ANATOLIAN ROVER CHALLENGE

2022

Design Report

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Team Name: GTU Rover Team

Name of the Rover: Adventure

Contact:

rover@gtu.edu.tr

https://www.linkedin.com/company/gtu-rover-team/
https://www.instagram.com/gturover/
https://www.youtube.com/c/GTURover

GTU ROVER

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Academic Institution:

Gebze Technical University
Cumhuriyet, 2254. Sk. No:2, 41400 Gebze/Kocaeli

Academic Consultant:

Recep ÖNLER from Gebze Technical University,
Mechanical Engineering department
ronler@gtu.edu.tr

ROVER

TEAM INFO

ANATOLIAN ROVER CHALLENGE

History of the Team:

ERC Remote

6

ERC On-site

11

URC

Finalist

GTU Rover Team was established in May 2020 with over 30 eager students in various engineering and positive science departmans. In the first year of it's foundation, team was attended both Remote and Onsite formula of the ERC (European Rover Challenge) and got the success of 6th and 11th from them. In the second year, which is 2022, team is qualified for the URC (University Rover Challenge) and ERC's remote formula. Waiting approvements are ERC's Onsite formula and ARC (Anatolian Rover Challenge). Beside competitions attended as team, team members has experience on different competitions in different aspects like Robotaxi and Autonomous Vehicle and Unmanned Air Vehicle competitions in TEKNOFEST, model satellite competition in CANBUS. We're continuing our studies at workshop inside the Gebze Technical University now.

ROVER

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Team Structure

Emre Eyuboglu
Team Leader

Lead					
Alpcan Soydas – Core Rover System Lead	**Sule Seyrek** – Drive System Structural Design	**Yusuf Gunan** – Drive System Embedded	**Ruveyda Gunal** – Electrical Architect	**Alperen Urey** – Communication System	**Selim Aygun** – Communication System
Halil Ibrahim Ilhan – Arm Lead	**Emre Senturk** – Arm Structural Design	**Enes Ata** – Arm Structural Design	**Jwan Hussaın** – Arm Embedded System	**Fatih Keskin** – Arm Embedded System	**Isa Kozan** – Arm Control Software
Fatih Kaan Salgir – Autonomous Navigation	**Asuman Sare Ergüt** – SLAM	**Serhat Sarı** – Marker Detection	**Ozan Yildiz** – Mission Control Interface	**Mustafa Karakas** – Path Planning	**Ahmet Furkan Kurban** – State Machine Design
Reyhan Bolat – Science Lead	**Beyza Nur Cebeci** – Researcher	**Cemal Eryigit** – Science System Embedded	**Mustafa Baydaroğlu** – Science Structural Design	**Buse Akturk/ Cem Gunduz** – Geological Mapping	**Atahan Evcen/Tunahan Unal** – Geological Mapping
Omer Faruk Sayar – Business&Organization	**Omer Faruk Akverdı** – Designer	**Ali Tilkicioglu** – Financer	**Beyda Ulusoy** – Sponsorship	**Eda Ozmen/ Esra Baykal** – Sponsorship	**Oguzhan Gunay** – Organization

ROVER

TEAM INFO

ANATOLIAN ROVER CHALLENGE

ROVER

MANAGEMENT

Work Calendar:

Task ID	Task Name	2021 SEPTEMBER	2021 OCTOBER	2021 NOVEMBER	2021 DECEMBER	2022 JANUARY	2022 FEBRUARY	2022 MARCH	2022 APRIL	2022 MAY	2022 JUNE	2022 JULY	2022 AUGUST
T01	Review the last year	■											
T02	Reading the ARC Rules and requirement evaluation	■											
T03	Research for fund		■	■	■	■	■						
T04	Discussion of the last year's systems and determining changes		■										
T05	Learning assignments to new coming members		■	■	■	■							
T06	Determining scientific requirements and work on them			■	■								
T07	Following courses about missing knowledge			■	■	■	■	■					
T08	Dimension analysis, Conceptual Design			■	■								
T09	Material Selection				■	■							
T10	Design of drive system, robotic arm, science mechanism				■	■	■	■					
T11	Developing the Autonomous Driving System				■	■	■	■					
T12	Motor selection and Cable management		■	■	■	■							
T13	Assembly of the Rover							■	■	■			
T14	Microcontroller and motor controller selection		■	■	■								
T15	Power System and Communication System design			■	■	■	■	■					
T16	Embedded Coding				■	■	■	■	■				
T17	Navigation studies						■	■	■				
T18	Autonomous testing							■	■				

MANAGEMENT

ANATOLIAN ROVER CHALLENGE

Team Formation:

Electronic

Software

Sponsorship

Mechanic

Science

Important parts that are necessary to built a rover is determined. After that, to work on each part, sub-teams are created considering requirements of divived parts.

