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THE ROBEX-ASN – A CONCEPT STUDY FOR AN ACTIVE SEISMIC NETWORK ON THE MOON

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1. Introduction

The Helmholtz Alliance "Robotic Exploration of Extreme Environments – ROBEX", brings together space and deep-sea researchers. The project partners are jointly developing technologies for the exploration of highly inaccessible terrains.
The research on the Moon and in the deep sea would answer different scientific questions but should be addressed by a common method (seismic surveys) and technological solution. The overall goal is to develop a combination of a stationary system and one or more mobile elements. The stationary system would provide the energy supply and the possibility to exchange data between the elements and the ground station. The mobile elements will perform the actual scientific exploration in the deep sea or on the Moon.
It is the overarching objective of the ROBEX Alliance is the equipment of these systems with innovative technologies for energy exchange and data transfer. Most processes should be conducted fully autonomously [4]. Science-critical decisions will be made semi-autonomously with Human-in-the Loop.

1. Robotic Exploration on the Moon

In the present study, we are developing the ROBEX – Active Seismic Network (ASN), a new mission concept that aims at conducting geological and geophysical experiments on the Moon with a high-level of autonomy. This will be done by the use robotic rovers to inform about (i) the lunar surface, (ii) the crustal layering, (iii) the deep lunar interior and (iv) the source mechanisms of moonquakes and other natural seismic events. The main goal of the ASN is to perform geological investigations of surface properties and rocks, active and passive seismic studies, and gravity survey on the lunar surface. A first mission design involving two mission phases was developed at the Concurrent Engineering Facility (CEF) at the DLR Institute of Space Systems in Bremen. Two individual landed spacecraft were considered that would provide enough volume for lunar seismology equipment and additional scientific experiments, e.g., gravity measurements, and laser reflectors. Since each experiment is packed in exchangeable module boxes, the ROBEX mission scenario would be able to accommodate the postulated modularity

1.1 Mission Scenario for Active Profile Experiment

The two landers would be deployed on the lunar surface at distance of 10 km. Lander1 would carry an active seismic source (blue star label) to excite seismic waves that are sufficiently intense to probe the lunar crust. Lander2 would carry a mobile element (rover), which is capable to carry, deploy and pick up a seismic sensor over a distance of at least 10 km, thereby obtaining data about the uppermost crustal layers. The rover would leave Lander2 using one of two available ramps. The Geological Context Imager, largely based on the Moonrise Context Imager (MCI) [1] or Lunar PanCam [6] mounted on top of the rover would survey the surrounding on its way to the first profile point. The Geological Context Imager is equipped with a High Resolution Camera and two Wide Angle Cameras for stereo and multispectral observations to perform 3D mapping and multispectral analysis of the lunar surface. The rover would deploy a Remote Unit (RU) for the first measurement. The RU comprises a seismometer with own batteries, data logger, on-board computer, antenna, and solar panel to work autonomously. The source would be fired for each measurement and, according to on-the-fly signal-to-noise evaluation, this process should be repeated in order to stack the signal. Afterwards, the

RU would be picked up again by the rover, and the Geological Context Imager would image the surrounding on its way to the next profile point. The entire process would be repeated several times until the profile is completed [5].

1.2 Mission Scenario for Passive Seismic Array

In addition to the active seismic survey, the mobile element would deploy a Y-shaped array of four seismic sensors for the passive seismic experiment. The array would be built up at a distance of at least 500 m to the lander to reduce equipment induced noise. The array would measure both signals caused by the active seismic source and by natural events such as moonquakes, microseismicity, and meteorite impacts. This array configuration resembles the Apollo 17 Lunar Seismic Profiling Experiment. Natural impacts conveniently could be used as seismic sources, if time and location of these impacts were precisely known from space- or ground-based impact flash observations. The physical properties of the impactor can be inferred from the brightness of the flash and knowledge of the impact velocity. Additionally, confirmation of the impact event is guaranteed by simultaneously monitoring the lunar surface from different observation sites and subsequent search for fresh craters within the area of the impact flash based on spacecraft imaging data. Telescopic observational techniques and impact modeling studies are carried out in a separate work package of the ROBEX research alliance [2, 3].

2. Demo Mission

To demonstrate the feasibility of the concept, it is planned to conduct a demonstration mission in the field in the 2015/2016 timeframe. The objective of the test will be to demonstrate that the intended science objectives can be met with the developed technology, and that the level of implemented autonomy, together with limited human intervention for science decisions, is suitable (and flexible enough) for high-quality science results.

For this purpose, at least one lander and one fully equipped rover (including the Geological Context Imager and a deployable Seismometer package) will be placed in a Moon-analogue environment. Part of the demo mission scenario will be the autonomous deployment of a seismic package by a rover, and a reduced active profile experiment. On the way from the lander to the deployment point of the seismic package, the rover will conduct geological context investigations with its Geological Context Imager. Criteria for a successful demo mission will be (a) the successful autonomous deployment of the seismic package by the rover, and the collection of geological context data on the way, and (b) the successful collection of scientifically meaningful data from both the seismic experiment and the Geological Context Imager.

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