

European Rover Challenge 2016

European Rover Challenge 2016 Rules

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1. General information

1.1. What is ERC

The European Rover Challenge (ERC) is a contest for Student Teams. A Student Team has to design and build a Martian rover prototype and use that robot to compete in various Tasks at a designated location. The aim of the Challenge is to give the participants a chance to expand their knowledge of Martian exploration, provide valuable professional experience in different fields of engineering, project and team management, project documentation and presentation while also popularize STEM (Science, Technology, Engineering and Mathematics) especially space exploration and robotics among the wider public, including the Challenge audience.

The European Rover Challenge is organized by European Space Foundation and Planet PR Agency, also referred to as the Organizers, in cooperation with group of independent experts as a Jury. Mars Society Polska, a Polish non-governmental organization, is a Partner of the event.

1.2. Date and Venue

The ERC 2016 will be held **September 10-12th, 2016** in Poland (for further information please follow updates on Challenge website (see 1.3)).

1.3. Information channels and contacts

The Challenge website address is: www.roverchallenge.eu

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

2. Teams

2.1. General

The 2016 edition of the Challenge is planned for approximately 20 Student Teams. The Organizer and the Challenge Jury will choose which of the registered Teams are allowed to compete in the Challenge. The choice will be made based on Registration Proposals and preliminary Reports that the Teams are required to send to the Organizer which are described in section 4. The deadline for their submission are **March 31st** and **May 5th** respectively. The Organizer will announce which Teams have qualified for the Challenge proper by **May 13th**.

2.2. Registration

Team Registration will be open from **20th January** till **March 31st**. Registration details shall be sent to the Organizer in English, via Teams' Contact Point e-mail address (see 1.3). If this document is not submitted in the form and within the time laid down, Team will not be allowed to participate in the Challenge.

The Team Registration e-mail shall include:

- a) 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 Team name);
- d) Project proposal - described in section 4;

- e) Approximate number of Team Members who plan on coming to the Challenge (i.e. appearing on site);
- f) Team Contact Point person name and surname, telephone number and e-mail address;
- g) University Team Coordinator name and surname, telephone number and e-mail address;
- h) Team website address or/and Facebook fanpage;
- i) The following declaration, in English:

“By sending this message and registering the Team to the European Rover Challenge we fully accept all terms and provisions of the European Rover Challenge Rules and all final decisions of the European Rover Challenge Organizer.”

2.3. Team members

Team must consist of higher education students and recent graduates only: undergraduate and graduate Masters-degree level students (with no limitations) and PhD students (but no more than half of the Team). It is recommended that Teams will cooperate with specialists from different institutions, but students must prepare and sign all the required documentation themselves.

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

3. Rover system requirements

Each rover must be compliant with requirements listed below to take part in the Challenge. Any non-compliance would cause disallowance to use the rover during field trials. It is highly recommended that Teams present this compliance in Technical Reports in transparent way.

3.1. General requirements

The rover has to be a stand-alone, mobile platform. No cables or tethers are allowed for connection to external sources during its operation.

Teams must design and build their own rover, but COTS (Commercial-Off-The-Shelf) components are allowed.

3.2. Rover weight

The weight limit for the rover during a Task is 50 kilograms. The limit 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.

If the rover will be lighter than maximum limit for every kilogram below limit a 0.5 point will be added to the score for each Task separately (but no more than 10 points). If a limit is exceeded, 1 point will be subtracted for every kilogram (but no more than 20 points). For scoring purposes, kilograms will be rounded upwards.

3.3. Rover speed

The rover maximum speed should be not higher than 3 km/h.

3.4. Rover control and operational range

The rover should be radio controlled, 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 be no farther than 50 meters from the control station area. All communication equipment, including antennas, should be deployed in vicinity of control station.

3.5. Rover autonomy

Rover autonomy or automation of single Tasks are not required but bonus points, specified in Task description, will be awarded for it.

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

- “start” command - command to be send at the beginning of the attempt;
- “working” state - nominal work during attempt;
- “wait” command - enter “wait” state. Team can use it at any time for sensor readings stabilization;
- “waiting” state - rover should wait still for “resume” command. This state should be automatically entered if rover reaches check-point. System should be prepared that during this state sensors can be obstructed by Judge or Team members presence in rover vicinity (e.g. checking distance to the check-point). Operator cannot influence a system during this state. Reaching this state do not stop Task time;
- “resume” command - transition from “waiting” to “working” state;
- “stop” - rover immediate stop - control can be switched to manual.

This list is not exhaustive and Teams can define additional states and commands.

In order to achieve points for autonomy or single Task automation, Teams can not touch the controls once the attempt begins. The only exception is to send commands listed above. If Team members touch the controls, then the autonomy points for that attempt will not be awarded. However, Teams may revert to manual control to complete the Task. Telemetry to monitor the rover operation could be received during autonomous operations.

3.6. Emergency stop button

The rover shall be equipped with an easily accessible red emergency stop button. It must be highly reliable and immediate. Therefore, an unmodified, commercial off-the-shelf, emergency stop button is required. The button action has to isolate the batteries from the system. If an unsafe event occurs, Judges will hit this button.

3.7. Communication requirements

3.7.1. General

Radio communication with the rover has to use legally available frequencies and legal power levels. ERC expects that maximum distance between rover and control station would be less than 100m.

3.7.2. Typical frequencies accepted by ERC

3.7.2.1. Radio amateur bands

Accepted bands up to 1 W signal transmitted to antenna and up 10 W EIRP (Equivalent Isotropic Radiated Power).

0144.000-0146.000 MHz

0430.000-0440.000 MHz

1240.000-1300.000 MHz

5650.000-5850.000 MHz

Remark 1: ERC highly recommends that each Team should have at least one member with radio amateur license CEPT class T/R 61-01 (<http://www.arrl.org/files/file/cept-ral.pdf>). If there is no radio amateur with this license type in the Team and the Team wants to use radio amateur bands, they can ask radio amateur from ERC Team for help, but any action (any transmitter switching) using this frequencies should be accepted by this radio amateur first.

