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Systems and Infrastructures to Implement Sustainable Space Development and Settlement - Systems (2A)

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KEY SYSTEMS AND INFRASTRUCTURE ENABLING ROUTINE TRAVEL BETWEEN THE EARTH AND THE MOON

Abstract

Abstract: In September 2021, SpaceX flew four private citizens to low Earth orbit (LEO) on the Inspiration4 "tourist" mission arranged by Space Adventures, Inc. In 2022, SpaceX will fly a 10-day tourist mission to the International Space Station (ISS), this time arranged by Axiom Space. NASA is also working with Axiom Space and three other companies, Northrop Grumman, Nanoracks, and Blue Origin, to develop a commercial LEO space station to replace the ISS when its operational lifetime concludes at the end of the decade. With these activities underway, how long will it be before a future tourist vacationing at a commercial LEO station points to the Moon and says, "I'd like to go there, can you take me?" In this paper we examine some of the key systems (e.g., next generation RL10 cryogenic engines, lunar propellant plants, fission power systems) and supporting infrastructure (e.g., commercial LEO stations, propellant depots) that could be developed over the next 10-20 years to enable routine travel between the Earth and the Moon to become a reality. A reusable Commercial Passenger Transport (CPT) capable of performing a variety of lunar flyby and orbital tourist missions provides a focal point for the paper. Key elements of the CPT include a LH2 propulsion stage with RL10CX engines, an in-line LO2 tank, and an inflatable habitat module carrying the crew, passengers, and their consumables. Passengers board the CPT at either a commercial LEO station, or directly in LEO, delivered there by a commercial launch provider. The CPT would then depart LEO, fly passed the Moon at altitudes of 300 to 6000 km, then return to Earth capturing into either a lower energy elliptical Earth orbit, or back into LEO. Between missions, the CPT would be resupplied with propellants at a LEO Space Transportation Node (STN) that provides both a cargo transfer and propellant depot function. Once STNs are established in polar and equatorial lunar orbits, they will provide convenient "ports of call" for stopover CPT missions where the passengers will have time for sightseeing while the CPT is refueled for its return trip to LEO. Lunar propellant plants, employing fission power systems and using polar and mare regolith, and volcanic glass as feedstock materials, will produce LO2 and LH2 and other important solar-wind-implanted volatiles that would be delivered to the STN by reusable, surface-based lunar landing vehicles. The paper quantifies the operational characteristics of key in-space and surface systems, and provides conceptual designs for the space transportation and infrastructure elements discussed.