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SPACE SYSTEMS SYMPOSIUM (D1)
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DESIGN OF EXECUTABLE SPACE MISSION ARCHITECTURES USING DISCRETE NETWORK FLOW OPTIMIZATION

Abstract

As humans explore Space, the demands for space logistics and infrastructure has increased dramatically since the pioneering suborbital flights: current space program goals such as sending humans to Mars force space mission architecture and planning to become far more sophisticated than simply sending a crewed mission to its destination with everything on board. To this effect, new methods have to be devised in order to address the problems of long duration space flight. One of these is generalized multi-commodity network flows. This approach was created by applying network-based logistics methods to space mission planning. Classical network flows optimize the distribution of flows through a network to achieve an optimum, such as the maximum through-put or minimum transportation cost. In the space mission case, commodities such as vehicles, propellant,crew, etc. are abstracted as flows and the problem is formulated to minimize initial mass in low earth orbit. However, this method has shortcomings regarding the fidelity of the models because of its linear network nature: examples of this include the inability of following a vehicle through the network or the generation of infeasibly small vehicles. In this work, these problems are addressed and solved using mixed integer linear programming and a tracking algorithm. The case study considered is a manned exploration mission to Mars with identical requirements to DRA5.0 using NTR, ISRU, and aerocapture. An architecture of this mission is obtained using this optimization method. It is found that lunar ISRU only reduces the IMLEO by 5% compared to a direct Mars mission. Lunar ISRU is found to be ineffective at reducing IMLEO below the critical value of 3 kilograms of propellant mined per kilogram plant per year. Removing NTR and aerocapture technologies is found to increase IMLEO by 33.0% and 27.5% respectively with respect to the baseline scenario using both technologies.