TEACHING PLANETARY GEOLOGY TO ENGINEERS DURING EUROPEAN ROVER CHALLENGE (ERC)

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European Rover Challenge (ERC) is an international robotics competition in which teams complete tasks analogous to those performed by rovers on the surface of Mars and the Moon. The project aims at stimulating and supporting a new generation of engineers by developing competencies, skills, and networks within the space sector. It is organized in Poland by a group of volunteers through the European Space Foundation. Each year ERC is associated with a large science-outreach event and a conference for the representatives of the space industry in Europe. The first edition was in 2014 in Checiny. The 2020 edition was the only major robotics competition that took place during the time of the global pandemic.

Fig. 1. Mars Yard developed for the ERC 2020 as seen on one of the drone photos provided to the teams. Compare it with the examples of geological maps prepared by the teams in fig. 2.

Competition: ERC2020 was a remote competition and its main part took place on 11-13 September at the campus of the Kielce University of Technology (same as 2019 edition: [1]). Teams were operating a robotic arm (by universal-robots.com/products/ur3-robot/) and a rover provided by ERC (developed by LeoRover.tech). Most of the competition took place at a Mars Yard (Fig 1.): a 40x30 m area designed to represent a variety of geological features of the Martian Jezero Crater that will be investigated by the Perseverance Rover.

Competition consisted of 4 tasks (detailed instructions are provided here: roverchallenge.eu/en/competitor-zone/)

- Presentation: introduce the team and present their rover project in an informative and interesting way.
- Science: described in detail below (Science Task).
- Navigation: navigate safely through Mars Yard and visit all prescribed waypoints (their locations were provided just before the traverse).
- Maintenance: use a robotic arm to set switches to the required positions and plug a variety of devices into proper sockets to demonstrate the ability of teams to perform in unknown conditions and flexibility and dexterity in tele-operating the manipulation device.

Science task: The aim of the science task was to prepare and execute a simple science-driven exploration plan of the Mars Yard (at the same time as the Navigation Task). The task was designed to mirror scientific activities performed before and during planetary missions. Because of that most of the work was expected to be done before the mission based on the "remote sensing" data. Required activities were like ones performed during analog Mars missions: DRATS [2], MARS2013 [3], MARS2015 [4], AMADEE-18 [5].

The science task was divided into two parts:

Science Planning (submitted 1 week before the ERC):

a) Preparing a geological map based on drone images and the Digital Elevation Model of the Mars Yard.

b) Describing geological evolution of the Mars Yard.

c) Identifying a location on the Mars Yard where photographic observations from the surface may help to validate a geological model of the Mars Yard based on remote sensing observations. Cameras were the only scientific instrument available on the rover.

d) Formulating a hypothesis and describing a plan to test it in the field.

Scientific Exploration (submitted up to 2 hours after the traverse through the Mars Yard during the ERC final):

a) Verifying hypothesis described in the Science Planning phase including appropriate photographic documentation.

b) Discussion of how this new knowledge influences the understanding of the geology of this area along with an amended geological map.

c) *Ad hoc* science: within the Mars Yard we have distributed a number of "interesting objects" such as: a 1:1 cast of a Morasko meteorite, a range of minerals and rocks, an artificial "Martian" flower, and even a ceramic bowl shaped like a flying saucer. Teams were expected to find, photograph, identify, and mark on the map 5 of those objects. The aim of this task was to ensure they pay attention to their surroundings during the traverse.

The results of science task competition: Each report was read and graded by 7 judges that after a panel discussion decided about the scores and prizes.

Science Planning phase: out of the 33 teams that qualified to the final, 25 delivered their science plan before the ERC. Teams can be divided into two groups – those that performed poorly (13 of them received <60%), and those that performed well (5 teams got 85-90%) or very well (2 teams >90%). Relatively few teams (5) were in the broader middle 60-85% zone. Most of the lowest scoring groups had failed to create an acceptable geologic map (fig. 2) but did slightly better in the "hypothesis" task. Interestingly some of the best teams proposed unexpected (by judges) but conceivable and coherent interpretations of the geologic history of the provided area (e.g., the ridge in the north that was intended to simulate a rim of a large crater was suggested to be a glacial moraine – other features were also analyzed assuming a post-glacial landscape). This variety of interpretations made us very proud and happy 😊.

Scientific Exploration phase: 26 teams delivered their reports (one more than in previous phase). The distribution of the grades was different than during the Science Planning phase and followed a normal distribution:7 teams got <60% of points what suggests they did not understand the task correctly; two teams received between 85-90%; two teams got >90%.

The quality of reports produced by some of the teams was exceptional. And it was even more impressive once we learned that some of the teams had only a very limited background in geology and consisted mostly of engineers.

Evaluation by teams: After the ERC we have performed a survey to learn about the team members' experience. In line with our assumptions most (37%) of respondents stated that the most difficult task was defining a falsifiable hypothesis. Open-end explanations clarified that they understood that this task not only required a true understanding of the geological evolution of the Mars Yard, but also a high level of insight into the uncertainty that should be associated with every element of a geological model. Interestingly though majority (~40%) of respondents indicated that the most valuable in terms of the learning experience was preparing a geological description of the area – probably because it allowed teams to re-think and confirm/stabilize understanding of geological evolution of the area that they gained during the preparation of the geological map.

