ANATOLIAN ROVER CHALLENGE

2022

Design Report

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Team Name:

Name of the team and if applies, name of the rover.

Yıldız Rover

Contact:

Contact information and social media links of the team.

rover@yildiz.edu.tr
rover.yildiz.edu.tr
instagram.com/yildiz_rover
twitter.com/yildiz_rover
linkedin.com/company/yildiz-rover

YILDIZ ROVER

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Academic Institution:

- Name and address of the affiliated academic institution.

Yıldız Technical University
Davutpasa Mahallesi, Davutpasa Caddesi, 34220, Istanbul/Turkey

Academic Consultant:

- Name, affiliated academic institution and contact information of academic consultant.

Ozlem Emanet, Ph.D.
Department of Mechanical Engineering
Faculty of Mechanical Engineering
panzehir@yildiz.edu.tr

YILDIZ ROVER

TEAM INFO

ANATOLIAN ROVER CHALLENGE

History of the Team:

- A paragraph of teams history including foundation date, attended competitions and experience.

YILDIZ ROVER

Yıldız Rover is an interdisciplinary robotics team gathered under the university club SPARK (Space and Art Kitchen), which aims to represent and promote Yıldız Technical University and Turkey at an international level with their future-oriented projects. The team was established in July 2020.

The team passed the first stage in the 2021 European Rover Challenge (ERC) competition and was qualified to submit a Preliminary Design Report (PDR). The report had ranked 22nd among teams from all over the world.

Yıldız Rover was qualified to compete as a finalist in the Agricultural Unmanned Land Vehicle category at TEKNOFEST 2021 and achieved 3rd place as a result of the performance of its vehicles in the field.

Yıldız Rover is currently competing in the 2022 University Rover Challenge (URC) organized in Utah, USA with the support of The Mars Society, the 2022 European Rover Challenge (ERC) organized in Kielce, Poland with the support of the European Space Agency, and TEKNOFEST 2022, organized in Turkey every year by the T3 Foundation.

In 2022 URC, the team has fulfilled every requirement with top notes and is set to compete in Finals on the fields of Utah with Yıldız Rover's first-generation rover, Sparkle, in June 2022.

In 2022 ERC, Yıldız Rover has submitted the required Proposal and is expected to deliver a Preliminary Report in May 2022.

The team has submitted a Preliminary Design Report for the TEKNOFEST 2022 competition in the Agricultural Unmanned Land Vehicle category and is prepared for the Critical Design Report submission in June 2022.

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Active Members List:

- A table of active members including following information: Name (or initial letters), University Major, and duty in the team.

Ataberk Atak, Electronics and Comm. Engineering, Organization Team Member
Bilge Nur Mektepli, Chemistry Engineering, Science Team Member
Mısra Naz Sevinç, Bioengineering, Science Team Member
Aleyna Çakır, Physics, Science Team Member
Saidnur Çalışkan, Mechatronics Engineering, Software Team Member
Barış Karataş, Computer Engineering, Software Team Member
Esra Neriman Öz, Electronics and Comm. Engineering, Electronics Team Member
Emre Emir Fidan, Electronics and Comm. Engineering, Electronics Team Member
Alperen Yılmaz, Mechanical Engineering, Mechanics Team Member
Enes Altıngemi, Computer Engineering, Mechanics Team Member

YILDIZ ROVER

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Team Photo

- A photo/screenshot of the whole or part of the team.

YILDIZ ROVER

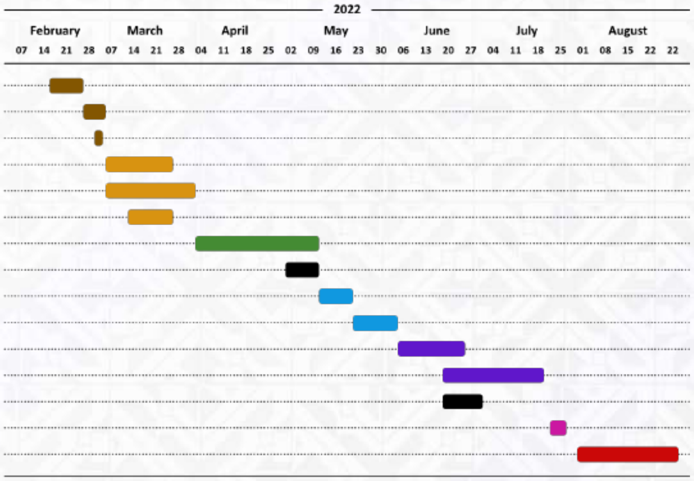
MANAGEMENT

Work Calendar:

- Explain the work on the project by a gantt chart. Include 10-15 items in the Gantt chart.

