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FORMATION, ORBIT AND ATTITUDE CONTROL FOR FUTURE LONG-BASELINE EARTH GRAVITY MISSIONS

Abstract

PostGOCE and postGRACE space missions will rely on a formation of freefalling proof masses and on the measurement of their distance variations for revealing anomalies of the Earth gravity. Spacecrafts hosting freefalling masses are drag-free satellites. Two alternatives are possible. 1) Free-falling mass solution: the satellite chases the proof mass to keep it centered in the cage through a control system fed by mass position sensors and actuated by thrusters mounted on the spacecraft. 2) Accelerometer solution: the proofmass is endowed with a suspension system keeping the mass centered. Since the known suspension force equals the non-gravitational forces acting on the satellite, the latter can be directly cancelled by thrusters driven by dragfree control. The paper is concerned with this solution. Gravimetry is improved by a long-distance formation as in the GRACE mission, by making each satellite drag-free as in the GOCE mission and by disposing of a high-accuracy measurement like that provided by laser interferometers. Formation distance requirements are dictated by the distance variation range of interferometers, which is of several hundreds of meters. During normal operations, attitude control must be rather accurate to allow the laser beam pointing to the receiving optics. We assume that each satellite launches its own laser beam to be aligned with the incoming beam of the companion satellite. Each satellite must dispose of sensors capable of accurately measuring axis misalignment. Laser optics is designed such as laser pointing is achieved by two degrees-of-freedom attitude control (pitch and yaw). The third degree (roll) is used for servoing solar panels to sun direction. Attitude, during laser pointing acquisition, and roll, during normal operations, are measured by star trackers. Formation control need to measure the relative satellite position which is done by differential satellite-to-satellite navigation instruments like GPS receivers. Drag-free control requires accelerometers providing linear and angular accelerations. Drag-free, formation and attitude control are actuated by a propulsion assembly , which in this case consists of eight small proportional thrusters capable of a few millinewton thrust. The control problem is tackled within the Embedded Model Control, which calls for a control unit around the real-time embedded model of the controllable dynamics to be complemented by the dynamics of the disturbance to be rejected. Orbit and drag-free control can be considered as subsystems of the formation control. Laser pointing and roll control take advantage of an angular drag-free control, which is demanded to zero angular accelerations.