Paper ID: 23525
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21st IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Access to Space for Small Satellite Missions (5)

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LAUNCH AND DEPLOYMENT OF DISTRIBUTED SMALL SATELLITE SYSTEMS

Abstract

The rise of small satellites in the past decade has spawned interest in the development of distributed systems or constellations of small satellites. The success of Earth imaging constellations such as DMC (Disaster Monitoring Constellation) and RapidEye has paved the way for constellations of even smaller satellites but in larger numbers, such as the anticipated Planet Labs Flock (10kg) and Skybox Imaging SkySat (100kg) constellations. Small satellite constellations can also enable many simultaneous and distributed measurements of interesting phenomena, resulting in proposed missions in the fields of meteorology, climate science, atmospheric, magnetospheric, and ionospheric observation and measurement, and gravity and other Earth science.

However, whilst a variety of missions have proposed the use of constellations of small satellites, issues relating to the launch and deployment of these distributed systems mean that few have actually been launched. Unlike individual small satellites which are typically launched as secondary payloads, constellations of small satellites have the additional requirement of being distributed once in orbit in order to effectively perform their mission. Furthermore, to reduce the cost of development and launch, particularly those in the nanosatellite and picosatellite classes, the use of individual propulsion systems is typically avoided or restricted to low delta-V operations, limiting the ability of the satellites to individually manoeuvre into their mission orbits.

In order to achieve the distribution required by the proposed constellations, various deployment strategies have been hypothesised allowing multiple satellites to be launched on a single vehicle and efficiently separated on-orbit. The use of the natural nodal precession of Earth orbits can be used to separate orbits in Right Ascension of Ascending Node, whilst the use of the Lunar L1 point as a staging site for phased return to different low Earth orbits has also been proposed. The FORMOSAT-3/COSMIC mission, launched in April 2006 is a prime example of deployment of a LEO small satellite constellation from a single launch vehicle.

This paper will primarily investigate the current practicality of the different deployment strategies to enable novel mission types by considering the launch and propulsion requirements of the small satellite constellations. Secondly, the deployment strategies are compared to each other and their respective range of operations analysed in order to determine their relative effectiveness and cost efficiency.