Conclusions: We demonstrated that robotics competition that includes a properly constructed scientific task, develops new skills related to mapping, understanding the morphology and geology – also within people of purely engineering backgrounds. However, in the future we also recommend teams to include at least one geologist (earth scientist). This proves that events such as European Rover Challenge can serve as a tool for building understanding between scientific and technical communities in space science. And that it is possible to accomplish all of it in a fun and involving way: most of the respondents stated that through exercise they gained a new level of understanding of planetary geology and they plan to recommend future editions of the competition to their friends.

References: **[1]** Karahan et al. 2020. European Rover Challenge (ERC) – An Annual International Robotics Competition in Poland. LPSC 2020 Abstract # 2188. **[2]** Eppler et al. (2013) Desert Research and Technology Studies (DRATS) 2010 science operations: operational approaches and lessons learned for managing science during human planetary surface missions. Acta Astronaut 90:224–241. **[3]** Losiak et al. (2014) Remote Science Support during MARS2013: Testing a Map-Based System of Data Processing and Utilization for Future Long-Duration Planetary Missions. Astrobiology 10.1089/ast.2013.1071. **[4]** Lalla et al. (2019) Laboratory analysis of samples from the AMADEE-18 Mars analog mission in the framework of the Exploration Cascade. Astrobiology doi.org/10.1089/ast.2019.2038. **[5]** Groemer et al. (2016) The AMADEE-15 Mars simulation. Acta Astronautica 129: 277–290.

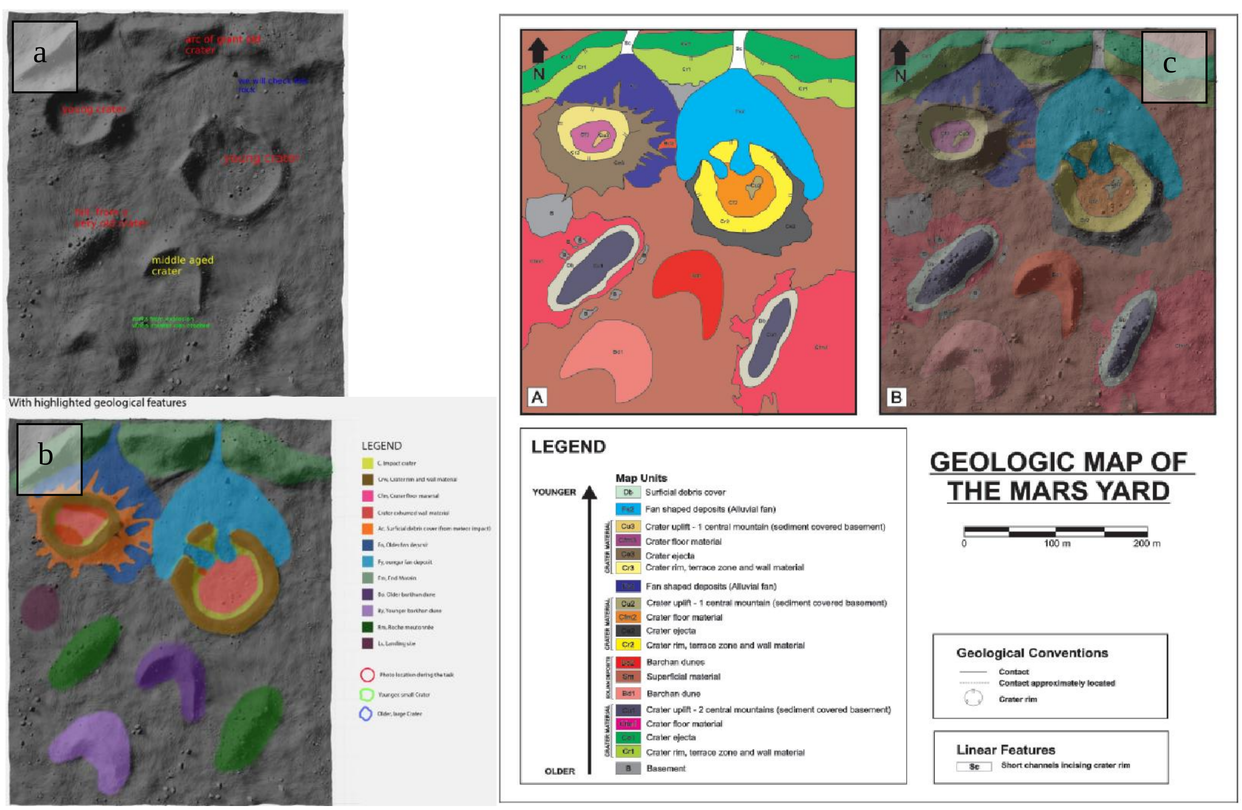

Fig. 2. Examples of maps prepared by different teams as part of the ERC2020 competition: a) an example of one of the unsuccessful attempts in preparing a geological map made by annotating some of the features on the provided DEM; b) an example of a map that was graded in a lower-middle range – note that some of the features were correctly identified and outlined while others are missing and that some places are just unclassified at all, the map legend is rudimentary and does not clearly indicate age and genetic relationships. C) a nearly perfect example of a geological map of the same area.