IMPROVEMENTS AND TELECONTROL OF THE EXOGEOLAB LANDER IN ANALOGUE ENVIRONMENTS. A. Lillo[1,2,4], B.H. Foing[1,2,3], G. van der Sanden[1,2,3], L. Dubois[1,2,4], E. Clavé[1,2,4], P. Evellin[1,2,5], A. Kołodziejczyk[1,2], C. Jonglez[1,2,4], C. Heinicke[2,3], M . Harasymczuk[1,2], L. Authier[1,2,4], A. Blanc[1,2,4], C. Chahla[1,2,5], A. Tomic[2], M. Mirino[1,2], I. Schlacht[2,3,6], S. Hettrich[7], T. Pacher[8], [1]ESA/ESTEC & [2]ILEWG (PB 299, 2200 AG Noordwijk, NL, Bernard.Foing@esa.int), [3] VU Amsterdam, [4] ISAE-SUPAERO Toulouse, [5] ISU Strasbourg, [6] Extreme Design, [7] SGAC, [8] Puli team

Introduction: The ExoGeoLab Lander has been developed at ESA/ESTEC in the frame of ILEWG task groups [1-5], at first as a competitor for Google Lunar X-Prize. The lander is composed of a hexagonal body with an aluminium frame, supported by three legs. It is equipped with a rover deployment hatch and ramp, and its modular payload includes UV-VIS, NIR and Raman spectrometers, environmental sensors, a telescope and various cameras. These instruments can be remotely operated from a laptop connected to the lander via a WiFi network, and through Internet from anywhere in the world.

Figure 1: Fully equipped ExoGeoLab lander deployed on the lunar analogue area at LunAres base in July 2017

Goals: The ExoGeoLab Lander was designed with off-the-shelf components as a small class prototype to demonstrate how remote operation of scientific instruments can be used jointly with Extra-Vehicular Activities (EVA) on the Moon or Mars. For that purpose, the Lander is easily transportable to analogue environments like the LunAres facilities, allowing realistic operation on site and from remote control station. The three main goals associated with this project are science (geology/spectrometry, astrophotography), technology (remote control), and ergonomics (joint operation with astronauts).

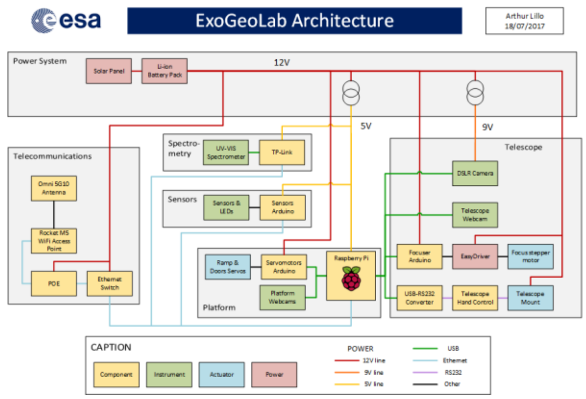

Figure 2: New architecture of the ExoGeoLab Lander

Technical improvements: Over 2016 and 2017, the Lander's architecture was updated with the latest Raspberry-Pi technology [6-8], allowing development of a robust, modular and user-friendly interface for remote control. On the ground station side, teleoperation relies on the community-supported software K-Stars Ekos. With these improvements, the computerized telescope can now perform astrophotography and take pictures of remote geological features. Moreover, the webcam attached to its motorized mount can be used for panoramic context or to remotely follow the activities of a rover or an astronaut all around the Lander. Visual inspection of the Lander is also possible with this system. The high level of modularity in the architecture allows the addition of USB-compatible scientific instruments, like off-the-shelf environmental sensors mounted on an Arduino board.

