HERACLES: An ESA-JAXA-CSA Joint Study on Returning to the Moon. H. Hiesinger[1], M. Landgraf[2], W. Carey[2], Y. Karouji[3], T. Haltigin[4], G. Osinski[5], U. Mall[6], K. Hashizume[7], HERACLES Science Working Group, HERACLES International Science Definition Team; [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (hiesinger@uni-muenster.de), [2]European Space Agency (ESA), Directorate of Human Spaceflight and Robotic Exploration Programmes, [3]Japan Aerospace Exploration Agency (JAXA), Space Exploration System Technology Unit, [4]Canadian Space Agency (CSA), [5]University of Western Ontario, Centre for Planetary Science and Exploration, [6]Max-Planck Institut für Sonnensystemforschung, [7]Ibaraki University, Dept. of Earth Science.

Introduction: In the past two decades, the Moon has been attracting the growing interest of space-faring nations for both scientific and exploration goals, resulting in missions such as Chandrayaan, SELENE, the Lunar Reconnaissance Orbiter, and GRAIL. Many fundamental concepts of planet formation and evolution, as well as Solar System bombardment history, have been developed on the basis of lunar samples and remote sensing information. Although they have been applied to other planetary bodies, we are far from completely understanding these concepts. This necessitates returning to the Moon for extended periods of time with orbiters, landers, rovers, and human explorers. Several space agencies have recognized [1] the scientific (and strategic) benefits of returning to the Moon and the opportunities the Moon offers for testing hardware and operational procedures for the exploration and utilization of space beyond Low Earth Orbit (LEO). For example, China as well as Russia have developed programmatic frameworks of several comprehensive lunar missions within the next 10-20 years, ultimately resulting in putting humans back on the Moon. In this context, the Human Enhanced Robotic Architecture Capability for Lunar Exploration and Science (HEREACLES) is an ESA-led international effort to prepare for the return of human missions to the Moon and to provide opportunities for unprecedented science utilizing the lunar Gateway. Currently, HERACLES is a joint phase-A study of the European Space Agency (ESA), the Japan Aerospace Exploration Agency (JAXA), and the Canadian Space Agency (CSA) with NASA and Roscosmos having observer status. HERACLES will land on the lunar surface, demonstrate surface operations, and will return about 15 kg of samples from the surface to the lunar Gateway to eventually be brought to Earth by the astronauts on board the NASA Orion spacecraft. Hence, it is intended as a robotic pathway toward sustainable international human exploration of the Moon and beyond.

Mission Concept: The key objectives of HERACLES include: (1) Preparing for human lunar missions by implementing, demonstrating, and certifying technology elements for human lunar landing, surface operations, and return; (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. To achieve these objectives, proposed HERACLES concept will consist of the Lunar Descent Element (LDE), which will be provided by JAXA, the ESA-built Interface Element that will house the Canadian rover, and the European Lunar Ascent Element (LAE) that will return the samples to the lunar Gateway (Fig. 1). A more detailed description of the engineering aspects of the mission is available in an accompanying paper by the HERACLES Architecture Working Group [2].

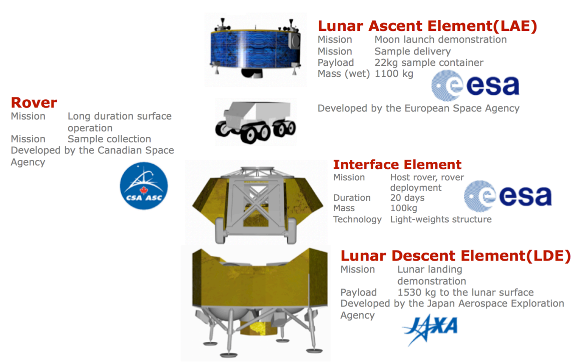

Fig. 1: The elements of the HERACLES mission.

