

Satellite Ballet by Flower Constellations

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1. Extended Abstract

In recent years, satellite constellations and constellations around planets received a great deal of attention. However, to date, only simple string-of-pearl type simple constellations have been flown in Earth observing missions. The challenge lies in the difficult and high cost of maintaining non-trivial constellations that have prevented this technology from blossoming. The *Flower Constellations* solutions not only solve the constellation maintenance problem, but also provide a new capability for global 3D spatial observations around the planets. In other words, they create space art as shown in Figures 1 and 2.

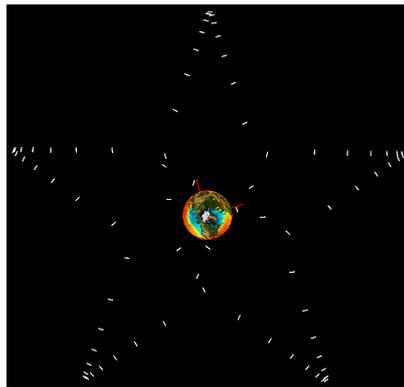


Figure 1: (C) The *Lone-Star* Flower Constellation [2]

The satellites do not only form interesting shapes in space but also keep their relative position constant by creating an illusion of satellite ballet in space. The reason behind this phenomena is that with the introduction of the *Flower Constellations* theory [1], the resulting constellation can be seen as a new *object* characterized by an axis of symmetry about which the constellation is rotating, as a rigid body, with a prescribed angular velocity. The dynamics of a *Flower Constellation* can be seen as made of two distinct parts: 1) an *internal part*, that describes the dynamics of the satellites within the “object-constellation”, and 2) an *external part*, where the “object” has an assigned shape which rotates in the inertial space about a spin axis and with an angular velocity that can be positive or negative. Some of these objects are shown in Figure 2, showing both the versatility and the infinite variety of possible shapes which we call “*choreographies*”.

The *Flower Constellations* open a new frontier on complex satellite constellations for two main reasons. Firstly, the *Flower Constellations* can be seen as constituted of two distinct parts: an “internal part”, associated with the motion of all the satellites along a prescribed identical relative space track, and an “external

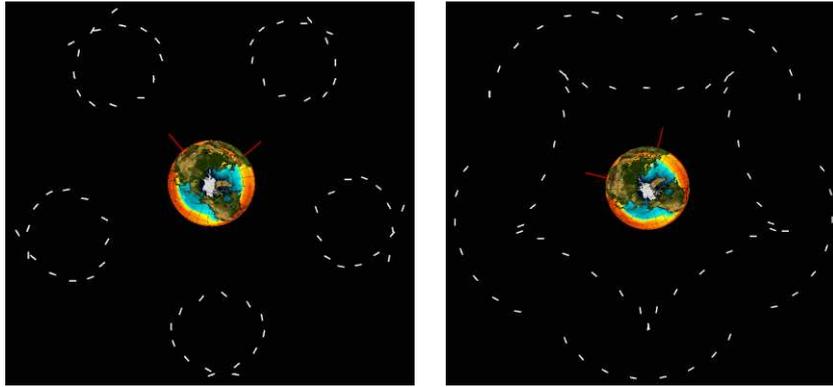


Figure 2: An example of morphing Flower Constellation [2].

part”, associated with the dynamic of the whole constellation, as a rigid *object*, that spins about an axis with a prescribed angular velocity. Secondly, these new constellation-objects are used, as *building blocks*, to construct more complex configurations that allow to accomplish more complex tasks.

Flower Constellations are elegant, majestic, beautiful, and are characterized by order and symmetry! By using different object-constellations as building blocks enabling embedded objects into one another, we are achieving the same level of shift as the one that occurred in programming. We believe that our suite of embeddable objects with their own functionalities makes it easy to think of building constellations in the same manner as “Object Oriented Programming” (OOP). OOP was a paradigm shift for traditional programming, the *Flower Constellation* will provide a similar paradigm shift in thinking of constructing constellations. *Flower Constellations* will provide a means to think of constellations as an ensemble of modular functionalities in space.

The *Flower Constellations* are revolutionary, new and not duplicative of concepts previously studied by NASA. They are the building blocks of a very large space architecture that has functionalities. The *Flower Constellations* can be very easily thought of as viable concepts within NASA’s present and future mission. The *Flower Constellation* concept is revolutionary because current approaches to satellites constellation are a simple by-product of the functionality they are designed for. By enabling the general population and the research community to think of constellation as *objects*, with morphing capabilities show two snapshots of a morphing *Flower Constellation*), we want to enable new functionalities of satellites that have not been devised, except maybe in science fiction books. In effect, objects defined by these constellations could then be used as building blocks to construct more complex and large objects for which functionalities have yet to be found.

This architecture not only provides space art but also presents a new means of enabling different functionalities such as a near-term better communication throughout the solar system. It also provides a means to establish a basis for a significantly large observation platform to study extra-solar planets and it has the potentiality to replace very large one-piece structures.

References

- [1] D. Mortari, M. P. Wilkins and C. Bruccoleri, Journal of the Astronautical Sciences, Special Issue: The John L. Junkins Astrodynamics Symposium, Vol. 52, No. 1-2, pp. 107-127, January-June, 2004.
- [2] <http://flowerconstellations.tamu.edu/>