While preparing this plan, we examined the basic project plans of NASA, ESA, and TURKSAT. And we created the most suitable plan for the Anatolian Rover Challenge requirements and our team.

Mission Name	Start Date	Finish Date
✓ Examination of ARC Documents	Feb 17	Feb 27
✓ Discussing Subsystem Requirements	Feb 28	Mar 4
✓ Selection Process of Engineering Programs	Mar 5	Mar 6
✓ Analysis of Subsystems	Mar 7	Mar 27
✓ Preliminary Design and Modelling	Mar 7	Apr 3
✓ Selection Process of System Materials	Mar 14	Mar 27
✓ Final Design and Production of Subsystems	Apr 4	May 9
✓ Preparing the Design Report	May 2	May 9
Integration of the System	May 10	May 23
Assembly and Debugging of the Subsystem	May 23	June 5
System Tests and Debugging	June 6	June 26
Mission Operation Tests and Debugging	June 20	July 20
Preparing the Scientific and Cost Report	June 20	July 1
Challenge Days	July 22	July 26
Analysis of Obtained Data	Aug 1	Aug 28



Mission Feasibility · Preliminary Design and Modelling · Final Design and Fabrication · System Assembly and Integration · System and Mission Operation Tests · Operations and Sustainment · Closeout · Document

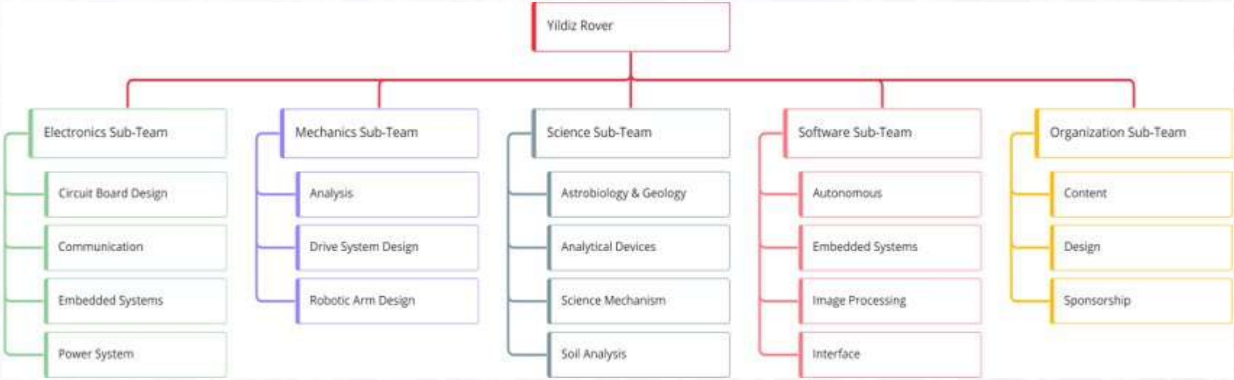
YILDIZ ROVER

MANAGEMENT

Team Formation:

- How is the team workforce structured? (2-3 sentences) Include a graphic to explain the structure as well.

Yıldız Rover consists of 47 members from 14 different engineering and science departments. The team has five sub-teams supervised by the team leader and the technical team leader; mechanical, software, electronics, science, and organization. To ensure the continuity of the team, members are recruited every year and a support team is formed by an online form and interviews.



MANAGEMENT

ANATOLIAN ROVER CHALLENGE

Workplace:

- How the team design, build and test the rover physically? Explain the workplace. (2-4 sentences) Include a photo/screenshot of the workplace.

The team carries out their collaborative work of designing and building the rover in the workspace given to them on Davutpasa campus of Yıldız Technical University in Istanbul. In addition, YTU offers its own Technopark Prototype Workshop to Yıldız Rover members, where the team can produce the parts needed in the construction of the vehicle. On campus, various virtual and physical tests including short circuit, thermal, drop, vibration, leak, data flow and sensor tests are conducted under appropriate conditions with the required equipment in order to operate safely on the Moon and Mars mission fields.

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MANAGEMENT

ANATOLIAN ROVER CHALLENGE

Funding :

- How are the funds of the project at the time of submission of this document?
- How much spending is expected for the development costs? How much spending is expected for the travel costs?
- What is the team's plan in an insufficient funding situation by the competition date?