3.7.2.2. WiFi 2.4 GHz

Accepted channels: 1-13 (2412 MHz – 2472 MHz) up to 100 mW EIRP

Remark 1: At 2.4 GHz band ERC accepts WiFi communication standard only. We do not accept other systems like analog video cameras or RC controllers. System must be ready for connection and operation in 802.11g WiFi standard.

Remark 2: Teams should be careful about maximum RF power limit of 100 mW EIRP. For example: if robot uses 10 dB gain antenna, then it can use up to 10 mW RF feeding signal.

Remark 3: At 2.4 GHz band rover can use only one 20 MHz WiFi channel, and it will be selected by Judges (depending on the current occupancy and time).

Remark 4: SSID name should be set to “<erc_teamname>”.

3.7.2.3. WiFi 5.6 GHz

Accepted channels: 52, 56, 60, 64, 100, 104, 108, 112, 116, 120, 124, 128, 132, 136, 140 (5260 MHz – 5700 MHz)) up to 100mW EIRP.

Remark 1: If Team uses WiFi frequencies (for example for RF video transmitter or for WiFi communication), it should be ready for changing frequency to another channel.

Remark 2: If Team uses WiFi technology its SSID name should be set to “<erc_teamname>”.

3.7.2.4. ISM bands

Remark 1: It is possible to use ISM bands (https://en.wikipedia.org/wiki/ISM_band) within their RF power limitations (typically 1 or 10 mW) but Team must show which Polish regulation they use (in Poland there are several regulations in this subject and those depend on different RF power limits, modulation, usage area etc.)

Remark 2: ERC does not accept ISM bands used in USA which are not accepted in Poland (e.g. 915 MHz).

3.7.2.5. For voice communication using 500 mW PMR licensed transceiver

Channel Frequency (MHz)

1. 446,00625

2. 446,01875

3. 446,03125

4. 446,04375

5. 446,05625

6. 446,06875

7. 446,08125 - reserved for organising team

8. 446,09375 - reserved for organising team

3.7.2.6. Other frequencies

Any other frequencies are possible if Team has licenses for those and those licenses would be accepted by RF communication Judge. However, powers and frequencies will be limited to those proposed by ERC in order to ensure fair play competition with other Teams.

3.7.3. Other communication rules

Remark 1: Before the Competition, rovers and ground stations must be checked and accepted by radio communication Judge after passing EMC (electromagnetic compatibility) test.

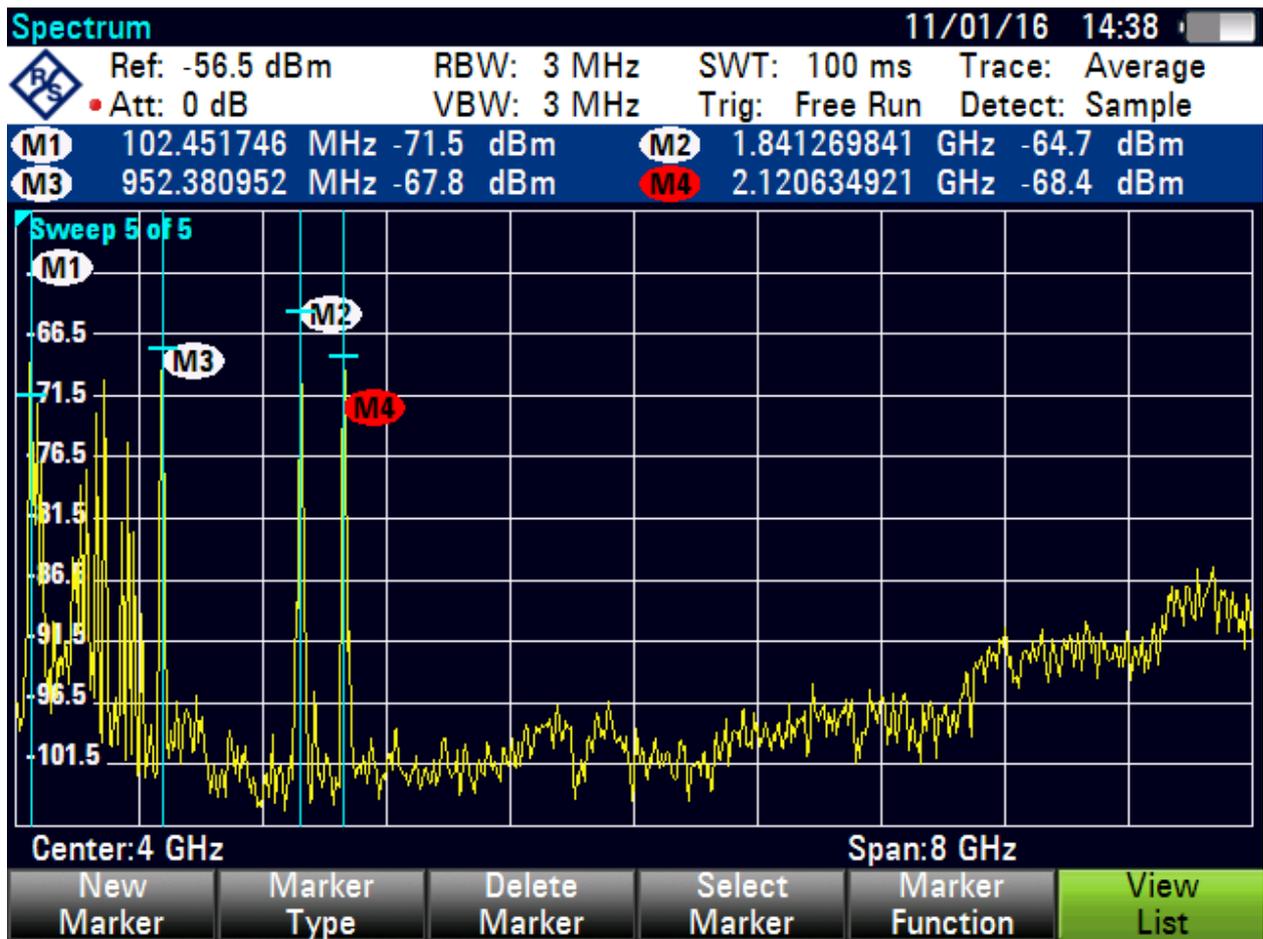
Remark 2: During Competition, rovers and ground stations will be randomly EMC tested. Unauthorized changes to the RF configuration may result in disqualification.

