05/4108   The Flower Constellation Set and its possible applications.

Type of activity: Extended Study (4 months, 35 KEUR)

Background

The first satellite constellation ever thought about was as simple as three satellites on the geostationary orbit providing almost global coverage for telecommunication purposes. The idea, originally appeared in a paper by A.C.Clarke (1945) entitled "Extra-Terrestrial Relays" and published in *Wireless World*, was revolutionary at the time it was proposed. Since that visionary work, many different constellations have been studied from many points of view and many have been proposed for different space missions. Popular geometries proposed are the Walker constellation (GPS and GALILEO), the Molniya constellations and others such as JOCOS, LOOPUS, and COBRA. Given the objective of a certain constellation, the optimal configuration is usually searched by the mission designer in the rather limited space defined by the characteristic of the chosen geometry: a search in the entire space of all possible configurations would in fact be very difficult or anyway rather inefficient. This approach, although common, often leads to suboptimal constellation designs.

In May 2003 a group of researchers from Texas A&M University lead by Prof. Daniele Mortari proposed the novel concept of Flower Constellation Set, a set that contains a large number of interesting constellations such as the JOCOS, LOOPUS, and COBRA and a great number of new and unexplored constellation geometries that have many interesting yet still poorly understood properties. The set is mathematically defined by only eight parameters, five integers and three real numbers that completely characterize it. Some studies performed by the same research group suggest that the Flower Constellation set contains constellations geometries that rival the Walker constellations for positioning and navigation systems. They also suggested some applications of the concept to Formation Flying and deep space observation missions. Much work still has to be done to fully understand the benefits of adopting this novel viewpoint.

Study Objectives

The main objective of this study is to carry out a critical review of the Flower Constellation concept with respect to the applications that have been proposed and to study the possibility of optimising the design of a flower constellation. Some particular applications could be investigated such as radio-occultation constellations, continuous Earth coverage constellations, space interferometry constellations.

In summary the study objectives are as follows:

- To review critically the Flower Constellation theoretical background and the applications that have been proposed so far.

- To build up the necessary methodology to determine a Flower Constellation, that is to determine the orbital parameters of the various satellites starting from the eight parameters defining the whole Flower Constellation.

- To optimize, using some evolutionary algorithm or any equivalent, the design of a Flower Constellation for a test case proposed, or agreed with the ACT, assessing its complexity.

- To compare the procedure with previously used methodologies.

- To investigate the benefits that Flower Constellations may introduce to already existing constellation concepts.

The study will be performed in close cooperation with the ACT, and its results should be at a high standard that makes them suitable for publication in a peer reviewed journal.

References

[1]   Mortari, D., Wilkins, M. P., and Bruccoleri, C., "The Flower Constellations," John L. Junkins Astrodynamics Symposium, Paper AAS 03-274, College Station, TX, May 24, 2003.

[2]   Park, K., Wilkins, M. P., Mortari, D., "Uniformly Distributed Flower Constellation Design Study for Global Navigation Systems" AAS Paper 04-297, AAS/AIAA Space Flight Mechanics Conference, Maui, HI, Feb 8-12, 2004

[3]   Wilkins, M. P., Mortari, D., Bruccoleri, C., "Constellation Design Using the Flower Constellations," AAS Paper 04-208, AAS/AIAA Space Flight Mechanics Conference, Maui, HI, Feb 8-12, 2004.

[4]   Wilkins, M. P., and Mortari, D., "Constellation Design via Projection of an Arbitrary Shape onto a Flower Constellation Surface" AIAA/AAS Astrodynamics Specialist Conference, Paper AIAA 04-4975, Providence, RI, August 16-19, 2004.