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Forward to the Moon with HERACLES

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Abstract

In the context of an accelerated lunar exploration agenda on international level, ESA is ingaging with international partners to enable European roles in the near and mid term. While in the near term opportunities exist in "boots-on-the-ground" human lunar return, ESA continues to prepare the next step in sustainability with the HERACLES (Human-Enhanced Robotic Architecture and Capability in Lunar Exploration and Science): reusability of lunar vehicles, survival of the cold, dark lunar night, mobility, and resource prospecting.

1. Introduction

Several space agencies identified the Moon as a target with large scientific and strategic benefits. Returning to the Moon not only yields fundamentally important science opportunities for our understanding of the Solar System but also allows us to test hardware and operational procedures for the exploration and utilization of space beyond Low Earth Orbit (LEO). The Human Enhanced Robotic Architecture Capability for Lunar Exploration and Science (HEREACLES) is a joint study of ESA, JAXA, CSA and NASA. Thus, HERACLES is an international effort in preparation of returning humans to the Moon and providing opportunities for unprecedented science, utilizing the lunar Gateway. HERACLES will land on the lunar surface, demonstrate surface operations, and will return ~15 kg of lunar samples to the lunar Gateway and from there eventually to Earth by the astronauts. Hence, HERACLES will be a robotic pathway toward sustainable international human exploration of the Moon and beyond. Some of the key objectives of HERACLES include: (1) Preparing for more sustainable human lunar missions by implementing, demonstrating, and certifying technology elements for vehicle reusability, mobility, and night survival; (2) Create opportunities for science, particularly sample return; (3) Gain scientific and exploration knowledge, particularly on potential resources; and (4) Create opportunities to demonstrate and test technologies and operational procedures for future Mars missions. HERACLES will consist of the Lunar Descent Element (LDE, JAXA), the ESA-built Interface Element that will house the 330 kg Canadian rover, and the Lunar Ascent Element (LAE, ESA) that will return the samples to the lunar Gateway. The rover will be powered by radioisotope batteries that will allow for driving more than 100 km and surviving the lunar night. The rover will be partly operated from astronauts on the lunar Gateway while it will be operated for most of the time from Earth. Once landed on the lunar surface, the rover will immediately collect a contingency sample and will then collect additional samples along a ~35 km long traverse. The rover will carry a suite of scientific instruments (expected combined payload mass of 90 kg) that will allow us to comprehensively study the sampling locations and the context of the samples, as well as the geology along the traverse. The instrument suite will most likely include cameras, spectrometers, a laser reflector, and potentially some geophysical instruments (e.g., GPR). After having deposited the samples into the LAE, the rover will go on a >100 km long traverse. The international science definition team (iSDT) is evaluating a suite of potential landing sites, guided by the recommendations of the 2007 NRC report and several subsequently published documents. The list of potential landing sites includes the Schrödinger basin, the Moscoviense basin, Copernicus crater, Jackson crater, and some young basalts in the Flamsteed region. In summary, HERACLES will bridge the gaps between science, exploration and human space flight, and will allow us to accomplish many necessary steps in each of those domains.

2. Science Definition

The international HERACLES Science Definition Team is investigating five landing sites: Mare Moscoviense, Copernicus Crater, Jackson Crater, Young Basalts in the Flamsteed Region, and the

Schödinger Basin. The latter has been selected for the sole purpose of providing engineering requirements for the on-going development phase of the HERACLES elements.

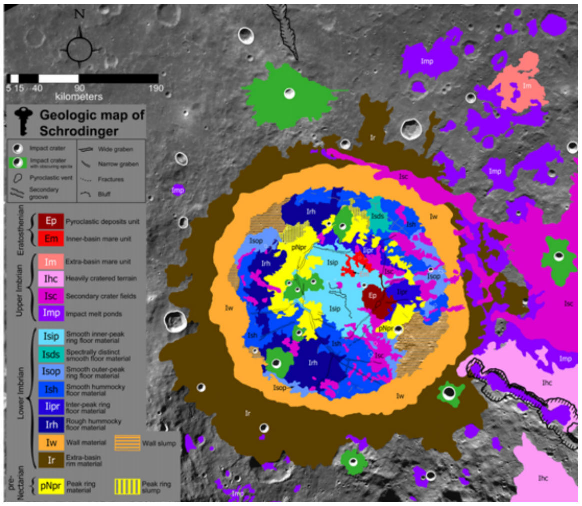

Figure 1: HERACLES reference landing site: the Schrödinger Basin and its Geology (Kramer et al. 2013)

In order to meet the science objectives, the science definition team has agreed on a preliminary science payload, which will have to be comprised of instruments with high level of maturity in order to make the envisioned 2026 launch date. The major payload mass is available on the HERACLES rover: 90 kg (including robotic arm), but there is also an allocation for static payloads on the lander: 15 kg.

