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RECONFIGURABLE DISCONTINUOUS COVERAGE SATELLITE CONSTELLATIONS ON REPEAT GROUND TRACK ORBITS

Abstract

The study investigates the concept of reconfigurable LEO discontinuous coverage constellation to be explored for prospective SAR-based Earth observation missions. To ensure robust constellation performance, its design pattern is based on LEO repeat ground track orbits.

Discontinuous coverage satellite constellations for earth observation missions are typically being designed to meet a number of requirements given in terms of coverage figures of merits (FOMs). The main FOMs are the maximum and average revisit or gap time, maximum and average response time, percent coverage and others. For a given constellation the FOMs are typically evaluated with the aid of Earth grid nodes' coverage statistics using the point coverage model.

The constellation design process relies typically on multi-objective optimization together with analytical approaches to meet the predefined figures of merits provided by a stakeholder. The reason is that a single FOM does not give a proper insight into the constellation coverage efficiency. On the other hand, the constellations design requirements tend to take into account a wide range of constellation operation modes and stakeholders' needs. Although, a constellation designed to meet generalized requirements has lower efficiency for particular observation tasks.

Therefore, we propose a concept of reconfigurable Earth observation constellation utilizing low-thrust maneuvers for its pattern reconfiguration throughout the mission to meet various sets of stakeholder defined FOMs requirements.

We present a method to design a constellation pattern of predefined efficiency utilizing repeat ground track orbits and heuristic optimization techniques and following the limitations of satellite's instrument field of regard and range of operating orbit altitudes.

Secondly, the approach for constellation reconfiguration and maintenance is proposed. The assignment problem is taken into account in order to find a reconfiguration scenario yielding least propellant consumption. The nonlinear control techniques utilizing low-thrust maneuvers are used for constellation maintenance and reconfiguration problems.

Thirdly, different scenarios of reconfigurable Earth observation constellation operation are analysed to get estimates on possible number of reconfigurations throughout the mission lifetime depending on the FOMs sets diversity and satellite composition.