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# RECONFIGURABLE SATELLITE CONSTELLATIONS: MODULAR TOOL FOR OPTIMAL DESIGN AND MANEUVERING

**Abstract**

Recent developments in space technologies are changing how we approach space missions and innovative solutions are required to deal with the increasing complexity of space systems. Miniaturization is having a huge impact on how satellites are designed and operated, saving orders of magnitude in mass and volume of individual components and allowing increased redundancy. Among the latest technologies, a disruptive role is played by the advances in electric propulsion and the new opportunities offered by maneuverable small satellites.

Exploiting the technological progress, constellations of small satellites are rapidly evolving, providing both advanced capabilities and existing capabilities at lower costs. In such context, developing techniques to design and operate these systems is crucial to maximizing scientific and commercial outcome. One of the most promising opportunities opened by miniaturized electric propulsion is represented by he increased flexibility of constellation configurations. Suitable maneuvers could be planned to improve system performance, enabling the fulfillment of mission objectives with a reduced number of satellites. Adaptations in the constellation pattern offer the possibility to trade-off between changing requirements on resolution, downlink capabilities and revisit rates, enabling also efficient management of failures or additions of satellites.

In this work, we propose a modular tool able to support operators during constellations design and to compute reconfiguration strategies to enhance the overall performance of the system. In particular, the developed solution relies on Genetic Algorithms (GA) to autonomously generate the best configuration to maximize the return over a given area of interest. GAs allow also to further optimize the geometry in order to satisfy changes in the space environment or in mission objectives. A dedicated module able to design time-of-flight and/or fuel optimal trajectories determines the low-thrust maneuvers needed to reach the desired configuration. Two different approaches can be used to calculate the maneuvers, depending on user objectives. A heuristic technique performs fast analysis and trade-offs between several scenarios, while accurate guidance and control laws are available through a separate module that implements proper numerical optimizations.

The developed tool is tested and validated considering an EO constellation. Each module is analyzed separately, presenting the results of the optimized design to obtain the desired coverage over certain areas and comparing the performance of heuristic and numerical trajectory optimization.