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VERY LOW EARTH ORBIT CONSTELLATIONS FOR EARTH OBSERVATION

Abstract

Very Low Earth Orbits (VLEOs), those below 450 km, present a number of benefits and challenges for the development and operation of Earth observation spacecraft at both the system and mission level. This paper examines the design of constellations of satellites for operation in VLEO for Earth observation considering both system and mission level trade-offs. The resulting analysis identifies general design trends and proposes suitable mission architectures for Earth observation from VLEO.

The principal benefit for satellites operating in VLEO is that the reduction in the distance to the Earth's surface allows better imaging resolution to be achieved using smaller and less powerful payloads. This has corresponding benefits for the system mass and cost. However, the sustained and controlled operation of spacecraft in VLEO is challenging due to the increased atmospheric density at these altitudes, which increases propulsive and attitude control requirements. Technologies to facilitate the commercially viable operation of spacecraft in VLEO are currently being developed, for example materials to facilitate drag-reduction and aerodynamic control and atmosphere-breathing electric propulsion systems (ABEP), each of which influence the design of other sub-systems, requiring, for example, varying levels of power or new geometric considerations.

At the mission level, the reduction in altitude has a generally negative influence on the coverage and revisit characteristics of a given satellite. However, deployment of these satellites in constellations can provide improvements in the overall system metrics. Systems operating in VLEO may also benefit from improved launch vehicle capability and assured end-of-life deorbit. It is clear, therefore, that important and non-intuitive trade-offs between the satellite platform design, constellation configuration, and total cost arise in the design of these systems.

This paper uses combined platform-level system modelling, mission analysis, and cost estimation methods to explore the design of constellations of satellites in VLEO for Earth observation. The trade-offs associated with altitude and the use of emerging technologies is considered for Earth observation missions. For these systems an optimal altitude and system configuration can be identified that will minimise overall mission cost while meeting the defined mission requirements. This demonstrates the necessity of a holistic approach to mission and system design when considering operations in VLEO.