LUNAR SURFACE SCIENCE AND EXPLORATION: A HIGHLIGHT FROM THE ESA-ESRIC SPACE RESOURCES CHALLENGE. M. Battler, M. Cross, K.V. Raimalwala, H. Burd, M. Pitropov, G. Landry, V. Van Decker, C. Gilmour, C. Kinney, M. Faragalli. Mission Control Space Services Inc., 162 Elm St. West, Ottawa, ON K1R 6N5, Canada, melissa@missioncontrolspaceservices.com.

Introduction: In 2022 Mission Control Space Services Inc. (Mission Control) had multiple opportunities to demonstrate and test our rover-integrated software with interfaces and user tools for the scientific exploration of analog environments. Here we provide an overview of our participation at the ESA-ESRIC Space Resources Challenge.

Demonstration at the ESA-ESRIC Space Resources Challenge

2021 Challenge. In 2021, Mission Control was selected among 13 teams to compete in the Space Resources Challenge organized by the European Space Agency (ESA) and the European Space Resources Innovation Centre (ESRIC) in Luxembourg [1]. The challenge took place close to ESA's ESTEC facility in the Netherlands, in November 2021. With a strong team well-versed with lunar rover operations, our team was selected among the top 5 teams to move on to the second phase of the challenge, which took place at ESTEC in Luxembourg in September 2022.

2022 Challenge – Overview and Objectives. The second phase of the Challenge required a 2500 m^2 region of interest (ROI) to be explored, mapped, and prospected for resource potential within 4 hours. The ROI was set up as a south lunar pole analogue with challenging lighting conditions, and various features of interest to investigate. A 2.5-second latency in each direction and random communications drop-outs were incorporated to emulate a lunar mission scenario, allowing judges to evaluate the approaches taken by teams to handle the communications challenges.

Figure 1: *The analogue terrain at the European Space Resources Innovation Centre (ESRIC), used for the second phase of the ESA-ESRIC Space Resources Challenge in September 2022*

The challenge asked teams to accomplish 5 science objectives and 5 Technology objectives. The science objectives were related to finding resource-rich deposits and boulders placed in unknown locations, characterizing their distribution and composition, and providing images at appropriate scales. The technology objectives were to provide a Digital Elevation Model (DEM), demonstrate ability to continue operations during signal loss, demonstrate ability to navigate obstacles, demonstrate user-friendly operator interfaces and collaborative operability with additional robotic elements.

2022 Challenge – Development and Operations. As a software-focused company, Mission Control entered the Space Resources Challenge with a baseline solution based on three elements:

- Focus on operations software technology and strategies based on our Mission Control Software platform for mission operations (Fig. 2)
- Rigorous practice and operational readiness by the team, leveraging our easily accessible indoor lunar analogue testbed.
- Pur baseline technology development rover platform that consists of reliable COTS hardware components: the Clearpath Robotics Husky, NVIDIA Xavier developer platform, a Pan-Tilt-Zoom camera, and Zed-2 stereo camera.

Figure 2: *A screenshot of the Mission Control Software operations interface used in the challenge, highlighting how distance estimation tools were used by the team for evaluating decisions for navigation and instrument targeting.*

To further address the science and technology objectives, Mission Control also incorporated instruments from key partners:

- The mWABS, a compact, next generation, 2-axis scanning LiDAR, from Canadian space robotics and sensing company MDA, and
- The L3VIN LIBS (Laser Induced Breakdown Spectroscopy) from US-based Impossible Sensing.

The L3VIN also includes a context camera for co-boresighted micro-imagery.

Both payloads, mWABS and L3VIN, are compact for lunar rover applications and are being developed for flight missions. Each payload required customized data visualization within Mission Control Software, shown in Figs 3 and 4, which was enabled by the flexibility of the platform.

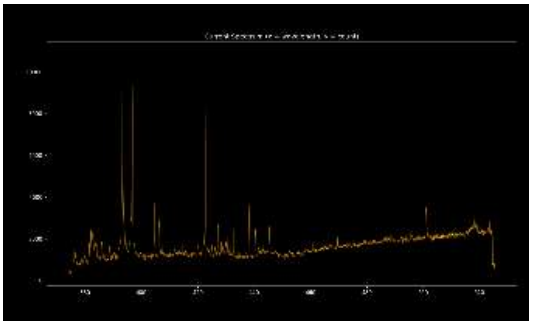

Figure 3. *A sample spectra chart from the L3VIN LIBS instrument by Impossible Sensing.*

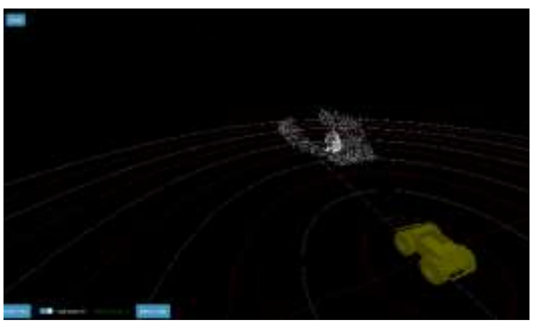

Figure 4. *A sample point cloud from the mWABS LiDAR by MDA.*

Mission Control developed a mapping tool that also integrated with Mission Control Software for generating and visualizing the 3D environment (Fig 5). The map was auto-populated with data labels when measurements were captured during the mission.

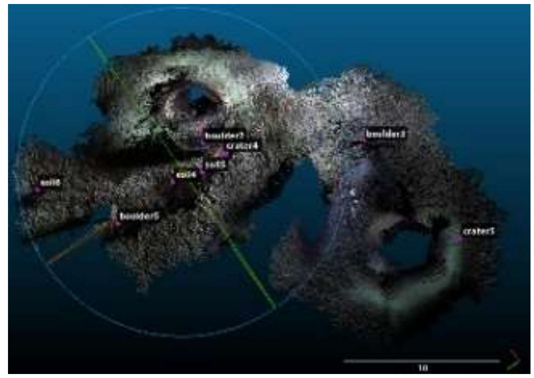

Figure 5. *A map generated from a traverse at ESRIC.*

All systems testing was conducted in Mission Control's Moonyard, our indoor lunar analogue terrain. The Moonyard is reconfigurable, contains representative lunar analogue samples and terrain features, and has representative lighting conditions. Using Mission Control Software, our team would frequently and iteratively test the system under operational parameters at the Moonyard, including a lunar communications emulator that allows for control of time delays, bandwidth restrictions and network dropouts, and to practice operational procedures under expected Challenge conditions.

Mission operations for the Space Resources Challenge were conducted by a team of five team members on site and three remote participants demonstrating the utility of remote and distributed mission operations with Mission Control Software. The team members exhibit high levels of conscientiousness, which is a key indicator of team success, and have a shared value of open, honest, and clear communications, and share a passion for pushing the boundaries of interdisciplinary teamwork.

Summary

Through the ESA-ESRIC Space Resources Challenge, Mission Control demonstrated easy-to-use operations software with in-built tools for streamlining rover navigation and instrument operations alike in a lunar rover science investigation and prospecting scenario.

References: [1] Battler et al. (2022) *LPSC LII* #2951.