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

Author: Mr. Benjamin Merrel
SpaceWorks Enterprises, Inc. (SEI), United States, benjamin.merrel@spaceworks.aero

Mr. Caleb Williams
SpaceWorks Enterprises, Inc., United States, caleb.williams@spaceworks.aero
Dr. John Bradford
SpaceWorks Enterprises, Inc. (SEI), United States, john.bradford@spaceworks.aero
Mr. Mark Schaffer
SpaceWorks Enterprises, Inc., United States, mark.schaffer@spaceworks.aero

REDUCING THE COST OF LONG-DURATION HUMAN SPACEFLIGHT WITH TORPOR-INDUCING TRANSFER HABITATS

Abstract

In addition to extraordinary technical challenges, cost reduction remains a significant hurdle when designing for sustainable, long-duration human space spaceflight. Many solutions have been proposed for these technical challenges, but few cost estimates and cost mitigation strategies have been proposed. In an effort to reduce the cost of manned, deep-space missions, SpaceWorks Enterprises has been advancing the medical research and novel mission architecture designs to enable astronauts to be placed into a medically-induced hypothermic state during the transit phases of a deep space mission. The authors propose that extending existing medical procedures to achieve this inactive, torpor state during human spaceflight can enable novel mission architectures that reduce mission transportation costs by as much as 25%.

SpaceWorks began investigating the use of torpor for human stasis in 2013 through a study funded by the NASA Innovated Advanced Concepts (NIAC) program. Following promising initial results, the authors created a framework for sizing and costing a deep space Crew Transportation System (CTS). By exploring a variety of mission profiles and alternative system architectures, the authors have demonstrated that a torpor-enabled system consistently delivers reduced total system mass and complexity. These reductions enabled system architectures that required less engines, a lower number of propulsive stages, and fewer heavy-lift launch vehicles. The authors performed cost analysis on these alternative system designs to demonstrate the significant cost reductions associated with torpor-enabled CTS designs.

This paper focuses on cost-saving architecture changes enabled by the use of torpor-enabled habitats for long duration human space. As a case study, cost estimates are presented for the development and operation of a Crew Transportation System (CTS) in the context of a three mission Mars campaign. Cost-optimal CTS designs are presented for architectures with and without torpor-enabled habitats. Special attention is given to key architecture changes, such as reducing the total number of heavy launch vehicles required. Broad design space trades are presented to adequately characterize the impact of torpor on the CTS design. Finally, alternative uses for the cost savings, such as reduced mission duration or increased scientific payload, are discussed to demonstrate the extensibility of torpor to a broad class of deep space missions.