Those sub-teams are Mechanic, Electronic, Software, Science and Sponsorship & Media.

Each sub-team is approximately consist of 6-9 members from relevant departments to meet the requirements of sub-teams.

MANAGEMENT

Workplace:

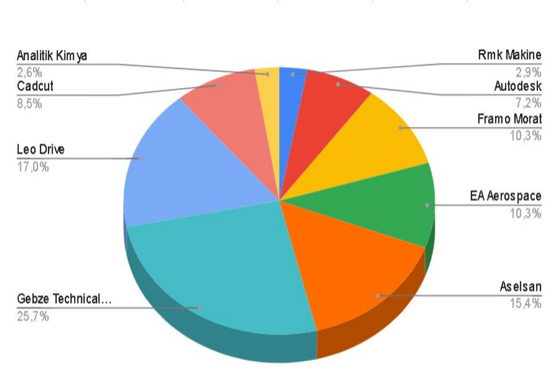
Design step is done both remote and physically.
Meetings are held to exchange ideas on design and take actions according to the results.
Build stage realized with the cooperation of team members, production facilities and factories.
After rover is produced, it is tested for all considered scenarios in the campus.

In the workplace, following precautions are taken:
-Protective equipment has been used, when used tools that could pose a danger
- A fire extinguisher has been kept on hand in the workshop in case of fires or other emergencies.
- Precautions have been taken against coronavirus

MANAGEMENT

Funding :

Financial planning was created with a budget plan, taking into account the requirements and material needs of the sub-teams. Because this project required a large number of material resources, finding support in terms of donated products as well as financial support was critical. After some initial design concepts were examined at the start of the project, a realistic budget estimate was prepared to predict the team's spending. Component costs, manufacturing expenses, the cost of workshop equipment, promotion, and the cost of additional needs were all included in these prices. The search for sponsorship will continue in line with the needs throughout the competition process. The funds that we have received are as stated in the table. Total money we received is 11.713 $. Owing to location is close, we will use the vehicle that is provided by the school. There will be no extra charge for travel. Depending on situation, we can spend 400 $ for development. We don’t have any financial problem , so we didn’t make any second plan. For now, the funds are sufficient for competition.



RMK Makine -	340$
Autodesk -	850$
Framo Morat -	1210$
EA Aerospace -	1207$
ASELSAN -	1811$
CADCUT -	1000$
GTU -	3000$
Leo Drive -	2000$
Analitik Kimya - 300$	

MANAGEMENT

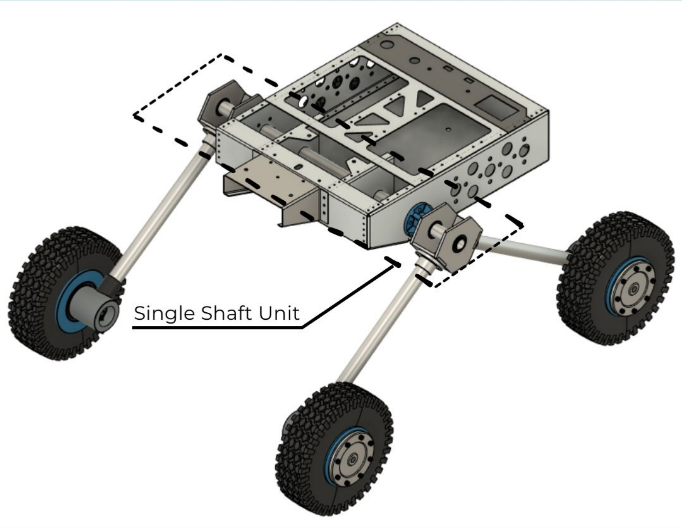
Logistics:

Due to competition site is in the boundary of our country, Turkey, there is no need to shipment plan. To protect rover from damage while bringing it to the competition site, hard case will be used. Transformation will be provided via team bus, arranged from university. Rover will be at the same place with team members during transformation.