As of May, the supply of all electronic and mechanical components was completed. Since our team is close to the competition ground, transportation will be provided free of charge by our school. For accommodation, we will use the dormitories provided by ARC. Our budget for the electronic components and the manufacturing of the rover is $13,096.58.

If there was a problem, thanks to our prototypes from the previous year, we can build a rover that can perform basic operations. However, since we did not have any financial problems this year, we developed a brand new and more advanced system from scratch.

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MANAGEMENT

ANATOLIAN ROVER CHALLENGE

Logistics:

- What is the team's plan to package and bring the rover to competition site by July? (4-6 sentences)

Because our team's workplace is 25 km away from the competition field, transportation is very easy for us. We will bring our rover safely into a vehicle arranged by our team. We will only bring disassembled parts that can be affected by the shaking on the way.

We can bring the rover to the competition field with our own cars, even in case of any problem with the support of vehicles from the university.

YILDIZ ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Mobility System:

- What is used? Describe the system (3-5 sentences)
- Why the system is chosen? What are the considerations? What are weaknesses and strenghts? (3-5 sentences)

Rover's chassis is designed with t-slot aluminum profiles which is durable, lightweight and easy to modify. Also, carbon fiber composite tubes are used in rover's legs to reduce the weight. Custom made 6063 aluminum parts constituting the rest of the chassis. By designing a differential bar mechanism, we ensured that the vehicle stays stable and that at least one wheel touches the ground from both sides while passing through obstacles. The carbon fiber composite tubes will also be used in differential bar to increase strength and reduce weight. Carbon fiber tubes have an outer diameter of 38 mm and an inner diameter of 35 mm, providing both lightness and a high safety factor. The specially designed tire was produced with a TPU filament, as it is less costly and accessible than other manufacturing methods. Thanks to flexibilitiy of TPU filament, the rover is not affected by sudden impacts. T-slot aluminums we use while building up the chassis do not allow us to form complex shapes due to the inadequacy of the fasteners. The cylindrical shape of carbon fiber tubes brings about complex connection methods.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Mobility System:

- Unique points and inspirations (3-5 sentences)

Wide variety of modifications are possible due to the chassis made from 20x20mm sigma profiles. The TPU tires (inspired by current airless tire studies in the automotive industry) have vertical and arrow-shaped horizontal treads (just like another vehicle which moves slowly in soft terrain,tractor) to increase traction, and the radius structure in their contours also reduces friction as the tank moves. In addition, the hexagonal channels in the tire provide maximum area coverage with minimum material and resist impacts.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Mobility System:

- Visuals of the system (2 photos/screenshots)

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Mobility System:

- Technical Specifications including mass and size (3-5 sentences)
- Discuss system's adequency for it's role in competition missions. (3-5 sentences)

Our rover has a length of 1100 mm, a width of 800 mm, and a height of 1000 mm. Weight of the chassis without manipulator or science mechanism is less than 30 kilograms. The vehicle can cross obstacles up to 30 cm high by taking them between its legs due to the height of the floor from the ground.

The wheels with a diameter of 25 centimeters provide an ideal climbing ability against obstacles and its width of 12 centimeters also allows sufficient mobility on the soft ground. The high-torque brushed DC motors we use on each wheel enable the vehicle to climb up to 45 degrees and to get rid of the vehicle easily in cases such as being stranded or stuck in an obstacle.

This traction capability also allows towing heavy wheeled weights such as refueling equipment.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Electronics and power system:

- What is used? Describe the system (3-5 sentences)
- Why the system is chosen? What are the considerations? What are weaknesses and strengths? (3-5 sentences)

Rover has NVIDIA Jetson Xavier AGX as mainframe, STM32F407 and STM32F103 as Development boards. ZED2 Stereo Camera, 3D Lidar, and Logitech C920 Cameras are used, also electronic equipment such as Pixhawk, Here 3 GNSS, MIMO omnidirectional antennas, and Rocket M2 Access Points used with TCP/IP modules are used. A 25.2V 41.6Ah Li-ion battery pack is used to power the system. There are fuse and button to cut the power in case of danger. It has a Battery Management System PCB for more reliable use of the battery pack and a Power Distribution PCB with multiple outputs at different voltages controlling the power distribution. Li-ion batteries were chosen for their lightweight construction, high energy storage capacity and long lifetime, but they require a protective circuit to operate safely. In addition, Pixhawk control board is preferred, because it has own application in GNSS and communicates well with the ROS.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Electronics and power system:

- Unique points and inspirations (3-5 sentences)

Electronic equipment such as Battery Management System and Power Distribution current and temperature sensors have been added. The current sensor placed on the 24V input on the Power Distribution PCB can instantly monitor the current drawn from the battery and transfer it to the interface. In addition, the BMS PCB is designed for both Li-Po and Li-ion battery systems.