The 330 kg rover will be deployed from the Interface Element via two ramps and will be powered by a radioisotope power system that will enable the rover to drive more than 100 km and to survive lunar night. During particularly difficult operations, the rover will be operated from astronauts on the lunar Gateway while it will be operated for most of the time from Earth (Fig. 2). The current plan foresees that the rover will immediately collect a contingency sample upon landing. It will then collect samples along a

~35 km long traverse from about ten individual sampling stations and will return them to the LAE. The rover will be equipped with 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 international Science Definition Team (iSDT) is currently discussing an appropriate instrument suite, which will most likely include cameras, spectrometers, a laser reflector, and potentially some geophysical instruments. After the samples have been deposited into the LAE, the surface mobility demonstration phase will begin during which the rover will go on a >100 km long traverse with the instruments continuously collecting data while roving. For example, a Ground Penetrating Radar (GPR) could provide an unprecedented view into the regolith structure of various terrains visited by the rover. Similarly, a camera permanently looking at the wheels of the rover could provide us with information on the physical characteristics of the regolith while spectrometers could provide geochemical/mineralogical information along the traverse. The iSDT is evaluating a suite of potential landing sites, guided by the recommendations of the 2007 NRC report [3] and several subsequently published documents [e.g., 4]. 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 [5]. The Schrödinger basin has been extensively studied [e.g., 6-8] and currently serves as a case study to develop mission scenarios and scientific rationales. With a landing in the Schrödinger basin, HERACLES could be the first mission to sample farside material, including potentially South Pole-Aitken material, to sample a basin melt sheet and deep-seated crustal lithologies, and to evaluate the In Situ Resource Utilization (ISRU) potential (also see our companion abstract by [5]). Thus, 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.

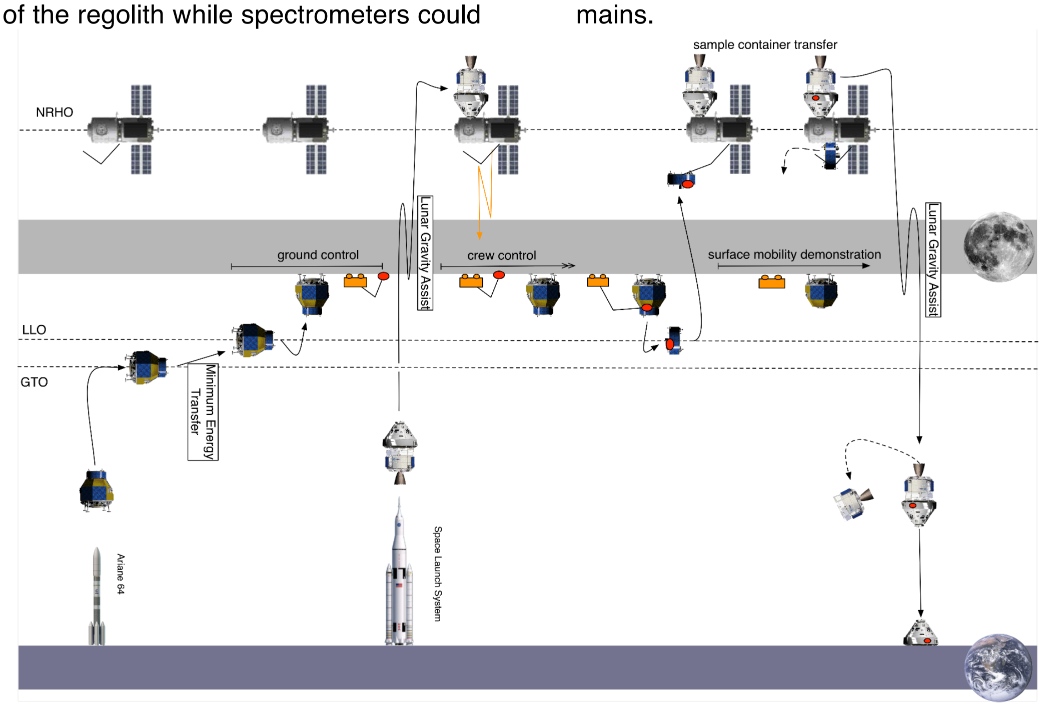

Fig. 2: The HERACLES mission concept.

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