ROVER DESIGN

Mobility System:

The mobility system is designed to move the rover around rough terrain while protecting onboard components from impact and vibration. The rocker suspension, wheels, and chassis of the rover are the main parts of the drive system. Because of its maneuverability, ability to overcome obstacles larger than the wheels, and fewer components, a four-wheeled rocker suspension design was preferred over a rocker-bogie design. The rocker suspension mechanism consists of two rockers, a differential bar, and a single shaft (Figure X). The rockers load each wheel equally and the tires squeeze to distribute the load over a large area. For modularity and ease of servicing, every rocker is linked to the chassis through a single shaft that also interfaces with the differential bar and holds the rocker's level with the chassis. To maximize ease of manufacturing and assembly, aluminum laser cut were chosen as a material for the rocker, differential bar, and single shaft unit plates. In the design stage, static and dynamic analyses are conducted.



ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

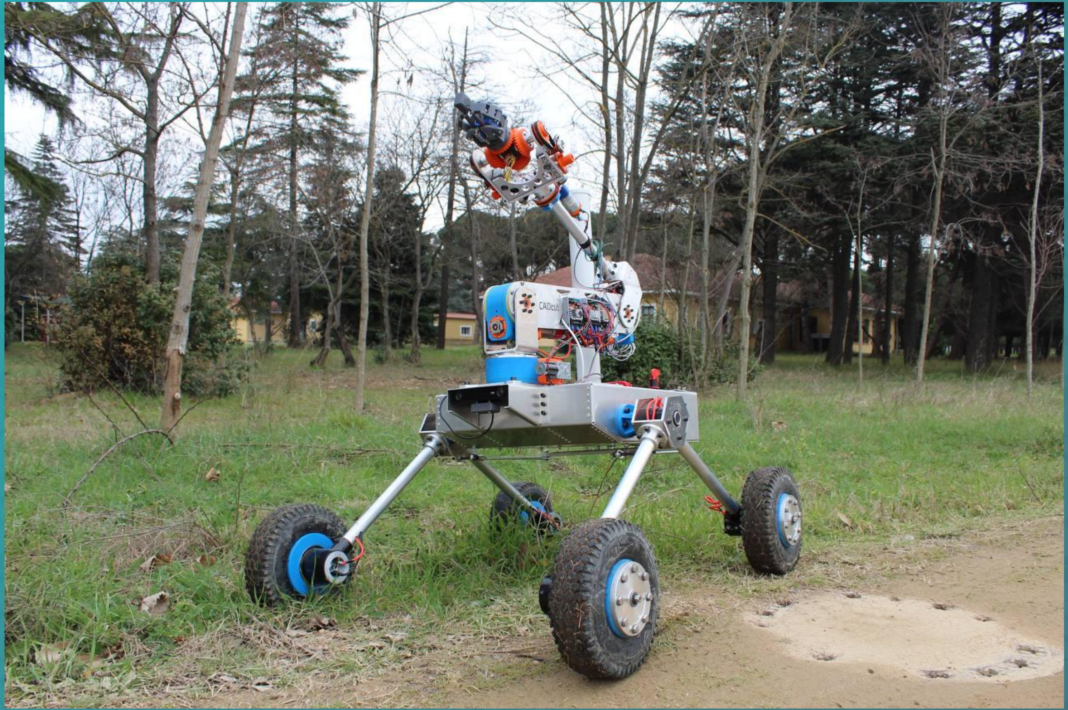
Mobility System:

The aluminium sheet metal body as an electronic box is used to house all hardware components, batteries and protect them from external factors such as dust and rain. With the use of aluminium sheet metal body design, more lightweight design is achieved. After the computer aided analyses, the thickness of the sheet metals was determined as 2mm. The dimensions of the rover are 85 cm wheelbase and 87 cm track length. Finally, the mounting parts in front of the chassis offer modular mounting for the arm and autonomy equipment. The wheel assembly consists of two main parts, the 3D printed rim (PETG) and the motor housing components. The dimensions of the wheel are 30 cm in diameter and 10 cm in width. The treads on the outside of the tires increase grip and traction. In this way, a more efficient drive will be achieved. The motors, one of the most important parts of the system, were placed in a block to protect them from external factors. Two ball bearings are placed between the motor mount and the bearing mount to take both radial and axial loads from all directions and allow the parts to rotate freely.

