ANATOLIAN ROVER CHALLENGE

2022

Design Report

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Team Name:

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

RoverOva, and the name of our rover is **K3P4**

Contact:

Contact information and social media links of the team.

Our website: http://rover.vsb.cz
Email: adam.boleslavsky@vsb.cz
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Instagram: team_roverova
Facebook: VŠB – RoverOva
Twitter: @team_roverova
YouTube:
https://www.youtube.com/channel/UCfU2Bp1K4kTPW45GMakMAjg

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Academic Institution:

- Name and address of the affiliated academic institution.

VSB - Technical University of Ostrava
17. listopadu 2172/15
708 00 Ostrava-Poruba
Czech Republic

Academic Consultant:

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

Robert Pastor, VSB - Technical University of Ostrava,
robert.pastor@vsb.cz
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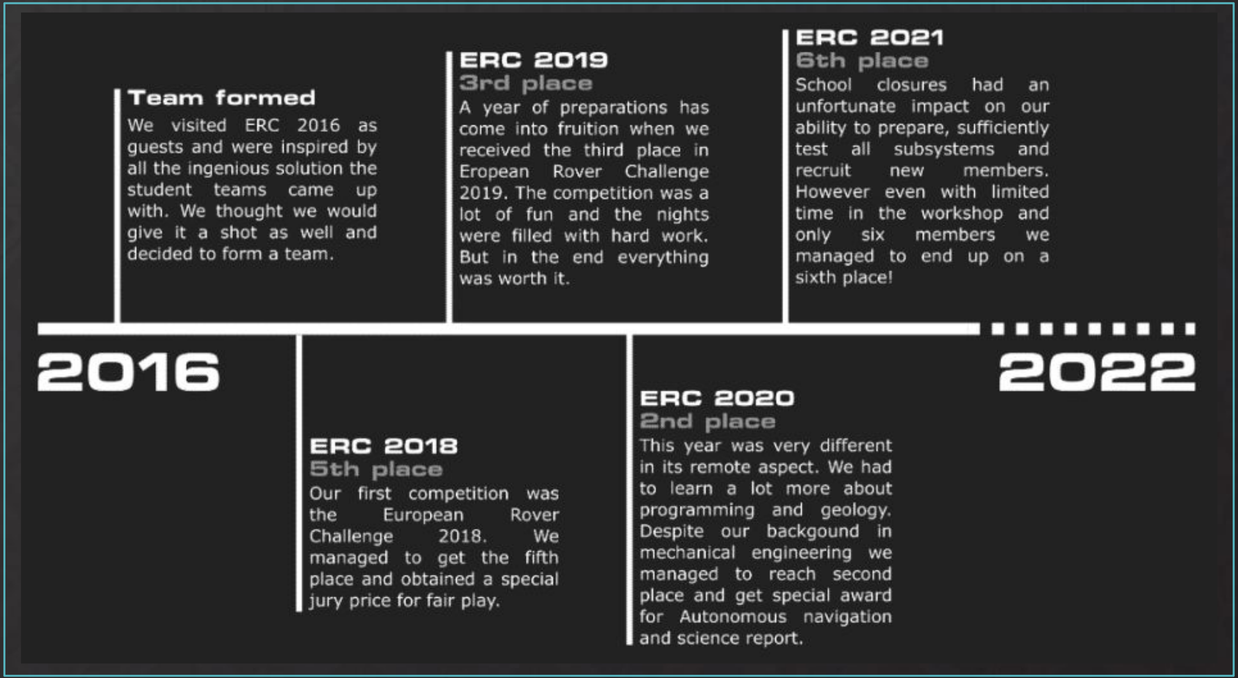
TEAM INFO

ANATOLIAN ROVER CHALLENGE

History of the Team:

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



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TEAM INFO

Active Members List:

