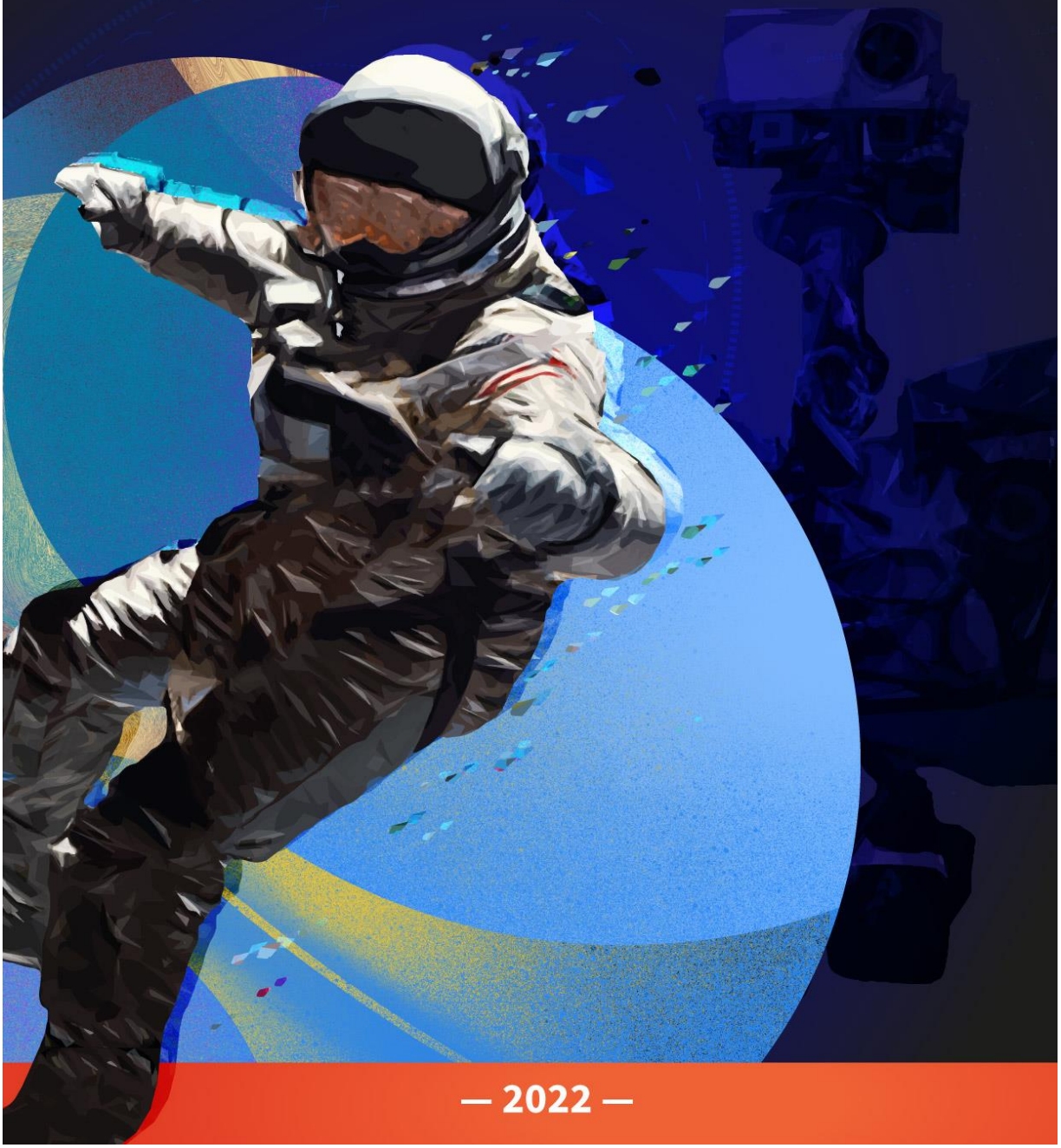
Rules

on-site

ERC
EUROPEAN ROVER CHALLENGE



— 2022 —

Change Record

Revision	Date	Section	Description
1	05.02.2022	All	Public document version – initial issue.
1.1	06.02.2022	Science Task Time Available for the Tasks	The remaining references to mega task from ERC edition 2021 were removed. There is no mega task in ERC 2022 edition.

Contents

General Information

What is the ERC?

The European Rover Challenge (ERC) is an integrated programme working towards technological developments, specifically those in GPS-denied environments, with space exploration and utilisation as the leading theme. The ultimate goal of the ERC is to become a standardised test trial and benchmark for planetary robotic activities, coupled with strong professional career development platform.

The European Rover Challenge is owned and coordinated by the European Space Foundation, organised in cooperation with a group of independent experts who make up the steering and jury boards. Mars Society Poland is partner of the programme.

What is ERC-Student?

One of the main components of the ERC is the ERC-Student track (hereafter referred to as the ERC or ERC2022). ERC-Student consists of an engineering project where university teams build robots to compete on an extra-terrestrial inspired arena performing tasks based on international roadmaps for space robotics. This means that the competition tasks present the same level of problems as industry drivers for space robotics which have been devised for future decades. Perhaps most importantly, whilst set against the background of a competition, ERC-Student is a continuous mentoring effort which is intended to educate the next generation of multidisciplinary engineers, boost innovation in research and business, and popularise STEM (Science, Technology, Engineering and Mathematics) advancements, all conceptually rooted in future space exploration.

Two Parallel Formulas of ERC-Student

ERC has been organised as on-site competition since its beginning. Starting in 2020 a completely new formula of competitions (i.e. remote) was introduced as a result of COVID-19 spread. Based on the feedback collected during the 2020 and 2021 editions, the Organiser has decided that ERC-Student 2022 edition will be organised in both formulas (i.e. on-site and remote).

The following rules are applicable to teams:

- It is possible for each Team to decide on the formula they would like to compete.
- Qualification may be granted to either on-site or remote or both formulas based on the quality of the provided deliverables (different in case of on-site and remote formulas)
- It is possible to take part in both formulas, however the Organiser would like to highlight that planning has to be thoroughly considered by the teams. It is recommended that different sub-teams would be responsible for each formula. Organiser will make every effort to grant the non-colliding slots on Mars Yard for the two formulas, however teams have to consider also the scenario when the same time slot has been assigned in case of both formulas (especially considering that number of tasks in the on-site formula increases in the ERC 2022)
- Teams who participate in both formulas have to provide together with a registration form a short planning description explaining how do they intend to approach such complex projects at the same time

Schedule and Venue

ERC is a venue independent, year-round programme. For information about the ERC2022 edition venue, please follow our updates on the challenge website (see *Information channels and contacts*). The official schedule (applicable for both on-site and remote formulas) can be found in the *APPENDIX 1 - Schedule*.

Information Channels and Contacts

The Challenge's website address: www.roverchallenge.eu

Teams Contact Point's email address: teams@roverchallenge.eu

The official communication channel for challenge announcements is the list of email addresses provided by Teams during registration process. In addition, Mattermost tool will be used to assure the daily-based contact with the Teams participating in ERC. All Team Members will be duly invited by the Organiser to register on the ERC Mattermost group.

Teams

Qualification

The ERC programme is planned for a limited number of teams. **At the moment up to 15 teams per formula are considered by the Organiser, however this number may be changed until announcement of the final qualification lists**. Together with the Jury, the Organiser will choose which of the registered Teams will be invited to compete in the challenge. The choice will be made based on the delivered documentation (described in the *Documentation* section), which teams are required to send to the Organiser by the deadline given in the schedule. The Organiser will announce qualifying Teams before another deadline given in the schedule.

Team Members

75% of a Team must be comprised of higher education students and recent graduates (i.e. max two years after receiving masters or PhD degree): undergraduate and masters-degree level students (with no limitations) and PhD students. It is highly recommended that Teams cooperate with specialists from different institutions but students must prepare and sign all of the required documentation themselves.

A Team may consist of students from more than one higher education institution. An institution may also be affiliated with more than one Team. Team membership is exclusive – each person can only be a member of one team.

In case the abovementioned requirement is not fulfilled, please contact the Organiser in order to confirm if your Team can register for the competition.

Challenge Milestones

Here's a list and rules of each milestone the Teams will approach during the ERC on-site edition preparation and performance. The milestones schedule is attached as an *Appendix 1* to this document.

1. Registration (incl. Proposal)
2. *Update Report #1* (update of the Rules including Scoring, remaining documents templates)
3. Preliminary Report (from Teams)
4. *Update Report #2* (clarifications from the Organiser, Navigation and Probing Plan Template)
5. Final Report (from Teams)
6. Video Material (from Teams)
7. *Update Report #3 / Environmental Report* (data required for the final competition - environmental update from organizers)
8. Science Planning Report (to be delivered by Teams 1.5 week before the ERC finals)
9. European Rover Challenge 2022 (finals)

Update Reports will be published by the Organiser. Those milestones do not need any deliverables from the Teams but are intended to clarify requirements and provide additional information to the Teams in order to proceed with and finalise the rover's design.

The milestone will be delivered in a form of report sent to the Teams contact point's email address.

The Update Report #3 delivered to the Teams will contain e.g.

1. Drone photos and a digital elevation model of the ERC2022 Mars Yard
2. For Science Task: An approximate location of the Mars Yard on the surface of the Red Planet
3. Starting points' positions for the tasks

Registration

For registration dates, please refer to the challenge schedule above. Registration details shall be sent to the organiser (to email: teams@roverchallenge.eu) in English, via the Team's contact point email address (see *Information channels and contacts*). In cases where this information is not submitted prior to the specified deadline, the team will not be allowed to participate in the challenge.

The Team **registration shall be done by filling and sending the form provided by the Organiser (link: https://forms.gle/x2y9ikvHPDqgZeFT6**). It shall include e.g.:

a) The name of the higher education institution with which the team is affiliated (if the team is affiliated with more than one institution, please list all the names, in descending order of involvement)
b) Team name
c) Rover name (may be the same as the team's name)
d) Project proposal (see the *Documentation* section)
e) Short planning description (in case the Team takes part in both *on-site* and *remote* formulas)
f) The approximate number of team members who plan on coming to the challenge (i.e. appear on site)
g) Team contact point: the contact's name and surname, telephone number and email address **(remember that this email address will be used as the main contact. No information from the organisers will be delivered to any other address – please refer to the "Comments on the contact point")**.
h) University team coordinator/supervisor and key members: name and surname, telephone number and email address
i) Project website address or/and Facebook fan-page
j) The following declaration in English:

'By sending this application and registering the team to the European Rover Challenge each team member fully accepts all terms and provisions of the ERC rules and all final decisions of the European Rover Challenge organiser.'

k) To register the Team to participate in the competition, complete the application form below, sign GDPR form (print and scan separate for each Team Member) and attach it in the registration form

In case of any issues with attaching the requested files in the registration form, please send these to the following address: teams@roverchallenge.eu. Use your contact point's email address (see General Comments below) and confirm with us that we have received your registration.

General comments on the CONTACT POINT:

- All teams are requested to create alias address teamname@xx.yy (where xx and yy are not defined and can be selected by the teams).
- It is advised that the mentioned alias shall resend all the received messages to all members of the team in order to minimise chance to omit any of the information received from the organiser.
- It has to be highlighted that messages from the organiser will be send only to the defined contact point's email address (teamname@xx.yy, see above). The organiser is responsible only for sending all the details to the contact point's email address. Teams are responsible to check the provided contact point's emails on a regular basis in order not to miss any important communication from the organiser.
- No response will be provided to the email addresses other than the contact point. These emails will be considered as spam.
- Mattermost is not considered as official contact point! The organiser will try to respond to all messages posted on the Mattermost, however short time of response cannot be guaranteed in this case. The primary contact will be Q&A sessions. Those will be held as planned in the Schedule (see Appendix 1) and 2 weeks after every update of the Rules.

