the backup avionics computer is deactivated, and when the main avionics computer cannot achieve the separation status, the backup avionics computer activates and continues the separation processes.

Card Functionallty Tests: Verification was made with instant GPS data display in order to ensure that healthy data comes from all components of the avionic computers separately and to verify the incoming data.

Communication Tests: It has been observed that the mandatory data is sent to the ground station, which is 5 kilometers away from the avionic computers in the open area, in a healthy way.

Youtube Video Link: https://www.youtube.com/watch?v=ZEA-TUaRpkE

Referee Ground Station Test

Referee Ground Station Test: After the avionic computers and payload computer data are sent to the telemetry systems in the ground station, they are transferred to the telemetry computer with Arduino Nano cards for the telemetry of each computer. The received data is combined in the ground station application designed by EVA X and turned into a 78 bytes package. After the created package is converted to hexadecimal data type according to UINT8 and FLOAT32 data, package constants are added. After the added packet constants, the final version of the packet is created and the referee ground station serial port settings are made. The packet created after the parameter settings are sent to the referee ground station via USB-UART communication.

Youtube Video Link: https://www.youtube.com/watch?v=80DVB5OFNqM

Nose Cone Mechanical View

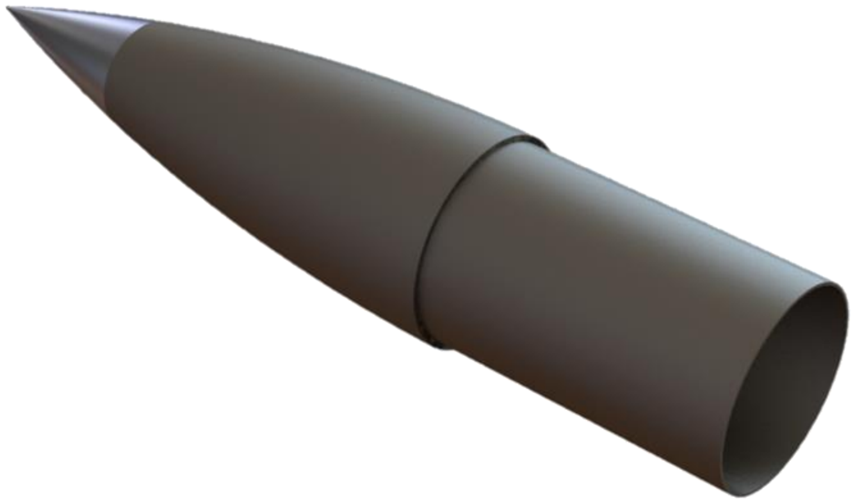

Figure 17. Nose Cone
3D View (CAD)

Figure 18. Produced Nose cone.

Blade Mechanical Appearance

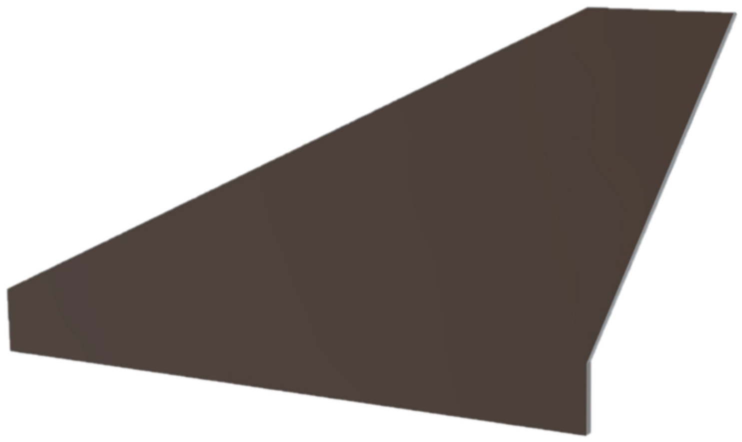

Figure 19. Fin 3D View (CAD).

