ORBIT ACQUISITION CONCEPTS FOR FORMATION FLYING

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1. Abstract

Repeat ground-track orbits are of paramount importance for Earth observation missions. Additionally, more and more missions require a predefined ground-track or phasing with a satellite currently in the same orbit. In these cases, the manoeuvres for acquiring of the nominal orbit shall be carefully planned so that not only the nominal altitude is reached but also the predefined longitude of ascending node or phasing are achieved.

This paper addresses the criteria for selecting the injection orbit and the ground-track acquisition concept. A general overview of the different factors affecting the orbit acquisition will be given followed by some examples, namely, Sentinel-1B, Sentinel 2-B, and Sentinel-5P.

With the help of an in-house tool, a parametric analysis which considers the launch dispersions and the a priori unknown initial phase is performed to assess the expected duration and delta-v consumption to reach the desired orbit from the satellite's injection orbit. Different algorithms are available that either minimise the duration of the orbit acquisition phase or minimise the required delta-V. Several constrains are considered, such as available delta-v, propulsion performance and operational restrictions, that is number and size of manoeuvres performed per day and non-available days for manoeuvring. Additionally calibration and tuning manoeuvres are taken into account.

Sentinel-1B, Sentinel 2-B and Sentinel-5P have significant different characteristics. Sentinel-1B and Sentinel-2B need to be phased approximately 180 degrees with respect to their respective mission precursors. Sentinel-5P will fly in loose formation 5 minutes after Suomi-NPP.

Sentinel-2B is a standard case. It has a propulsion system with good performance and a comfortable delta-v budget. Thus, performing extra manoeuvres to speed up the drift is not a major problem. Consequently, the altitude of the orbit targeted by the launcher is lower than the nominal altitude, which allows to increase the convergence to the desired final orbit position. It will be showed that, under reasonable launch dispersions and with small extra propellant consumption, the expected orbit acquisition duration remains within a month, depending mainly on the initial phasing with respect to Sentinel-2A rather than on the initial altitude difference.

Sentinel-1B is an example of a satellite with a reduced thrust propulsion system, where a minimum number of the manoeuvres is preferred. For Sentinel-1B, the nominal altitude is selected, being the fact that the orbit is already occupied by Sentinel-1A a significant challenge. This has been addressed by imposing constraints on the initial phasing between both satellites in

order to avoid contamination of Sentinel-1A by the launcher thrusters, collision and communication interference between both satellites.

In Sentinel-5P mission the available time to acquire the desired orbit and the available delta-v are not major constraints and the propulsion capability is ample. In this mission, safety is the driving factor both for the selected injection orbit and for the final approach to Suomi-NPP.

The developed tool was design for the plan of orbit acquisition concepts when a phasing or a longitude of ascending node are required. Another straight forward application is the computation of a draft orbit acquisition plan once the launch orbit is known. In some missions, the nominal orbit needs to be acquired as soon as possible and the manoeuvring plan needs to be ready by the end of LEOP. Usually optimization tools take long to analyse each case and some initial guesses are needed. This tool can be used speed the process by performing a holistic assessment of several strategies before using an optimization software. It is planned to test the tool for the Sentinel-2A launch, where the simplified orbit acquisition plan proposed by the tool will be assessed with respect to the actual implemented manoeuvres.