Rover System Requirements

Each rover must be compliant with the requirements listed below in order to take part in the challenge. Special cases of non-compliance should be discussed with the Organiser as soon as possible in the development process. The Organiser has the right to exclude the Team from field trials, especially when non-compliances are reported too late (e.g. during the finals). It is highly recommended that Teams present their status of compliance with the specified requirements in a transparent way in their technical reports.

General Requirements

The rover has to be a standalone, mobile platform. No cables or tethers are allowed for connection to external data links or power sources during its operation.

Teams shall design and build their own rover, however COTS (Commercial-Off-The-Shelf) components are allowed and recommended. A COTS rover platform would be considered but all such applications will be discussed separately to ensure that competition abides by the standards of fair play.

System Weight

The suggested rover weight, including payload, is 50kg. The limitation applies to every task (i.e. task-relevant rover configuration) separately. Equipment used for rover maintenance and preparation, unused spare parts, and elements not mounted during a particular task are not included in this limit.

There is no weight limit on equipment used to steer and control the rover from the rover control area, communications equipment in that area or maintenance equipment.

Rovers which are lighter than the limit will be rewarded, while those which are heavier will be penalised by a number of points defined in the scoring rules (see Appendix 2 to this document).

Rover Control and Operations

The maximum speed of the rover cannot be greater than 1 m/s.

The Team should be able to control the rover via a radio link in real-time. Each task will require the rover to travel a certain distance, but never more than 100m from the starting point. The starting point will not be further than 50 meters from the antenna mast. All communication equipment, including antennas, should be deployed in the vicinity of the control station. Teams should be prepared to place their antenna mast at a maximum of 20m from the control station location.

The rover should be built to handle challenging terrain, appropriate dust and general weather conditions described in the *Field Trials* section. The operational temperature range should be between +10 and +30 °C and should be able to handle up to moderate amounts of rain.

Rover Autonomy

Rover autonomy or capabilities of automation of particular tasks or its elements are highly rewarded and can provide a major advantage in scoring for all the tasks.

In automated control, states and commands defined below should be differentiated:

- *'IDLE'* state - initial state, motors deactivated, the rover awaits a command
- *'START'* command - the command to be sent at the beginning of the task attempt
- *'WORKING'* state - nominal work during an attempt
- *'WAIT'* command - the team can use this command to enter the *'WAITING'* state at any time for sensor readings stabilisation purposes
- *'WAITING'* state - the rover should wait stationary for a 'resume' command. This state should be automatically entered if the rover reaches a task check-point. The system should be prepared to compensate or allow for the fact that sensors may be obstructed by the judge or team members who are present in the rover's vicinity (e.g. checking the distance to the check-point). Operator cannot influence the system during this state and reaching this state does not stop the task time;
- *'RESUME'* command - a transition from the *'WAITING'* to a *'WORKING'* state;
- *'ABORT'* command - leading to autonomy abort and the rover coming to an immediate stop. The rover then transits to *'IDLE'* (not to be confused with Emergency Stop) - at this point control can be switched to manual.

The above list is not closed. Teams can define additional states and commands.

In order to score points for autonomy or single task automation, the Team Members cannot touch the controls once the attempt begins. The only exception is to send the commands listed above. If Team Members touch the controls, then the autonomy points for that attempt will not be awarded. However, the Team may switch to manual controls to complete the task by tele-operating their rover at any point. Telemetry of the rover should be monitored during autonomous operations and recorded. It is highly recommended (but not required) that these recordings should be archived and shared in open access after the event.

In autonomy mode, extra safety precautions should be taken. Minimum requirements are specified in the *Rover Safety* section of this document.

Rover Safety

Elements listed in this section are mandatory for all Teams and compliance with them should be clearly presented in both the technical documentation and during checks before task attempts. This compliance will be strictly checked and failure to ensure it may result in the disqualification of the Team from the entire challenge.

Emergency Stop

The rover shall be equipped with an easily accessible red emergency stop button. It must be part of a highly reliable circuit designed to isolate the batteries from the system by a single button hit and until reset a procedure is executed. Only laptops with their own batteries can remain powered on. Therefore, an unmodified, industrial, commercial-off-the-shelf, emergency stop button and other parts of the safety circuit are required. If any unsafe event occurs, judges must be able to access this button and deactivate the rover without any additional actions being necessary. The operation must be possible by means of an open hand hit. The button

mounting should be capable of withstanding a hard hit and should be attached to a stiff element of the rover's body.

Even if the RF certified EM button is in use, at least one physical emergency button must be placed in the easily accessible place of the rover's body.

Activity Indicator

Rover shall be equipped with an indicator lamp. It shall be active whenever the rover is ready to perform an action (e.g. drive or operate a manipulator) at least 5 seconds before the action is executed. During this time the rover should be completely still and safe. The indicator should be clearly visible from at least 10m attracting the attention of people in the vicinity by blinking or flashing. The suggested colours are: yellow, orange or red. It is highly recommended to use a standardised industrial device.

Autonomous Functionality

Any autonomous operation shall start with a delay of at least 5 seconds after issuing the command.

By all means, Teams should avoid situations when an immediate or rapid movement is executed after activation of the system or issuing the command. An overflow of any communication/interface buffers or broadcast of multiple commands to the rover or its subsystems when it should stay still or deactivated should be prevented by means of the design.

Communication Requirements

General

Radio communication with the rover has to be designed for use of legally available frequencies and power levels. It is expected that the maximum distance between the rover and the antenna mast would be less than 100m. It has to be highlighted that direct line-of-sight between the control base and rover antennas may be occluded by different forms of terrain morphology.

Accepted Frequencies

Radio Amateur Bands

Accepted bands up to 1W signal transmitted and up 10W EIRP.

- 144 - 146 MHz
- 430 - 440 MHz
- 1240 - 1300 MHz
- 5650 - 5850 MHz

It is highly recommended that each Team should have at least one member with an amateur radio license (CEPT class T/R 61-01). When using amateur radio bands, Team should provide a scan of the license of at least one member.

2.4 GHz Band (2412 - 2472 MHz)

Only Wi-Fi communication standard is accepted (IEEE 802.11). Any other systems such as analog video cameras or RC controllers are forbidden.

- Accepted channels: 1-13 (2412MHz – 2472MHz)
- Up to 100mW EIRP
- Accepted standards: IEEE 802.11 b/g/n
- Rover can use only one 20MHz channel

SSID should be set to “ERC_teamname”.

5 GHz Low Band (5150 - 5725 MHz)

Inside the band between 5150 and 5725MHz Team can use one 80MHz channel for Wireless Access Systems: Wi-Fi and AirMax only. Up to 1W EIRP power is permitted.

SSID should be set to “ERC_teamname”.

5 GHz High Band (5725 - 5875 MHz)

Inside the band between 5725 and 5875 MHz team can use one 30 MHz channel for any communication system - FPV etc.

ISM bands

It is possible to use ISM bands within their limitations but Team must designate which rule is in compliance with European regulations (https://cept.org/files/4940/TCAM%20Subclasses%20(17)08%20rev%202%20-%20RED%20Subclasses%20of%20Class%201%20Valid%20as%20of%201%20January%202018.pdf).

The ERC does not accept ISM bands which are not accepted in Europe (e.g. 915 MHz).

Voice communication using a 500 mW PMR licensed transceiver is allowed on following channel frequencies (MHz):

- 446,00625
- 446,01875
- 446,03125
- 446,04375
- 446,05625
- 446,06875
- 446,08125 - *reserved for the Organiser*
- 446,09375 - *reserved for the Organiser*

Other Frequencies

Other frequencies are only allowed when a relevant license, valid in the territory of the venue, is presented by the Team. Those communication channels must be described in the documentation and agreed with the Organiser.

Other Communication Rules

Channels on different bands will be assigned to the Teams on the warm-up day of the competition.

Before the competition, rovers and ground stations must be checked and accepted by the radio communication judge during an EMC (electromagnetic compatibility) test, ensuring that proper channels and power limits have been set.

During the competition, rovers and ground stations will be randomly EMC tested. Unauthorized changes to the RF configuration may result in immediate disqualification.

The use of any communication channels for testing (at any time outside of the duration of the competition attempt) must be consulted with the RF judge. Testing that can be conducted without RF communication is preferred. The organiser will provide rules for the usage of RF links for the main parts of the challenge venue. Requests to limit the usage of RF links can be expected and should be respected throughout the entire duration of the event.

For the whole duration of the challenge, the Team is responsible for the legal use of the frequencies used in the venue’s territory. The Organiser can only help with frequency coordination and does not take responsibility for any license violations, such as exceeding RF power, frequency band or area of use.

It has to be highlighted that Organiser is not responsible for any communication issues encountered by the Teams. It has to be highlighted that nevertheless the Organiser will make all the reasonable steps to assign different channels for competing Teams as well as assure that other equipment does not use the same ranges of frequencies, there may be some external interferences as multiple teams can be driving in the Mars Yard or WiFi access will be provided.

Radio Frequency Form

Each Team must fill in a Radio Frequency Form for every RF module used. It should be included in the relevant technical reports as an Appendix (see documentation specification). If these documents are not submitted in the requested form, the Team will not be allowed to participate in the challenge.

The RF Form shall contain:

a) Team name
b) Country
c) Name of the person responsible for the communication system
d) Contact to the person responsible for the communication system (email address)
e) Photo of the rover
f) Photo of the ground station
g) Number of different communication systems
h) System information (this part should be completed for every RF system):
    - RF system name
    - Short description
    - Models of the used transceivers
    - Access point software version
    - Frequency
    - Bandwidth
    - RF power (output power + EIRP)
    - Modulation
    - Antennas on the rover and ground station - models, radiation patterns (see Fig. 1 for an example), pictures

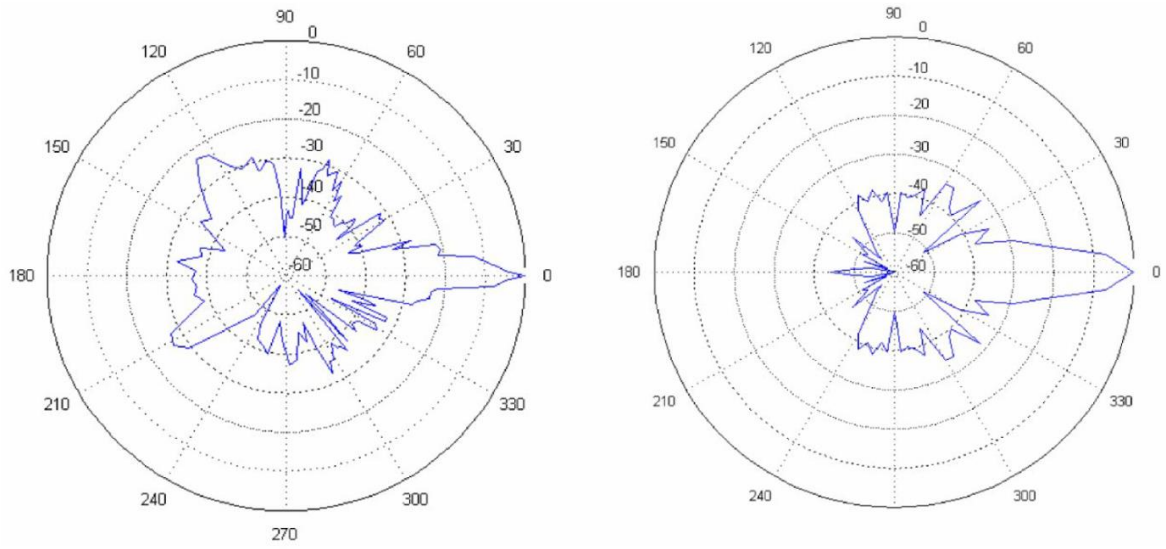


Fig. 1: Example of horizontal and vertical RF antenna radiation pattern for ground station

Documentation

General

Each Team must provide technical documentation for their project.