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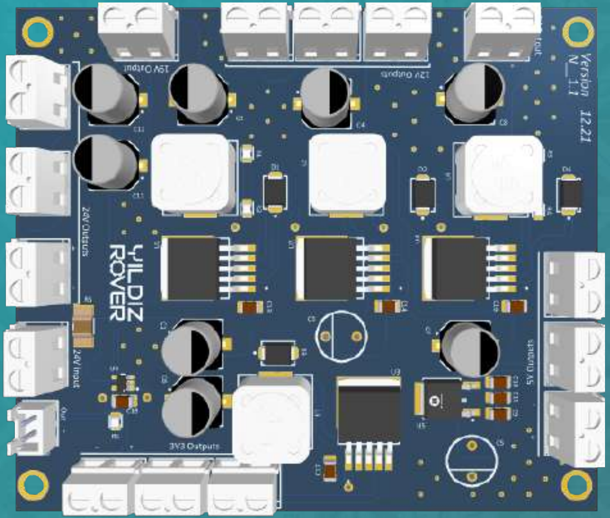
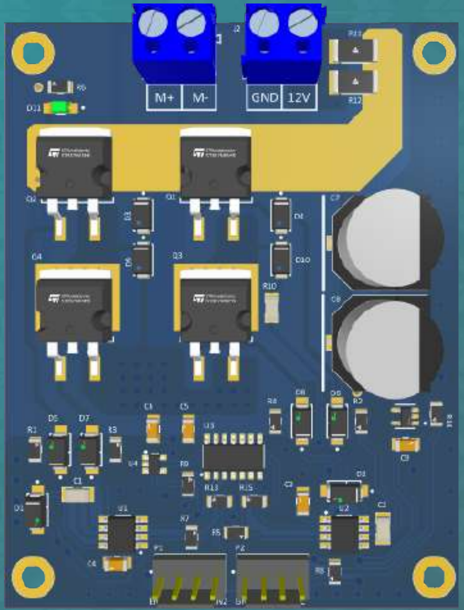
ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Electronics and power system:

- Visuals of the system
(2 photos/screenshots)





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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Electronics and power system:

The competition area has an open structure and equipment was selected in case of encountering different weather conditions.

- Technical Specifications including mass and battery duration (3-5 sentences)
- Discuss system's adequency for it's role in competition missions. (3-5 sentences)

Component	Piece	Power Per Unit (Watt)	Power Per Component (Watt)	Active Run Time of The Part During Mission	Consumed Energy (Ws)
NVIDIA Jetson Xavier AGX	1	30	30	8400	252.000
ZED 2 Stereo Camera	1	1.9	1.9	8400	15.960
3D LIDAR	1	18	18	7500	135.000
Ubiquiti Rocket M2	1	8	8	8400	67.200
Indicator Lamp	1	5	5	8400	42.000
RS775 BrushedDC Motor	4	120	480	4200	2.016.000
Pixhawk+HERE 3GNSS	1	2.5	2.5	8400	21.000
Logitech Cameras	2	1.5	3	8400	25.200
STM32 Development Boards	4	2.5	10	8400	84.000
Linear Actuators	2	36	72	900	64.800
RS775 Brushed DC Motor	1	120	120	900	108.000
MG996R Servo Motor	2	15	30	900	27.000
Pololu 131:1 DC Motor	1	6	6	900	5.400

Component	Piece	Kilo Per Piece (g)	Total Kilo (g)
NVIDIA Jetson Xavier AGX	1	780,00	780,00
STM32F407G-DISC1	3	91,00	273,00
Printed Circuit Boards	6	50,00	300,00
Logitech Camera	2	162,00	324,00
3D LIDAR	1	425,00	425,00
Indicator Lamp	1	150,00	150,00
Chassis and Differamtial	1	6400,00	6400,00
Legs	4	161,00	644,00
Wheels	4	3000,00	12000,00
Manipulator	1	*	*

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ROVER DESIGN

Manipulation system:

- What is used? Describe the system (3-5 sentences)
- Why the system is chosen? What are the considerations? What are weaknesses and strengths? (3-5 sentences)

The manipulator features six-axes to perform the tasks at the optimum level. In order to reduce the overall weight, the manipulator's joint parts were made of aluminum, while the link parts were made of carbon fiber composite tubes. Additionally, some of the shafts were made with steel for increasing th e durability at the high-stress points. We used servo motors, high reduction DC motors and linear actuators to ensure the manipulators pulling, pushing and lifting capability. We use epoxy at some points to montage the carbon fiber tubes to the aluminum parts. This method is not sufficiently resistant to vibration and sudden impacts.
Another method is to drill and screw the carbon fiber tubes to the aluminum. In this method, since the knit structure of the carbon fiber deteriorates, its strength decreases, but the arm is not exposed to a load that may cause deformation.

