

## HUMAN EXPLORATION OF THE SOLAR SYSTEM SYMPOSIUM (A5) Human Exploration of the Moon and Cislunar Space (1)

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## INTERNATIONAL INDUSTRY CONCEPTS FOR EARLY ASTRONAUT MISSION BEYOND LOW EARTH ORBIT

### Abstract

An international space industry team has developed plans for future human spaceflight in parallel to the International Space Exploration Coordination Group (ISECG). Our goal is to extend cooperative relationships developed during the International Space Station (ISS) Program. The industry team includes Airbus, Boeing, Lockheed Martin, MDA, Mitsubishi Heavy Industries, Rocket and Space Corporation (RSC) Energia, and Thales Alenia Space. The companies believe it is important to fly astronauts to deep space at least annually beginning in the early 2020s. We agree with ISECG that early deep-space missions should send astronauts to an outpost near the Earth-Moon libration point EM-L2. The outpost could move to other circumlunar locations such as L1 or a Distant Retrograde Orbit if desired. Exploration objectives include preparing for Mars missions by testing biomedical responses, hardware, and operational procedures in deep space. Science objectives include human-assisted sample return from the SPA and Schrödinger basins on the lunar farside, returning lunar polar volatile samples, deploying radio telescopes in the farside radio-quiet zone, and exploring a redirected asteroid. Accomplishing these objectives supports later Mars Sample Return missions and human missions to Mars. The NASA/ESA Orion spacecraft launched on the NASA Space Launch System (SLS) will provide crew transportation, as will Russia's Advanced Crew Vehicle when it is ready. Proposed co-manifest capabilities on the SLS Block 1B will allow additional mission elements to launch with Orion. We envision a Russian-built habitable module as the backbone of the outpost with a docking node similar to Russian or Italian ISS nodes to accommodate visiting vehicles and so the outpost can grow later with additional modules. Additional modules could include a short arm human centrifuge for combined gravitational and radiation biological research as studied by Airbus/DLR,

or a cupola module to provide views of the Moon and deep space. Multiple logistics vehicles can be derived from ISS resupply vehicles and could be launched on existing or planned launch vehicles. For example, JAXA is studying a derivative of the HTV and Thales Alenia can provide a derivative of the Cygnus logistic module. The Canadian Space Agency and MDA have studied a next-generation robotic manipulator in the Deep Space Exploration Robotics project which could berth these logistics vehicles. Japan, Canada, and European nations could contribute robotic lunar landers, rovers, or robotic ascent vehicles, which could transport lunar surface samples to the EM-L2 outpost, enabling in situ analysis and sample return by Orion.