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CARGO LOGISTICS FOR A NOTIONAL MARS BASE USING SOLAR ELECTRIC PROPULSION

Abstract

The current aim of NASA's Journey to Mars is a stepwise approach that plans for landing humans on the Red Planet, potentially culminating in a sustained presence. There are many recent studies on how this can be achieved in an evolvable and affordable manner. Most architectures being studied assume crewed missions to Phobos or Mars orbit in the mid-2030's, progress toward short-stay missions on the surface, and would then culminate with regular, long-stay missions at a permanent outpost in the 2040's.

A common factor of these conceptual architectures is that many robotic launches would be required in order to support the crew by prepositioning mission elements and other needed supplies. In this paper, we study the use of 150 kW reusable Solar Electric Propulsion (SEP) tugs as a means to deliver elements both to orbit and the surface. The SEP tugs would make use of technology currently being developed for the proposed Asteroid Retrieval Robotic Mission (ARRM). They would also be used to deliver food and supplies to sustain the crews similar to resupply missions for the International Space Station. These SEP tugs would cycle (with loitering) between stable orbits in cislunar space and Mars orbit.

In order to characterize mission design parameters such as dates, masses, and durations, thousands of optimized trajectories were run using low-thrust optimization software. Solutions are found for all launch/arrival date pairs for the years 2038-2053. They can be displayed as contour plots called Bacon plots – the SEP equivalent of porkchop plots. In this paper, we describe possible mission architecture concepts for planning a steady-state human presence on Mars along with the cargo missions that would be needed to keep it functioning. Tables and diagrams will be used to illustrate the relevant mission parameters such as launch dates, masses, arrival dates, etc. We find that the reusable SEP tug architecture would be highly beneficial to the logistics of a sustainable Mars outpost.

'Pre-decisional information: for discussion and planning purposes only'