Figure 20. Produced Fins.

Body Parts & Body Assembly Parts (STRUCTURAL) Mechanical View

Figure 21. Primary Body CAD.

Figure 22. Main Body CAD.

Figure 23. Produced Primary Body .

Figure 24. Produced Main Body .

Body Parts & Body Assembly Parts (STRUCTURAL) Mechanical View

Figure 25. Boat-Tail 3D CAD.

Figure 26. Produced Boat-Tail .

Structural – Body/In-Body Structural Supports (Integration Bodies, etc.)

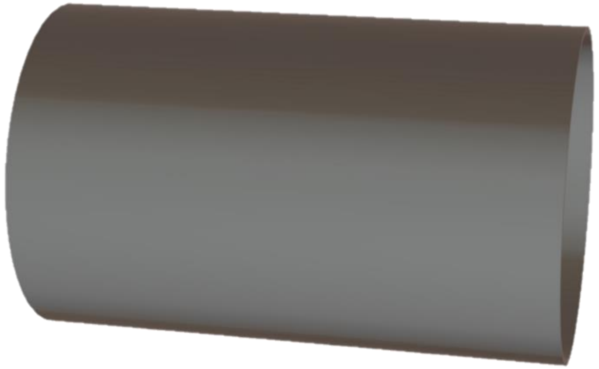

Figure 29. Coupler 3D CAD.

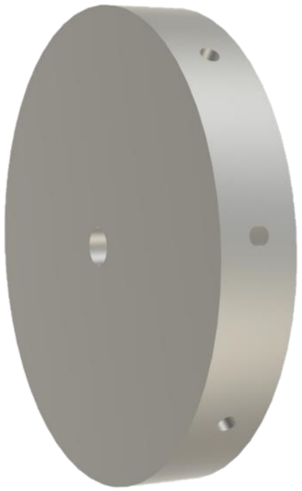

Figure 30. Engine Block 3D CAD.

Coupler will keep the two frames attached to each other (primary and main frames). One side of the coupler will be installed inside the main body using M5 screws, while the other side will be fastened to the primary body using shear pins. The piston separation technique will press the coupler, breaking the shear pins and separating the bodies (primary from the main),and releasing the main parachute

Figure 31. Produced Coupler.

Figure 32. Produced Engine Block.

Structural – Body/In-Body Structural Supports (Integration Bodies, etc.)