ROVER

ROVER DESIGN

Mobility System:

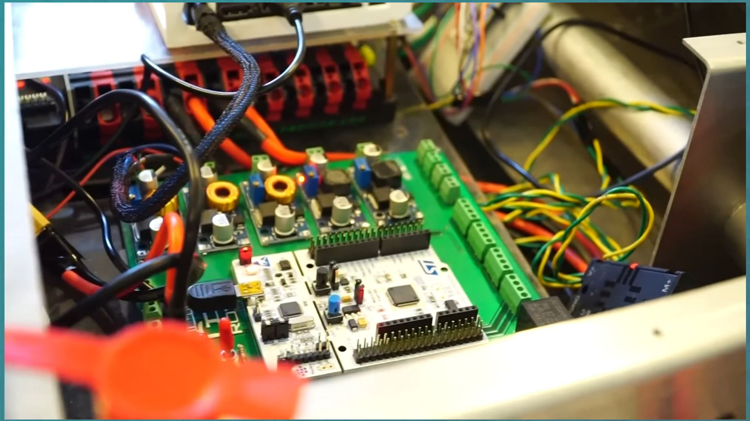


ROVER DESIGN

Electronics and power system:

Adventure system mainly consist of a super computer (Xavier), a microcontroller (STM32) , a antenna and DC motor controllers. Adventure has two different model DC motor controllers. Victor SPX motorconrollers for Drive System and Roboclaw motor controllers for robotic arm. System has an emergency button and a motor stop switch for safety. 6S and 3S Lipo Batteries used to meet the required energy. A fuse box and relays support to system.

The system was chosen for its high processing capacity and minimal response latency to data transmission. The system components work harmoniously together. Due to the number of regulators used, the system energy consumption is slightly unbalanced, which is a weakness for the system. On the other hand, the system was installed simply, avoiding complexity, so that the time for detecting an error that has occurred is minimized. This is one of the strengths of the Adventure.



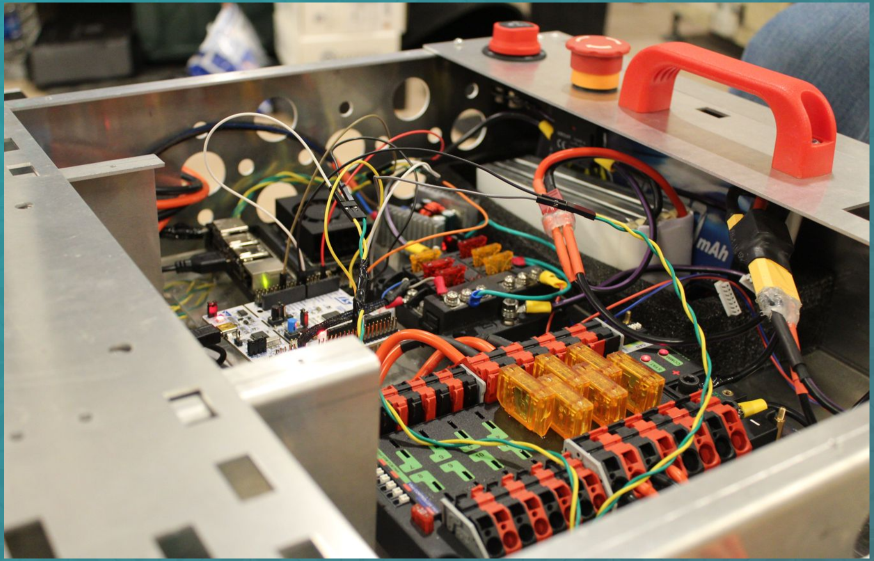
ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Electronics and power system:

