



**ANATOLIAN
ROVER CHALLENGE**

— 2022 —

Design Report

TEAM INFO

Team Name:

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

METU ROVER - IMPROVER

Contact:

- ◆ Contact information and social media links of the team.

Aysima Beril Baydar(Team Leader) mail: aysima.beril@gmail.com

meturover@gmail.com

<https://meturover.com/>

<https://www.instagram.com/meturover/>

<https://www.youtube.com/meturover>

<https://www.facebook.com/meturover/>

<https://twitter.com/meturover>

<https://www.linkedin.com/company/meturover>

TEAM INFO

Academic Institution:

◆ Name and address of the affiliated academic institution.

Middle East Technical University
Üniversiteler, Dumlupınar Blv. 1/6 D:133, 06800 Çankaya/Ankara

Academic Consultant:

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

Assoc. Prof. A. Buğra KOKU
Middle East Technical University
mail: kbugra@metu.edu.tr

TEAM INFO

Active Members List:

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

Mechanics Team

Berk Ünlü (ME)
Zeynep Neslişah Yılmaz (ME)
Abdülkadir Sarıtepe (ME)
Kaan Dere (ME)
Mahmut Bahadır Özbek (ME)

Electronics Team

Taha Tolga Saadet (EEE)
Evren Uçar (ID)
Alper Karasuer (AE)
Parnian Rastkar Abbasalizadeh (EEE)
Şevval Yuvarlaktaş (AE)
Bahadır Yıldırım (EEE)

Bold - Team Captain
Underlined - Team Lead

Software Team

Özgür Şanlı (ME)
Umut Akkaya (ME)
Alev Ayaz (PHYS)
Ercihan Kara (EEE)
Jasmien Hassanien (EEE)
Muhammed Ahmed (ME)

Science Team

Aysima Beril Baydar (PHYS)
İlayda Ayyıldız (CHE)
Zain Anwar (AE)

Organization & Finance Team

Zehra Nur Erol (ME)
Furkan Kaya (ME)

TEAM INFO

Team Photo

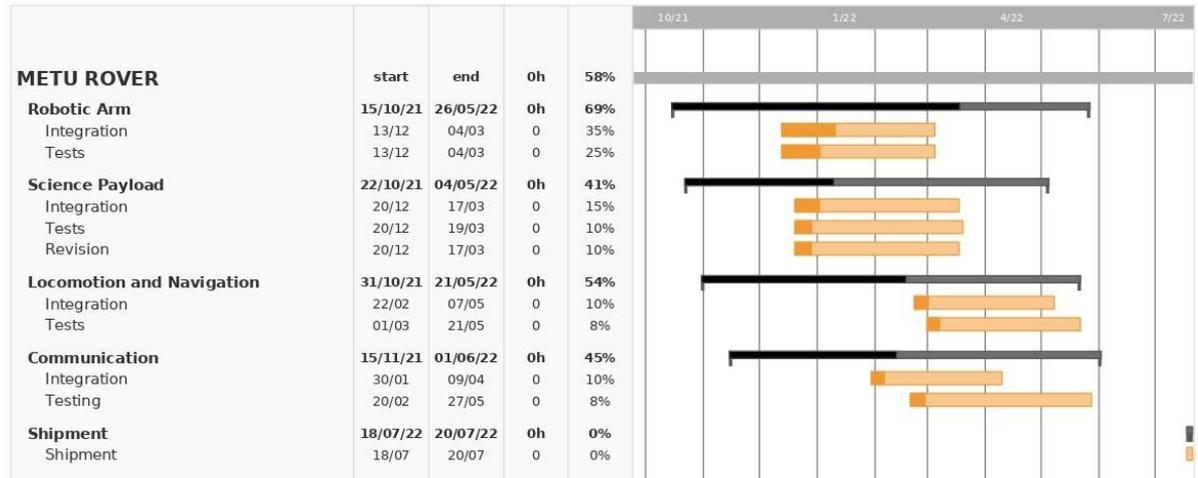
- ◆ A photo/screenshot of the whole or part of the team.



MANAGEMENT

Work Calendar:

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



MANAGEMENT

Team Formation:

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

METU ROVER has 22 members with the ability to work multidisciplinary. The team is divided into five sub-teams: Mechanics, Electronics, Software, Science, and Organization & Finance (O&F). Each sub-team has its team captain for tasking team members and report to the team leader.