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

Name	University Major	Duty in the team
Adam Boleslavský	Robotics	team leader, chemist, Scientific researcher, mechanical engineer
Tomáš Spurný	Robotics	system engineer, programming, autonomous driving
Jan Bém	Robotics	mechanical design, manufacturing, sample collection
Jan Maslowski	Robotics	programming, autonomous operations with arm
Tomáš Poštulka	Robotics	mechanical design, effectors designer
Petr Sehnálek	Robotics	mechanical designeer, scientific researcher
Jan Szturc	Robotics	mechanical design, calcultations
Sebastian Matuš	Robotics	photographer, public relations, programming

TEAM INFO

ANATOLIAN ROVER CHALLENGE

Team Photo

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

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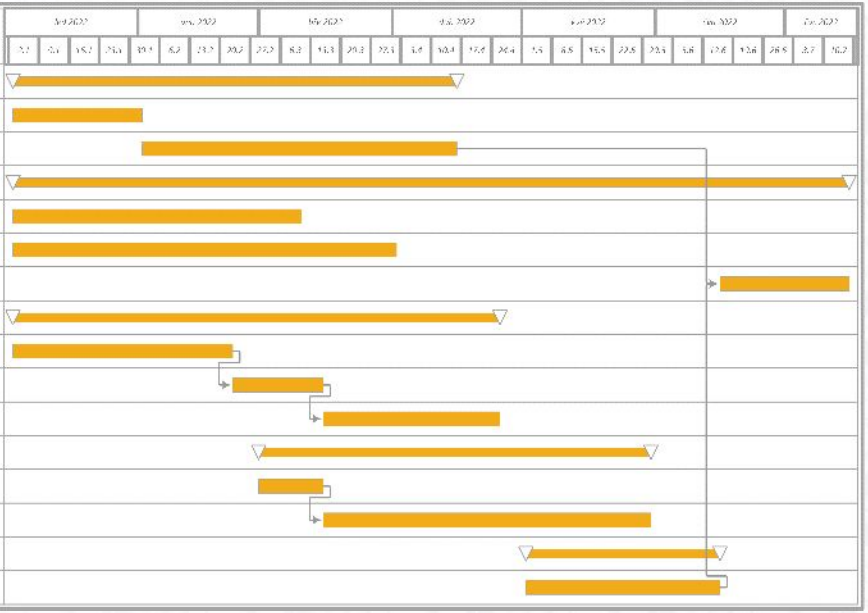
MANAGEMENT

Work Calendar:

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

ID	Task Name	Responsible person	Start	Finish	Duration
1	**Mobility subsystem**	**Jan Bém**	**03.01.2022**	**15.04.2022**	**75d**
2	Manufacture and assembly	Jan Bém	03.01.2022	01.02.2022	22d
3	Testing	Tomáš Spurný	02.02.2022	15.04.2022	53d
4	**Communication**	**Jan Maslowski**	**03.01.2022**	**15.07.2022**	**140d**
5	Wifi	Jan Maslowski	03.01.2022	10.03.2022	49d
6	RC and FPV	Tomáš Spurný	03.01.2022	01.04.2022	65d
7	Field tests with all systems	Tomáš Spurný	16.06.2022	15.07.2022	22d
8	**Manipulator**	**Adam Boleslavský**	**03.01.2022**	**25.04.2022**	**81d**
9	Assembly	Adam Boleslaavský	03.01.2022	22.02.2022	37d
10	Integration	Adam Boleslavský	23.02.2022	15.03.2022	15d
11	Testing	Tomáš Spurný	16.03.2022	25.04.2022	29d
12	**Navigation**	**Tomáš Spurný**	**01.03.2022**	**30.05.2022**	**65d**
13	GNSS based driving	Jan Maslowski	01.03.2022	15.03.2022	11d
14	Item search policy	Jan Maslowski	16.03.2022	30.05.2022	54d
15	**Control**	**Tomáš Spurný**	**02.05.2022**	**15.06.2022**	**33d**
16	Operator user interface	Tomáš Spurný	02.05.2022	15.06.2022	33d