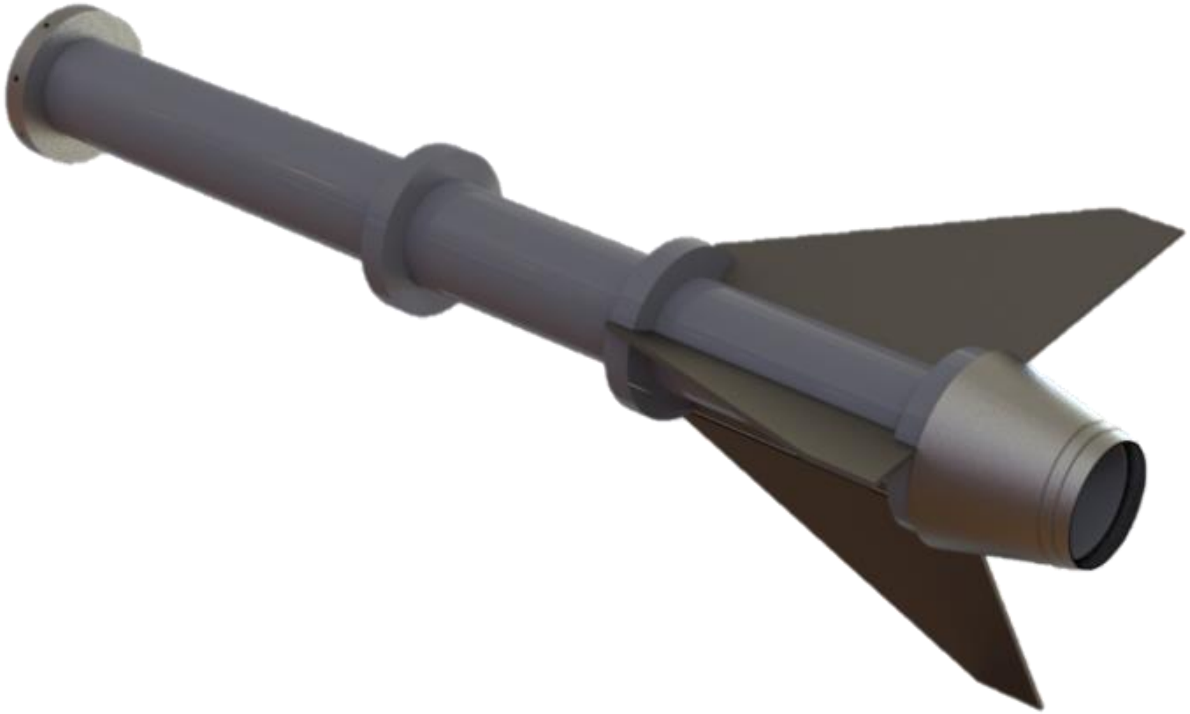

Figure 33. Engine Block One-Piece 3D View (CAD).

Figure 34. Engine Block One-Piece Part Produced.

Engine Section Mechanical View & Detail

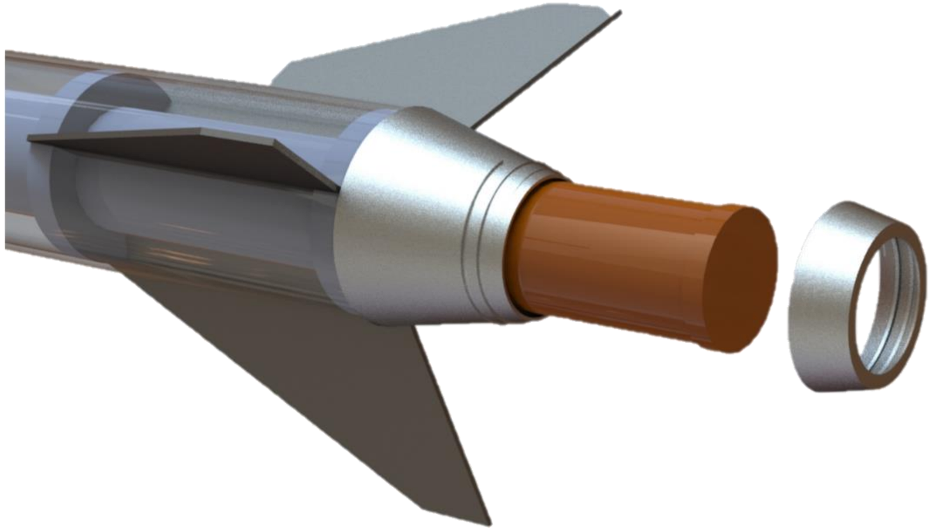

Figure 35. Engine Inserted Last (CAD).