3.7.4. Radio Frequency Form

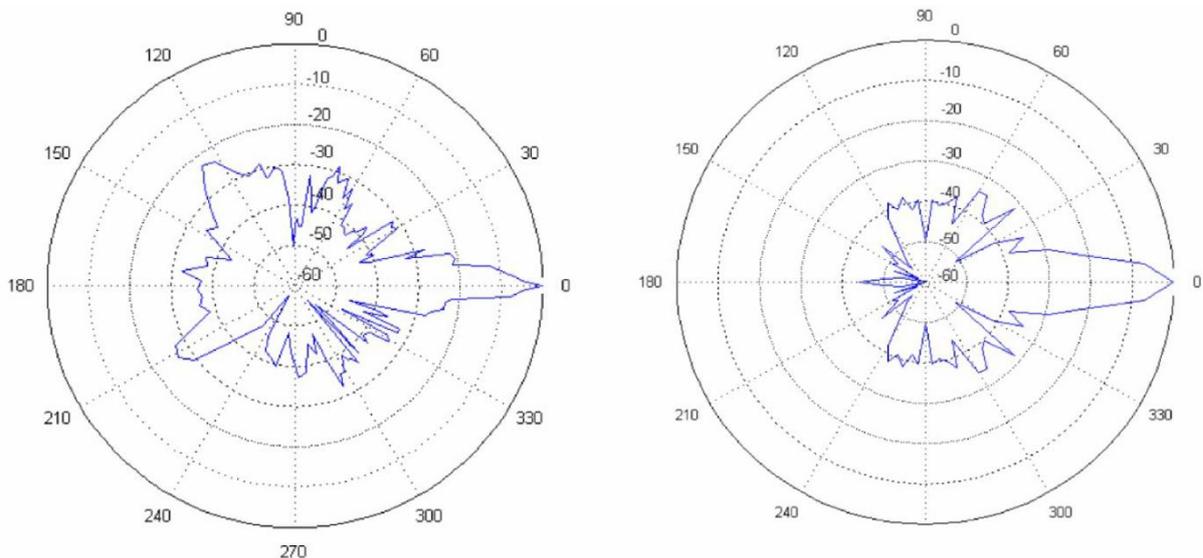
Each Team must fill Radio Frequency Form for any RF module used. It shall be included in relevant Technical Reports as an appendix (see 4). If these documents are not submitted in the form, Team will not be allowed to participate in the Challenge.

RF Form shall contain:

- a) Team name;
- b) Country;
- c) How many different communication system will you use?;
- d) Name of the person responsible for communication system;
- e) Contact to the person responsible for communication system (e-mail address);
- f) Photo of the rover;
- g) Photo of the ground station;
- h) System information (multiply this part for any RF system):
 - RF system name;
 - Frequency;
 - Bandwidth;
 - RF transmit power;
 - Modulation;
 - Short description.
- i) RF spectrum analyses when all systems (on rover and ground station) are on. Spectrum analyses must be measured from 100 kHz up to double frequency + 1 GHz used by Team (for example if highest band used is 2.4 GHz, Team has to measure pattern up to $2.4 \times 2 + 1 = 5.8$ GHz);
- j) RF spectrum analyses in the same frequency range when all systems are off;
- k) RF antenna radiation pattern for rover;
- l) RF antenna radiation pattern for ground station.



Pic. 1.: Example of the RF spectrum analyses



Pic. 2.: Example of the Horizontal and Vertical RF antenna radiation pattern for ground station

Remark 1: It is advised to measure RF spectrum analyses and antenna radiation in RF anechoic chamber but it is not obligatory.

Remark 2: If Team provides RF form after deadline, they will be not frequency coordinated. ERC will prepare special competition time window (typically in the morning, which is highly unpopular time) for uncoordinated Teams. Team still has to be checked by ERC (for passing RF regulations) before the Competition starts but if Team would be causing interferences for other uncoordinated Teams it will be not fixed.

Remark 3: For the whole duration of the ERC Challenge, the Team is responsible for the legal use of frequencies in Poland. ERC can only help in frequency coordination, but does not take responsibility for any license violation (may it be exceeding RF power, frequency band or area of use).

Remark 4: If Team has not enough experience to estimate/measure such properties, it is highly recommended to consult this point with specialists from your or cooperating institution with such specialisation.

3.8. Budget requirements

Nett cost of the rover cannot exceed 15 000 Euros. If expenses are paid in another currency, the exchange rate from **January 20th 2016** should be used. The cost limit applies to payments for rover parts, equipment and any paid work done on the project (e.g. paid services, paid work hours). It does not include tools, volunteer work and Team travel expenses.

Teams may have sponsors or donors who provide them with money, tools, parts or equipment. Such donations and sponsorships must be properly documented and included in the rover cost balance. If Team receives tools, parts, equipment or any other asset that is not cash, standard market value must be used when calculating its value.

4. Documentation

4.1. General

Each Team shall provide a technical documentation which will cover following topics:

- a) management;
- b) technical design;
- c) safety;
- d) financial.

The documentation is divided into three parts. The first set of information, called Proposal, shall be submitted with the registration form (see 2.2). The second, called Preliminary Report, shall be submitted until **May 5th** and the last, called Final Report, shall be submitted until **August 25th** to the Organizer.

The documentation is intended to be a substantial set of information describing a project and giving a clear image on how the project is being managed and developed until a beginning of the Competition.

Furthermore, the intention of documentation is to motivate the Teams to develop their project according to the standards widely used in space industry. The Organizer wants to emphasize quality management, strategy of development and risk management topics. The intention is to improve quality of the rovers and minimize a risk of occurring simple and obvious errors and mistakes which might negatively impact on the projects. The work-flow of the three phases shall present how you manage the project, how you work on systems and subsystems and how you solve problems/issues. Please note that the documentation is not

intended to be a big paper with lot of excessive information. The documentation should be “from engineers to engineers”.