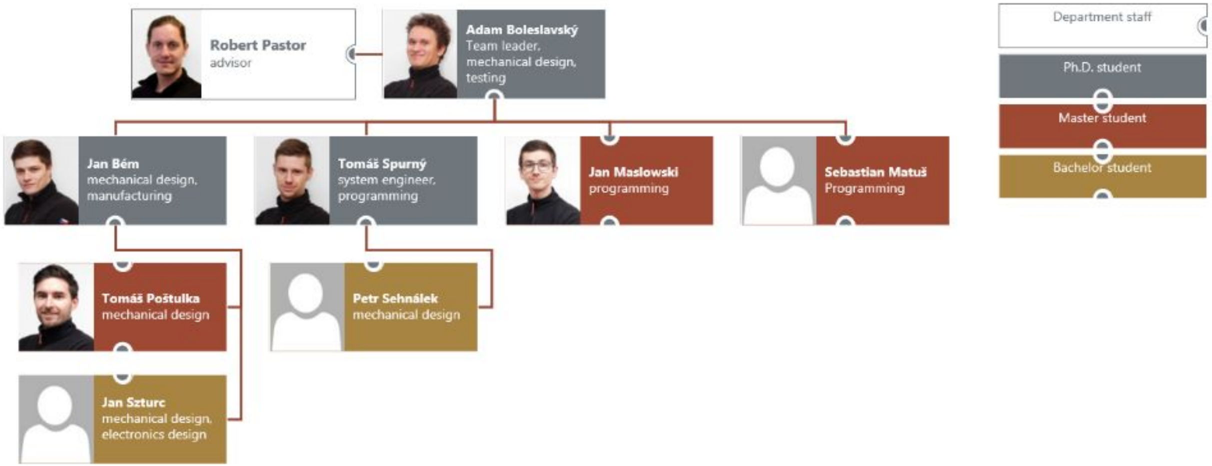


MANAGEMENT

Team Formation:

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

Our team currently consists of 8 members. We are not divided into subteams with different focus. We organize ourselves on a subsystem basis, with each team member overseeing one or more subsystem. Team structure could be approximated as a diagram below. However, we form subteams as needed.



MANAGEMENT

Workplace:

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

Our design methodology is: Keep it simple.
When designing new parts, we always ask ourselves if the part can be 3d printed. If not, we look for ways to build it with off-the-shelf components, or aluminium extrusions with minimum adjustments. And only if these methods are not available, we solve the problem with custom machined parts. This methodology is fast and efficient and allows us to do most of manufacturing in our workshop, which is equipped with only a 3d printer and a pedestal drill.

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?

We are mostly working with hardware that we have purchased in previous years. In last year we were mostly sponsored from a faculty project that provided us with 6000 USD for the rover hardware. We have also received gifts from our sponsors over the years.

The current value of our rover is about 10000 USD. The operator's equipment is valued at about 5000 USD. Between the time of this submission and the competition we are planning to spend additional 1000 USD on rover hardware.

We estimate the travel costs to be about 2000 USD.

All funding is secured.

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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)

We are considering multiple ways of transport at this moment.
We will most likely drive from Czech Republic in cars or in a rental van.
Packing the rover is simple since we just need to fit it into the trunk and secure it from movement.
The rest of our equipment will be transported in luggage and boxes alongside the rover.
We will need to make sure to have enough drivers for the trip.

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ROVER DESIGN

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)

We have a simple rocker suspension. Each rocker is manufactured from a single aluminium extrusion profile. On the rear side of the rover the rockers are connected with a linkage that rotates them in opposite directions. This helps maintain approximately equal wheel contact. Each wheel has an individual steering motor, which allow the vehicle to turn in place, or drive using several configurations.

We have experimented with different types of suspension in the past and this minimalistic design provides great rigidity. The consideration is that we think that a well executed simple design is a great advantage in an inhospitable environment over unnecessarily complex systems. Its strengths are that it is rigid simple mechanically robust and has good ground clearance. As for the weaknesses, we are now testing it on the track and so far no problems have been encountered. All the problems we had with the previous chassis have been eliminated, but we expect that there will be some before the competition and we will try to solve them.

