Paper ID: 76458
oral
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (2) (7)

Author: Mr. Joshua Gribben
University of Strathclyde, United Kingdom

Dr. Christopher Lowe
University of Strathclyde, United Kingdom
Mr. Ruaridh Clark
United Kingdom
Prof. Malcolm Macdonald
University of Strathclyde, United Kingdom

# MATRYOSHKA ORBITAL NETWORKS

**Abstract**

This paper introduces the concept of Matryoshka Orbital Networks (MatrON), an abstraction of the orbital environment where satellites and terrestrial targets (sources and sinks) are modelled as network nodes traversing a series of rotating, nested surfaces (shells) with the Earth's surface at the centre: reminiscent of Matryoshka, or nesting dolls. This abstraction allows pair-wise node interactions to be considered based on the nodes' motion as projected onto a common surface, thus providing a powerful alternative to modelling node interactions via their respective trajectories. With this, the interactions of proliferated constellations, or constellations of constellations, and their interactions with Earth targets can be modelled and analysed as a network system.

New constellations are continually being deployed into Earth orbit with their own concepts of operations; MatrON nests these constellations into a single heterogenous space system of systems. Regardless of a satellite's position in space, the movement of the associated node is bound to the non-Euclidean shell surfaces allowing for interactions between nodes to be directly considered. As the number of satellites increases, the number of node interactions increases non-linearly. Typically, these contact interactions are predicted by using high-fidelity orbital propagators to numerically calculate the position of each satellite – based on their equations of motion – and determine the range to the target at each timestep. MatrON is a new approach to contact identification in space networks; by exploiting favourable node-pair dynamics available from the direct modelling of satellite ground track trajectories on the nested shells, data can be gathered on the topology of the entire MatrON network. These insights enable optimising operations of new and existing constellations in the network structure which can lead to improvement of service delivery. Further analysis at the scale of the entire constellation of constellations can reveal interactions between each integrated system, thereby revealing opportunities for cooperation between interacting systems of different capability and/or operated by different stakeholders.