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# CYCLING PATHWAYS TO OCCUPY MARS VIA LUNAR RESOURCES

**Abstract**

Cycling trajectories between the Earth and Mars could provide a human space transportation system that benefits from the reusability of a cycler vehicle. Such cycler vehicles, once placed in their heliocentric orbits can provide ballistic or near-ballistic trajectories that continue on their own momentum (or nearly so). The concept of cycler trajectories has been so well-established that new architecture warrants a name which we have coined, "Cycling Pathway to Occupy Mars." Since a cycler vehicle is placed in its permanent orbit as a single investment, it can be designed to provide protection, safety, and comfort to the astronauts during their interplanetary transit to Mars.

A second important consideration is the potential of using lunar ice to provide rocket propellant that can be used to transfer lunar colonists on to a hyperbolic rendezvous with a cycler vehicle. Lunar ice can of course provide the most essential human nutrients, water and oxygen. Current estimates indicate that the amount of water may be 5% by mass of the lunar regolith contained in the permanently-shaded regions (PSRs) near the South Pole. Two likely craters for these resources are Shackleton and Cabeus.

Besides providing propellant from the Moon for hyperbolic transfer for the Mars cycler, the purpose of a lunar base is to address human challenges that must surmounted to establish a permanent human presence on Mars. Prominent among these challenges are protection against space radiation, maintenance of musculoskeletal fitness in low-g, and preservation of mental and psychological health.

In the current effort, the objective is to establish an international lunar base by developing the cislunar "plus" proving ground missions at the Moon that paves the way for international colonization of Mars. From the lunar base, a crew of four to eight astronauts (two landers with up to four crew members per lander) are sent to Mars every synodic period using Earth-Mars "S1L1 cycler" trajectory, with the first crew reaching Mars in 2037. The first activity can start as early as 2018 when prototype habitation (exploration modules or XMs) ready for tests in LEO, followed by tests in deep space environments, and lunar surface, for long-term use with minimal maintenance, while only being crewed for six months every 4 2/7 years. Thereafter, the surface XMs are placed on the Moon creating the international lunar base which will answer questions critical to colonizing Mars including in-situ resource utilization, human factors (physical or mental), and surface operations.