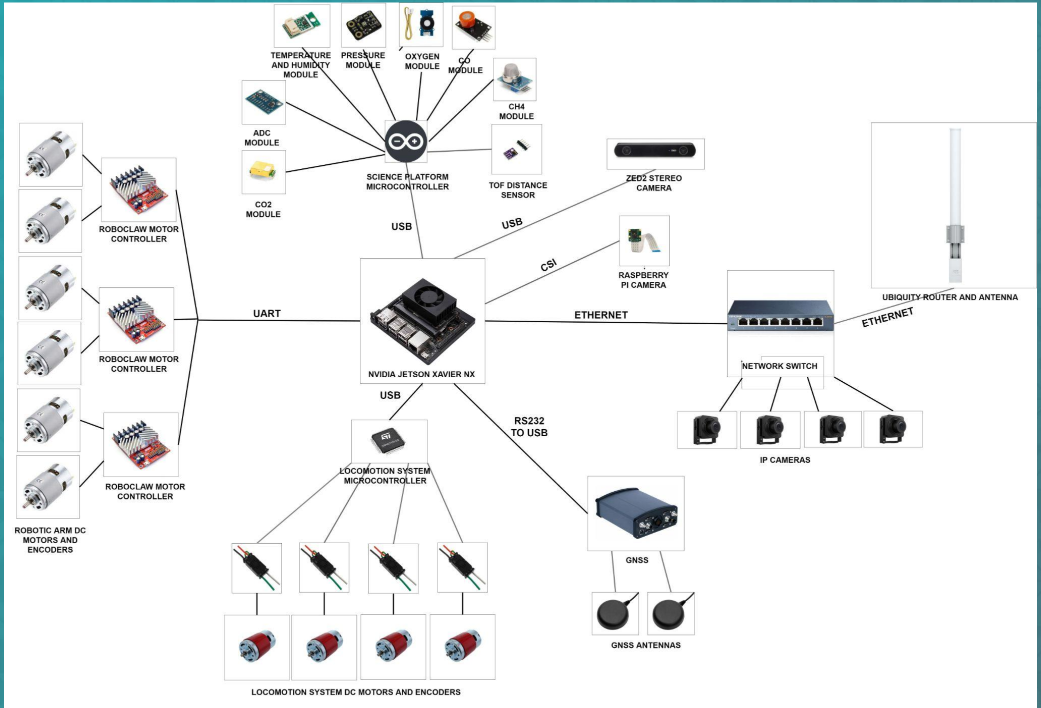
The custom brake circuit was designed for working effectively on incline terrains. A customized PCB was created by considering the requirements, so that the negativity that may occur in the wiring has been prevented. Emergency stop system has a button and a switch.The button has been used for shut it down whole system and the switch has been chosen for stop only Advanture's wheels thus accidents that may occur was prevented without shut it down whole system.



ROVER

ROVER DESIGN

Electronics and power system:



ROVER DESIGN

Electronics and power system:

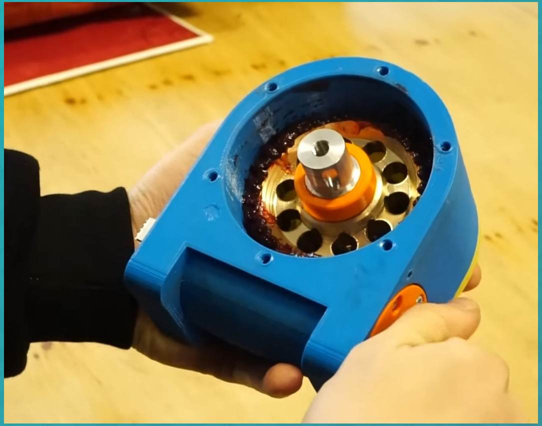
The PCB, made specifically for the Adventure, is powered by a 24V lithium polymer battery with a minimum capacity of 6.2 Ah. The supply of components is ensured by adjusting the regulators on the PCB to the appropriate voltage values. The drive system and the robotic arm are powered by a 12V lithium polymer battery with a minimum capacity of 44 Ah. The capacities of the batteries were selected taking into account mission time periods.

ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manipulation system:



The arm utilizes three nearly identical general joints to maximize ease of manufacturing and assembly. The gear mechanisms are placed in cast-amide cases in the first three axes. Worm and gear shafts are manufactured from brass alloy and aluminium. In software, robotic arm is controlled by the MoveIt framework running on the ROS.

Worm gear mechanisms was used in joints to provide the high reduction and an output torque while minimizing backlash and system mass.

