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AN ADVANCED MULTI-ORBIT PRECISE TARGETING TOOL TO RAPIDLY DESIGN MULTI-PAYLOAD DISPENSER DELIVERY STRATEGY

Abstract

The growth of the space market, the ever-increasing request for continuous coverage by means of huge constellations for commercial purposes and the large development prospects of micro-nano satellites missions lead to the need of space segments efficient in orbit insertion strategies to minimize the launch cost and the time to operations. The way to is offered by multiple vehicles dispensers, which play the role of intermediate stages to hop between operational orbits and cleverly deliver each space segment at due position in space. Therefore, existing launchers are still adaptable to the new needs and satellites can still be designed focusing on their operational functionalities with no care of the insertion leg. The challenge then results in solving the multi-points in space delivery combinatorial problem the dispensers shall take care of, driven by their efficiency maximization. The paper proposes a strategy to visit the solutions space and produce a top-level plan while considering at the most the several degrees of freedom the for problem offers. The developed tool may be extremely useful to make decisions on both deployment operations setting and dispensers/upper stages design. Given a satellite set to be put in place, the tool solves the constrained combinatory optimization problem with respect to the number of dispensers, which satellites on which dispenser, the deployment sequence for each dispenser, the launch number and launcher class. The N-P hard, mixed variables nature of the problem led to choose meta-heuristics techniques, which work in synergy with powered orbit transfer trajectory optimization to output fuel-optimal deployment scenarios in perturbed Earth environment. Great attention is given to real mission constraints, such as engine restarts limitations and launch vehicle capacity. The algorithm is able to manage both impulsive and continuous thrust with an efficient and robust semi-analitycal approach, leading to a flexible and effective tool. Solutions obtained on possible deployment scenarios of increasing complexity, from simple walker constellations to missions which make use of many satellites of various mass and size on different orbits are presented and discussed. Maps between the solution spaces and the cost function space and constraints are also offered as useful tool to drive the dispensers and their operations design. The proposed tool is flexible and highly customizable to support kinds of analyses that deal with vehicle routing problem applied to space missions. These include missions of current interest like multiple spacecrafts on orbit servicing and multiple debris removal.