HERACLES CONCEPT – AN INTERNATIONAL LUNAR EXPLORATION ARCHITECTURE STUDY.
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Introduction: In the frame of the strengthening global lunar exploration program as part of the Global Exploration Roadmap (GER [1]) the natural partnership of human and robotic components is looked at as an opportunity to implement exploration-driven missions in the mid 2020ies. This new breed of mission architectures can be expected to prepare sustainable exploration using local resources, and to produce unprecedented opportunities in a wide variety of scientific fields. Advancing the already existing knowledge about lunar polar volatiles requires more capable mission architectures. At the same time, in particular the challenging aspects of accessing, selecting, collecting, and preserving a delicate pristine samples of lunar material (e.g. intact polar volatile deposits), benefits from the less constrained mission scenario compared to an autonomous stand-alone mission [2]. Therefore, there are key objectives from exploration as well as science to study high-capability exploration architectures for the near to mid term.

In the frame of the Human-Enhanced Robotic Architecture and Capability for Lunar Exploration and Science (HERACLES) concept study we assess the enhanced science and exploration knowledge return at equal or lower cost compared to conventional systems that are based on non-robotic unmanned autonomous systems. The HERACLES concept study provides a frame for multiple international space agency members of the International Space Exploration Coordination Group (ISECG) to invest in studies with the objective to define an end-to-end architecture for lunar exploration. The objective of those studies is to determine the performance and requirements of the architecture vis-à-vis the objectives to prepare human lunar exploration, advance scientific and technology knowledge gain and provide opportunities to demonstrate sample return technologies for Mars.

Architecture Elements and Scenario: Since the release of the second revision of the GER the ISECG has advanced the definition of exploration architectures, in particular the near-term extended duration crew missions to a habitat in cis-lunar space (evolvable Deep Space Habitat eDSH). The objective of this phase is to “advance deep space exploration capabilities and create innovative opportunities for exploration of the Moon through human-robotic partnership” [1].

The ESA-lead HERACLES study has yielded a scenario, in which, based on habitation infrastructure installed in cis-lunar space, a robotic surface element is assembled there and landed on the Moon up to four times. On the surface a mid-size rover is available to address the objective to prepare human operations and to provide opportunities for scientific investigations – in particular sampling before returning to the landing site for sample delivery. The reusable ascent stage of the architecture rises from the surface and links up with the eDSH to deliver the samples that are then sent to Earth in a crew vehicle.

The sample return scenario represents the best approach to address the dual purpose of testing relevant technologies and operations in preparations for human Moon missions on one side and to provide high-priority [3] science opportunities on the other.

All elements of the architecture: the ascent and descent stage, the rover, the sample container, the eDSH, the eDSH robotic manipulator system, the tele-operations infrastructure: all are considered representative precursors to or elements of an infrastructure, which enables the third mission theme of the GER: human Moon missions. In the course of the study, the design emphasis on sample return capabilities was reduced in favor of more substantial mobility capabilities of the rover.

At the current manifestation of the HERACLES concept, one rover will cover the traverse between three landing sites (e.g. [4]) within the South Pole Aitken Basin region – representing a distance of hundreds of kilometers . A fourth mission to the lunar South Pole region is considered to deploy a second rover. Its operational capabilities have been extended to safely operate in darkness and to obtain samples from permanently shadowed regions. The first and the fourth landing mission are planned to carry rovers of an estimated mass of 500 kg, leaving a payload opportunity of equal mass open for missions number two and three.

While the main driver for the element design remains the preparation of human exploration capabilities, this architecture scenario – pending programmatic decisions of the participating space agencies - opens up unprecedented opportunities in geophysics, geochemistry, astrophysics, life sciences, and engineering sciences - within the given operational framework. It is intended to discuss these opportunities openly with the appropriate communities.

Way Forward: As the study efforts advance, more definition is added to the architecture with the goal to update the GER in due time showing a human-robotic lunar exploration scenario as one possible design reference mission of the roadmap. It is up to the participating space agencies to take programmatic actions to implement all or some of the elements of the architecture in preparation for the continued, sustainable exploration of the solar system, providing benefits in science, technology, innovation, education, and knowledge for all.

References:

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