The operator can display the 3D model of the arm on GUI. Thus, the operator knows the current position of all components of the arm, convenient for observing the arm while performing the autonomous tasks.

Since the position control system is a closed loop, errors are faster distinguishable in the system, it can be developed with a precision that conforms to the mechanical design. But it is more costly and more complicated, care is required to have a stable system, feedback can oscillate and reduce system gain.

ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manipulation system:

Semi-autonomous driving with preset commands allows rapid and precise task completion and makes possible to transfer the process into autonomous way. Operator has both controls of inverse and forward kinematics at their fingertips: inverse kinematics with a joystick controller and forward with configurable keys on the keyboard.

Time-parameterized joint trajectories generated on the computer are transmitted to motor drivers via custom hardware interface. The hardware interface takes the current state of the arm as input and sends the desired state as a command. In this way, problems such as mispositioning, collisions that will occur during movement can be viewed on the computer and tried to be solved.

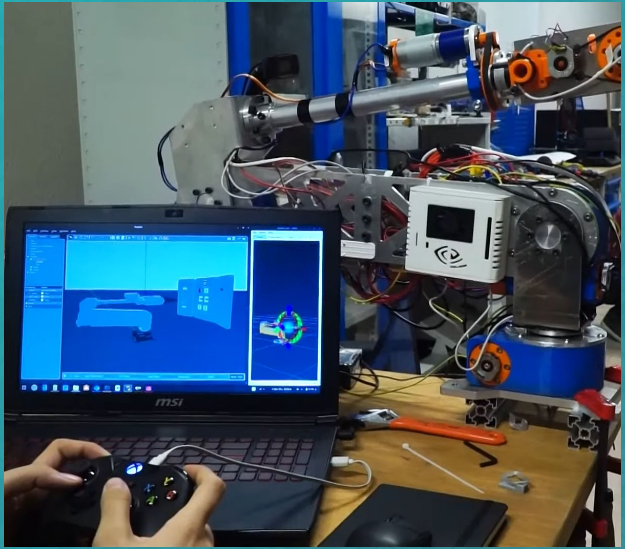
Kinematic design inspired by modern collaborative robotic arm which provides ease of kinematic calculations and high reachability.

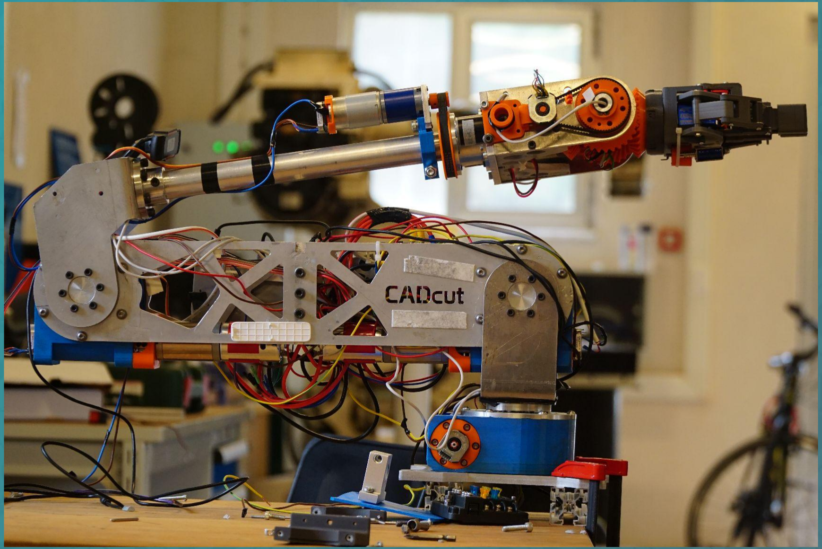
ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manipulation system:





ROVER

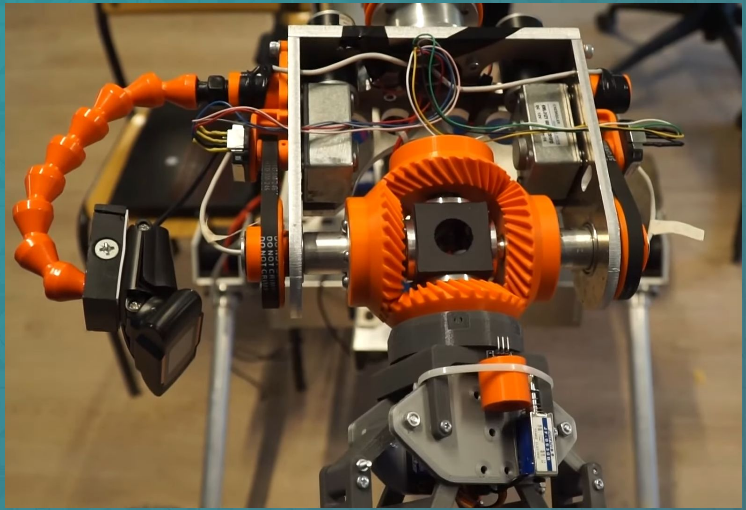
ROVER DESIGN

Manipulation system:

The arm can operate effectively in a 1.3-meter diameter area with a lifting capacity of 8 kg thanks to its multiple axes. The entire arm, including electronic parts, weighs 15 kg. To supply power to the robotic arm, a 12V lithium-polymer battery is used.

Geared DC motor worm gear systems used in the first four axes prevent backdrive and give the required torques. A belt-driven differential wrist mechanism ensures better motion in the 5th and 6th axes.

Autonomous tasks can be performed using inverse kinematics. Sleeve with spherical wrist design. It can easily turn the switches, push the buttons, insert the usb stick and operate the thermal blanket at close range.



ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Science Payload:

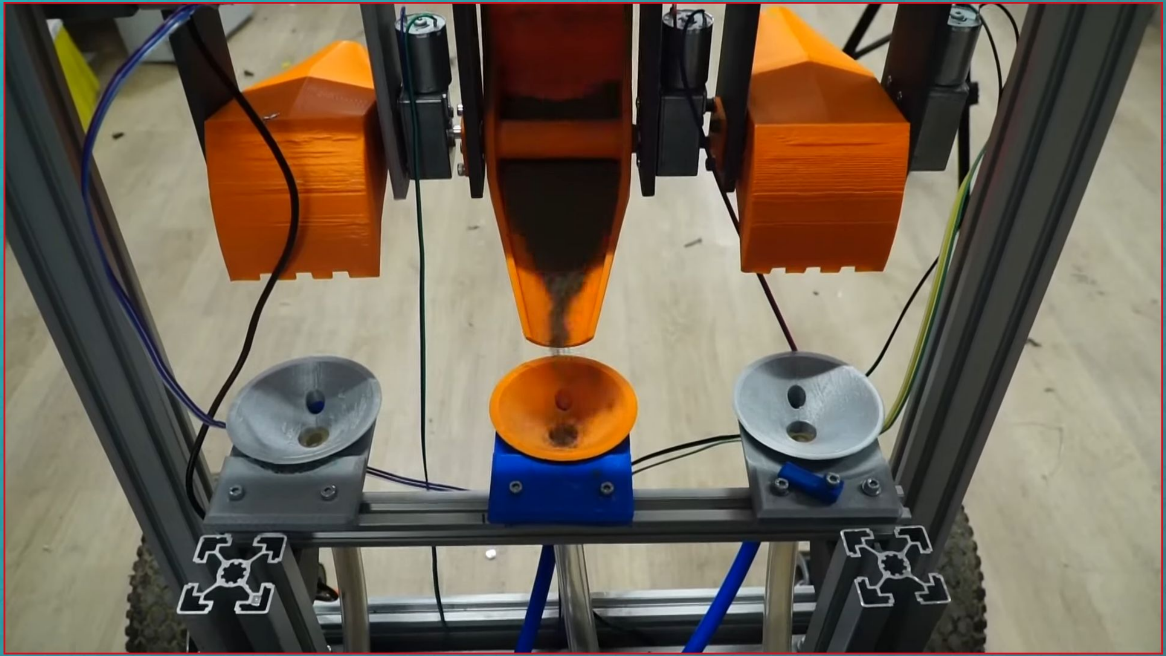
Three separate scoops are linearly actuated to collect soil samples without cross-contamination. The ball-screw mechanism is driven by a DC motor to make linear movements towards ground or plastic tubes. A camera will be mounted on the top of scoops to provide an operator view in the tasks. The 3D printed (PLA) scoops have a unique shape, with large and small cutouts that assist to take soil samples. According to the analysis, corners and edges of the design are replaced with a structure with radiuses to increase the strength and avoid cracks. After that, the collected samples are transferred through plastic pipes to the test tubes. The overall science payload's weight is 11 kg.

ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Science Payload:



ROVER

ROVER DESIGN

Communication between the rover and the base station is installed by Rocket M2 routers. The wireless system operates at a 2.4GHz band along with an Ubiquiti Omni-directional antenna on the Rover and a Ubiquiti sector antenna at the base station. Omni-directional and sector antenna combination provides high data rates and long-range communication. Two ethernet cables and one POE are used for communication between routers and devices, and a computer is sufficient to provide communication between the rover and the base station.

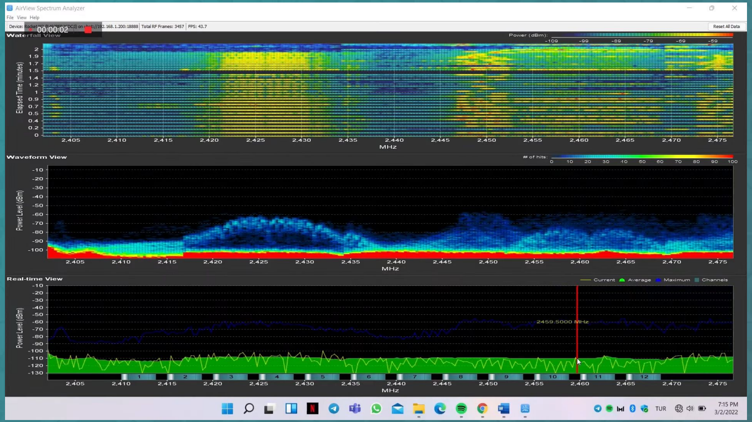
The system was chosen to provide uninterrupted display and control under the given conditions. Although the 2.4 GHz frequency band provides high data communication, the use of high frequency reduces the transmission distance. However, considering that the assigned tasks will be 40 meters in diameter, thanks to the AirMax and AirSelect features of the equipment used, the tasks can be accomplished without interruptions.

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Ground station equipment and communication system:

The hardware and software features of the equipment used allow the communication between the rover and the base to be continuously monitored and controlled. Considering the field where the competition will be held, it can be predicted that the interference will be high. In this context, with the AirSelect feature of the equipment we used, clear communication is ensured by automatically switching to the channel with the least interference. We saw that the teams that were successful in other international Rover competitions preferred such useful devices that could easily observe the signal and adjust frequency-related settings, and we were inspired by this.

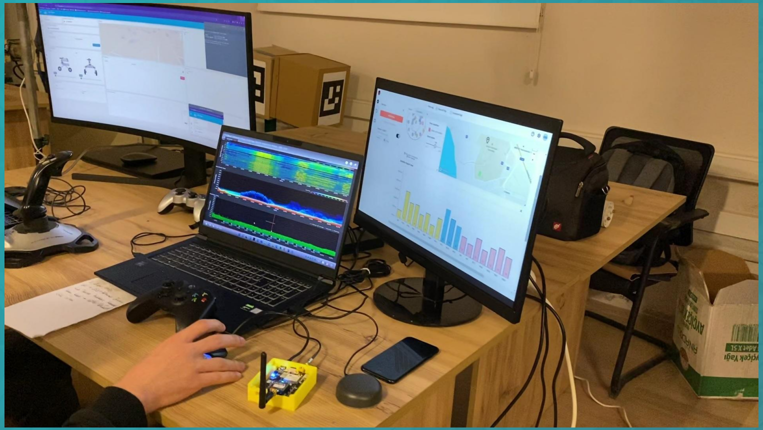


ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Ground station equipment and communication system:



ROVER

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Ground station equipment and communication system:

To avoid interference, AirMax and AirSelect features of the equipment are used for the automatic frequency hopping. The communication system's elements are chosen as competition rules and law numbered 5809 of the constitution of the Republic of Turkey. The main communication equipment is tested in line-of-sight up to about 500m.

Considering the real time multi-image transmission and uninterrupted communication for the given diameter range, the system is considered to be suitable enough. The mobility of the directional antenna on its axis at the base station can be improved and made adequate if there is no interference with the orientation of the antennas.

ROVER