Table 1: Preliminary Strawman Payload for HERACLES

Instrument	Young basalts	Anorthosite	Olivine	Volatiles	Interior structure	Other
Camera	•	•	•		•	•
Spectrometer (0.3-0.9 μm, ilmenite)	•				•	
Spectrometer (0.7-3.5 μm, olivine, pyroxene)	•	•	•	•	•	
Spectrometer (7.0-14.0 μm, plagioclase)	•	•	•		•	
XRF	•	•	•			
LIBS	•	•	•	•		
Magnetometer					•	•
GPR	•	•	•	•	•	•
Seismometer					•	•
Radiation dosimeter						•
α-Spectrometer (5-10 MeV, dust, Radon, outgasing)				•		•
Heat flow experiment				•	•	•

The most significant science opportunity of HERACLES lies however in the return of a set of high-quality diverse samples (total mass of 15 kg) from a region of ~30 km around the landing site.

3. Summary

HERACLES is an exiting mission concept that enables Europe to gain access to the Moon and to play a leading role in the international exploration of the Moon. The concept is ambitious but offers enormous benefits particularly by the combination of human and robotic assets on the lunar Gateway. The mission will also allow excellent science from orbit, on the surface, and in terrestrial laboratories once the samples have been returned.

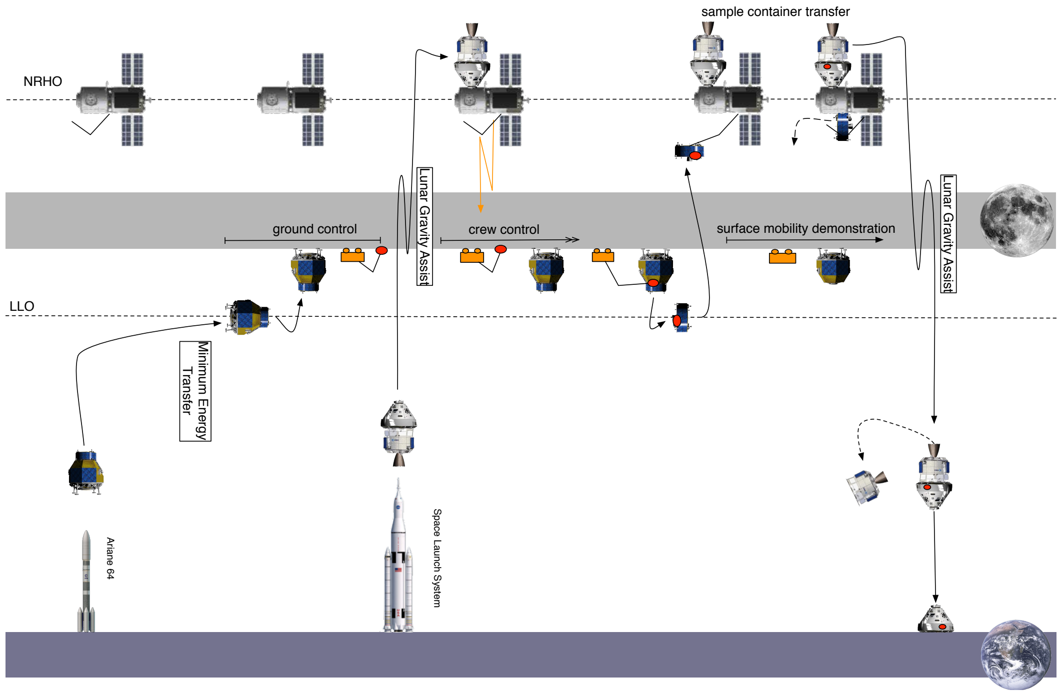

Fig 1: Baseline Mission Operations Scenario (left to right