ROVER DESIGN

Mobility System:

- Unique points and inspirations (3-5 sentences)

The wheels have been fitted with electric motors from electric bikes, which we have disassembled and modified for our own use. This gives our rover a very good drive with a small size. We think the concept with the robust rocker arms on the back of the rover is quite creative and, in our experience, reliable.
Our mobility system has a vertical rotation above each wheel, which means that we do not turn by skidding like some types of vehicles, but by rotating the wheels. Thanks to this, the mobile system can work in different modes and steer better and more precisely, such as omnidirectional mode, double Ackermann mode or sideways mode.

ROVER DESIGN

Mobility System:

- Visuals of the system (2 photos/screenshots)

ROVER DESIGN

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)

The mobility system alone weighs 35 kilos. Some of the modules are still under development, but we calculate that together they should not exceed 20 kilos, resulting in 55 kilos and meeting the minimum weight requirement. The outline dimensions of the rover do not exceed 1.2m x 1.2m x 1.2m. We have tested the rover in various terrain with obstacles, with speeds up to 2 m/s. The clearance of the mobility system is 25cm.

This subsystem is designed to transport service equipment to its destination and also serves as its base. Our system therefore fulfils all the points that we consider important for its function, namely the ability to overcome obstacles, to travel in different directions, and to be sufficiently robust and lightweight. For control, it is equipped with sensors and camera systems that allow us to visualize all obstacles and robot states. For navigation, it again uses cameras to orient itself for its autonomous driving.

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 rover is powered by two Li-Po batteries, each powering a separate circuit: motor power and logic power. The motor power circuit runs on 24 V and powers only motors. The logic power circuit runs on 15V and power everything else: computer, microcontrollers, communication, cameras etc.
Each circuit uses custom PCBs with integrated relay and is monitored by a volt/ampere meter with a display.
We have chosen to separate the circuits in order to be able to stop all motors without cutting power from the logic components. This makes prototyping easier, since we do not have to restart the computer and reestablish Wi-Fi connections after motor stop.

ROVER DESIGN

Electronics and power system:

- Unique points and inspirations (3-5 sentences)

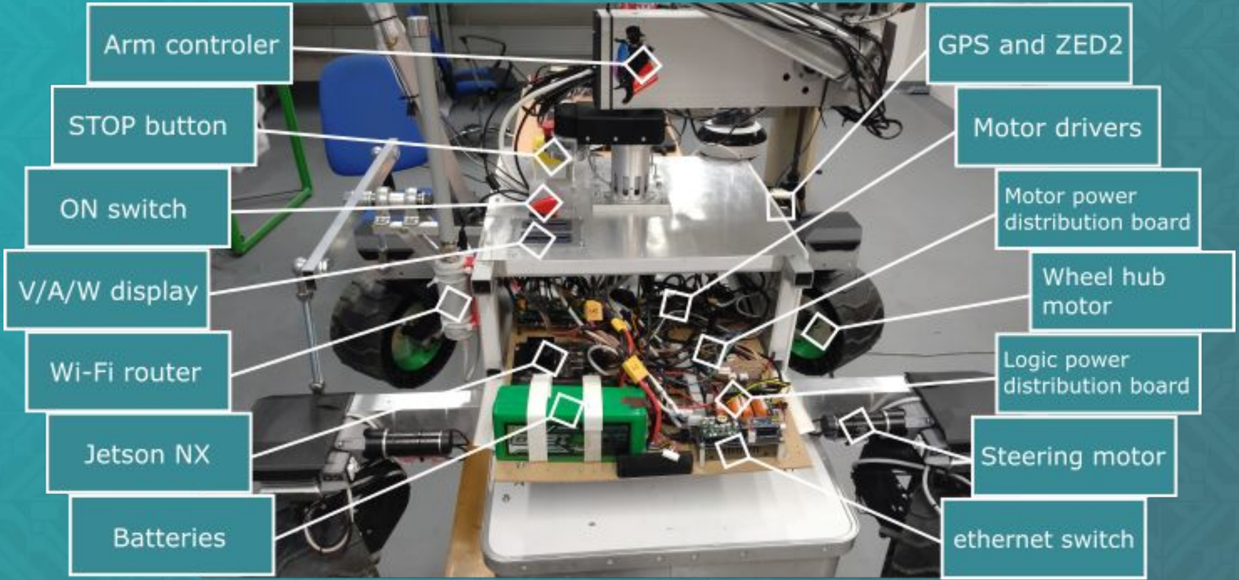
The inspiration to make the system centered around one computer comes from experience. In the past we have had multiple computers in the rover all connected to one network. This worked well, however, startup was longer, and networking was more complicated.