4.1.1. Proposal (max 30 points)

Proposal should introduce Team and contain information why project presented by the Team should be chosen for ERC2016. It should confirm that Team read, analysed and understood system requirements (rules of the Competition).

In the Proposal the Teams shall include following information:

- a) Reasons why you want to attend the ERC2016 (substantial information are welcomed) (max 7 points);
- b) Team introduction contains information about Team’s experience (e.g. short people profiles, other projects etc.) (max 3 points);
- c) Initial project assumptions and initial technical requirements (max 10 points);
- d) Your realistic expectations (“what Team really wants to achieve?”) (max 10 points).

Requirements:

- a) First page: Team name, project name, heading “European Rover Challenge 2016”, affiliation, title “Proposal”;
- b) Format: A4, searchable PDF;
- c) Length: max 6 pages (including a title page);
- d) Language: English;
- e) Appendixes: no.

4.1.2. Preliminary report (max 50 points)

This document should be written after analysis and design phase, what means that Team should present in it idea how to solve presented problems under limits and boundaries listed in requirements and additional identified by a Team. Document should also contain (management and system) breakdown of the project and chosen technologies and technical solution to achieve goal.

The Preliminary Report shall include following information:

- a) Project assumptions (compare them with those presented in the proposal, if changed, please describe why and how changes have an impact on the project) (max 10 points);
- b) Technical requirements definition (compare them with those presented in the proposal, if changed, please describe why and how changes have an impact on the project; make a full list of your technical requirements and present the way you want to fulfill them) (max 10 points);
- c) Present technologies you want to use, designs you have and you are working on (at any stage) (max 5 points);
- d) Pre-final System Breakdown Structure (pSBS) (max 5 points);
- e) Safety Systems description (max 5 points);
- f) Present preliminary budget (financial) (max 5 points);
- g) Present problems and issues you are facing (management, engineering, logistics, etc.) and how you solved them and/or plan to solve (max 5 points);
- h) Pre-final Radio Frequency Form (pRFF) (as an appendix, see 3.7.4 for details) (0 or 5 points).

Requirements:

- a) First page: Team name, project name, heading “European Rover Challenge 2016”, affiliation, title “Preliminary report”;
- b) Format: A4, searchable PDF;
- c) Length: max 20 pages (including a title page);

- d) Language: English;
- e) Appendixes: yes (optional; only additional information which could not be included in main document, for example: drawings and charts).

4.1.3. Final report (max 60 points)

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 project after manufacturing and testing phase:

- a) Final project assumptions (fixed) (max 10 points);
- b) Final technical requirements (fixed) (max 10 points);
- c) Final design (max 20 points):
 - System Breakdown Structure (SBS) + description;
 - System architecture;
 - Operational scenarios;
 - CAD drawings (2D, 3D, dimensions, assembly, details);
- d) Safety Systems description (max 5 points);
- e) Final budget (max 5 points);
- f) Difficulties and solutions applied (max 5 points);
- g) Final Radio Frequency Form (RFF) (as an appendix, see 3.7.4 for details) (max 5 points).

Requirements:

- a) First page: Team name, project name, heading “European Rover Challenge 2016”, affiliation, title “Final report”;
- b) Format: A4, searchable PDF;
- c) Length: max 30 pages (including a title page);
- d) Language: English;
- e) Appendixes: yes (optional; only additional information which could not be included in main document, for example: drawings and charts).

4.2. Promotional video (max 30 points)

Each Team shall prepare a promotional video, which must be completed and submitted by **July 28th**. The file should be submitted in MP4, MOV or AVI format with information about any necessary codecs to view it. The Organizer will provide an FTP server to which the video file must be uploaded. If the promotional movie is not submitted in the correct form (or it is not playable by Organizer) and within the time laid down, Team will not be allowed to participate in the Challenge.

Promotional video shall be 3-5 minutes long and shall present rover’s capability to take part in the Challenge and it shall contain following elements:

- a) Introducing Team name, Rover name, and the higher education institution name (1 point);
- b) Introducing the Team members and their responsibilities (max 3 points);
- c) Introducing the reasons for proposing the Team to the Challenge (max 3 points);
- d) A presentation of a safety systems (including emergency stop button) performance (max 4 points);
- e) A presentation of remote control ability (max 4 points);
- f) A presentation of rover’s ability to ride and operation of manipulation subsystem (max 8 points);
- g) Quality and proper visual aesthetics value of the movie and presentations skills (max 7 points).

4.3. Official statement

By providing the Organizer with the design draft, technical specification, other data, promotional materials and visuals (e.g. photos and videos), the Teams indicate they agree to any and all of this data being stored and processed in the Organizer's computer systems.

Teams grant permission to the Organizer 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.

On the other hand, the Organizer will keep all technical documentation confidential and will not publish or disclose it to third parties without the express approval of a Team's representatives. The sole exception to this is the Challenge Jury – technical documentation will be disclosed to the Judges for scoring purposes only.

5. Field trials

5.1. General

- a) The Challenge Tasks take place before an audience;
- b) Challenge Tasks are independent. Teams will be permitted to change 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;
- c) The Challenge Jury consists of a number of specialists selected by the Organizer. While judging the Challenge the Jury acts independently of the Organizer, but they will adhere to the schedule provided by the Organizer. In case of an unforeseen by the Competition Rules issue, Jury will adhere to the rules to be announced reasonably in advance and provided on the Challenge website.