The project documentation is divided into three parts. The first set of information, called the Proposal, should be submitted with the registration form. The second and third are called the Preliminary Report and the Final Report, accordingly. Additionally, Teams are required to deliver a video material and the Science Planning report (1.5 weeks before the ERC finals). All should present the required content and quality of professional engineering documentation, therefore it is strongly recommended to have it reviewed by experienced engineers.

All the documents are scored and counted as a part of the challenge final points (for details, see Appendix 2). Scoring is designed to consider documentation as an aspect that can influence the order of Teams on the podium, therefore it is important to deliver all documents in the best possible quality according to the requirements listed below and on time according to the schedule (see Appendix 1).

Proposal

The Proposal should introduce the Team and provide information as to why the project presented by the Team should be chosen for ERC2022 based on technical expertise, Team's experience, and the first draft of the proposed solution. It should confirm that the Team has read, analysed and understood the system requirements (rules of the competition).

In the proposal, the Teams must include the following information:

1) A Team introduction, containing information about the Team's experience and expertise (short profiles of key people, the experience of the Team, especially in similar engineering projects and key research work for delivering this project on time and good quality, general focus, other projects etc.); please highlight experience in any past ERC competitions
2) A short presentation of the proposed (initial) solution to the challenge. That should state your initial compliance with the rules (understood here as the ERC rules), and clearly present achievable (within the project timeline) ideas, initial project assumptions and an analysis of challenge tasks (including scientific aspects of the Science task)
3) A first draft of project risk analysis and planned mitigations
4) First conclusions as to how your project or its parts could be commercialised/which elements and how it could be continued as further potential research, considering current technological trends

Document requirements:

1) First page: Team name, project name, heading 'European Rover Challenge 2020', affiliation, title 'Proposal'
2) Format: A4, searchable PDF
3) Length: max 10 pages (including a title page)
4) Language: English
5) Appendices: no

6) Minimum font size to be used is 10, margins shall be at least 2.54 cm (or 1 inch) from all edges of the page (‘Normal’ in MS Word)

Preliminary Report

This document shall be written after analysis and design phase, meaning that the Team should present an idea how to solve the presented problems with limitations and boundaries listed in the requirements and others which may have been additionally identified by the Team. In fact, it should be the next iteration of the Proposal, without repeating any basic points, already included in the Proposal. The document should also contain descriptions of management, system breakdown of the project, technologies selected and technical solutions to achieve the goals.

The Preliminary Report should include the following information:

1) Definition of technical requirements (compare them with those presented in the Proposal, if changed, please describe why and how the changes will have an impact on the project. Make a full list of your technical requirements and present the way in which you plan to meet them) and a test plan covering the requirements and other aspects important to show that your design is compliant with the requirements and can demonstrate a readiness for the trials
2) Project assumptions (compare them with those presented in the proposal, if changed, please describe why and how these changes will have an impact on the project)
3) Architecture, technical budgets, technologies you plan to use and designs you have or are working on (at any stage of readiness)
4) Safety system description, with a special focus on the emergency stop circuit (circuit design and analysis - e.g. signal sequence etc.)
5) Work Breakdown Structure (WBS), Product Tree (PT)
6) Financial planning (sources and expenditures)
7) Risk analysis - problems, issues and other risks (management, engineering, logistics, etc.) and how you plan to mitigate them
8) The Preliminary Radio Frequency Form as an appendix (see *Communication Requirements* for details).

Document requirements:

1) First page: Team name, project name, heading 'European Rover Challenge 2022', affiliation, title 'Preliminary report'
2) Format: A4, searchable PDF
3) Length: max 25 pages (excluding a title page, list of contents/figures/tables)
4) Language: English
5) Appendices: yes, if part of the same document (optional: only additional information which could not be included in the main document, for example large, detailed drawings and charts). It shall be highlighted that appendices are included in 25-pages limit, therefore please carefully select the content you want to share with the Jury Team
6) Minimum font size to be used is 10, margins shall be at least 2.54 cm (or 1 inch) from all edges of the page (‘Normal’ in MS Word)
7) Preliminary Radio Frequency Form is included in the mentioned 25-pages limit

Please refer to the provided templates.

Final Report

The Final Report is a continuation and extension of the Preliminary Report. It shall contain detailed information on the elements presented in the Preliminary Report and summarise the project after the manufacturing and testing phase:

1) Final project assumptions (fixed)
2) Final technical requirements (fixed)
3) Test plan covered by test report
4) Science preliminary planning: select and shortly describe (in a form of a map and text) a best landing site a pre-defined region on Mars. Selected landing site should be geologically interesting, and safe to access by a rover. This section should include a composite map fitting on an A4 format and consisting of a 1) location map showing selected landing site in a global scale, 2) a regional geological map (based on an appropriate map from the Astrogeology Science Center publications) and 3) a close up map based on CTX or Hirise photos, with a clearly marked landing ellipse and an indication of a region of interest. You should also include an up to 500 words long technical (why is it safe to land there) and scientific (why is it worth landing there) justification of the selected area. To prepare your analysis you should use Google Earth Pro (choose Mars as a base planet) or, if you are more ambitious, JMars. The region selected for the ERC2022 is a boundary between Utopia Planitia and Elysium (130-147E, 22-35N) a volcanic province where there are numerous examples of probable ice-lava interactions. Our Mars Yard will be modelled on this geological area on Mars
5) Final design:
    a) System Breakdown Structure (refer to definition by INCOSE)
    b) System architecture - hardware and software diagrams and description
    c) Technical budgets (mass, power, communication, etc.)
    d) CAD drawings (2D, 3D, dimensions, assembly, details)
6) Safety Systems description
7) Final financial report (sources/revenues and expenditures)
8) Risk assessment update - difficulties, solutions applied and lessons learnt
9) Final Radio Frequency Form (RFF) as an appendix (the final version of the form presented in the preliminary documentation)

Document requirements:

1) First page: Team name, project name, heading 'European Rover Challenge 2022', affiliation, title 'Final Report'
2) Format: A4, searchable PDF
3) Length: max 35 pages (excluding a title page, list of contents/figures/tables)
4) Language: English
5) Appendices: yes, if part of the same document (optional: only additional information which could not be included in the main document, for example large, detailed drawings and charts). It shall be highlighted that appendices are included in 35-pages limit, therefore please carefully select the content you want to share with the Jury Team
6) Minimum font size to be used is 10, margins shall be at least 2.54 cm (or 1 inch) from all edges of the page (‘Normal’ in MS Word)
7) Final Radio Frequency Form is not included in the mentioned 35-pages limit (it has to be delivered after submission of the Final Report – i.e. until 15th August)

DOCUMENTATION – GENERAL COMMENTS:

- Check document requirements (margins, font size, which pages are not included in the limit etc.)!
- Include all the relevant information mentioned above
- Try not to elaborate too much, sometimes a clear chart is better than a page full of text

Video Material

Each Team should prepare promotional video material presenting their readiness for the competition. This deliverable must be completed and submitted by the date presented in the challenge schedule (see the *Schedule - Appendix 1*). The material should be uploaded to one popular video service (e.g. YouTube) and a relevant link must be delivered to the Organiser by the specified deadline. Teams that fail to deliver this recording will not be allowed to participate in the challenge.

The video should be a maximum of 8 minutes in length and present the rover's capability to take part in the challenge, containing the following elements:

1) Introduction of team name, rover name, and the higher education institution name
2) Introduction of team and present teamwork
3) Introduction of the reasons for proposing the team to the challenge
4) Presentation of safety systems (including emergency stop button) performance
5) Presentation of the remote control - mobility and task related subsystems
6) Presentation of the rover's ability to resolve the challenge tasks
7) An explanation of what scientific project will be performed by the team, and why it matters
8) Quality and proper visual aesthetics for a video clip and presentation skills

Elements 1,2,3 and 7 shall not exceed 3 minutes in total.

Elements 4, 5 and 6 are crucial for assessment of rover's ability to take part in the final competition and **shall not exceed 5 minutes in total**. These elements shall show rover's ability to perform manoeuvres and operations including:

1) Roving forward/backward
2) Turning right/left
3) Driving on the slopes
4) Emergency button performance (rover driving forward shall stop immediately after the button is pressed)
5) Operation realised by rover's manipulator or other scientific tools

Important: manoeuvres 1-4 shall be recorded in a single shot in order to ensure that rover is fully functional. In case the Team is not compliant with this requirement is no points for elements 4-6 will not be given.

In special cases, the video may be the basis to request more details concerning the Team's readiness to participate in the competition. Failure to present the requisite level of readiness may influence the extent to which the Team is allowed to participate in the trials.

VIDEO – GENERAL COMMENTS:

- Remember about the sequence
- Check scoring, some of the moves (1-4) shall be performed without cuts – in a single sequence recorded

Science Planning Report

Each team needs to prepare a Science Planning Report and send it 1.5 weeks before the ERC finals. Information on detailed requirements are provided in the description of the Science Task.

European Rover Challenge 2022

Tasks list:

- Science Task
- Navigation Task
- Probing/Collection Task
- Maintenance Task
- Presentation Task

Disclaimer on Science, Navigation and Probing/Collection Tasks

All tasks in the Mars Yard will be performed **separately** (i.e. Science Task, Probing/Collection, Navigation, Maintenance). Each Team will be assigned a time slot for execution of each task.

Field Trials

Field trials are organised as a benchmarking activity to compare the performance of Teams in the resolution of several tasks. Each task presents an independent set of problems to be solved and which are related to the particular technologies required by future space robotics missions.

General

a) The challenge tasks take place in front of an audience in the form of a public event
b) Challenge attempts are independent. Teams are permitted to change their rover configuration between tasks. A certain amount of time will be scheduled in between tasks to allow teams to modify, repair and optimize their rovers (it is not applicable to tasks that are realised in a continuous manner, i.e. it applies only to the maintenance task in case of the on-site Formula)
c) The challenge Jury consists of a number of specialists selected by the Organiser. While judging the challenge, the Jury acts independently of the Organiser but adheres to the schedule provided by the Organiser. In case of any unforeseen issues not specified in the competition rules, the Jury Board will propose a solution
d) Technology priorities assigned to each task describe the focus areas for each task in order of priority. This order will be reflected by the scoring system summarised in the appendices
e) The scoring of each task is independent and summarised in Appendix 2
f) Excellence shown in a particular task can be rewarded with additional points or multiplication factors (see scoring details)

Schedule

a) On the first day, Teams should register at the challenge venue
b) Additionally, for all Teams, a warm-up day is planned for the day before the challenge. This day should be used for calibration and other preparation activities. The Organiser will give each team a limited time slot within which Teams are allowed to do any kind of measurements agreed with the Organiser and based on the final report specifications. Some task elements which are considered too detailed may be removed for this day by the organiser. All dynamic elements may not be placed in their final locations. The Organiser cannot guarantee that the challenge area and its elements will be fully ready for this day
c) On the last day of the challenge, total scores are calculated, winners are announced and prizes awarded
d) A detailed schedule containing the exact time window for each task will be announced by the Organiser one week before the event in a preliminary version, with the final one being issued on the first day of the competition
e) Each Team is obliged to respect the schedule. Any request for the modification of time slots etc. may be rejected by the Jury without any reason given.