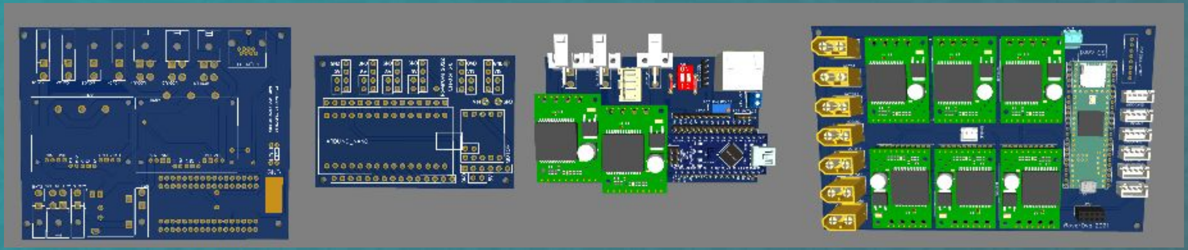
We have chosen to put only one computer inside the rover this time and base everything else on microcontrollers Arduino or Teensy. This way the startup is much faster.

ROVER DESIGN

Electronics and power system:

- Visuals of the system (2 photos/screenshots)





ROVER DESIGN

Electronics and power system:

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

	Motor circuit	Logic circuit
Voltage	24 V (22.2 V nominal)	15 V (14.8 V nominal)
Capacity	12000 mAh	5000 mAh
Technology	6S Li-Po	4S Li-Po
Weight	1680 g	490 g
Operating time	60 – 300 min (heavily dependent on motor use)	120 min

Mission 1 with its 80-minute duration is the longest mission in the competition. Out rover can function for up to 120 minutes, depending on the motor usage. Therefore, the power capacity is adequate for ARC missions.

ROVER DESIGN

Manupulation 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 five degrees of freedom. It is driven by DC motors with planetary gearboxes and spur gearboxes. It has a flange at the end of the fifth axis to which the end-effector is mounted. We use a custom control console that we developed to control the arm. On this console you can switch between different control modes or control the arm and end-effector using buttons.

We chose a five-axis angular robot for its versatility of range and motion ranges. The arm was designed to meet the requirements defined by the challenge tasks. For verification, we built a test panel on which we tested the necessary functions. The newly developed end-effector is not yet sufficiently tested, so we expect that there may be a problem in its mechanism. The robot has a large payload capacity and is very stiff and light.

ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manupulation system:

- Unique points and inspirations (3-5 sentences)

The end-effector for handling is equipped with its own control electronics. This is because we have several types of effectors and there are different control and code settings for each, so having each carry its own control electronics ensures a safe and functional modularity of the end-effector system.
The arm can be controlled in different states such as manual (master-slave), autonomous motion or by inverse kinematics.
We are really interested and passionate about autonomous arm control, so we pay a lot of attention to this. During the competition we would like to do most things with the arm in autonomous mode.

