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IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Future Space Transportation Systems (4)

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INTERPLANETARY TRANSFER NETWORK DESIGN AND TECHNOLOGY ROADMAP FOR A SUSTAINABLE OFF-WORLD HUMAN COMMUNITY

Abstract

An interplanetary human civilization that expands beyond Earth to settle on other planets of the Solar System will require a transportation network to connect the different human outposts via fast transfers and high-capacity spacecraft. Such network will serve initially as a vital link with Earth to transport workers, settlers and critical resources until full sustainability is reached. In time, these interplanetary connections will evolve to serve functions similar to what is expected between countries: tourism, commerce, trans-border jobs. Under this premise, a fast transportation grid within the Solar System with high-payload spacecraft and high propulsive efficiency is a key enabler for both development and flourishment of sustainable off-world colonies. This work seeks to understand the requirements for such fast transfers in terms of engine technology and dry mass fraction, and identify when these propulsive capabilities could be available based on current TRL of space propulsion industry.

The analysis methodology focuses on developing a series of 1-way and round-trip Earth – Mars trajectories, to then map the resulting ΔV requirements against minimum viable Isp, spacecraft DMF and refueling capability. Multiple data filters are applied yielding actionable insights on different aspects of round-trip transfers. Similar analyses are also performed for Venus and Jupiter.

The results show that a mid-term propulsive technology such as NEP (Isp 5,000s) will enable 60d 1-way trips to Mars and round trips of 150d. Such technology is likely to be human-rated and flight ready within 20 years and could cover most of the fast transfer requirements to Mars. Better propulsive technologies such advanced fission NTP (Isp 10,000s) can bring 1-way trips down to 1 month and round trips down to 100d. However, the exponential behavior of propulsive costs with round trips approaching 100d is such that no technological advancement effort can be reasonably justified in exchange for such a small improvement in transfer time. An instance where an advanced Isp of 10,000s makes a difference is optimizing for max. frequency of round trips per year rather than for duration of a single trip. An Isp of 10,000s would enable these networks to complete 2 round trips per year (vs. the 1.3 – 1.4 NEP-enabled). Beyond this, again the propulsive costs become too high to pursue any further frequency improvement.

This work identifies key requirements and constraints to be considered when designing and roadmapping an interplanetary transfer network capable of enabling a sustainable off-world human community.