5.2. Schedule

- a) The Challenge will take three days;
- b) On the first day, Teams shall register themselves at the Challenge location;
- c) Field tasks are held on the first, second and third day. The non-field Presentation Task is held at some point during that two day period;
- d) On the third day, at the end of the Challenge, Team total scores are computed, winners announced and the prizes awarded. Additionally, for all Teams but especially for those which are planning to automate part of the Tasks, one day before Challenge begin - Warm-up Day - is planned to calibrate and test their systems;
- e) Detailed schedule, containing also the exact time window for each Task, will be specified by the Organizer **one week before** the Challenge in preliminary version and final one **on the first day**;
- f) Schedule is rigid – no Team is allowed to exceed the permissible time limit or postpone task's time window. A certain amount of time will be scheduled in between Tasks to allow Teams to modify, repair and optimize their rovers.

5.3. Challenge site details

- a) All Challenge Tasks will be organized indoor under huge openwork, glass-covered dome (follow Challenge website (see 1.3) about venue details);
- b) Organizer will provide a map of the Challenge area no later than at the first day of Competition with all reference points;
- c) The Organizer provides each Teams' site with tables, chairs and a power strip with four 230V, 50Hz standard Polish sockets (type E, generally compatible with 'German' type F);

- d) The spaces will be numbered and assigned to Teams through a draw for the whole duration of the contest;
- e) Challenge location will be separated from Teams area to avoid RF interferences;
- f) The Challenge field, where field Tasks will be held, will be artificially landscaped specifically for the Challenge. Sandy, non-cohesive soil as well as hard, dry terrain should be expected. The rover should be built to handle such terrain including appropriate dust resistance and a temperature tolerance of at least 10 to 30 degrees Celsius.

5.4. Operations

- a) Teams will control their rovers from rover control areas designated for them on site. The areas will be set up so that Team Members will not see their rover during the tasks;
- b) Each Team will have maximum 25 minutes (if Task description does not state different) to complete each Task;
- c) Each Team must designate two Observers, who will be allowed to follow the rover at a safe distance to ensure the machine's basic safety, but the Observers will not be allowed to communicate with the Team Members in the control area. Observers must be able to carry rover but they should stay in safe distance from the working machine and cannot interfere with any rover's sensors (e.g. be visible on the image from the camera) during realisation of the Task attempt;
- d) During tasks only Judges and Team's Observer can access field of the task. No manual intervention is allowed except events for which Task rules stand different;
- e) Any maintenance made by the Team during Tasks (any operations made by the crew/Team with rover's hardware in the field) causes starting the Task from the beginning and cancellation of the all earned points;
- f) The Team can use video systems to navigate the rover if Task requirements does not state different;
- g) The Team shall not use any voice/visual communication with the crew in the field. No radio/internet/other communication is allowed. The Judge will be equipped with radio communication system which Observers can use to contact with the rest of the Team in operation center;
- h) The Team has the right to interrupt 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;
- i) During whole Challenge any rover as well as any part of system infrastructure must not do harm or interfere with systems of the other Teams. Any reports about such activities will be checked independently by Judges or Organizer and violation of this rule can cause disqualification from Challenge;
- j) Any erratic behaviour of the rover causing damage of Task infrastructure can result with immediate interruption of the Task attempt and cancellation of collected points.

5.5. Tasks descriptions

5.5.1. Science task - geology

The aim is to obtain three samples of "Martian soil" - a rock/stone, a surface soil and a piece of deeper soil - each taken from different locations selected by the Organizer. The Team has to transport the samples to the finish line where they will be measured by Judges. In the bonus part Team must perform several additional Tasks such as taking photos of samples, measuring samples, making excavation, etc.

5.5.2. Goals

- a) Reach sampling areas pointed by Judge;
- b) Collect 3 geological samples from terrain:
 - a piece of rock (a stone), weighing at least 100 grams - suggested extraction method: grasp;
 - a sample of loose surface soil, weighing at least 200 grams - suggested extraction method: scoop;
 - a sample of deeper soil (15cm below surface), weighing at least 25 grams - suggested extraction method: drill;
- c) Bonus: prepare photographic documentation;
- d) Bonus: weight samples on-board;
- e) Bonus: measure dimensions of the rock sample;
- f) Bonus: collect several measurements of samples or sampling area that could be valuable for planetary science;
- g) Bonus: excavate trench;
- h) Deliver samples to the start line.

5.5.3. General requirements

- a) Rover must have at least one sample containers mounted;
- b) Samples should be delivered in dedicated containers, one container for each sample;
- c) Containers can be manipulated and removed from the robot only in the company of Judge;
- d) Bonus: The minimum resolution of the image part covering the sample/sample area is 800x600 pixels. Image quality should be reasonable for scientific needs;
- e) Bonus: rock dimensions should be measured in two perpendicular directions with accuracy of 5mm;
- f) Bonus: Any additional physical parameters must be documented in the Control Site and stored till the final Judge's inspection after Task time elapsed. Judge will decide if the parameter can be used in planetary science;
- g) Bonus: Trench should have minimum 30cm length and minimum 5cm depth and at least one wall will be steep presenting clearly visible layers documented on a photo.

5.5.4. Expected results

- a) Delivered samples with correct weights in separate (sealed) containers;
- b) Results of in-situ measurements of the samples and sampling area;
- c) Photographic documentation showing different aspects of samples and operations;
- d) All data reported to the Judge;
- e) Presentation of innovative methods of samples extraction and measurements.

5.5.5. Additional information

- a) Every additional manipulation of the containers/samples (like adding material, shaking/hitting rover etc.), not done by the rover tools during Task, will be the basis to cancel all points for this Task;
- b) Teams are not required to follow the sample extraction method suggested in the Rules;
- c) After the rover returns to the start line, each sample will be judged and weighed;

- d) The Team will decide which rock will be collected, set of various sizes will be present on site;
- e) Judges will verify sampling depth based on the sample's color (soil color will differ depending on depth), according to a reference key;
- f) Bonus: points will be scored if additional functionalities of rover will be demonstrated during Task. All necessary equipment to meet the bonus point awarding rules must be attached to the rover itself, no part of additional equipment can be operating standalone;
- g) Bonus: The collected deep soil sample must be clearly visible in undisturbed state at least before the sample will be stored in the container. It's possible to use core sampler as a container if it will be completely separated from the manipulator or other part of the rover and safely placed in the predefined point on the rover.

