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Very Low Earth Orbit mission concepts for Earth Observation. Benefits and challenges.

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ABSTRACT

Very Low Earth Orbits (VLEO) can be defined as the orbits with a mean altitude below 450 km. Flying in these orbits can provide a number of benefits to Earth observation spacecraft. Flying closer to the observation target increases the resolution of optical payloads, the radiometric performance of passive sensors and the geospatial accuracy of the platforms. Therefore, the performance of platforms in higher orbits can be matched with simpler and smaller payloads in VLEO. This can result in smaller spacecraft and hence in lower costs.

Flying at such low altitudes also means flying through a denser part of the atmosphere and thus increased aerodynamic forces. These higher aerodynamic forces can be seen as challenge, as they might limit the spacecraft orbital lifetime and introduce disturbance torques, but they can also represent an opportunity. If spacecraft are designed with these forces in mind, these can be used to help control the orbit (specially in formation flying, constellation management and collision avoidance) and to help control the attitude (aerostability and active aerodynamic attitude control). Unfortunately, rarefied gas aerodynamics is not completely understood and more research is required in order to fully exploit these techniques.

Aerodynamic drag can be also considered an asset at the end of life, as it removes the non-operational spacecraft quickly from their orbit. The increased drag also removes debris from these orbits quicker. These features increase the resilience of these orbits to space debris. The potential shorter orbital lifetimes can also

represent an opportunity for constellations to replenish their fleets of smaller spacecraft more frequently and thus become more responsive to technology and market changes. Manufacturing higher numbers of spacecraft launched at regular intervals can also become an asset as it can help relax the reliability requirements, can help increase the performance incrementally and may introduce cost savings due to the higher volumes.

In this paper, the different benefits of VLEO with respect to traditional high altitude orbits are quantified considering both optical and Synthetic Aperture Radar (SAR) payloads. The challenges and opportunities emerging from the significant increase in aerodynamic forces are discussed, with some examples of aerodynamic orbit and attitude control provided. The debris resilient properties of these orbits are briefly quantified and discussed with different lifetimes scenarios analysed (from different combinations of altitudes and ballistic coefficients). Finally, several concept studies that highlight the main design drivers of platforms operating at such orbits are briefly presented.