

IAF SPACE EXPLORATION SYMPOSIUM (A3)  
Moon Exploration – Part 2 (2B)

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## FINALLY! INSIGHTS INTO THE ARCHES LUNAR PLANETARY EXPLORATION ANALOGUE CAMPAIGN ON ETNA IN SUMMER 2022

### Abstract

Teams of mobile robotic assets will play important roles in future planetary exploration missions. Plans for upcoming missions for lunar exploration and to other extraterrestrial bodies consider the extensive use of robots to fulfil their scientific and technical goals. Human-robot cooperation will be a key aspect, not only with regard to humans cooperating with robots on surface missions, but also regarding the operation of intelligent robots during different tasks and applications to achieve the mission goals in a safe and efficient manner.

The ARCHES (Autonomous Robotic Networks to Help Modern Societies) project focuses on the development and validation of robotic key technologies to achieve autonomy with a high degree of local perception and task execution capabilities. Besides performing fundamental research, it highlights the advantages of cooperative aspects of heterogeneous robotic teams.

The ARCHES partners cooperate with the ESA ANALOG-1 mission team in order to internationally widen the scope of ARCHES: Both field campaigns will be performed in partnership between the June 13th and July 9th 2022 on Mt. Etna (Sicily, Italy). The analogue mission consists of three parts, focusing scientifically on geological research and radio astronomy, which are relevant scenarios for future exploration activities.

In the first two scenarios, technical and operational aspects of in-situ geological analysis and sample return will be investigated. The first scenario focuses on a cooperative heterogeneous team of two wheeled rovers (LRU1 and LRU2) and a flying drone (ARDEA), which will fully autonomously explore sites of interest and perform scientific-triggered remote spectral imagery, LIBS spectroscopy as well as sample selection, analyses, and collection tasks.

In the second scenario, another robotic asset, the Interact rover, will survey sites via supervisory control from a control room at ESOC (European Space Operations Centre) in Darmstadt, Germany. The focus is on interactions of a trained astronaut with operations and science teams in a control room on Earth, while teleoperating a highly dexterous rover with a robotic arm. Shared autonomy with visual and haptic feedback is used to enhance the astronaut's capabilities when operating the rover. Furthermore, a second scout rover will provide communication links required for haptic feedback of the Interact rover during teleoperation.

In the third scenario, the installation and maintenance of a low-frequency radio antenna array will be demonstrated with the LRU rovers and ARDEA drone. The array consists of four antenna elements and includes a novel technique for precise positioning based on radio communications.