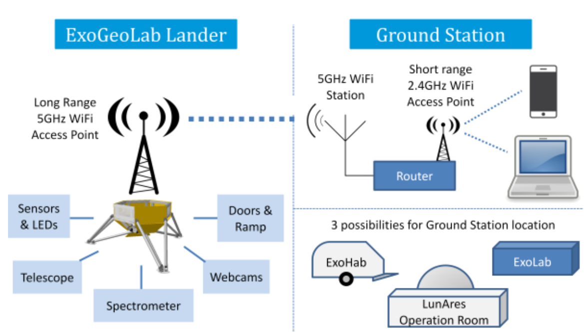

Figure 3: ExoGeoLab telecontrol architecture

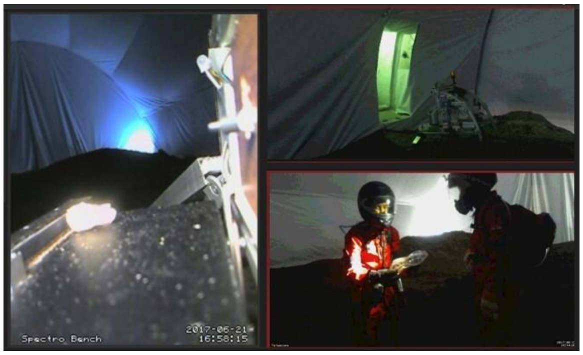

Figure 4 Livestream recorded at ESTEC during remote operation, showing spectrometer bench, UNAM-PMAS robot and PMAS astronauts in the LunAres analogue environment

EuroMoonMars campaigns at ESTEC and LunAres: in the frame of the EuroMoonMars Workshop set in July 2017, the ExoGeoLab Lander was deployed on an analogue simulation conducted at ESTEC. The UV-VIS spectrometer, the telescope and an electric drill, all of them connected to the Lander's platform, were remotely operated from the ExoHab module while analogue astronauts brought rock samples and calibrated the instruments. In August 2017, the Lander was deployed in the Moon/Mars analogue environment of the new LunAres base in Piła, Poland [9-12]. It was operated by the astronauts of the PMAS mission and remotely from ESTEC, where spectral and environmental data are processed, along with videos of the EVAs captured by the cameras onboard.

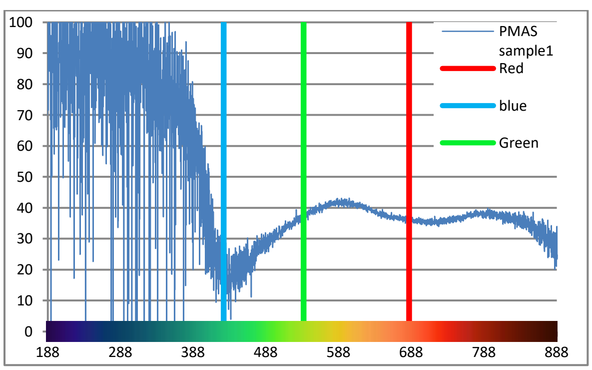

Figure 5: Spectrum of a rock sample found by PMAS astronauts, spectroscopy performed remotely from ESTEC while ExoGeoLab lander was at LunAres base

Developments: The protocols written to guide analogue astronauts on the use of ExoGeoLab instruments were tested on field and will be corrected according to the feedback of both the astronaut team and the mission control team. In particular, the remote control of the spectrometer has to be improved, since only three spectrums are exploitable on seven recording attempts. Moreover, during the EuroMoonMars and the LunAres campaigns the telescope was not used extensively, except for orientation of the webcam mounted on it, since EuroMoonMars was performed during the day and the LunAres base is an enclosed area. For proper use of the telescope in open areas, the next step in the development of the ExoGeoLab lander involves the improvement of the Go-To function, with the addition of a computer-vision algorithm using the webcam to do wide-field identification of bright objects like the Moon, Sirius or Jupiter.

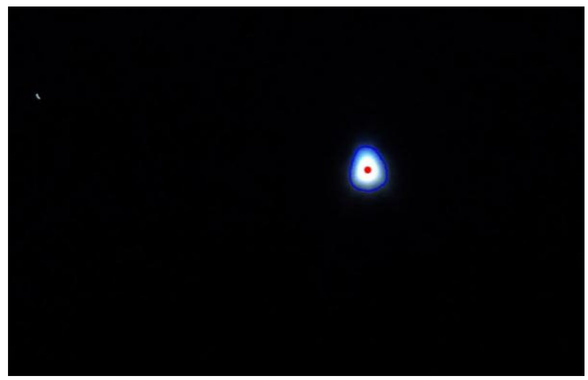

Figure 6: Contour and center detection on a picture of the Moon taken with the webcam on the telescope's tube

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