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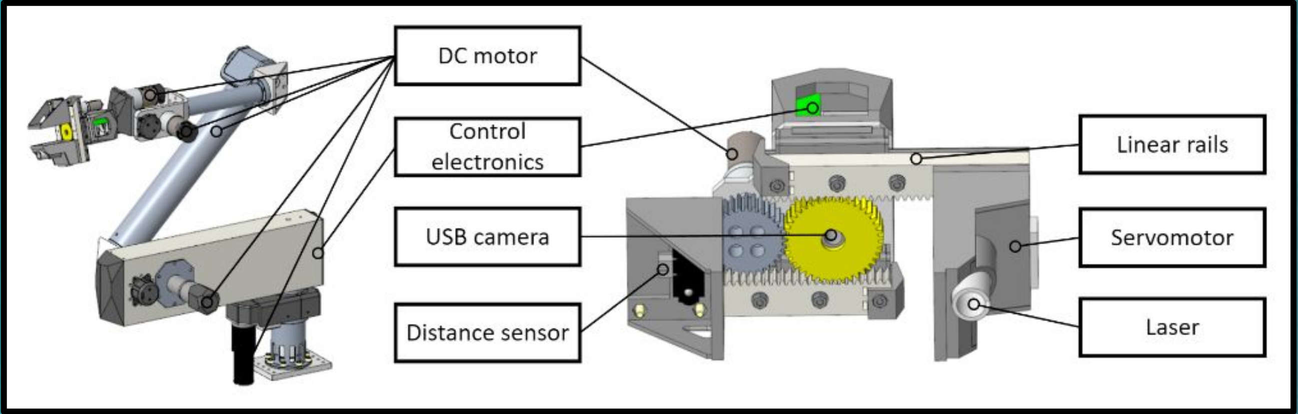
ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Manupulation system:

- Visuals of the system (2 photos/screenshots)



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ROVER DESIGN

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 reach of the arm is 1200 mm and it can reach the ground on three sides of the rover (front, left and right). The joints of the arm use AS5600 absolute magnetic potentiometers, which are located in each joint and provide rotational feedback. The arm is controlled by a Teensy 4.1. microcontroller and Pololu VNH5019 drivers, mounted on a custom PCB located inside the arm itself. The weight of the manipulator is around 9 kilograms and its maximum load capacity is around 5 kilograms.

As far as the manipulator is concerned, its ranges are designed to do all the work that will be prepared for it, from covering the astronaut with a blanket, to pulling the trolley, to working on the panel. The effective force of the end-effector has been determined for its worst-case scenario of being able to hold 5 kilograms. The end-effector is currently being tested but the currently designed design is expected to succeed in all tests and will not have to undergo any major changes. Control console is key to controlling the arm and we have taken great care in developing it. Preparations and tests for autonomous robot control are already underway and we would like to fine-tune it and use it as much as possible.

ROVER DESIGN

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)

Science modul is a fixed module with four separately detachable containers. The containers are always closed and open automatically only for a short moment to allow pouring of the soil sample, then it closes again and keeps the sample from contamination. The sample containers feature sensors to measure weight, temperature, humidity, color and gas emissions. The chassis and arm are equipped with camera systems to capture the images that need to be collected during sampling. Next, we already have the chemical procedures in order to test the samples inside the hub.

The system was chosen for its ease of handling and opening for emptying. Our idea is that a robot with a special effector will pick up a sample of soil from a depth of at least five centimeters and transfer this sample to the containers. Then it will go more than half a meter further and pick up another sample of soil, and we plan to do this up to four times. The advantage is the easy maneuverability, interchangeability and modularity of the whole system and electronics. The disadvantage is when collecting the second and subsequent samples, the effector will be dirty from collecting the previous sample.

ROVER DESIGN

Science Payload:

- Unique points and inspirations (3-5 sentences)

We plan to collect more than one sample. The entire sampling should be done autonomously from the moment we arrive at the sampling place. Sensors are placed directly in the container to test the sample for weight, moisture, colour, gas emission and temperature.

ROVER DESIGN

Science Payload:

- Visuals of the system (2 photo/screenshots)

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 system contains a lot of electronics thanks to the sensors. However, these electronics are not overly power consuming and therefore there should be no problems with battery drain when the battery is fully charged. The system is currently still being manufactured and modified but the final weight should be under four kilos due to most of the parts being made from 3D printed plastic.

The system is designed to pick up a sample in a short time interval and move to the next position where it picks up the sample again. Thanks to the sensors, it can measure important parameters (mentioned earlier) of the sample before delivery to the hub. The camera system is more than capable of performing the photo-documentation part of the task.

