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Mission Design, Operations and Optimization - Part 1 (1)

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MISSION DESIGN AND ANALYSIS FOR A LASER OCCULTATION DEMONSTRATION MISSION

Abstract

The study of a "**Laser Based Occultation Demonstration Mission to Monitor Chemical Species**" (LODM) was carried out in the frame of ESA's Earth Explorer missions selection process. It aimed at designing a technology demonstration mission for greenhouse gas monitoring through atmospheric limb sounding with a satellite-to-satellite laser in the SWIR spectral range (2 μm - 2.5 μm). In a consortium led by Thales Alenia Space (TAS), DEIMOS Space was responsible for Mission Analysis.

An extensive set of laser occultation scenarios was assessed, including Earth-to-satellite, LEO-LEO, LEO-MEO and LEO-GEO. The combination of a wide range of performances, in which the sounding profiles "verticality" played a driving role, led to select a **two-satellite LEO-LEO counter-rotating orbital configuration**. The satellites fly one towards another, at near-polar inclinations (about 80 deg) and slightly different altitudes.

An in-depth analysis of the laser occultation behaviour of two satellites flying on counter-rotating repeat orbits led to the definition of two key parameters, derived from the orbits repeat cycle/cycle length: the **Pattern Repeat Cycle** and the **Combined Repeat Cycle**. They allow easily choosing the orbits, so that the resulting occultation measurements repeat after a certain time and feature an optimized geographical distribution.

The major drawback of a counter-rotating orbital configuration is the apparent necessity of performing two launches. This is not in line with the scope of a demonstration mission, where cost is a major driver and the small size of the satellites favours shared launches. The feasibility of a **single-launch** scenario has been analysed and ultimately demonstrated. Both satellites are placed by the same launcher at low altitude (350 km). One of them then raises its altitude to about 1300 km, thus enabling a significant **relative drift of the lines of nodes**. After one year, during which the lower satellite actively counteracts the atmospheric drag, the desired counter-rotating configuration (180-deg RAAN shift) is achieved. Such a waiting time is deemed acceptable for a climatology mission. The satellites bring themselves to their operational orbits (500 and 600 km) and start their nominal activity. A full ΔV analysis has been performed to demonstrate the feasibility of such a scenario, considering TAS' PRIMA platform and the VEGA launcher.

Despite the constraint of a single launch, the counter-rotating orbital configuration enables numerous high-quality occultation events. Thus, the LODM not only offers a demonstration of spaceborne laser atmospheric sounding, but also provides significant scientific return.