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CLOSE SATELLITE FORMATION FLYING FOR "ULID" MISSION

Abstract

The framework of this paper is a CNES demonstration mission called "ULID" which is dedicated to the moisture and ocean salinity monitoring using L-band interferometry.

This mission consists of 3 nanosatellites flying in formation. The distance between the satellites in operational configuration is about 40 meters and that's one of the challenging aspects of the mission. The satellites are equipped with ISL (inter-satellite link) equipment that are used to exchange GNSS information for the maintenance of the formation with the required accuracy. Given the small inter-satellite distances and control windows, the formation will be controlled autonomously on board.

The orbit chosen for the mission is a 6h/18h quasi Sun-synchronous orbit with an altitude of about 600 km. Only the relative geometry is controlled and maintained, so the altitude of the orbit is allowed to drift freely during the mission lifetime which is nominally 1 year, but that could be extended to 2 years.

The spacecraft are 6U nanosatellites, with mass close to 20 kg. They are equipped with a propulsion system delivering 0.35-0.5mN thrust. Due to power limitation, it is not possible to activate the propulsion system more than about 12 min per orbit.

The paper will first detail the geometry of the formation, which is defined such that the satellites describe a circle in the plane perpendicular to the radial direction. The way differences in orbital elements are derived will be explained in the paper as well as how the inter-satellite distances are sensitive to these differences (which is useful for formation keeping).

An important phase is the formation acquisition phase from launch to acquisition of mission configuration. The spacecraft are first operated by the ground control center. The good performance of the ISL equipment is assessed when the satellites are about 5 km apart of each other, then the GNSS-based relative navigation system is activated, allowing to reduce progressively the inter-satellite distances. The control is then transferred to the autonomous onboard system which continues bringing the spacecraft closer and closer until the desired configuration is reached.

Specific methods and models (continuous approximations with polynomials) are used to evaluate the trajectory that should be followed by the satellites before they reach the "5 km" target given the low thrust capability of the spacecraft. Other specific algorithms are used in the following phases, including the formation maintenance phase, which requires about 3 maneuvers per day in order to counteract the effect of perturbations and keep the geometry of the formation. One major aspect during all the phases is collision risk, either between the satellites of the formation, or with external objects.

Maneuver execution errors and failures are factors that may endanger the mission, and they require appropriate actions. The maneuver strategies that are envisioned will be explained and discussed.