Challenge Site Details

a) Each challenge task can be organized either indoors or outdoors. The outdoor challenge elements may be placed under tents. Teams can expect typical interior furnishings, buildings, industrial installations (metal pipes etc.) and natural objects (e.g. trees, bushes) in the vicinity of the challenge area
b) For outdoor tasks, teams and their systems should be prepared for a range of weather conditions. Temperatures between 10 and 30 degrees Celsius, wind gusts, light drizzle, strong or weak levels of sunlight are acceptable. In case conditions are unfavourable for the particular design, the Team may request to reschedule certain time slot but the final decision will be made by the trial judge. This will be made based on the schedule, other requests and the potential impact on Team's performance. In case of major weather problems, the Organiser will make all reasonable efforts to reschedule/reorganise the trials within the available time slots and facilities. However, it cannot be guaranteed that all of the trials will take place or will be organised strictly in accordance with the provided specifications
c) The Organiser will provide each Team with a workspace equipped with tables, chairs and 230V, 50Hz power socket ('type E', compatible with the 'German type F')
d) The challenge location is separated from the Team area to avoid RF interference but the Organiser cannot guarantee that extra precautions will not be requested to avoid disruption of the challenge attempts
e) The challenge field (i.e. Mars Yard - the place where terrain dependent tasks are held) will be artificially landscaped specifically for the event. Sandy, non-cohesive soil, as well as hard, dry terrain, all at a variety of slope angles, should be expected. In case of tasks which do not score locomotion aspects, a flat industrial surface (e.g. concrete) can also be expected

Operations

a) The aim of the challenge is to demonstrate and evaluate the performance and robustness of the proposed solutions. All tasks are designed to eliminate 'luck factor' from challenges. Therefore, Teams should present a high level of readiness for each task and platforms should be equipped with all the devices needed to solve all task elements. Rovers that are not equipped with all of the necessary elements may not be allowed to attempt a certain task
b) For the reasons stated above, Teams can expect dynamic elements in the task description i.e. elements that will be defined separately for each Team at the beginning of the attempt (e.g. changing the start position, different positions of task elements etc.). In those cases, the Jury will propose a fair modifications and the Team cannot influence those decisions
c) Teams will control their rovers from rover the independent locations. The control stations locations will be set up by Organiser so that Team Members will not see their rover during the tasks
d) Each Team has about 30-60 minutes (if a task description does not state otherwise) to complete a task. This value will be fixed by the time of the final schedule release
e) Some of the tasks may be realised during night, depending on the schedule (information to be provided by the Organiser in advance at the qualification and updated later in the final schedule)
f) Each Team must designate two observers who are allowed to follow the rover at a safe distance to ensure the safety of the machine and others around. Observers are allowed to communicate with the team from the control area only through a judge, and only in one way - from control base to observer - and solely to coordinate actions unrelated to task details like task reset, abort or unsafe event. No communication during the normal execution of the task is allowed. The observers must be able to carry the rover, but

they should remain at a safe distance from the working machine and cannot interfere with any of the rover's sensors (e.g. be visible on the image from the camera) during the realisation of the task attempt

g) During the tasks, only judges and observers can access the field. No manual intervention is allowed, except during events where the task rules state otherwise
h) Any maintenance made by the Team during tasks (any operations made by the Team to the rover hardware on the field) results in a restart of the task, going back to the start line and cancellation of all previously earned points for this task
i) The Team can use video systems to tele-operate the rover if the task requirements do not state otherwise
j) The Team must not use any voice/visual communication with the crew on the field. Only the judge can communicate between the task field and the control station
k) The rover’s operator has the right to abort the task at any time by notifying the judge about it. The Team will receive the points gathered to the moment of notification according to the rules of the task
l) Throughout the entire event, no rover or any other part of the system may do harm or interfere with the systems of other Teams. Any reports of such breaches will be investigated independently by the judges or the Organiser, and any violation of this rule can lead to disqualification from the challenge
m) Any erratic behaviour of the rover or Team Members causing damage to the task’s infrastructure can result in the immediate termination of the task attempt and cancellation of all collected points

Tasks Specification

REMINDER:

It shall be taken into consideration that all tasks in the Mars Yard will be performed separately (i.e. Science Task, Probing/Collection, Navigation, Maintenance). Each Team will be assigned a time slot for execution of each task. Changes of rover's configuration are allowed in the Probing/Collection Task only.

Science Task

The aim of the science task is to prepare and execute a simple science-driven exploration plan of our Mars Yard.

The science task will be divided into two parts. The first part *"Science Planning"* is to be submitted before the European Rover Challenge, the second part *"Scientific Exploration"* is to be submitted up to 2 hours after the ride through the Mars Yard. Reports will be submitted as a PDF file. **Please note that the maximal length of the answer to each question will strictly enforced**. Late submissions will be penalised. At some point after the finals, every team will receive a short information about their grades and performance and may request a longer assessment with the science team after the ERC 2022 (delivered remotely at a mutually convenient time).

Materials provided by the ERC Organiser

You will be provided with the following data based on which you will prepare your reports:

1. Detailed instruction (below)
2. An approximate location of the Mars Yard on the surface of the Red Planet (Elysium – please see info in preliminary report section). Please note that the Mars Yard does not copy any particular area of real Mars, but is an artificial model that represents the entire region. This information should help you to better understand the geological context of geomorphological forms present on the Mars Yard
3. Drone images of the Mars Yard along with the digital elevation model of the area
4. Support of our Science team through Mattermost

Documentation

Science related description included in the Final Report is an introduction to geology presented at the Mars Yard.

Science Planning Report is due about a 1.5 weeks before the first day of ERC. Planned Science Report and Unplanned Science Report are due up to 2 hours after your ride on Mars Yard.

Part 1 - Science Planning (before ERC finals)

The goal of the **Science Planning** part is to analyse the "landing site" and design a scientific mission in this area.

Please refer to *Challenge Milestones: Update Report #3* to see what data will be provided to be used in the Task analysis and documentation.

This Task documentation is based on information (drone footage and digital elevation model) provided during the Update Report #3 and is **due 1.5 weeks before ERC finals**. Science Planning report has to contain detailed information on the topics listed below.

The Task documentation is scored according to *Appendix 2 (Science Task)*.

1. **Geological map of the Mars Yard** including a coherent geological interpretation of the 'landing site' (pdf format).
    a) Outline of all geological features visible on the Mars Yard with a focus on what they are, how they were formed, and what their relative ages are (assigned from the oldest to the youngest).
2. **A short description of the geological history of the area.**
    a) A narrated description of the geologic map; description of a formation mechanism of the oldest geological feature identified on the Mars Yard, and how this area was later changing. (This section should be no longer than 3000 characters (with spaces) and include no more than one figure.) Longer descriptions WILL NOT BE ACCEPTED.
3. **A falsifiable hypothesis and its justification.** A hypothesis related to the geology of Mars Yard that can be tested by taking pictures in a specific location on the Mars Yard. (This section should be no longer than allocated number of characters (with spaces) and include no more than one figure.) Longer descriptions WILL NOT BE READ, more than one (possibly composite) figure will not be taken into account.
    a) 1st paragraph: stating a subject to be studied. e.g., Relative ages of Aeolian features present at the landing site. (up to 500 characters with spaces)
    b) 2nd paragraph: explaining why we should know that. e.g., determining the geological history of the landing site, and establishing when (and maybe why) dunes became immobilized. (up to 1000 characters with spaces)
    c) 3rd paragraph: a falsifiable hypothesis: e.g., an impact crater is younger than the dune located next to it. (up to 500 characters with spaces). Hypothesis cannot be ridiculously obvious like: "is this object a rock?", "is this dune made of sand?".
    d) 4th paragraph+ a **one** A4 figure (pdf format): predictions that will test the hypothesis; what is expected to be seen in the field, and how it will help the Team sustain or overrule the hypothesis e.g., we will go to the slope of the dune facing the crater and examine how material ejected from the crater interacts with the dune. If we find ejected material on the dune surface, we will know that the crater is younger than the dune >> it therefore supports our hypothesis. If we will find that material ejected from the crater is covered by the dune, we will know that the dune is younger than the crater -> our hypothesis will be rejected. (up to 3000 characters with spaces)
    e) Relevant scientific references that were appropriately cited in the text (do not cite Wikipedia or NASA web pages – we want to see you read papers or books).

Part 2 - Scientific Exploration

Objectives:

a) Gather data for Planned Science Report based on the information within Science Planning Report.
b) Gather data for Unplanned Science Report

c) Perform the Navigation Task
d) Perform the Probing Task
e) Submit Planned Science Report and Unplanned Science Report up to 2 hours after your ride on the Mars Yard.

Please refer to *Challenge Milestones: Update Report #3* to see what data will be provided to be used in the Task analysis and documentation.

Aim: to verify the hypothesis stated in the Scientific Plan and perform scientific documentation or measurements on the way.

During the traverse, Teams shall pay attention to the scientifically interesting objects that will be placed around the Mars Yard (e.g., atypical rocks, meteorites, pieces of spacecraft, possible USO (Unidentified Standing Objects). The location of the objects will be changed for different Teams.

Deadline for submitting the report: up to 2 hours after completing the traverse.

Reports

1. Planned Science Report

Aim: an attempt to verify your hypothesis described in your Scientific Plan Report. Apart from the description, you should include a modified version of your geological map (with a traverse clearly marked) in order to show what you discovered during the traverse. You should also include annotated photographs from the rover showing geologic features that you discuss in the report. You should discuss how this new knowledge influences the understanding of the geology of this area. You should describe the samples you collected (type and at least approximate weight), explain its importance for testing the hypothesis.

The report should be no longer than 4000 characters (with spaces) and include no more than 3 figures with proper descriptions (figure caption included in the character limit).

2. Unplanned Science Report

Aim: to identify and describe “interesting objects” identified on the Mars Yard. When doing real science (on Earth and on other planetary bodies) usually the most important science is related to finding new, unexpected things while looking for other stuff. This is why it is crucial to pay attention to your surroundings while traversing Mars. Unexpected items can include: a) rocks that are not similar to other rocks present on the Mars Yard – it may be an important ore for future use, b) signs of extra-terrestrial life (you never know – maybe you will find something), c) signs of technological civilization (either human – related or not), and d) observations of any geological activity.

Deliverables: The report with 1) a short description of the object and 2) an ad-hoc hypothesis about the nature of this object, 3) an image of the object, and 4) it should include a map (drawn on the digital elevation map provided to you by the Organiser) with your traverse and the location of all found objects clearly marked on a single map. The description of each object should be no longer than 350 characters (with spaces) plus one annotated photograph, and up to 5 objects will be graded. Do not afraid to be funny in your descriptions – the judges will need some entertainment during grading.

More details, guidelines and examples of expected descriptions will be delivered in the Update Reports.

SCIENCE TASK – GENERAL COMMENTS:

- Remember about the required weighting and radio check before coming to the Science starting point! Consider additional 20-30 minutes before as weight and radio check will have to be done in the teams' zone before arrival to the Mars Yard
- Arrive early, you will have 15 minutes to prepare for the task (during this time you have to establish communication with the rover and place it on the start line)
- Judge will explain you the task during the preparation phase
- You have 15 minutes to complete the task
- Additional and random obstacles and Easter eggs may be introduced in the rover's way (e.g. big rocks). These will be randomly placed in the Mars Yard and their location will be changed a few times during each day
- You can prepare a significant portion of the planned science report in advance by truly understanding your exploration plan. As part of that you can predict a number of possible observations in the field and deduce what that would matter for your conclusions. This approach would make sure you are able to deliver your Scientific Exploration report on time
- Remember to provide energy report after completion of the task!
- Only hardware changes/repairs performed during the task will be penalised, no penalties due to the safety reasons are expected – e.g. when rover is going to flip over on the crater's edge, stop/catch it and avoid damages. In case damage happened it is not possible to repair it without penalty
- Remember about preparing the strategy for each task. What to do in case of any problems? How long shall we wait or try to perform certain action before giving up and moving to the next one? Planning it in advance will save you some time

Maintenance Task

The task is intended to demonstrate the ability of rovers to operate with a variety of elements mounted on a panel. The Team has to use the rover's manipulating device to set switches to the required positions, measure electrical parameters, set other panel controls and observe indicators' feedback.