5.5.6. Scoring (max 100 points + 100 bonus points)

- a) Rock [100g] - for every full 10 grams less, a 1 point will be subtracted from maximum 10 points pool. Additionally, if the weight will be correct and sample is correctly placed into container 10 points will be awarded (max 20 points);
- b) Surface material [200g] - for every full 10 grams less, a 1 point will be subtracted from maximum 15 points pool. Additionally, if the weight will be correct and sample is correctly placed into container 10 points will be awarded (max 25 points);
- c) Deep soil [25g] - For every full 1 gram less, a 1 point will be subtracted from maximum score. Additionally, if the weight will be correct and sample is correctly placed into container 20 points will be awarded. Any recognizable amount of the sample collected, will be awarded by 5 points (max 45 points);
- d) Delivery of at least one sample to the start line (0 or 10 points).

5.5.6.1. Bonus points

- a) Images of each sampling location or sample just after the collection will be worth 3 bonus points (max 9 points);
- b) Collected samples can be weighed on-board rover after collection with the accuracy of +/-2g, 5 points for each sample (max 15 points);
- c) Two measurements of dimensions of one of the collected rock (max 10 points);
- d) Storage of the samples in closed or sealed containers, max 7 points for each sealed container (max 21 points);
- e) Several additional physical measurements, samples or sampling area that could be useful in planetary science - reasonable parameters with reasonable accuracies, 3 points each (max 15 points);
- f) Excavation of regular trench - any excavation method is allowed and at least one wall steep and clearly visible documented on a photo (max 15 points);
- g) Collection of undisturbed core of deep sample - sampling device must enable easy visibility of collected sample to check state of the sample (max 15 points).

5.6. Maintenance task

The maintenance task is intended to demonstrate rovers and Teams ability and performance in operating electrical rack units where several switches and other electrical components are mounted. The Team has to use rover's manipulating subsystem to set switches to correct positions, measure electrical parameters, set other panel controls and observe device feedback. These units are placed in two different locations, thus mobility capabilities in fine positioning of a rover are also necessary to achieve a goal.

5.6.1. Goals

- a) Presentation of operator-rover coordination in fine manipulation task;
- b) Approach 1st panel;
- c) Set switches in correct states;
- d) Measure voltage on panel terminals;
- e) Approach 2nd panel;
- f) Turn designated switch on;
- g) Set knob to desired value;
- h) Bonus: grasp the plug from the ground and insert it to the socket.

5.6.2. General requirements

- a) Switches and other controls will be industrial grade elements;
- b) Switches can be lever or rotation type;
- c) Controls can be located on vertical panels between 0.2m and 1.5m above the ground;
- d) Voltage measurement is conducted on standard German type F/French type E similar (https://en.wikipedia.org/wiki/AC_power_plugs_and_sockets#CEE_7.2F3_and_CEE_7.2F4_.28German_.22Schuko.22.3B_Type_F.29) power socket or terminals with similar dimensions and connection requirements;
- e) Measured voltage level is between 1.0VDC and 24.0VDC;
- f) Voltage should be reported with 0.5V accuracy;
- g) Knob display/scale can placed not further than 15cm around it;
- h) Bonus: simplified (see 5.6.4.) plug type IEC 60309 with 10cm max grip diameter.

5.6.3. Expected results

- a) Panel 1: switches set to correct positions and voltage measurement reported to the Judge;
- b) Panel 2: switch set to on position and knob adjusted to desired position;
- c) Bonus: plug inserted to the socket.

5.6.4. Additional information

- a) Bonus: approach for automatic realisation of one of the goal points can be done from position where desired element is seen in sensors range and manipulating equipment is minimum 20 cm in front of the element;
- b) Bonus plug is a simplified high-power 3 phase cylindrical plug (https://en.wikipedia.org/wiki/IEC_60309). Simplification is done by removing all coding element what means that plug can be inserted with different orientations around connection axis. Additionally, gripping point will be modified to have partially flat surface with high friction coefficient.

5.6.5. Scoring (max 100 points + 50 bonus points)

- a) Panel 1: Turn the required switches on – 10 points per switch, 4 switches. (max 40 points);
- b) Panel 1: Plug into the measurement socket/connect with terminals (0 or 10 points);
- c) Panel 1: Voltage measurement (max 10 points):
 - reported with 0.5V accuracy – 10 points;
 - reported with 2V accuracy – 5 points;
- d) Panel 2: Turn switch on (0 or 10 points);
- e) Adjustment of specified value with use of the knob (max 20 points):
 - set with tolerance of 1 unit – 20 points;

- set with tolerance of 2 units – 10 points;
 - set with tolerance of >2 units – 0 points;
- f) Excellence in manipulation - can be awarded only if one of the above listed Tasks was successful (max 10 points):
- no collisions observed - 10 points;
 - minor collisions with infrastructure elements - max 9 points;
 - multiple collisions with infrastructure elements or violation of Task infrastructure integrity - 0 points.

5.6.5.1. Bonus points

- a) Any (except c)) mandatory Task done automatically (max 20 points);
- b) Bonus plug inserted to the socket (max 30 points).

5.7. Assistance task

This Task is intended to demonstrate rovers and Teams ability to perform a delivery task. The Team has to pick a part up and deliver it to a destination and put it there in a correct orientation, then return to a start line and deliver a report on performed mission. If a mandatory mission is done on a decent level, the Team is allowed to attend a bonus part, in which the Team must bring a part from a field to the start line.

5.7.1. Goals

- a) Reach a spot where a part is located;
- b) Pick the part up and demonstrate rover's performance of steady handling for at least 10 seconds;
- c) Transport the part to a location where it has to be delivered;
- d) Leave the part in a proper position and orientation;
- e) Take a photo of the part in the final location and deliver the photo to a Judge;
- f) Return to the finish line;
- g) Deliver a report to the Judge. Deliver the photo to a Judge (e-mail, USB stick, printed version);
- h) Bonus: Bring bonus part from hardly accessible area.

5.7.2. General requirements

- a) The rover shall be equipped with a robotic arm (or other device) which can pick up a part.