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 project is one of the projects of METU Mechanical Engineering and Innovation (ME&I) Society where students conduct their engineering-based projects. We carry out the production of the rover in the room belonging to this society and in a shipping container supplied by a sponsor located in the Mechanical Engineering department of METU. While the meeting room is used for studying at arranged hours as a team, varied trials to comprehend how the components work can be experienced in the workshop. Also, a workspace and a storage area are available in the container.



MANAGEMENT

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?

The O&F sub-team is responsible for the team's financial and facility resources. The budget aids by companies can be in various types such as manufacturing, equipment and materials, and discounts in their goods or operations. Our total budget is above our estimated total expenditure and we are still looking for revenue for any shortfalls.

Income Category	Income Source	Income	Expense Category	Estimated Expenses	Expenses
Production	Çimtaş	\$ 7,000.00	Logistics	\$ 500.00	\$ 0
Production	GES Eng.	\$ 1,500.00	Fixed Assets	\$ 95.00	\$ 95.00
Production	Petlas	\$ 365.00	Production Services	\$ 1,300.00	\$ 1,200.00
Financial	Silverline	\$ 729.00	Hardware	\$ 4,800.00	\$ 4,500.00
Financial	Bulut Makine	\$ 1239.00	Materials	\$ 5,700.00	\$ 5,200.00
Financial	Emek Kablo	\$ 642.00	Total Expenses	\$ 12,395.00	\$ 10,995.00
Financial	Roketsan	\$ 1,030.00	Funding required	-	-
Financial	AdimODTÜ	\$ 129.00	Net Income	(Total income - Total expense)	\$ 1,909.00
Financial	Playable Factory	\$ 365.00			
Total income	\$ 1 = ₺ 13.70	\$ 12,904.00			

MANAGEMENT



Logistics:

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

We are planning to transport the team, the vehicle, and the equipment that may be needed from METU to ITU Ayazaga campus(444 km road) by a rented bus. We have started negotiations with the school for this bus. The necessary inventory list will be prepared and supplied one week before this trip. We plan to set out on this journey, which takes five and a half hours with a break, on 20 July at 00:00. On the morning of July 20, we will settle in ITU Ayazaga campus with our vehicle, team and inventory and carry out our post-travel checks on rover.

ROVER DESIGN

Mobility System:

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

Rocker mechanism is used to keep the main body close to parallel to horizontal and to keep all 4 wheels in contact with the ground. The system provides simplicity in terms of stability of the rover.

The main body is made of carbon fiber square tubes and aluminum nodes. Square profiles provide simplicity for design and easy assembly with the other components. While the carbon fiber has high strength, it is expensive compared to its substitutes.

The rover is mounted on four wheels that are made of aluminum material, to provide less weight and more durability. Motors are placed inside the wheels and work independently with each other. In this way, the rover is capable of tank turning. Tank turning is a simple solution in terms of turning capability of the rover, however it is harder to obtain more accuracy compared to other turning methods.

Non-pneumatic tires are used to decrease shock on rocker suspension linkages. The choose of the tires provide well handling and grip for the rover.

ROVER DESIGN

Mobility System:

- ◆ Unique points and inspirations
(3-5 sentences)

It is decided that using a differential linkage mechanism rather than a differential gearbox to transmit motion to the other leg of the rocker system since the latter takes up some useful space in the body of the rover. For the simplicity, rocker mechanism is designed to be close to linear 1/1 ratio motion transmission like a differential gearbox.

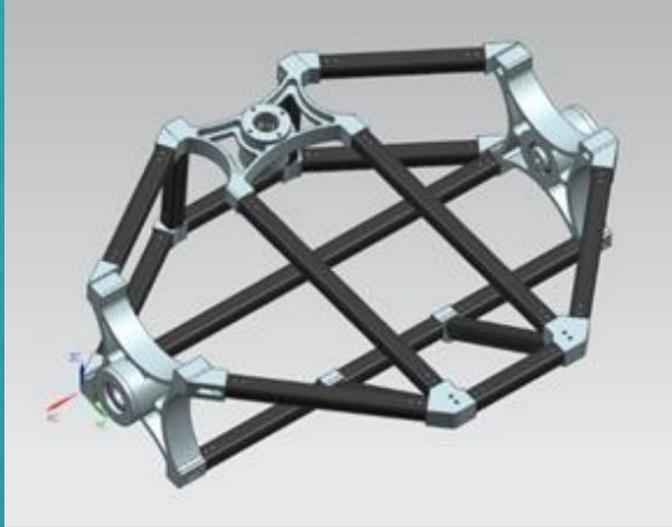
The center of mass is also considered so that the rover does not topple at high slopes. Therefore, the height of the main body is determined by considering both requirements.