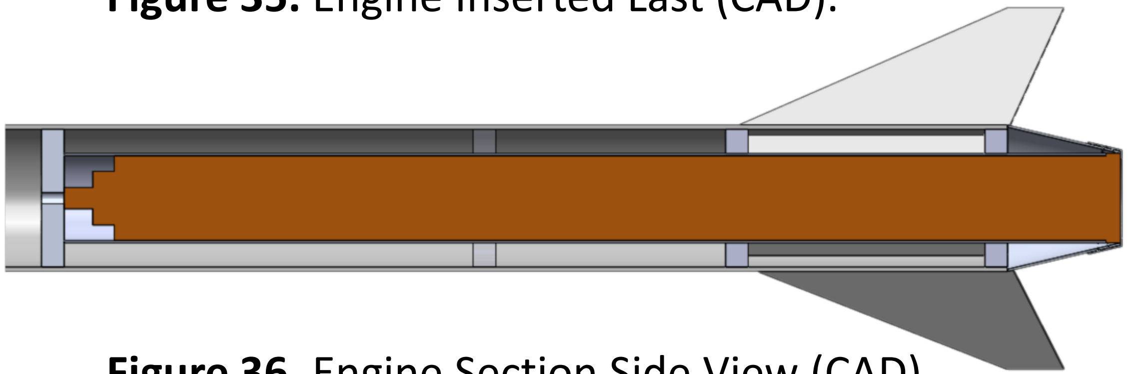

Figure 36. Engine Section Side View (CAD).

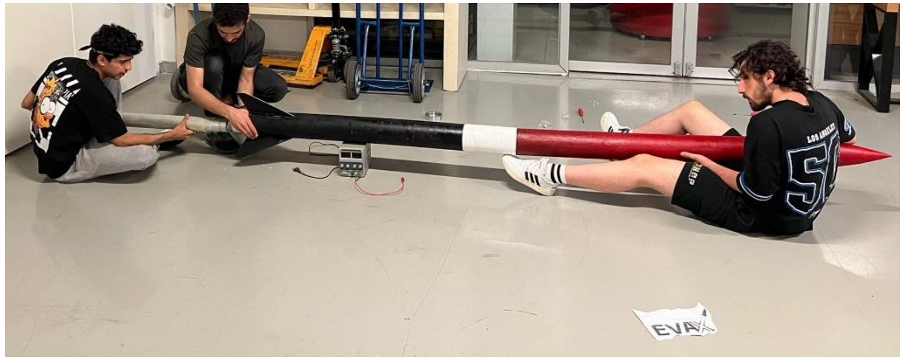

Figure 35. Engine Inserted Last Produced.

As can be seen in the above figures once the one-piece part is placed into the end of the assembled rocket and the engine block is mounted into the main body using 8XM5 screws, the motor (showen in orange) will be placed last and followed by an engine retainer to assure the motor stays in place during flight.

Structural Tests

- Two samples was prepared of fiber glass where one was cut as a wish bone specimen for a tensile test and the other was taken as the exact same dimensions as the rocket tubes but with a way shorter length. Both specimens had a thickness of 4 mm same as our rocket and extension/compression of 4 mm/min. Test was made in Altinbas University Mechanical laboratory.

- Structural Test Youtube Link: https://www.youtube.com/watch?v=Ne_TiUgLjo4

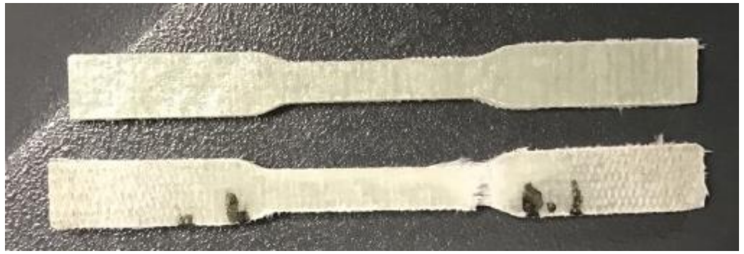

Figure 36. Before and after of prepared wishbone sample.

Figure 38. Prepared Fiber Glass Sample

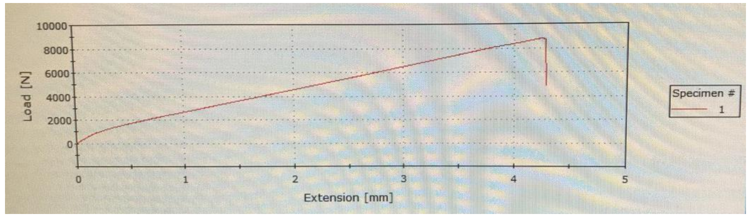

Figure 37. Results of Tensile Test.

