ESA'S JOURNEY TO THE MOON. J.D. Carpenter[1] for the Directorate of Human Spaceflight and Robotic Exploration, ESA, ESTEC, Noordwijk, The Netherlands (james.carpenter@esa.int).

Moon is the next destination: For ESA the Moon is the next destination for human exploration after Low Earth Orbit, where we have learned to work and operate over decades [1]. ESA is now preparing for a return to the Moon for humans. This new era of lunar exploration must be achieved in a sustainable way that delivers benefits to all of humanity. To do this some fundamental capabilities must be established and delivered through partnerships.

The role of in situ resources: While not on the critical path of a human lunar returnin In Situ Resource Utilisaiton is an important capability. Establishing ISRU as a capability for the future requires; 1) prospecting of deposits, 2) technology demonstration, 3) an ISRU pilot plant, 4) full implementation [3]. Through the missions in ESA's exploration roadmap and coordination with partners these steps are being addressed.

Missions: *Prospecting resources.* PROSPECT is package to assess the resource potential of lunar regolith at any given surface location [4]. It heats samples, thermochemically extracts volatiles and analyses them. It can be used to quantify water ice deposits as well as water and oxygen extraction processes from other regolith sources. PROSPECT is in development for first flight on the Rusian led Luna-27 mission in 2022, along with the PILOT precision landing and hazard avoidance system. ESA is coordinating lunar mission plans with other agencies.

Commercial partnerships. ESA is in a pilot phase with two commercial partners for lunar misisons. These commercially driven missions seek to establish robotic surface access, led by the Part Time Scientists [5], and produce a commercial lunar cubesat deployment and communication relay service at the Moon, led by SSTL and Goonhilly Earth Station [6].

Lunar vicinity as a staging post. ESA is providing the European Service Module [7] for NASA's Orion vehicle, to take humans to lunar vicinity. Once there human explorers will crew the Deep Space Gateway [8], humanity's first spaceship, which is currently in preparation by the agencies of the ISS partnership. This craft could be an enabling infrastructure for sustainable lunar surface access.

Demonstrating in situ resource utilization. ESA is targeting a commercially enabled ISRU demonstration mission not later than 2025. This mission would procure commercial access to the lunar surface and communication services to operate an ISRU demonstration payload. The goal of the mission is to demonstrate the production of drinkable water or breathable oxygen at the lunar surface to prepare for a future pilot plant, implemented in the early human missions.

Human surface exploration demonstration mission: In collaboration with CSA, and JAXA, ESA is studying the HERACLES mission (e.g. [9]), which would use the Deep Space Gateway to teleoperate a rover at the lunar surface, retrieve samples and return them to Earth using Orion via the Deep Space Gateway. NASA supports the study in the interfaces with the Gateway and Orion. The mission would de-risk technologies and prepare for the later human missions. A notional traverse, studied in the preliminary mission studies, would be in the Schroedinger basin [10].

The human mission point of departure. In the context of the International Space Exploration Group (ISECG) [11] a notional scenario for human exploration missions is under discussion. This point of departure is used as a means to coordinate strategic planning and identify potential roles and investments. This scenario includes 5 missions and the first long duration human lunar surface mission (~42 days) with long-range mobility and night operations. This would include the demonstration of re-usability (ascender, pressurized rover) and would offer unprecedented opportunities for science and applications.

Summary: ESA is preparing for the new exploration of the Moon, which will be achieved through agency programmes, international partnerships and new roles for the private sector. Driven by the missions in the ESA mission roadmap ESA is working to assure access to the capabilities needed for lunar explorations. This is achieved through technology development, development of flight systems and the establishment of partnerships with international partnerships and the commercial sector.

References: [1] ESA Space Exploration Strategy, http://esamultimedia.esa.int/multimedia/publications/ESA_Space_Exploration_Strategy, [2] www.esa.int/About_Us/Business_with_ESA/Business_Opportunities/Partners_for_Space_Exploration, [3] J. Carpenter et al. (2016) *Space Policy* 37 52-57, [4] exploration.esa.int/moon/59102-about-prospect, [5] hptscientists.com, [6] www.goonhilly.org/moon-50, [7] http://www.esa.int/Our_Activities/Human_Spaceflight/Orion, [8] www.nasa.gov/feature/deep-space-gateway-to-open-opportunities-for-distant-destinations, [9] M. Landgraf et al. (2015) LEAG, 2039, [10] E. Steenstra et al (2016) *Advances in Space Research*, 58(6), 1050-1065, [11] www.globalspaceexploration.org