The rover is designed to be modularly structured so that irrelevant modules according to task do not affect negatively the operation.

ROVER DESIGN

Mobility System:

- ◆ Visuals of the system (2 photos/screenshots)



The chassis of the rover in CAD environment.



The manufactured mobility system of the rover

ROVER DESIGN

Mobility System:

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

The overall system is designed to fulfill the requirements of the competition in terms of technical specifications. The weight, size, cost limitations and the challenges in the competition are considered to determine design specifications. The design advices are carefully examined so that the team can prevent any foreseen difficulty during the competition. The length, width and height of the rover are 1200 mm, 950 mm and 500 mm respectively. The rover is designed to have mass of less than 50 kg including its equipments. With the specifications indicated above, the rover is adequate for the competition to complete the given tasks in terms of mobility systems. Each mission in the competition is carefully analyzed to complete the tasks successfully. Also, the missions of the competition are taken into account during each design stage of the mobility systems.

ROVER DESIGN

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)

The heart of the rover electronics is the Jetson TX2. All heavy computational processes such as image processing, object detection and path planning are included in this task computer. In addition, a PCB powered by ARM Cortex M3-based microcontrollers, which will deal with the sub-main tasks of the vehicle, has been designed. The vehicle is wrapped with CAN-BUS network and all boards use this interface for communication.

The reason for choosing this architecture is to put the rover in a more modular structure, which makes debugging easier and updates to the rover are carried out faster. The negative side is that due to the PCB that will be placed all over the vehicle, the wiring becomes difficult and access to some places in the vehicle is restricted.

ROVER DESIGN

Electronics and power system:

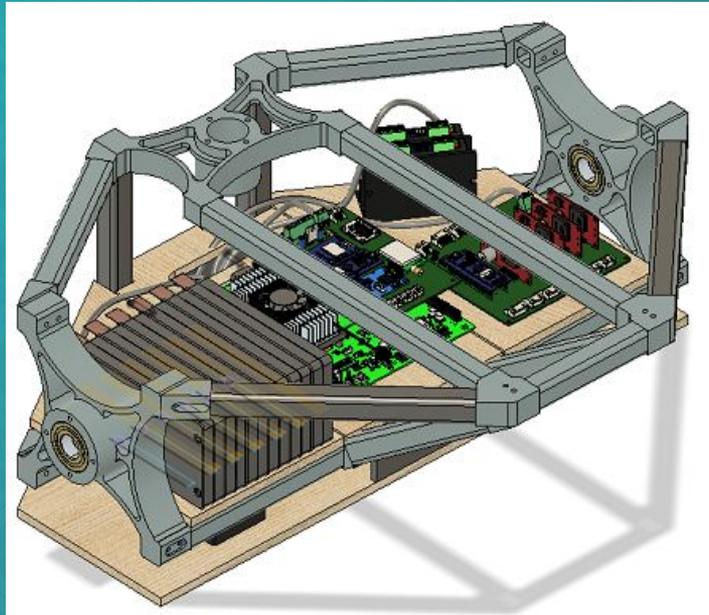
- ◆ Unique points and inspirations
(3-5 sentences)

While designing the electronics of the rover, modularity was prioritized and architecture was created in this way. For this purpose, different mission computers were designed for each main unit of the vehicle (robot arm, mobility, science payload) and the parts were prevented from affecting each other.

