

Two years of ESA PANGAEA-eXtension analogue campaigns in Lanzarote for testing technologies and operational concepts for field geology and lunar exploration

L. Bessone¹, F. Sauro^{1,2}, S. J. Payler¹, ¹Directorate of Human and Robotics Exploration, European Space Agency, loredana.bessone@esa.int, ²University of Bologna, Italy

Introduction: After the successful implementation in the last years of the CAVES and PANGAEA training programmes, ESA decided to develop and offer to internal actors, partner agencies, and external investigators analogue test campaigns focused on testing relevant technologies and operational concepts for field geology and exploration. These campaigns, called PANGAEA-eXtensions, were implemented in Lanzarote, Spain, immediately following the session of the PANGAEA astronaut planetary geology field training. The unique geological features present on the arid volcanic island of Lanzarote, the presence of lava tubes and the extensive expertise developed within the PANGAEA astronaut training provided an ideal setting. The campaigns were conducted with the participation of European astronauts and the assistance of ESA experts with the specific goal of evaluating potential applications and developments for future mission scenarios and to increase operational relevance of training.

PANGAEA-X 2017: The first campaign in 2017 was focused on two main objectives: testing of technologies and operations for geological and geo-microbiological sampling, and testing of technologies for exploration, mapping, navigation and communication in low lighting conditions, lava tubes and rough terrain. Fifteen experiments were proposed by eleven different research institutions and companies, involving four different space agencies, allowing to develop a testing programme with an ambitious set of inter-related goals, with outcomes applicable either or both to human and robotic exploration. The following research projects have been implemented:

Sampling Sequence with Constrains (SAMCO) and Operation Concept Comparison (OPSCO): the European Astronaut Center tested the use of a combination of instrumentation and protocols to support surface operations concepts for reconnaissance and sample collection on planetary surfaces.

Small Planetary Linear Impulse Tool (SPLIT): a geo rock-splitting tool developed by the Space Research Centre of the University of Leicester.

PANalytical (PAN): analytical XRF and VNIR devices were tested for in-situ analysis of samples taken by the astronauts, also with integration to the OPSCO experiment.

Environment Modelling and Navigation for Robotic Space-Exploration (ENTERN): lead by the DFKI, this research project focused on testing a rover system for exploration of rough terrain such as lava tubes.

Microbiological Sampling Sequence (MICSS) and DNA extraction (DNAX), with the support of the Mobile Procedur Viewer (MOBIPV).

Survival of Bacteria and Lichens on Mars Analogs and Space (SUBLIMAS): The Spanish “Instituto Nacional de Técnica Aeroespacial” investigated the colonisation of lichens in martian analogue geologic settings.

Augmented field Geology and Geophysics for Planetary Analogues (AGPA): a project of the Jacobs University Bremen and DLR with multiple experiments related to planetary geology investigation approaches and analytical tools.

Pegasus backpack (PEGASUS LEICA): Leica Geosystems (France) tested a combined SLAM/LIDAR systems for real-time mapping of lavatubes and rough terrains.

PANGAEA-X 2018: The 2018 campaign concentrated on tele-robotic operations (in the frame of the Analog-1 experiment) and lunar surface EVA operations and tools. The campaign involved different research institutions and companies, performing a total of 18 experiments during five days. The following research projects have been implemented:

Lunar EVA simulation (LEVA): testing of different operational concepts and scenarios for Lunar EVA with specific scientific goals with a Mission Control Centre (MCC)-based Science Team providing direction & support through a Lunar based IV Statio.

Analog 1 preparation (ANALOG 1): preparation and testing of the geologic ground for the Analog-1 experiment in the frame of Meteoron project.

Swarm of robots (SWARMNET): The experiment looked into the human-robot interaction using multi-robot systems with documentation and field geology applications.

Conclusions: The campaign was deemed by all participants a really usefull platform, mainly thanks to the integration in realistic operational scenarios and to the combination of field geology with surface and subsurface human and robotics. The synergies created by the PANGAEA-X campaigns have demonstrated to be extremely useful for ESA in the framework of future human and precursor planetary missions. These campaigns foster the exchange between research institutes, instrument developers and operational experts and thus boost and spin-in synergetically new technologies and research into operations,. Last but not least it provides a continuously increasingly relevant operational growth and novel scenarios for future CAVES and PANGAEA training events.