5.7.3. Expected results

- a) Demonstration of Team's skills of making decisions;
- b) Demonstration of rover's off-road performance;
- c) Demonstration of rover's payload performance (a robotic arm or equivalent) and operator performance in remote control;
- d) Placing the part in a proper position (the Team can expect some pattern or other structure where the part has to be left);
- e) Analysis of performed mission.

5.7.4. Additional information

- a) Proposed handle dimensions: 30 mm (diameter), at least 100 mm (length);
- b) Weight: less than 300 g;
- c) CoG: unknown.

5.7.5. Scoring (max 100 points + 30 bonus points)

- a) Reach a spot where a part is located (0 or 5 points);

- b) Pick the part up (0 or 10 points);
- c) Demonstrate rover's performance of steady handling for 10 seconds - 1 point for 1 second (max 10 points);
- d) Transport the part to a location where it has to be left. To receive points the Team has to be close enough to be able to deploy a robotic arm and the part shall be above the destination (0 or 20 points);
- e) Leave the part there in a proper position and orientation (max 20 points):
 - correct orientation - 20 points;
 - incorrect orientation - 10 points;
 - the part is outside the destination field - 0 points;
 If the part is dropped and fall on the ground, the Team has no right to pick it up. Thus this sub-task ends;
- f) Take a photo of the part in the final location and present it in a mission report (max 5 points);
- g) Return to the finish line (0 or 10 points);
- h) Deliver a mission report to the Judge (5 points);
- i) Extra points might be earned if automated methods are applied. For example a rover can go/return without help of an operator, recognise correctness of object placing or event correct object orientation or position - max if one of b)-e) part is fully autonomous (max 15 points).

5.7.5.1. Bonus points

- a) Reach a destination where a part is located (0 or 5 points);
- b) Pick the part up (0 or 5 points);
- c) Return with the part to the finish line (0 or 10 points);
- d) Extra points might be earned if an autonomy is applied. For example a rover can go/return without help of an operator (0 or 10 points).

5.8. Navigation task

This task is intended to demonstrate rovers and Teams ability of approaching locations on the field with limited or without supervision. The Team has to develop a system which will allow operator to navigate rover without access to visual data such as video streaming, photos and other sensor sources placed on the rover that are presenting visual information. However, any kind of data can be processed on-board to provide to operator localisation and operation support information. The smart navigation strategy, sensor fusion and image data processing are essential in this task.

5.8.1. Goals

- a) Reach sequentially 4 check points (A > B > C > D);
- b) Bonus: reach additional point located in more challenging terrain;
- c) Present advanced techniques in navigation, data presentation, on-board processing, etc.

5.8.2. General requirements

- a) Navigate rover, without information from imaging systems, using information detailed on the map and data received from the rover;
- b) Rover starts from the start point with orientation perpendicular to the start line;
- c) Any kind of sensor (i.e. camera, lidar, IMU, odometer, sonar, etc.) can be used for on-board processing. However GNSS receivers are not recommended since the navigation task will be performed indoor (under glassy roof adjacent to concrete building) which may result in limited access to GNSS signals and/or strong multipath effects;

- d) All data from imaging systems (camera, laser scanner, etc.) shall be processed on-board (i.e. cannot be broadcasted to the control room). However, derived information (e.g. result from image recognition algorithm) can be provided to the control room;
- e) If for some reason rover has to be moved, it can only be moved (penalties applied):
 - back to the last safe position (assistants define it) and/or rotated towards any point;
 - back to the last successfully reached check-point and/or rotated towards any point;
 - back to the start point.

5.8.3. Expected results

- a) Reach all check-points;
- b) Presentation of system that support operator in rover control;
- c) Bonus: reaching check-point X;
- d) Bonus: successful autonomous traverse between at least two check-points.

5.8.4. Additional information

- a) Technical Reports shall include a list of all sensors together with detailed information about working modes, ways they are used in navigation task and which data will be presented to the operator. Teams are entitled to consult all solutions with Judges before documentation submission. Documentation will be verified by Judges and in case of any doubts Team could be asked to reconfigure devices and/or communication strategy. Any difference between approved configuration and the one used during Challenges can cause a disqualification (0 points for this task);
- b) Task arena:
 - Final map with grid coordinates and POIs (Point Of Interests) will be provided not later than 3 days before the Competition;
 - Most landmarks will be visible from starting point but it must be taken into account that part of them could be obscured by terrain or other objects during traverse;
 - Two types of landmarks are foreseen: natural landmarks which are elements of landscape placed on the map, e.g. craters, small embankments, hills and artificial landmarks, e.g. artificial points for localisation purposes with characteristic hi-visibility labels with characteristic logotype, unique geometric figure and alphanumeric sign matching POI label on the map;
 - Artificial landmarks will be visible for camera from different direction on a field and will have physical base which can be detected by proximity/range sensors (e.g. placed on element of infrastructure or natural landmark);
 - Check-points will be flat characteristic elements with similar labels like on artificial landmarks;
 - Final definition of the check-points and landmarks will be provided not later than 30 days before the Competition;
 - Team cannot place any additional passive landmarks or active beacons on challenge field outside starting area but such elements can be deployed using rover during trial. All those landmarks must be documented in Technical Reports and presented for Judges acceptance at least 10 working days before submission of the final documentation. These equipment can be subject of negotiations so Teams should leave enough time to redesign/modify it in case of comments/rejection by Judges. Such equipment must comply with other rules of the Competitions (especially 5.4 i)) and if active radio beacons are

used, they must be compliant with radio communication rules (see 3.7) and described in RF form;

- c) Rover can be stopped and moved/rotated by Team members when it is stuck or in case of any other technical problems. Judge has to be informed before any action is undertaken;
- d) During Task attempt several photos of the current state of the Field will be delivered to the Team by Judge. Photos will be delivered periodically but the frequency does not allow Team to accurately navigate their rover. Photos will be taken from static position (in perspective, top-view or both) and can be used to correct control methodology by operator or control software;
- e) Details of the task such as landmarks appearance, location, map format, allowed custom landmarks and beacon types etc. will be discussed with the Teams and presented in the FAQ during registration and preliminary design phases. Teams are encouraged to initiate, take a part and follow outcomes of those discussions.

