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EMBEDDED MODEL CONTROL GNC FOR THE NEXT GENERATION GRAVITY MISSION

Abstract

A Next Generation Gravity Mission (NGGM) concept for measuring the Earth's variable gravity field has been recently proposed by ESA. The mission objective consists in measuring the temporal variations of the Earth gravity field over a long time span, with very high spatial and temporal resolutions.

This paper focuses on the GNC design for NGGM. NGGM will consist of a two-satellite long-distance formation like GRACE, where each satellite will be controlled to be drag-free like GOCE. Satellite-to-satellite distance variations, encoding gravity anomalies, will be measured by laser interferometry. The formation satellites, distant up to 200 km, will fly in a quasi-polar orbits at an Earth altitude between 300 and 450 km.

Orbit and formation control counteract bias and drift of the residual drag-free accelerations, in order to reach orbit/formation long-term stability. Drag-free control is the core of the orbit/formation control since it allows the formation to fly counteracting the atmospheric drag, ideally subjected only to gravity. Orbit and formation control, designed through the innovative Integrated Formation Control (IFC), have been integrated into a unique control system, aiming at stabilizing the 'formation triangle' consisting of satellites and Earth Center of Masses.

In addition, both spacecrafts must align their control axis to the satellite-to-satellite line (SSL) with micro-radian accuracy. This is made possible by specific optical sensors and the inter-satellite laser interferometer, capable of materializing the SSL. Such sensors allow each satellite to pursue an autonomous alignment after a suitable acquisition procedure. Pointing control is severely constrained by the angular drag-free control which must ideally zero the angular acceleration vector, in the science frequency band.

The control unit has been designed according to the Embedded Model Control methodology and is organized in a hierarchical way where drag-free control plays the role of a wide-band inner loop, and orbit/formation and attitude/pointing controls are narrow band outer loops. The relevant state equations are converted to discrete time providing the embedded model, part of the control unit. State predictor, control law and reference generator are built on and interfaced to the embedded model.

Simulated results, via a high-fidelity simulator, prove the concept validity and show that the control performances are in agreement with the defined mission requirements. Indeed, the presented control strategy has been shown capable of keeping the attitude and formation variables stable within the required boundaries, all over the 10-year mission, through a low-thrust authority in the order of few milli-Newton.