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Author: Ms. Simeng Huang
Politecnico di Milano, Italy

Dr. Camilla Colombo
Politecnico di Milano, Italy
Prof. Franco Bernelli-Zazzera
Politecnico di Milano, Italy

COMPARATIVE ASSESSMENT OF DIFFERENT CONSTELLATION GEOMETRIES FOR SPACE-BASED APPLICATIONS

Abstract

As services from space are becoming an asset for life on Earth and the demand for data from space increases, the international interest in satellite constellations is increasingly growing. GPS (Global Positioning System) provides positioning and navigation. Iridium contains a relatively larger number of satellites for communication purpose. Molniya is a high elliptical orbits constellation providing high latitude coverage. Disaster Monitoring constellation consists of remote sensing satellites and brings responsiveness needed for emergencies. Recently, some companies, such as OneWeb, Samsung and Space-X, have made public their plan to deploy mega constellations of nanosatellites for global internet.

Different constellation geometries have been proposed to meet various mission requirements, each one having specific advantages in terms of coverage, responsiveness, cost, etc. Thus, designing a constellation is a trade-off choice.

The choice for a constellation is highly influenced by many factors, such as the system cost, the interaction with space environment (radiation and space debris), and the targeted terrestrial coverage. The design of a constellation requires selecting the parameters that best meet the mission requirements. To accomplish this, several studies on the comparison of satellite constellations proposed detailed analysis, e.g. the multi-criteria comparison for responsive constellations, the coverage assessment of elliptical constellations. However, most of them only focused on one or few performances, lacking of generalisation.

A general study of constellation geometry can provide a basis for understanding the constellation design. This will allow the process of constellation design to be expedited by offering a proposal of an existing constellation style.

This paper comparatively assesses different constellation geometries, including the classical proposed geometries and some less used configurations, and chooses the constellation geometry best suitable for a given mission (e.g. remote sensing, global internet). In this work, several parameters of constellation design will be considered to make a quantitative assessment: coverage (global or local), frequency of ground track repetition, responsiveness (i.e., how fast a satellite can be launched and the data return to Earth after launch), robustness to failure and speed of replenishment, end of life disposal, number of satellites and orbital altitude. The assessment will be conducted in a parametric approach. Each factor will be quantitatively evaluated by deriving a fitness function. Then, a series of weighting coefficients adapted to the given mission requirements will be chosen for the global fitness functions. Through multi objective optimisation, the constellation geometry best suitable for the given mission requirements will be derived.