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manupulation system:

- Unique points and inspirations (3-5 sentences)

The clamps that we used to connect the linear actuators to the carbon fiber tubes provides an adjustable range of motion. The end effector, which we designed inspired by the human hand, uses a lead screw mechanism to obtain the maximum tightening force. A rubber material is used to increase the friction coefficient in the inner surfaces of fingers.

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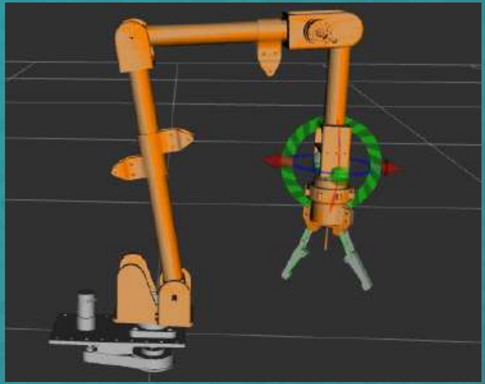
ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manupulation system:

- Visuals of the system (2 photos/screenshots)



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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manupulation system:

- Technical Specifications including mass, max payload and size (3-5 sentences)
- Discuss system's adequency for it's role in competition missions. (3-5 sentences)

The manipulator's horizontal range is 1200 mm, and its end effector can reach objects 1200 mm above the ground vertically. Also, it can be easily mounted on an aluminum plate in front of the rover and demounted for science mechanism. Weight of the manipulator is 9.95kg's. Thanks to linear actuators producing force around 1000 newtons, we ensure the arm is capable of lift and tow a payload up to 5,5 kilograms without trouble. The end effector that we designed has 2 fingers moving parallel to each other and these fingers capable of open up to 9 cm's. With smooth precision coming from the other axes, the end effector can easily manage the tasks on the panel, plug and unplug the USB and attach and detach the 35mm diameter refueling pipe from the rocket. In addition, due to the strength of the aluminum and PLA parts we use when connecting the fingers to the main part of the end effector, the arm can lift and carry toolboxes and similar objects using one finger.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Science Payload:

- What is used? Describe the system (3-5 sentences)
- Why the system is chosen? What are the considerations? What are weaknesses and strengths? (3-5 sentences)

YILDIZ ROVER

The science mechanism consists of two sub-systems, sampling and caching.
By using the science mechanism, samples are collected and storedefficiently. The system is based on analysis by identifying soil structure and minerals. In the science mechanism, UV/vis Spectrophotometer, vis/NIR Reflectance Spectrometer are the fundamental devices for the mission. Soil sensors, atmospheric sensors and a digital microscope are also used as auxiliary tools.
The mechanism was designed by selecting the devices that perform the most appropriate analysis in line with the financial and regional possibilities of the team.
The main weakness of the system is storage and reuse limitation for soil samples, system contains 4 different containers and does not have an unloading system.
On the other hand, the science mechanism has plenty of strengths. Science mechanism's custom-made spectrometers provide a wide spectral range analysis for experiments. In addition, spectrometers do not contain a complex sample preparation process and are designed to be adequate for all missions. Visual analysis data are collected by a digital microscope on the rover and thanks to image processing, minerals, and soil types can be identified effortlessly.

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Science Payload:

- Unique points and inspirations (3-5 sentences)

Besides sampling and caching, image processing and analytical devices are performed to detect minerals and soil type in custom-made UV/vis spectrophotometer and vis/NIR Reflectance Spectrometer are used to enrich the soil-rock analysis and life detection.
During the improvements of the mechanism and analytical devices, many articles, publishments, and previous Mars missions' scientific instruments are referenced.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Science Payload:

- Visuals of the system (2 photo/screenshots)

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Science Payload:

- Technical Specifications including mass and battery duration (3-5 sentences)
- Discuss system's adequency for it's role in competition missions. (3-5 sentences)

The science mechanism is designed to fulfill the competition missions. With the sampling mechanism, sufficient depth and amount of soil can be taken and transferred to the storage containers on the vehicle and safely preserved throughout the mission. During soil sample collection, both the sampling area and the environment are photographed by the cameras on the vehicle, and the hypothesis prepared by the team can be tested thanks to the spectrometers and sensors used.

