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SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Going To and Beyond the Earth-Moon System: Human Missions to Mars, Libration Points and NEO's (8-A5.4)

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CAMPAIGN-LEVEL DYNAMIC NETWORK MODELLING FOR SPACEFLIGHT LOGISTICS FOR THE FLEXIBLE PATH CONCEPT

Abstract

This research develops a dynamic logistics network formulation for high-level lifecycle optimization of space mission sequences in order to find the optimal space transportation architecture considering its technology trades over time. The proposed methodologies are inspired by the ground logistics analysis techniques based on linear programming network optimization. A new formulation with a generalized multi-commodity flow and a time-expanded network is developed for dynamic space logistics optimization. The developed methodologies are applied to three case studies: 1) human exploration of Mars; 2) human exploration of a Near Earth Object (NEO); 3) human exploration of both Mars and NEO. The results reveal multiple dynamic system-level trades over time and provide recommendation of the optimal strategy for the human space exploration architecture. The considered trades include those between In-Situ Resource Utilization (ISRU) and propulsion technologies as well as the orbit and depot location selection over time. The numerical results show that using the propulsion technologies, ISRU, and other space infrastructure effectively, we can reduce the Initial Mass to LEO (IMLEO) by 40-50%. In addition, the case study results also show that we can achieve 15-20% IMLEO reduction by designing NEO and Mars missions together as a campaign compared with designing them separately owing to their common space infrastructure pre-deployment. This research serves as a precursor for eventual permanent settlement and colonization of other planets by humans and makes us becoming a multi-planet species.