Technology Priorities

1) Task automation
    a) Automatic elements detection (e.g. spatial parameters, possible actions etc.)
    b) Automatic approach
    c) Automatic manipulation
2) Tele-operator's interface
    a) Dynamic operator feedback (e.g. presentation of feedback measures, force-feedback/control interfaces, etc.)
    b) Operator's situational awareness (e.g. vision, parameters presentation, display's ergonomics, etc.)

    c) Ergonomics of the operator's control interface
3) End-effector's performance
    a) Tool's relevance for a specific scenario
    b) Multiple tool systems (interfaces, exchange) or universal tool design
    c) Operation robustness (flexibility etc.)
    d) Operation accuracy and quality for a specific scenario
4) Manipulator's performance
    a) Operation robustness
    b) Operation accuracy and quality for a specific scenario

Task Scenario

Panel A:

1) Set the 'MAIN' switch to the ON position
2) Press the switches with numbers in a sequence in order to get the requested sum

Panel B1:

3) Turn on power of an electromagnetic lock (necessary to proceed with step 4) and report the measured voltage
4) Set the electromagnetic lock by placing a metal plate on it

PANEL B2:

5) Insert the plug (RJ-45 connector) into the socket on the panel "B2"

General Requirements

a) The time for this task is limited to 30 minutes (and 15 minutes of preparation prior execution of the task)
b) The rover should be equipped with a manipulation device allowing interaction with the control panel designed for a human operator
c) Switches and other controls will be industrial or home grade elements
d) Switches can be a lever or rotational type
e) The workplace will consist of three panels, designated as "B1", "A" and "B2" (counting from left to right), placed about 500mm from the ground
f) All switches should be manipulated one by one - activation of more than one in a single move will cause a reset of all the elements
g) Voltage measurement is to be conducted on standard 'German type F'/'French type E' or similar power socket (https://en.wikipedia.org/wiki/AC_power_plugs_and_sockets#CEE_7.2F3_and_CEE_7.2F4_.28German_.22Schuko.22.3B_Type_F.29) or terminals with similar dimensions and connection requirements
h) The voltage to be measured is between 1.0VDC and 24.0VDC and should be reported to within 0.5V accuracy
i) Some of the panel elements can be sensitive to forces and torques exceeding operational limits. Those elements should not be 'damaged' during operations

Expected Results

a) MAIN switch set to ON position (more points if done as the first operation)
b) Group of switches set to required positions, manually or autonomously
c) Voltage level reported to the judge
d) Plug inserted in the socket (electromagnetic lock is powered on)
e) Electromagnetic lock is turned on
f) RJ type plug inserted into the socket
g) No panel damage incurred (control elements, connectors, covers etc.)
h) Task automation efforts and results presented to the judge