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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 subsystem uses three radio bands: 5 GHz Wi-Fi, 868 MHz RC link, and a 5.8 GHz analog video broadcast. The Wi-Fi allows multiple operators to access rover functions, every system can be controlled through Wi-Fi alone and images from IP and USB cameras can be viewed.
We did have some issues in the past with the Wi-Fi connection, however. That is why we have decided to add a redundant communication for the driving and visual feedback. We have done this by adding a RC receiver module to the undercarriage. The RC receiver has a priority in the driving program, if no RC signal is detected, the system automatically switches and listens to the Wi-Fi drive commands. To get the most real-time video we have added three analog FPV cameras, analog video signal switch, and a 5.8 GHz transmitter. Therefore, we can drive the rover and see real-time video even if Wi-Fi is not available.

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ROVER DESIGN

ANATOLIAN ROVER CHALLENGE

Ground station equipment and communication system:

- Unique points and inspirations (3-5 sentences)

We believe our communication system is unique in its redundancy (Control: Wi-Fi or 868 MHz RC, Video: Wi-Fi or 5.8 GHz analog transmission).

Having a reliable connection between the operator station and the rover is crucial. In our experience, even if everything works in our lab and in the field during our tests, the Wi-Fi can function very differently during the competition itself. Therefore redundant communication is important for us.

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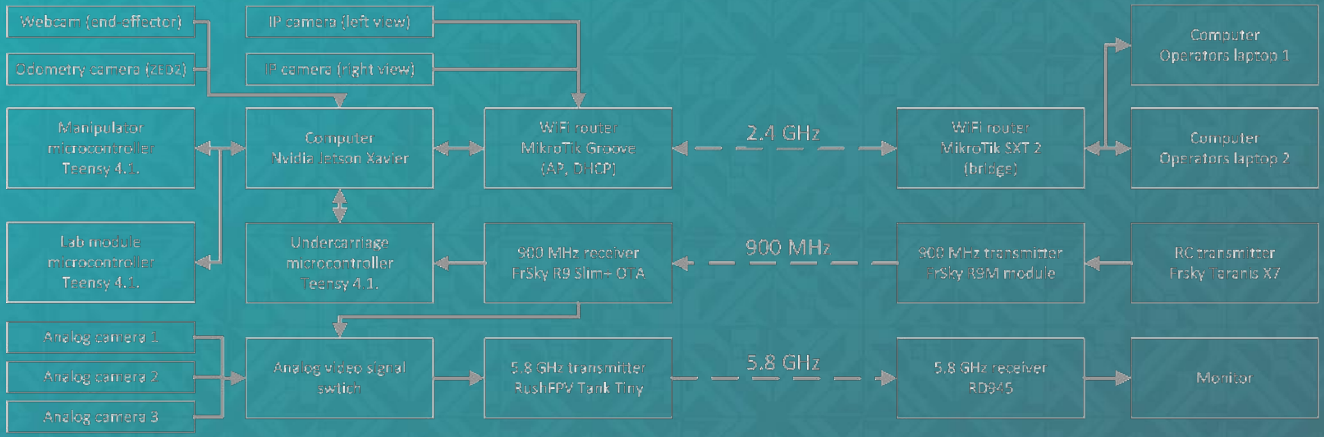
ANATOLIAN ROVER CHALLENGE

ROVER DESIGN

Ground station equipment and communication system:

- Visuals of the system (2 photos/screenshots)



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ROVER DESIGN

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)

	Wi-Fi	FPV video	Remote control
Rover hardware	MikroTik RBGrooveA-52HPn	RUSH Racing video transmitter	FrSky R9 Slim+ OTA
Operators' hardware	Mikrotik RBSXTG-2HnD	RD945	FrSky R9M 2019
Frequency	5 GHz	5.8 GHz	868 MHz
Range	600 m	800 m	10 km

The system provides sufficient range, data throughput and redundancy for all ARC missions. The operators will have 15-meter cables to connect their equipment to the antennas.
We will train for emergencies where one of the communication interfaces fail, in order to be prepared for field conditions.