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Abstract

This paper is the culmination of six months of project work completed by an international and multi-disciplinary team of 21 graduate students, from 11 different countries as part of the ninth edition of the unique 'SpacE Exploration and Development Systems' (SEEDS) Master's program. SEEDS is hosted, in turn, by Politecnico di Torino (Italy), ALTEC (Italy), ISAE-Supaero (France), the University of Leicester (United Kingdom), and the Concurrent Design Facility at ESA/ESTEC (the Netherlands). ESA's support of the project work, initiated by the Human Spaceflight Directorate, aligns with ongoing studies into the lunar architecture required to realise the moon village aspiration, as a stepping stone to the eventual human exploration of Mars. Since the days of the Apollo program, Mars has remained the long-term target of the global space community for humanity's next 'giant leap'. However, the best strategy to physically make that leap is not yet defined. Alternatives to traditional transfer strategies include the exploitation of the natural dynamics of Lagrange points, and synodic cycler orbits. There are advantages and challenges associated with both departing for Mars directly from Earth, or from cislunar space with an on-orbit assembled vehicle. Current roadmaps highlight the utilisation of the future cislunar station as a key stepping stone to the red planet. The research activities of this paper relate to the post-2025 timeframe, where the architecture of a cislunar station is known and has been derived by students from previous editions of the SEEDS program and industry studies. The work completed is concerned with the later stages of the station's lifetime, whereby it will be evolved into a Mars Transfer Vehicle, aided by the successful leveraging of lunar resources. This paper presents the result of trade-off analyses of different Mars transfer strategies for the cislunar station. A subsequent trade-off analysis is then provided for various propulsion systems, and a design of a Mars Transfer Vehicle is detailed.