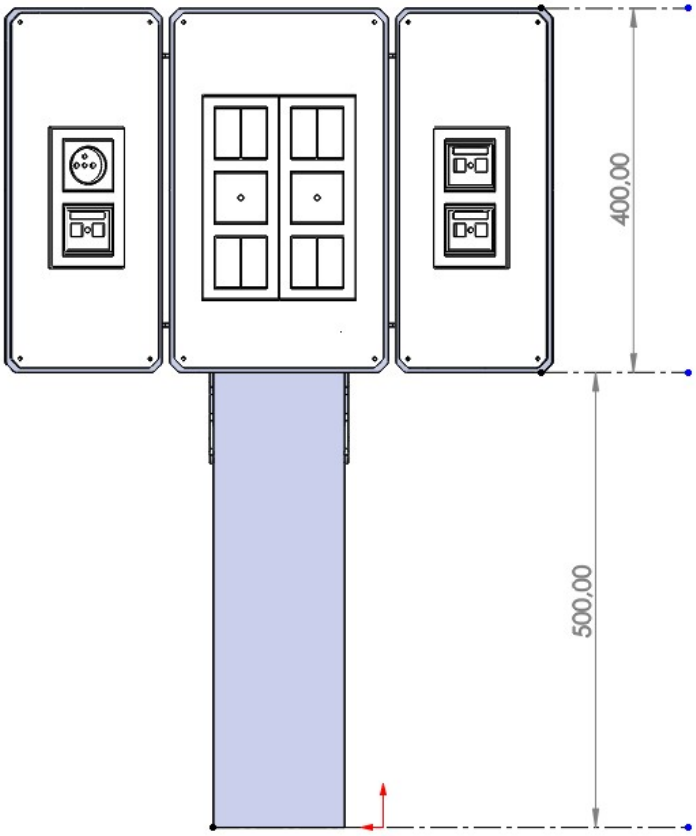


Fig. 2: Main dimensions of the panel

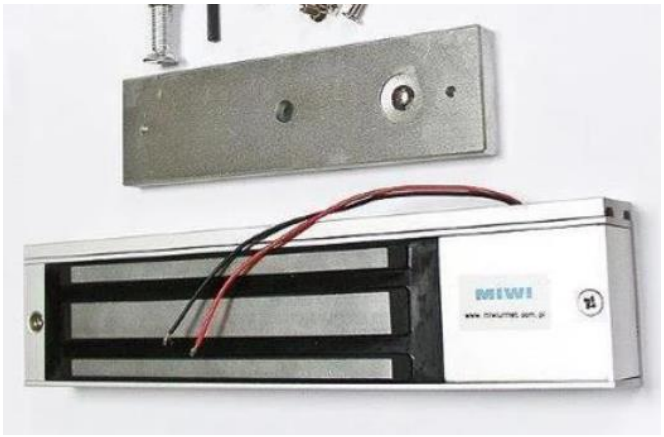


Fig. 2: Typical electromagnetic lock

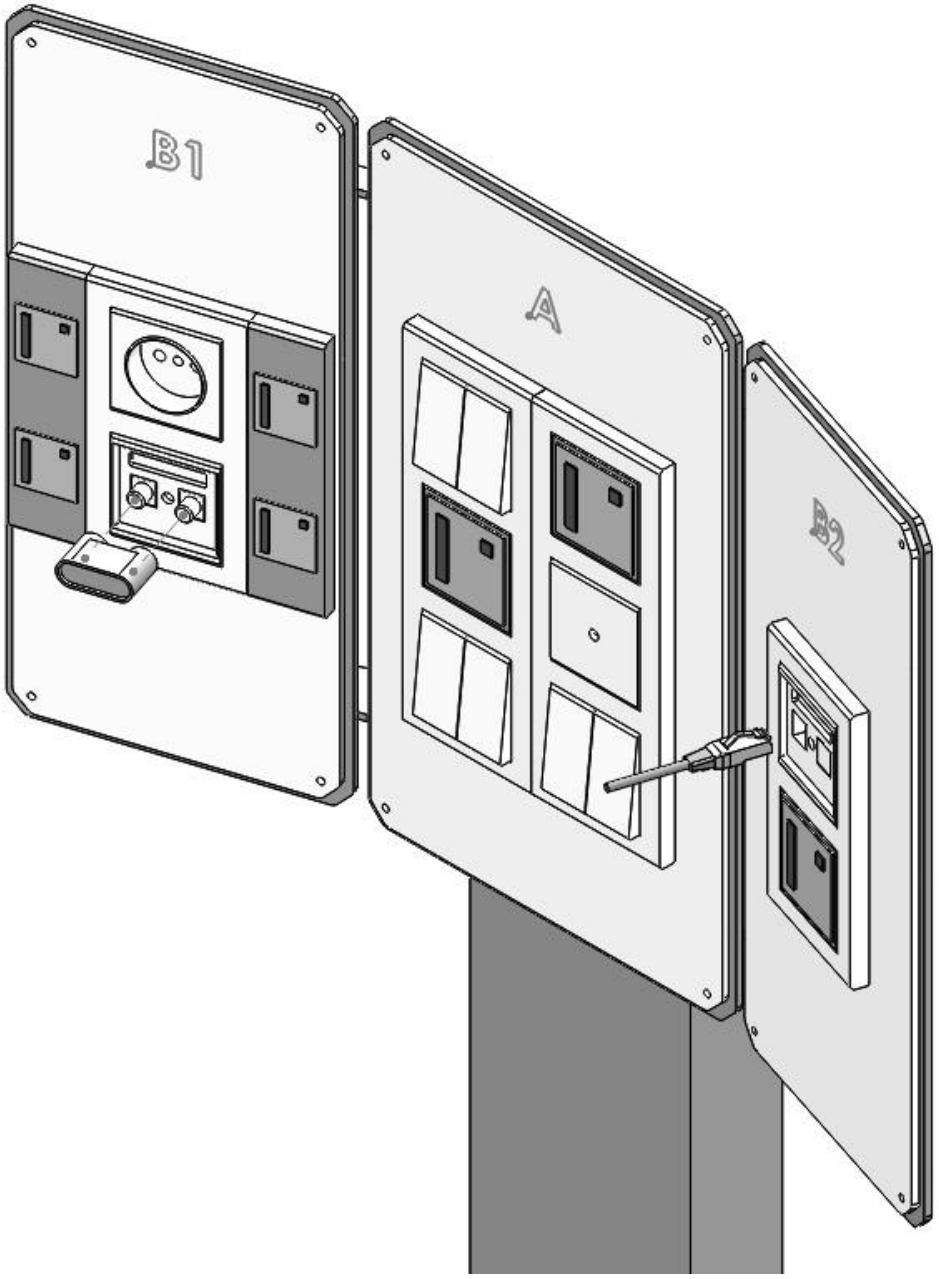


Fig. 3: On-site Maintenance Task panel overview

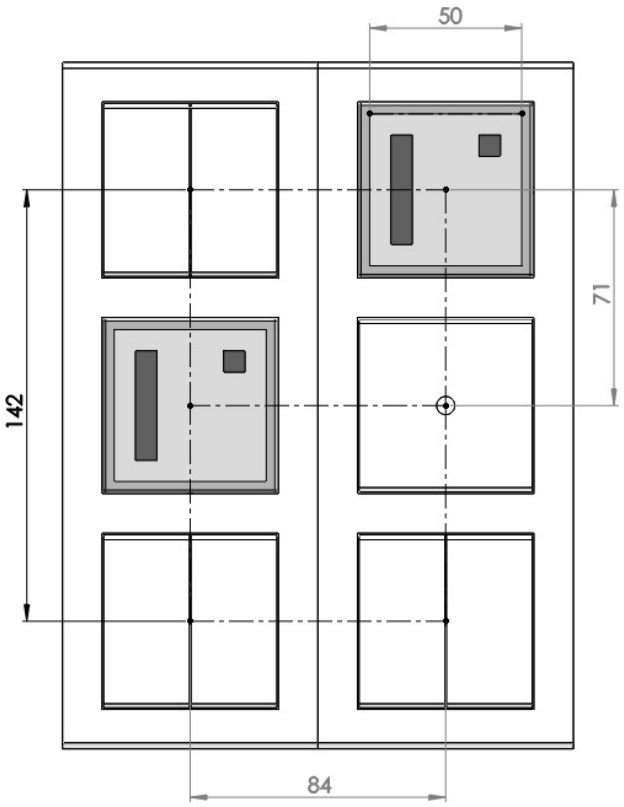


Fig. 4: Panel A – ArUco markers' arrangement

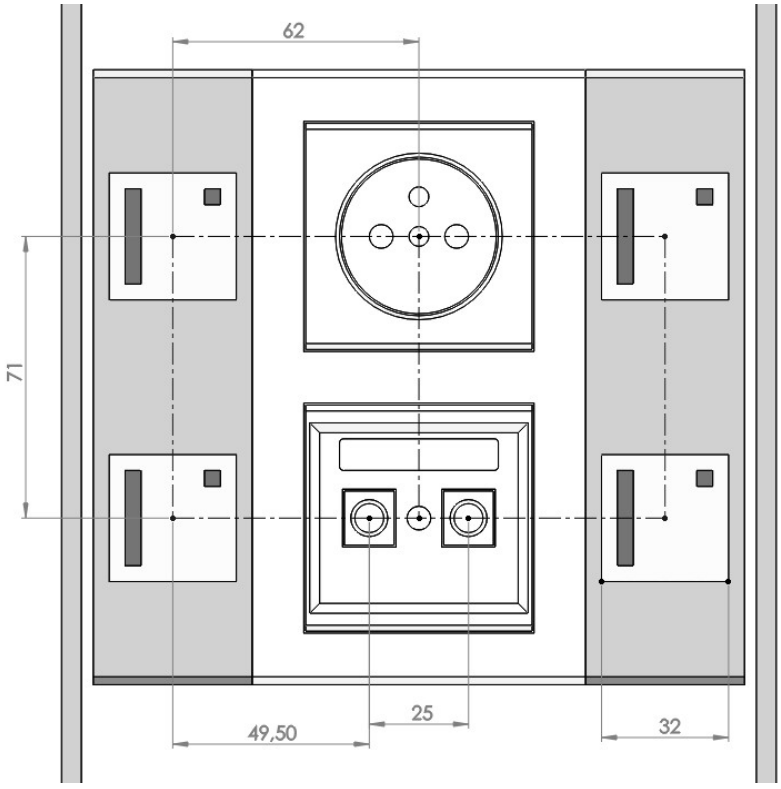


Fig. 5: Panel B1 – ArUco markers' arrangement

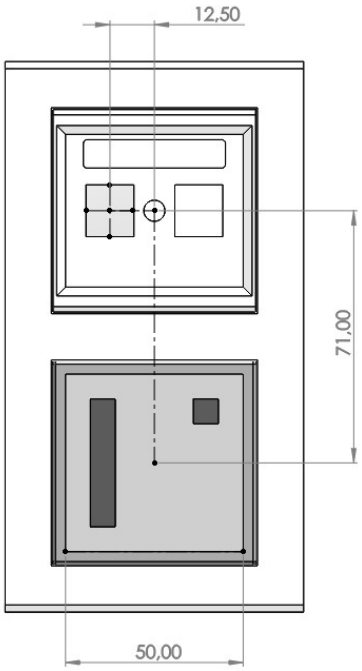


Fig. 6: Panel B2 – ArUco markers' arrangement

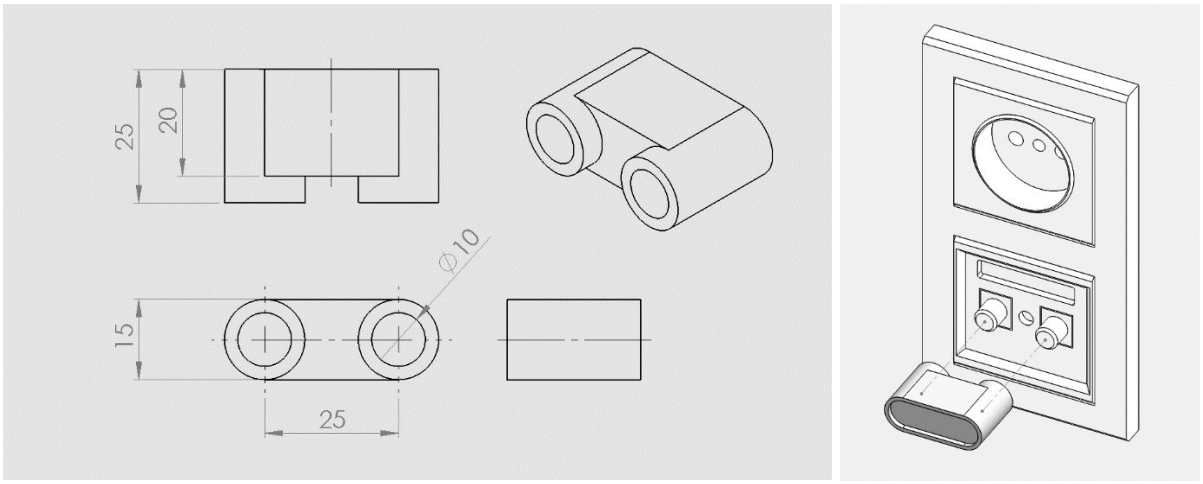


Fig. 7: Jumper's dimensions and presentation of its alignment with pins

Additional Information

a) Most of the panel elements will be specified before the challenge by means of a photo and general dimensions *(Update Report #2)*
b) Dimensions of the jumper, some of the crucial elements and reference markers will be defined before competition *(Update Report #2)*
c) Multiple tags will be placed on the panel surface. Tag type will be specified before the challenge *(Update Report #3)*

MAINTENANCE TASK – GENERAL COMMENTS:

- Remember about the required weighting and radio check before coming to the Maintenance starting point! Consider additional 20-30 minutes before as weight and radio check will have to be done in the teams' zone before arrival to the Mars Yard
- Arrive early, you will have 15 minutes to prepare for the task (during this time you have to establish communication with the rover and place it on the start line)
- Judge will explain you the task during the preparation phase
- You have 30 minutes to complete the task
- Remember to provide energy report after completion of the task!
- Only hardware changes/repairs performed during the task will be penalised, no penalties due to the safety reasons are expected – e.g. when rover is going to flip over on the crater's edge, stop/catch it and avoid damages. In case damage happened it is not possible to repair it without penalty
- Remember about preparing the strategy for each task. What to do in case of any problems? How long shall we wait or try to perform certain action before giving up and moving to the next one? Planning it in advance will save you some time

Probing/Collection Task

This task intends to demonstrate the ability of the system to:

- Collect either 3 surface samples from the given locations or 1 deep sample (perform drilling in a single location). Locations will be defined by Judges. The rover has to reach the collection/drilling locations, take the photo before, perform collections/drilling, take the photo, place each of the collected material on the rover and measure its weight
- Place and collect probes from the rover's cache in the locations selected by the Teams (3) and by judges (1). The Team has to reach locations marked on the map, pick up the probes from the rover's on-board container and place these in the specified locations.

Technology Priorities

1) Task automation
    a) Automatic element detection and localisation
    b) Automatic approach
    c) Automatic pickup from the container

    d) Automatic placement in the chosen location
2) End-effector's or drilling mechanism's performance
    a) Tool's relevance for a specific scenario
    b) Operation robustness
    c) Operation accuracy, repeatability and quality for a specific scenario
3) Container's design
    a) Container/mechanism design allowing the pickup of the defined probes with a limited accuracy manipulator with the key requirement being a high degree of probe's protection
    b) Container/mechanism design allowing the collection of the material from the defined location/s
4) Manipulator's performance
    a) Operation robustness
    b) Operation accuracy, repeatability and quality for a specific scenario

Task Scenario

Probing Part

a) Place 4 probes in the different locations
    a. Select 3 locations for probes' placement (4th location will be provided by the Jury Team). The 3 selected locations shall be provided to the Judge in the Navigation and Probing Plan (to be delivered in the *Update Report #2*)
    b. Reach the area where the probe shall be dropped (optionally: a drone can be used for this step, however the rover has to follow it and collect the samples. It is considered as a test scenario for the next editions of ERC)
    c. Take a photo of the area before placing the probe
    d. Grapple the probe from the on-board container
    e. Place the probe in the selected location
    f. Take a photo of the probe placed in the proper location
    g. Proceed to the Collection part of the task
    h. Collect all the probes on the way back (at least 5 minutes from placement of the last probe)

Collection Part

b) Collect 3 surface samples or 1 deep sample (drilling) in the defined locations
    a. Inform Judges if you are going to perform surface or deep sample collection (sampling locations will be provided by the Jury Team based on that information)
    b. Reach the area and take picture of it before the collection/drilling (optionally: a drone can be used for this step, however the rover has to follow it and collect the samples. It is considered as a test scenario for the next editions of ERC)
    c. Perform 3 surface sample collections (with e.g. scoop) or 1 deep sample collection (with e.g. drill). Samples have to be placed in separate container on the rover. Weight measurement has to be performed for each of the samples. In case of deep sample collection, the depth reached will be measured
    d. Take a photo of each of the sampling locations before and after collection
    e. Return to the start line

General Requirements

a) The rover shall be equipped with a manipulation device that is able to pick up the probes from the on-board container and place these in selected locations of the Mars Yard
b) The rover shall be equipped with a manipulation device that is able to pick up the surface samples from the Mars Yard and place these in the on-board container
c) The rover shall be equipped with a deep sample collection device that is able to pick up the surface sample from up to 30cm below the Mars Yard's surface and place it in the on-board container
d) The rover shall be equipped with a container/s allowing for the stable transport of probes and collected material over challenging terrain
e) The container/s shall keep probes and collected samples in a selected position and orientation and it shall prevent any movement
f) There shall be at least 4 slots for probes in the rover's on board container
g) The probe is a light green cylinder with the dimensions presented in the figure below. The maximum weight of the probe is 300g and its CoG position is unknown.
h) The thin part of the probe (20mm dia.) shall be protected during transport on Mars Yard in order to avoid any damages to the sensor
i) Optionally the rover can be equipped with a drone used for finding the probing and sampling locations. It is considered as a test scenario for the next editions of the ERC

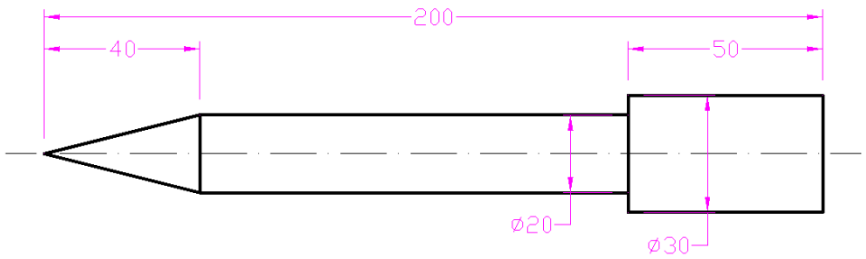


Fig. 7: Schematic view of probe's design

Expected Results

a) Demonstration of rover surface or deep sample collection equipment (a robotic arm with gripper, drilling mechanism or equivalents) and operator's performance via remote or autonomous control
b) Demonstration of system automation capabilities
c) Placement of the probes in the proper position from the rover's on board container
d) Collection of the surface/deep sample/s in the defined position/s and its placement in the rover's on-board container
e) Measurement of the collected material's weight
f) Presentation of operational approach algorithms used and other system solutions
g) Presentation of proposed designs of the container, robotic arm, gripper and accompanying elements

PROBING/ COLLECTION TASK – GENERAL COMMENTS:

- Probing/Collection Task is the only one in which change of the basic rover's configuration is allowed. In case of Science, Maintenance and Navigation rover's configuration cannot be modified
- Remember about the required weighting and radio check before coming to the Probing/Collection starting point! Consider additional 20-30 minutes before as weight and radio check will have to be done in the teams' zone before arrival to the Mars Yard
- Arrive early, you will have 15 minutes to prepare for the task (during this time you have to establish communication with the rover and place it on the start line)
- Judge will explain you the task during the preparation phase
- Please provide locations of the selected probing points to the judge before starting the task (in the Navigation and Probing Plan – template to be delivered in the *Update Report #2*)
- You have 30 minutes to complete the task
- In case of the Probing Part 0.5m accuracy (rounded up) measurement in case of the points selected by the teams (distance between '+' in the plan and the final probing location). In case the points are not marked with '+' 0.5m accuracy of measurement cannot be guaranteed. In case of the Collection Part 2.0m accuracy is required
- Remember that in the Collection Part either surface or deep sample collection can be selected. In case you want to perform both of these you will receive point only for the one you have performed in the first place
- Remember about taking pictures before and after placement of the probes (4) or collecting surface (3) / deep (1) sample material/s
- Measure weight of the collected sample/s
- Remember to provide energy report after completion of the task!
- Only hardware changes/repairs performed during the task will be penalised, no penalties due to the safety reasons are expected – e.g. when rover is going to flip over on the crater's edge, stop/catch it and avoid damages. In case damage happened it is not possible to repair it without penalty
- In case you plan to use a drone, please check the regulations and assess if you need a license to pilot it. It is recommended to use of-the-shelf solution. As explained before, drone is considered as test scenario for the next ERC editions. A special prize may be granted by the Organiser for the performance of this part
- Remember about preparing the strategy for each task. What to do in case of any problems? How long shall we wait or try to perform certain action before giving up and moving to the next one? Planning it in advance will save you some time

Navigation Task

This task is intended to demonstrate the system's ability for semi to fully autonomous traversal. The Team shall develop a project which gradually evolves into a fully autonomous system, traversing and gathering important data on its way. At an early stage, the system can be decoupled with the operator in the loop, but all planning and parameter estimation must be done by the computer system itself. This limits the operator to navigate the rover blindly i.e., without access to visual or any other spatial information, however, any kind of data can be processed on-board, providing the operator with support information about the localisation and state of the system. A smart navigation strategy, sensor fusion and image data processing are essential in this task.

The Teams will be given **20 minutes** to perform Navigation Task traversal. The Teams will be given 15 minutes before the Task start to prepare the Rover for the traversal. This time is called the Preparation Phase. During most of the Preparation Phase, full access to the Rover is granted, the Rover is put in a dedicated area of the Mars Yard and the Teams are allowed to drive in the area, upload software, check the functionalities, etc.

Task Scenario

a) Send the rover the start position and waypoint information
b) Reach the planned waypoints (4) according to the Navigation and Probing Plan
c) Return rover to its start position
d) After the traverse, present techniques used, visualise the system data, compare the results with the plan calculated at the beginning etc.

General Requirements

a) The rover mobility system should be able to drive over challenging terrain of the Mars Yard
b) An on-board data processing application should be used for rover localisation based on natural terrain features, however, navigation landmarks will be placed for absolute reference
c) The rover system can utilise a coarse height map of the arena provided by organisers
d) Use of GNSS receivers is not allowed. Any other type of sensor (i.e. camera, LIDAR, IMU, odometer, sonar, etc.) can be used for on board processing
e) If decided by the Team, camera may be used for driving based on visual, however a significant decrease of points will be considered in this case in order to assure fair-play approach for the teams that have performed this task without vision or in autonomous mode
f) At any time during the task attempt, the only data that can be transmitted from the rover to the control station are position ([x, y, z]) and orientation (Euler angles or quaternion)
g) The rover's starting position and waypoint coordinates (and landmark positions upon a team's request) will be provided in a local coordinate frame directly before the task attempt (*Update Report #3*)

Expected Results

a) Reach all waypoints
b) Present a system that supports the operator in rover control
c) Present the systems and methods used for autonomous traverse and gathered data (e.g. map, paths, plans, reached waypoints, position errors, etc.)

Additional Information

a) Initial rover position and orientation will be drawn at the beginning of each trial from a set of designated locations and with a limited heading
b) The rover can be tele-operated, but only using the position and orientation estimate available. This data can be visualised in any form (e.g. projecting the rover's position on the arena map provided or a top view picture etc.)
c) If the rover needs to be moved for any reason, it can only be moved back to the last successfully reached waypoint and/or rotated towards any point or back to the starting point. In both cases, penalties for manual intervention apply
a) Technical Reports should include a list of all sensors, together with detailed information about working modes, ways they are used in the navigation task and how the rover will be operated. Teams are entitled to consult all solutions with the judges before submission. Documentation will be verified by the judges and in case of any doubts, the Team may be asked to reconfigure devices and/or their control strategy. Any difference between the approved configuration and the one used during the challenge can lead to disqualification (0 points for this task)
b) Task arena:
    a. Final map with grid coordinates and POIs (Point Of Interest) will be provided on the warm-up day, if not agreed otherwise
    b. Two types of landmarks are foreseen: natural landmarks which are elements of the landscape placed on the map, e.g. craters, small embankments, hills and artificial landmarks, e.g. artificial points for localisation purposes. Artificial landmarks can contain characteristic hi-visibility labels, unique geometric figures, alphanumeric signs or an AR/QR tag matching a POI label on the map; An example landmark (A4 size) design using an ArUco marker is presented below:

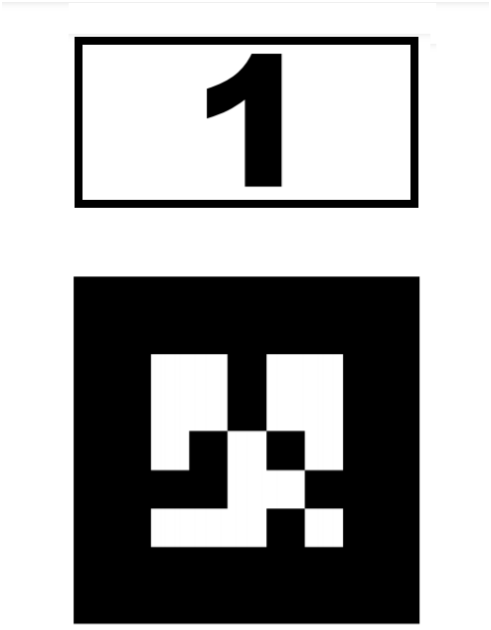


Fig. 8: Example of the ARTag/ArUco marker

    c. The artificial landmarks will be visible for cameras from different directions on a field (each landmark has 4 sides with identical faces) and will have a

physical base that can be detected by proximity/range sensors (e.g. placed on an element of infrastructure or natural landmark)

d. At least two landmarks will be visible from the starting point
e. It must be taken into account that some of the landmarks may be obscured by terrain or other objects during a traverse
f. The team cannot place any additional passive landmarks or active beacons on the challenge field outside the starting area, but such elements can be deployed using the rover during the trial. All landmarks must be documented in the technical reports and presented for approval at least 10 working days before the submission of the final documentation. This equipment may be subject to negotiation, so teams should leave enough time to redesign/modify it in case of comments/rejection by the jury. Such equipment must comply with the other rules of the competition e.g. if active radio beacons are used, they must be compliant with the radio communication rules (see *Radio Communication* section) and described in RF form

c) The rover can be stopped and moved/rotated by team members when it is stuck or in case of any other technical problems. A judge shall be informed before any action is undertaken
d) Details of the task, such as exact appearance of landmarks, location, map format, allowed custom landmarks and beacon types, etc. will be discussed with the teams and presented during the preliminary design phase. Teams are encouraged to initiate and actively participate in these discussions

Description of Landmarks

Dimensions of landmarks are shown in the figure below.

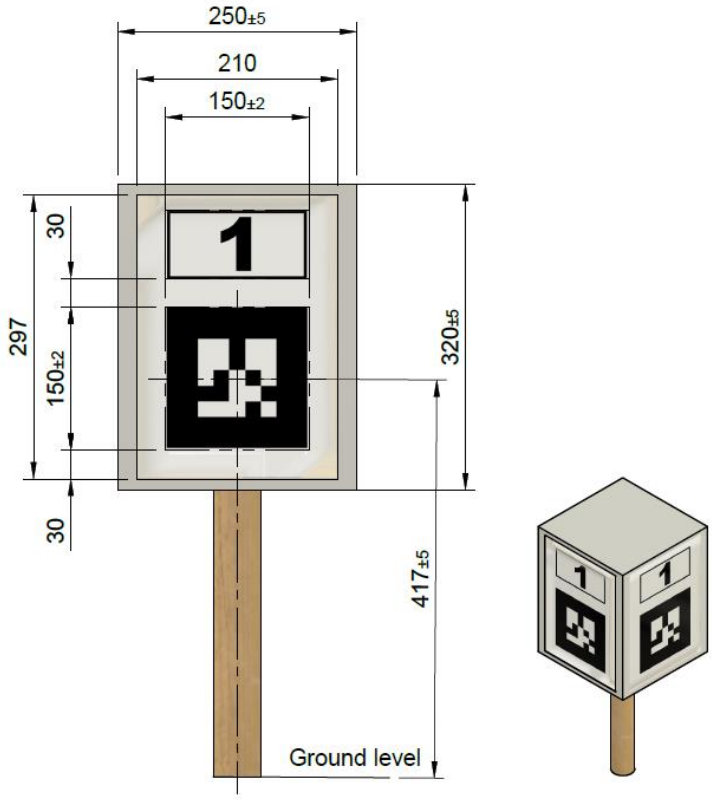


Fig. 9: Dimensions of landmarks

Each artificial landmark face consists of:

a) A white background of at least 210x297mm (A4 size)
b) A landmark number indicator located in a 150x70mm (+-2mm) rectangle
c) An ARTag square corresponding to the landmark number, with dimensions of 150x150mm (+-2mm) and at least 30mm white margin on each side

Each artificial landmark pole consists of:

a) A box with 4 landmark faces and dimensions of 250x250x310mm (+-5mm)
b) A wooden pole that elevates the landmark box above the ground (according to the drawing)

Each landmark's coordinates are counted from an artificial point located in the landmark's pole axis – on a height of the landmark ARTag's centre point.

For the **list of ARTags** – please refer to the official Alvar documentation to find and generate each landmark ARTag: http://wiki.ros.org/ar_track_alvar (Section 3, Generating AR Tags).

NAVIGATION TASK – GENERAL COMMENTS:

- Remember about the required weighting and radio check before coming to the Navigation starting point! Consider additional 20-30 minutes before as weight and radio check will have to be done in the teams' zone before arrival to the Mars Yard
- Arrive early, you will have 15 minutes to prepare for the task (during this time you have to establish communication with the rover and place it on the start line)
- Judge will explain you the task during the preparation phase
- Please provide the planned traverse path to the judge before starting the task (in the Navigation and Probing Plan – template to be delivered in the *Update Report #2*)
- You have 20 minutes to complete the task
- Remember to provide energy report after completion of the task!
- If decided by the Team, camera may be used for driving based on visual, however a significant decrease of points will be considered in this case in order to assure fair-play approach for the teams that have performed this task without vision or in autonomous mode. You can decide to use video at any time (e.g. in case you perform 1 of 4 points in autonomous mode you will still receive increased number of points for that one, scoring will be decreased only in case of the points reached with visual). Don't hesitate to make this decision in case of any problems – finally it is better to drive the rover than look how it stands on the Mars Yard ☺
- Team has to be in the tent with no view on the rover during the task (applicable to the part when no vision – see above – is used)
- Only hardware changes/repairs performed during the task will be penalised, no penalties due to the safety reasons are expected – e.g. when rover is going to flip over on the crater's edge, stop/catch it and avoid damages. In case damage happened it is not possible to repair it without penalty.
- Remember about preparing the strategy for each task. What to do in case of any problems? How long shall we wait or try to perform certain action before giving up and moving to the next one? Planning it in advance will save you some time

Presentation Task

The Presentation Task lets Teams introduce themselves and present their projects. The Jury expects to learn how the Team worked on the project, what kind of technical solutions are implemented in the rover (on-site formula) or in the software (remote formula), what was the approach of the Team to solve particular tasks during the competition (e.g. electro-mechanical design, algorithms for both onsite and remote formulas), and how the team solved problems and issues which occurred during development (lessons learnt). The team should also be prepared for a Q&A session and discussions with Judges. The last part is also important for the Teams as starting this year the Organisers would like to focus more on mentoring and development of the Team Members. Therefore, we would like to encourage you to prepare not only for the presentation part but also for the discussion. Questions from the Team Members are also welcome!

