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ANALYSIS OF THE SOLUTIONS PROPOSED FOR THE MULTI-TARGET ADR MISSION OPTIMIZATION PROBLEM

Abstract

The optimal use of active spacecraft-collector occupies an important place in the implementation of ADR mission. At present, more than 50 papers by different teams have been published in which this nonlinear, time-dependent, multi-objective and multi-target optimization problem has been solved. ADR mission optimization has two aspects. On the one hand, it is necessary to provide flights between neighboring objects with minimal fuel consumption, and on the other hand, it is necessary to find the most favorable sequence of transfers between the objects according to the criterial function. Three classes of proposed solutions can be distinguished.

- In the first case, the path optimization is reduced to a traveling salesman problem, static or time-dependent. Orbital flights are realized either by spatial variant of Hohmann scheme, or by Lambert algorithm. For low-thrust engines an approximate Edelbaum formula can be used. The search for transfer sequence is usually performed using various heuristic methods (annealing simulation, ant colony, etc.), which can give a solution close to the optimal one.

- In the second case, a drift orbit is introduced, which has a different precession rate and allows the planes of motion to align by the Right Ascension of the Ascending Node for a specified duration of flight. By numerically finding the semi-major axis and inclination of the drift orbit, the authors reduce the ΔV costs, but new variables appear in the model, such as the acceptable duration needed to stay in the drift orbit. The same heuristic methods are used to find the orbit sequence. Most often we see a time-dependent variant of the traveling salesman problem, which involves finding a route on a four-dimensional cube grid (previous object, next object, approach time to the next object, and departure time from the next object).

- In the third case, the authors choose a sequence of transfers, using the mode of maximum favorable for the precession of the drift orbit. Restriction on the duration this drift is either not introduced, or is allowed to be in order of several months. The properties of the relative motion of the orbital planes of objects are widely used. Calculation of maneuvers can be performed in a way that provide a mutual link between the parameters of the drift orbit, the duration of flight and the solution of the boundary problem.

This report attempts to summarize the proposed solutions and compares advantages and disadvantages of methods used.