Component	Piece	Power Per Unit (Watt)	Power Per Component (Watt)	Active Run Time of The Part During Mission	Consumed Energy (Ws)
Pololu 101:1 DC Motor	1	6	6	120	720
RS775 Brushed DC Motor	2	120	240	240	57.600
Nema 17 Step Motor	2	6	12	120	1.440
STM32 Development Boards	1	2.5	2.5	8400	21.000

Component	Piece	Kilo Per Piece (g)	Total Kilo (g)
RS775 DC Motors	2	220,00	440,00
Pololu DC Motor	1	180,00	180,00
Step Motor	2	240,00	480,00
STM32F407G-DISC1	1	91,00	91,00
Spectrophotometer	1	1000,00*	1000,00*
Plexiglass Box	1	450,00	450,00
Sensors	1	300,00	300,00

YILDIZ ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Ground station equipment and communication system:

- What is used? Describe the system. (3-5 sentences)
- Why the system is chosen? What are the considerations? What are weaknesses and strengths? (3-5 sentences)

The communication between the ground station and the rover is achieved with 2.4 GHz Rocket M2 access points with TCP/IP modules. High-speed data transfer is provided with the airMAX protocol. By using omnidirectional antennas, it is aimed to reduce the positional disadvantages that may occur in case of working in large areas as much as possible. CANBus and UART protocols were preferred to maintain wired communication The CANBus protocol only needs two wires, which simplifies the wiring. In addition, SPI, I2C, MAVLink and Ethernet protocols are also used in in-vehicle communication. UART protocols are preferred to enable wired communication and CANBus protocols to simplify wiring.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Ground station equipment and communication system:

LoRa communication protocol was preferred as an alternative solution in order not to have problems in the data flow between the rover and the control station in case of a possible communication interruption in the airMAX protocol and to continue the motor control.

- Unique points and inspirations (3-5 sentences)

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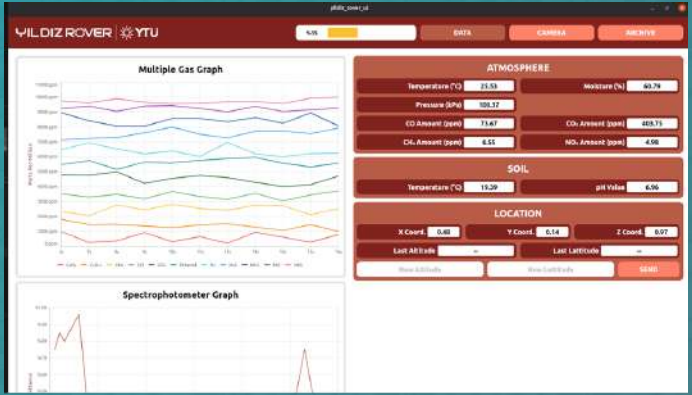
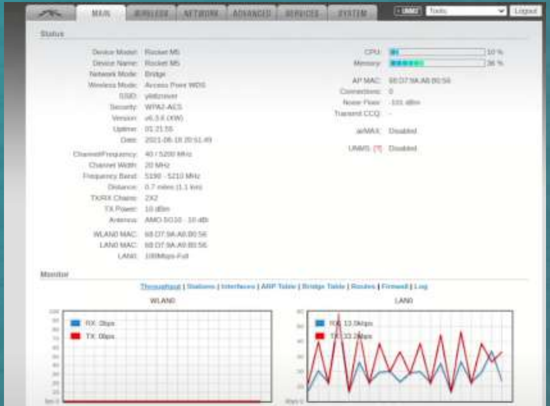
ROVER DESIGN

Ground station equipment and communication system:

- Visuals of the system (2 photos/screenshots)





ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Ground station equipment and communication system:

- Technical Specifications including resilience to noise and communication range (3-5 sentences)
- Discuss system's adequency for it's role in competition missions. (3-5 sentences)

Considering that the diameter of the competition area is 40 meters, the rover is expected to reach a range of 1 km thanks to the communication equipment used.

CANBus, which is preferred in wired communication, is expected to have a filtering system and prevent noise problems with CAT7 cables being less affected by electromagnetic waves compared to previous UTP cables.

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