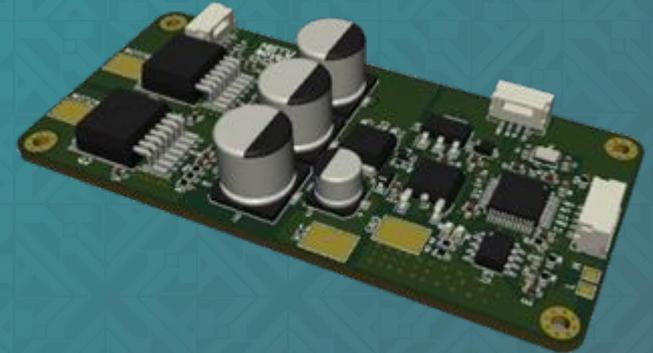
ROVER DESIGN

Electronics and power system:

- ◆ Visuals of the system
(2 photos/screenshots)



Electronic component layout in the chassis



General view of the motor control unit

ROVER DESIGN

Electronics and power system:

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

The rover is powered by two 3S 6P 18650 Li-Ion battery packs. The total battery capacity on the rover is 36000 mAh, with each pack being 18000 mAh. With this battery capacity, approximately 1 hour of driving is obtained. The total weight of the battery packs is 1650 grams.

While designing the battery pack, it is designed to last for 1 hour in the scenario where all the main parts of the rover will consume power at the same time. Also with the amount of C it has, it can provide enough current for all equipment.

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 robotic arm system has 5 degrees of freedom. For the azimuth axis, a spur gear train of 4 members is to be used with a stepper motor. For the shoulder elevation, an OTS worm gear pair is used to negate transferring the reaction forces to the motor as well as preserving position without any energy on the stepper motor used. For the elbow axis, a linear actuator is used to achieve high torque, self-locking, and low back-lash properties in a cheap and reliable manner. The wrist pitch is achieved using a DC motor with a worm-gear type gearbox. The gripping surfaces operate rectilinearly by using a four-bar mechanism to hold different objects. The movement of the system is provided by a lead screw

While designing the system indicated, the requirements of the different tasks are considered. The requirements of each tasks are listed and analyzed. In terms of weaknesses, the chosen manipulation system of the rover is bulky compared to other candidate systems and the size of the rover. However, the chosen system provides well handling of the missions by the rover.

ROVER DESIGN

Manipulation system:

- ◆ Unique points and inspirations (3-5 sentences)

Non-dimensional “skeleton” of the arm is tested on the CAD models of the panel. Also, this “skeleton” is placed on the rough design of the rover for testing on-board box, container.

For the wrist roll axis, a slip ring is used with a spur gear mate to achieve infinite rotation on this axis. A DC motor with encoder and planetary reductor is used on this axis

Longest links of the arm are mostly made of standardized Carbon Fiber Reinforced Epoxy pipes. The connector parts are manufactured using FFF (Fused Filament Fabrication) whenever applicable. However, on elbow, shoulder, and azimuth aluminum is preferred.

ROVER DESIGN

Manipulation system:

- ◆ Visuals of the system (2 photos/screenshots)



The manipulation system of the rover in CAD environment.



The end effector of the rover in CAD environment.

ROVER DESIGN

Manipulation system:

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

Overall robotic arm is calculated to be slightly lower than 13.7 kg without gripper and electronic components(except motors which are included in the given value). The gripper has 0.8 kg of the weight including the tips. The robotic arm 1740 mm in length including the end effector and 50 mm in diameter.

The robotic arm is designed to complete missions in the competition such as panel manipulation. Reaching the panels, payloads and manipulating different instruments included in the competition's missions are considered during the each design stage of the manipulation system. The end effector is carefully designed to have grip and hold capability.

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)

In the science payload, the sample will be acquired with driller from different depths at the designated area will be transferred to different containers. The rotating platform with the load cell is also tested to see if samples are weighed and moved through the science-hub with ease. Biomarkers in samples such as polysaccharides and proteins will be tested using Lugol's Iodine and Biuret reagents. Atmospheric sensors are used to detect any signs of bioactivity such as presence of methane gas. Science Payload which is equipped with a camera will be used to determine the mineral composition in the area using a neural network trained by the team.

The system is chosen with consideration of remote and autonomous capabilities of the rover. The experimentation of the soil on the rover had to yield fast results, easy to observe and execute. However this has limited the amount of biomarkers to be tested. A neural network to detect mineral composition is chosen to analyze the area without making the payload too heavy since all it requires is an on-board camera. As a weakness, using only images to sort through minerals is less reliable than chemical methods.