5.8.5. Scoring (100 points + 50 bonus points)

- a) Reaching the control point: $25 - (5 * \text{floor}(d))$ points, where d is a distance (in meters) between an actual control point and nearest element of the rover structure. The rule is only applied if $d < 5\text{m}$. Distance will be measured on request after Team (or rover software) declares reaching a given check-point. The measured distance will be provided (without any other indications) to the control site. (max 25 points).
- b) **Penalties**
 - In case that measured distance between the current control point and rover is equal or greater than 5m, Team will be asked for another attempt. Once the distance is less than 5m no other attempts (to minimize distance) are allowed - rover can go to the next control point (-5 points);
 - Moving rover back to the start point, the last successfully reached check-point or the last safe position (-5 points);
 - Any non-authorized communication between assistants and control site (-25 points).

Total score for this task cannot be less than zero

5.8.5.1. Bonus tasks

Judge must be informed in advance - before Team proceeds to the optional task.

- a) Reaching the hardly accessible check-point marked by X (the same rules as for the regular A,B,C,D points are applied) - bonus check-point can be reached either in a way from A to B or from B to C (max 25 points);
- b) Autonomous traversal (max 25 points):
 - Autonomous traversal from start point to check point A – 5 points;
 - Autonomous traversal from A to B or A to X or X to B or B to C or C to D – 10 points (no more than 2 traversals will be scored).

Distribution of bonus points for autonomous traversal can change according to the final definition of the operational area.

5.9. Project review – presentation

The presentation Task lets Teams to introduce themselves and present their projects. The Judges expect to learn how the Team worked on the project, what kind of technical solutions are implemented in the rover and how the Team solved problems and issues during development. The Team should be also prepared for Q&A session.

5.9.1. Goals

- a) Introduce Team and project;
- b) Present organization structure, management methods and work-flow;
- c) Present an engineering approach;
- d) Present technical design;
- e) Present difficulties occurred and applied methods to solve them.

5.9.2. General requirements

- a) Time for presentation is limited to 15 minutes and after that time presentation will be interrupted immediately;
- b) Q&A session takes 10 minutes;
- c) The Team can use a projector provided by the Organizer (VGA connector as a standard, other connectors might be available);
- d) The Organizer does not provide a computer;
- e) Presentation must be conducted in English;
- f) Presentation can be done in any format and creativity is welcome.

5.9.3. Expected results

- a) Demonstration of Team's presentation skills;
- b) Detailed information on: key-drivers which influenced the Team to build exactly this design, engineering approach, system breakdown structure, management, difficulties and solutions;
- c) Scientific/engineering inventions.

5.9.4. Scoring (max 70 points)

- a) Introduce the Team and the project (max 3 points);
- b) Present organization structure, management methods and work-flow (max 8 points);
- c) Present an engineering approach (max 8 points);
- d) Present a technical design (max 9 points);
- e) Present difficulties and solutions (max 8 points);
- f) Present how the project was promoted (max 4 points);
- g) Bonus: Overall impression (presentation style) (max 10 points);
- h) Bonus: Generated IPR, possible applications and implementations of developed technology/ies, research (max 15 points);
- i) Information about computer aided design tools/methods applied to development process (max 5 points).

6. Schedule summary

Event	Date
Rules publication	Jan 20th
Registration start	Jan 20th
Registration end	Mar 31st
Preliminary Report	May 5th
Qualification	May 13th
Video	Jul 28th
Final Report + RF form	Aug 25th
Warm up day	Sep 9th
Competitions	Sep 10-12th

- registration Sep 10th morning
- closing ceremony Sep 12th late afternoon

7.Awards

The award for 1st place, Grand Prix ERC, is a cash award. Smaller cash awards will be given for the 2nd and 3rd place. The award amounts will be announced on the Challenge Website.

The Organizer will also give a separate Special Bonus Award to the Team with the highest number of bonus points. The form of the award will be specified on the Challenge Website.

The Organizer may also announce other awards and allow awards funded by third parties. Third party award funders must have the Organizer's approval.

8.Miscellaneous

8.1. Changes to Competition Rules

The Organizer has the right to extend the deadline for submission of documents and provide essential but inevitable changes to the Competition Rules. However, introduced changes cannot concern the key issues for the rover's design. All introduced changes will be reasonably announced in advance and provided on the Challenge website.

8.2. Deadline extension

The Organizer has the right to extend the deadline for submission of documents and announce it reasonably in advance and provide on the Challenge website.

8.3. Q&A

Answers to any Challenge related questions that arise will be provided on the Challenge website. If you have questions, contact the Challenge Contact Point (see 1.3.).

The Organizer will provide 'European Rover Challenge 2016 Questions & Answers' as a part of the Competition Rules. All arrangements contained therein are ultimately binding – even if they change the Competition Rules. FAQ will be reasonably announced in advance and provided on the Challenge website.

8.4. Challenge scoring issues

Any and all issues with scoring during the Challenge shall be resolved solely by the independent Jury (i.e. Challenge Judges). Teams may not appeal to any other party.

8.5. Organizational issues

Organizational issues, including: Team eligibility, Challenge organization and the execution of Jury decisions, shall be resolved by the Organizer.

8.6. Challenge issues

Should there arise any conflict related to the Challenge, the Organizer's decision shall be considered final and binding.

8.7. Disqualification

The Organizer may disqualify a Team in the event of a serious breach of Rules or fair play.

8.8. Personal data storage

Team Members agree to their personal data being stored and processed in the Organizer's computer systems. They also give the Organizer, parties designated by the Organizer 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. Personal data and information about Team Members other than their names and surnames will not be published.

8.9. Team members' responsibility

Teams and Team Members accept sole responsibility for securing and insuring the safety of their equipment and luggage in the Challenge location. They indemnify and release the Organizer of any responsibility in the event of damage, destruction or theft of any property.

8.10. Organizer's responsibility

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