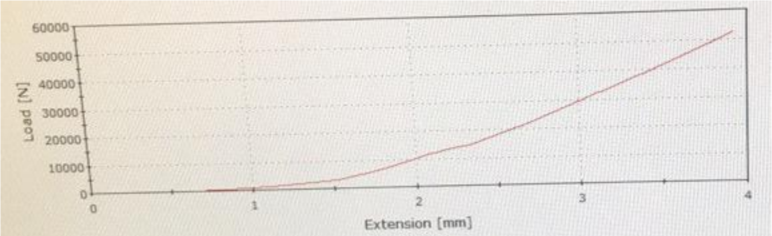

Figure 39 . Result of Compression Test

Rocket General Assembly and Firing Preparation

On this page, the videos of the general assembly test of the rocket, the readiness to fire test, the assembly of the engine to the rocket and the altimeter tests are shown. In the general assembly video of the rocket, it is shown that all subsystems of the rocket can be assembled. In the launch test, it has been shown that the rocket can be prepared in less than 10 minutes. In the test of mounting the engine to the rocket, it was shown how the engine given by Teknofest was mounted to the rocket last. In the Altimeter Test, it was shown how to position the AltimeterTwo given by Teknofest on the rocket.

Youtube Video Link: https://drive.google.com/file/d/1jn1dJW5UxBeCjAUFXGWoOpthsZkYZely/view?usp=sharing

Competition Area Planning

Table 6. Assembly and Shooting Day Business Plan

Team Members	Assembly Day	Shooting Day
Sohaib Aboualyan (Team Captain)	Assembly of the mechanical parts of the rocket, placement of the powder tube and recovery explaining the system. Team coordination	Placing the rocket on the ramp, installation of rocket engine and referee altimeter. Team coordination.
Eda Nur Göksal	Ground station installation and control. Responsibility for communication with the race area referee and officials.	Going to the rescue after the shot. Transfer of data to referee ground station. Going to the payload rescue after the shot.
Osama Hammoodi	Assembly of the mechanical parts of the rocket, placement of the powder tube and recovery explaining the system.	Placing the rocket on the ramp, installation of rocket engine and referee altimeter. Going to the payload rescue after the shot
Bedirhan Köksoy	Checking avionic cards. Ground station installation and control.	Checking the GPS data on the telemetry computer. Transfer of data to referee ground station.
Kaan Avcı	Control of circuit boards and power units in the rocket. Checking avionic cards.	Pre-fire circuit, power and electrical connection check. Going to the rocket rescue after the shot.
Rabia Kazaz	Ground station installation and control. Responsibility for communication with the race area referee and officials.	Going to the rocket rescue after the shot.

Competition Area Planning

Table 7. Emergency and Solution

Possible Emergency	Possible Emergency Solutions
In case of fire during the assembly process.	First response with a fire extinguisher, detecting and replacing the damaged parts of the rocket.
Damage to the parachute during transport.	Replacing the parachute with a backup.
Damage to any component during assembly.	Replacing it with the same module that was brought before.
The prepared software is not approved.	Use of prepared backup algorithms.
Problems with cables during assembly.	Protecting the cable and pulling a new cable.
Breakage of aluminum noscone.	It will be switched to PLA type noscone.
Minor injuries during assembly.	Providing first aid and informing the authorities in the area.

Competition Area Planning

Table 8. Risk Analysis and Solution

Risks	Solutions
Damaged DRFA-433Y antennas during tests, which are difficult to guarantee.	Carrying out 5 km distance tests by wiring to ensure maximum receiver power.
Breakage of the payload glass as a result of being dropped on the ground.	There is an extra glass for payload.
Delay of products supplied from abroad.	Contacting the company abroad and accelerating the procurement process.
Damage to components due to vacuum machine during pressure tests.	Checking the operability of the components daily until the race day.