ROVER DESIGN

Science Payload:

- ◆ Unique points and inspirations
(3-5 sentences)

The Science Payload is designed to work together with the different testing methods in order to analyse the designated area with multiple inputs. Colorimetric assays on the soil samples will be evaluated with the atmospheric analysis of the designated area which makes the analysis rather unique. The area's mineralogical composition will be also analyzed by the science payload to give another input to factor in the evaluation process. This is inspired by the actual missions on Mars where environmental factors are taken into account when a hypothesis is being formed and tested.

ROVER DESIGN

Science Payload:

- ◆ Visuals of the system
(2 photo/screenshots)



The general view of the science box of the rover



The elevation mechanism containing soil temperature and humidity sensors.

ROVER DESIGN

Science Payload:

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

The science payload is designed to be less than 3 kg including the electronic components and relevant equipments.

Science Payload is equipped with a drill which is used to collect samples, a sample testing mechanism that is capable of executing colorimetric analysis and a camera to document the designated area and its components such as rocks and landform. The payload also has atmospheric analysis unit to analyse the site in a broader sense. The gathered information through different instruments are efficient to test the area for various hypotheses.

ROVER DESIGN

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)

5 GHz will be used as the main communication network between the ground station and the rover. In addition, a 900 MHz LoRa module will be used as a backup. In addition to this, there will be a computer, joystick and screen to be used in the ground station to monitor the vehicle and control it when necessary. Since the wi-fi module used is directional, antenna tracker is designed to track the rover. Thanks to the directional Wi-Fi antenna, the range has been increased, but the system has become more complex as it will follow the rover.

ROVER DESIGN

Ground station equipment and communication system:

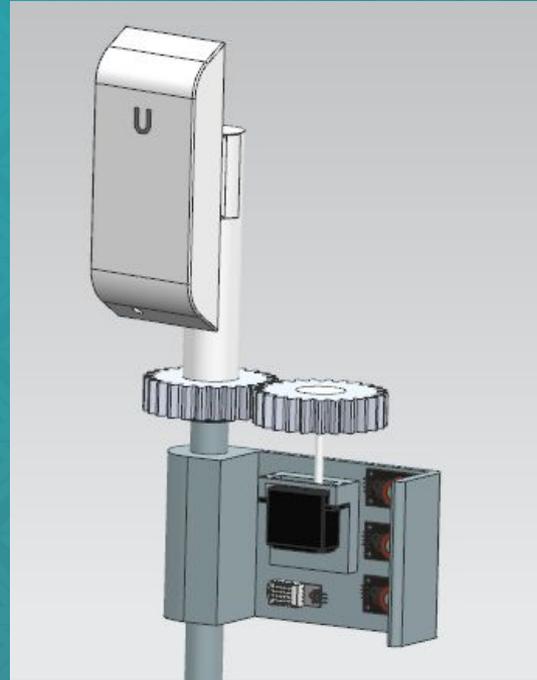
A directional antenna is used in communication, so much more range is obtained for the same cost. Thanks to the strong communication established, it is aimed to prevent disconnections.

- ◆ Unique points and inspirations (3-5 sentences)

ROVER DESIGN

Ground station equipment and communication system:

- ◆ Visuals of the system (2 photos/screenshots)



Wi-Fi module and rotation mechanism



Antenna rotation controller

ROVER DESIGN

Ground station equipment and communication system:

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

With its powerful antenna and rotating mechanism, the rover has a communication range far above the dimensions of the competition area. The range, which is 13 km according to the datasheet of the module used, has been tested with a rover from a maximum of 1.5 km and has passed this test successfully.

TEAM INFO



History of the Team:

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

METU ROVER has been working under METU Mechanical Engineering and Innovation society since October 2018. As of May 2022, our team consists of 22 members who are divided into 5 sub-teams which are mechanical, software, electronics, science, and organization & finance. The team has attended ERC 2020 which was held online. METU ROVER received the 4th place in the overall competition and obtained the 'Best Scientist' title. The team also applied for ERC 2021 and made it to finals yet could not attend the physical competition due to logistic problems. In 2022, METU ROVER was selected as a finalist to URC 22 but will not attend the competition due to difficulties during visa application process.