The Presentation Task is applicable for both on-site and remote formulas of the ERC 2022. Teams that take part in both formulas will perform the Task <u>twice</u>.

Goals

a) Introduce the team (expertise and experience) and project
b) Present organisational structure, management methods and work-flow
c) Present an engineering approach
d) Present the technical design
e) Present the scientific project design
f) Present the approach selected and realised in each task
g) Present difficulties which occurred, methods applied to solve them as well as lessons learnt
h) Present elements designed to fulfil the rest of the trial tasks
i) Present Team's outreach and PR activities related to the ERC (posts, events etc.)
j) Present well-considered and realistic ideas for potential applications and future development of the designed rover or its subsystems (spin-off/spin-out ideas)

General Requirements

a) The time for the presentation is limited to 20 minutes and after that time the presentation will be immediately interrupted
b) The Q&A and discussion session takes 10-30 minutes
c) The team can use a projector provided by the Organiser (HDMI connector as a standard, other connectors may not be available therefore please consider bringing those as an essential to present)
d) The Organiser does not provide computers
e) The presentation as well as Q&A and discussion session must be given in English
f) The presentation can be done in any format and creativity is welcome
g) One member of the Team may be selected to present, however, all Team Members shall attend the presentation as well as the Q&A and discussion sessions

Expected Results

a) Demonstration of Team's presentation skills
b) Detailed information on technical key drivers which influenced the Team to build this design, engineering approach, system breakdown structure, management, difficulties, solutions and lessons learnt
c) Scientific/engineering inventions, design propositions
d) Spin-off, spin-out/in ideas and opportunities
e) Team outreach and promotion of the ERC

f) Discussion with Judges focused on the presented design or approach, problems encountered, possibilities to further develop the project or certain skills of the Team Members
g) Teams should feel more than welcome to provide additional topics that they would like to discuss. One of the main assumptions of this task is to provide as much mentoring support to the Teams during the ERC 2022 finals.

PRESENTATION TASK – GENERAL COMMENTS:

- Arrive on time, you will have 10 minutes to prepare for the task and solve the potential technical issues related to sharing the screen or the Internet connection
- Do not select only one representative for the Presentation Task. We want to meet and talk to the Team (or at least as many members as it is possible)
- Do not underappreciate this task. Presentation skills will be essential in your professional career. Prepare for this task in advance
- Judge will explain you the task during the preparation phase
- You have 20 minutes to complete the presentation
- In the presentation please especially remember about addressing the following topics (we have noticed in the recent editions of the ERC that teams forget about those or do not have idea what to present):
  - ✓ Explanation of outreach part. Describe the activities that increase your and ERC's visibility (e.g. posts on Facebook, articles in newspapers, events/workshops that you have organised etc.). Include also PR activities related to the ERC (posts, events etc. – *at least 5 posts including* ***#ERC2020*** *hashtag will be required and scored*)
  - ✓ Explanation of spin-off/out part. Come up with ideas for further commercialisation of your work. Try to think outside the box and consider more specific possibilities, e.g. commercialisation of a small part (e.g. software, gripper, camera etc.) of the rover instead of the complete rover (however it is also a possibility but not the only one)
- Use the 30-minutes slot for the discussion with Judges. Do not be afraid, this time is specially for you than for us. You can discuss any topic with us (considering that we have a knowledge in a certain area, if not we will try to help you and lead you to the person who has experience in it). Do not hesitate to ask any questions, even the stupid ones

Time Available for the Tasks

The table below summarizes time available for preparation and completion of each task.

No.	Task	Preparation time [min]	Execution time [min]
1	Science	15	15
2	Navigation	15	20
3	Probing/Collection	15	30
4	Maintenance	15	30
5	Presentation	10	20 (presentation) 30 (discussion)

Miscellaneous

Awards and Recognitions

The first three best teams in each formula will be presented an award. Multiple other awards are planned to recognise excellence in different parts of the programme and competitions. The form of the awards will be specified on the challenge website. The Organiser may also allow awards funded by third parties. Third-party award funders must have the Organiser's approval.

The following awards are foreseen:

- **Best three teams in on-site formula competition**
- **Best three teams in remote formula competition**
- **Best team awards for each task accomplished within on-site (Science, Navigation, Probing/Collection, Maintenance, Presentation – 5 awards in total) and remote (Science, Navigation, Maintenance, Presentation – 4 awards in total) formulas**

By taking part in the ERC, teams agree to place a promotional sticker on their rover (max. size of the sticker: 10x10cm).

Number of commemorative medals for each awarded Team is limited to 15 (medals are not applicable for best team awards for certain tasks). Other members of the Team present in Poland may receive certificates only.

Organiser's Disclaimer

Teams take full responsibility for any damages, accidents or unsettling events caused by their hardware-software as well as for the members of the team. Teams are obliged to follow all safety and good conduct rules specified by the organisers. Any breaches of safety rules and requirements will result in the disqualification of the team from the entire competition.

Changes to Competition Rules

The Organiser retains the right to extend the deadline for the submission of documents and provide essential but inevitable changes to the competition rules. However, any changes introduced cannot concern key issues for the rover's design. All changes will be announced in advance and provided on the challenge's website.

Deadline Extension

The Organiser has the right to extend the deadline for submission of documents. All deadline extensions will be announced in advance and provide details on the challenge website.

Q&A

Answers to any challenge related questions that arise will be provided on the challenge's website. If you have questions, please contact the challenge contact point (see *Information channels and contacts*).

The Organiser will provide ‘European Rover Challenge 2022 Questions & Answers’ as a part of the competition rules. All arrangements contained therein are ultimately binding – even if they change the competition rules. The FAQ will be announced in advance and provided on the challenge’s website.

Challenge Scoring Issues

All issues with scoring during the challenge will be resolved solely by the independent jury (i.e. challenge judges). Teams cannot appeal to any other party.

Organisational Issues

Organisational issues, including team eligibility, challenge organisation and execution of jury decisions will be resolved by the Organiser.

General Challenge Issues

In case any conflict related to the challenge is encountered, the Organiser’s decision will be considered as final and binding.

Disqualification

The Organiser may disqualify a team in the event of a serious breach of the rules or fair play.

Personal Data Storage

Team Members agree to their personal data, the documentation delivered as well as other promotional materials and visuals being stored and processed in the Organiser’s computer systems for the purpose of the ERC programme.

On the other hand, the Organiser will keep all technical documentation confidential and will not publish or disclose it to any third parties without prior approval from the Team’s representatives. The sole exception to this is the challenge’s Jury Team – technical documentation will be disclosed to judges for scoring and mentoring purposes only.

The Team Members also give the Organiser, parties designated by the Organiser and the audience, the right to disclose and publish any photos, videos or other visuals, their names and surnames, identifiable pictures of themselves and any other persons, as well as pictures of machines, devices and equipment in any and all of the available formats, by any and every known method, in any and every known medium.

Teams grant permission to the Organiser to use promotional materials and visuals (e.g. photos and videos), as well as any additional photos, videos, portraits, documents, interviews and other materials resulting from participation in the challenge (using the name of the participant or not) on all media, in any language, anywhere in the world, in any manner, for advertising and promotional purposes.

Personal data and information about Team Members other than their names and surnames will not be published without the prior consent of each team member.

Teams and Team Members Responsibilities

Teams and Team Members accept sole responsibility for securing and ensuring the safety of their equipment and luggage in the challenge's location. They release the Organiser from liability in the event of damage, destruction or theft of any property.

Cancellation of Event

The Organiser reserves the right to cancel the ERC 2022 finals (either one or both formulas) in the event of circumstances preventing its safe organisation (e.g. high risk associated with increasing pandemic spread). In case of event cancellation, the Organiser will decide on the alternative approach and present it to the Teams affected by the decision.

Organiser's Responsibility

The Organiser's civil liability is limited solely to the responsibility for organising a mass event in accordance with the Polish law and local regulations.

Copyright

The Organiser retains all copyright to the competition rules, especially the description of the tasks. No alterations or additions to the competition rules can be made and their sale is expressly forbidden. The rules can only be used or copied for the ERC-connected activities (e.g. registration process).

APPENDIX 1.

Challenge Schedule

The table below presents the schedule of the ERC2022 programme.

Event	**Date (2022)**
Rules publication	5th February
Registration start	5th February
Registration end	15th March
Update of the Rules (e.g. Scoring) / Update Report #1	2nd April
Preliminary Report Delivery	30th May
Qualification	20th June
Update of the Rules #2 / Update Report #2	22nd July
Video Delivery	31st July
Final Report Delivery	31st July
RF Form Delivery	15th August
Update Report #3	mid-August (TBC)
Science Planning Report	29th August
Competitions - ERC finals event	**8th - 11th September**
Warm up day for teams	*8th September*
On-site registration	*8th - 9th September*
Competitions – ERC tasks	*9th – 11th September*
Closing ceremony	*11th September*

APPENDIX 2.

Challenge Scoring

General Rules

The scoring of the competition is designed to reflect the Technology Priorities identified as well as gaps in the designs from previous editions. It is intended to motivate teams and, as a result, help the team develop the relevant expertise and provide missing solutions to previous challenges.

Some flexibility in scoring is left to reflect many aspects that cannot be covered by rules like the quality of solutions, its robustness and performance, but judges will be equipped with detailed guidelines to make the scoring as objective as possible.

A detailed number of points will be provided with Update Report #1. The following scoring for tasks is considered at the moment.

- **Documentation (250 points max)**
- **Science Task (150 points max)**
- **Navigation Task (150 points max)**
- **Probing/Collection Task (150 points max)**
- **Maintenance Task (150 points max)**
- **Presentation Task (150 points max)**
- **Rover's Weight (60 points max)**
- **Energy Reports (40 points max)**

The total number of points in the ERC on-site formula is 1100.

Documentation

The following scoring is considered for the Documentation:

- **Proposal (30 points max)**
- **Preliminary Report (50 points max)**
- **Final Report (100 points max)**
- **Video Material (70 points)**

Proposal

Scoring as per the following table. A template is available on the ERC website.

PROPOSAL (MAX 30 POINTS)					
No.	**Req. No.**	**Scored Parameter**	**Max Partial Points**	**Max Task Score**	**Description / Scored Parameter**
1	O/PRO-010	Team introduction	4	4	Description of the Team members, experience (short profiles of key people, experience in similar engineering projects, key research work and in the past ERC editions).
2	O/PRO-020	Analysis of the rules and a short presentation of the proposed initial solution	12	12	Initial project assumptions and initial technical requirements, derived assumptions, analysis of challenge tasks and Team's approach to solving the tasks.
3	O/PRO-030	Risk assessment	8	8	The first draft of project risk analysis and planned mitigations.
4	O/PRO-040	Commercialisation ideas	6	6	Which elements (and how) could be commercialised or continued as further potential research considering current technological trends, other benefits .
TOTAL				**30**	**Max. possible number of points.**

Tasks

The following scoring is considered for the Field Trials:

- **Science Task (150 points max)**
- **Navigation Task (150 points max)**
- **Probing/Collection Task (150 points max)**
- **Maintenance Task (150 points max)**
- **Presentation Task (150 points max)**

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