Paper ID: 90214
oral
student

22nd IAA SYMPOSIUM ON BUILDING BLOCKS FOR FUTURE SPACE EXPLORATION AND DEVELOPMENT (D3)
Space Technology and System Management Practices and Tools (3)

Author: Mr. Ben Parsonage
University of Strathclyde, United Kingdom

Dr. Christie Maddock
University of Strathclyde, United Kingdom

MULTI-OBJECTIVE DESIGN OPTIMISATION AND ANALYSIS OF A CREWED EARTH-MARS TRANSPORTATION SYSTEM USING NUCLEAR THERMAL PROPULSION

Abstract

Establishing a human scientific settlement on Mars will require significant collaborative development across several important areas. In particular, an efficient and effective interplanetary transportation paradigm to support both initial and sustained future development of surface-based activity. The technological challenges of such an architecture will necessitate a synergistic amalgamation of novel technologies within fields such as propulsion, long-duration habitation, radiation mitigation and mission design, including the use of in-orbit structural assembly and re-fuelling.

The aim of this paper is to identify systems-level design drivers for a crewed interplanetary transportation solution to support future scientific settlement on Mars. Numerical models were developed to broadly represent current and near-future propulsion systems (with a particular focus on Nuclear Thermal Propulsion), habitation modules, nuclear/cosmic radiation exposure, power systems and vehicle structure. Models were then integrated into a multi-objective problem formulation examining both the static system/mission design parameters (e.g. planetary conjunction angles, dry/wet masses and engine system sizing) and the optimal trade-offs between outbound/inbound transfer trajectories for a variable surface stay duration on/around Mars. The problem was solved using a novel adaptive-mesh evolutionary solver for multi-objective optimal control problems.

Preliminary results suggest that the relative duration of mission segments (outbound, stay, inbound) conform to distinct groups of solutions within objective space. This represents a quantifiable set of transfer opportunities/mission architectures differentiated by total propellant requirements and the desired duration of surface activities at Mars. Furthermore, considering Nuclear Thermal Propulsion (NTP) technology, a tendency to reduce the size of the propulsion system towards the lower end of the performance spectrum is observed. This implies that current/future development should focus on improving system reliability, including investigations into extended operational cycles and restartability, rather than base performance statistics.