**Lessons Learned - A students' approach to designing a rover for an analogue Mars mission**

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1. **Introduction**

Space analogue missions are multitask field tests conducted in conditions similar to those found in extraterrestrial environments. As such, various competitions simulating Martian analogue missions are held every year all around the world to test student-made designs in field conditions. Students are given an excellent opportunity to gain experience in engineering as well as learn the basis of teamwork and project management.

The Students’ Space Association has been participating in analogue rover mission competitions since 2010 with its first rover design ‘Skarabeusz’ (‘Scarab’), developed since 2008. Since then five more rovers have been designed, constructed and tested, with several refinements (including complete redesigns) implemented as a response to constantly evolving competition rules. However, on account of the specificity of being a student project, the team have been undergoing numerous changes along with the rover design itself. A constant rotation of team members forces a student team to adapt a specific approach to the system design process, a process that should remain immune to losses of knowledge and experience. This paper summarizes our team’s technical experiences gathered during developing systems as a part of a multidisciplinary project that is fully managed by students in their spare time.

1. **Systems’ overview**

The rover project consists of the following systems: power, control, communication, autonomy, vehicle, science module and manipulator. While working on each system the team encountered a number of unexpected issues. The vehicle system consists of the running gear (propulsion, gearboxes, suspension), wheels, frame and electronics compartment (including the rover’s accumulators). The correct tuning of the suspension elements was carried out during tests of the assembled rover. Simple and widely accessible manufacturing methods mitigated the risk of workshop delays. The control system allows to send commands to the rover and relies on a communication link that has to be capable of real-time, with least delay, operating and video stream from on-board cameras. Connection reliability is especially difficult in hilly terrain. The autonomy system allows the rover to operate autonomously deciding upon its actions on data from several sensors and cameras. Its development was particularly difficult and the team had to face many complications such as lack of standardization and modularity in the previous design, that the new one was based on. The on-board power system uses a set of Li-Ion accumulators, the type and capacity of which have been developed since the early rovers’ projects (2008). The light accumulators can be recharged quickly, coupled into multiple sets to power different systems and safely transported in airline hand luggage for the analogue missions. A manipulator, the rover’s robotic arm, was designed to perform multiple tasks connected with widely understood remote operations, such as transporting tools or using switchboards. The main idea for this is to use rovers as a replacement for humans, especially in life-hazardous environments (Moon, Mars, Chernobyl Nuclear Power Plant). Excessive exploitation of the arm led to the deformation of crucial parts, consequently resulting in lack of operating precision. This is being constantly assessed during maintenance and the constant introduction of mechanical ameliorations. During the design process of a science module, which is a specialized on-board laboratory, a substantial issue were the unexpected workshops' refusals to manufacture elements designed as non-complex and machine-compatible (as seen from Team’s perspective).

1. **Conclusions**

Despite being a strictly student project, the Martian rover is a valuable opportunity to start the involvement in the space industry, gaining professional and scientific experience and learning-by-doing education. More details, references and thorough information on the introduced improvements in the project’s systems are to be presented in the final paper and the presentation. The management aspects of the rover project is a subject of another SECESA work.