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ADCS CONCEPTUAL DESIGN FOR GOSOLAR DEMONSTRATOR MISSION.

Abstract

This paper aims to provide a detailed analysis of the initial ADCS (Attitude Determination and Control System) design of DLR's (German Aerospace Center) demonstrator mission GoSolAr (Gossamer Solar Array). The goal of this mission is to demonstrate the two-dimensional deployment of a 25m2 flexible solar array in orbit. Understanding of the satellite configurations and control phases is critical for the design of the ADCS. The main structural configurations are stowed and deployed, in which the satellite consists of a central part to which the solar array is attached via four composite booms. The control phases are detumbling, deployment and acquiring and maintaining an orientation w.r.t. the Sun.

This study focuses in developing a control approach for the attitude of the satellite able to deal with the difficulties inherent to the GoSolAr satellite. These difficulties can be divided in two groups, related with the particularities of the deployed structure and to the limitations of the attitude actuators selected. In relation with the structure, the most concerning issues are related with the considerably high area-to-mass and moment of inertia-to-mass ratios, which increase the effect of external disturbances and reduce that of the control actuators. This initial design contains only magnetorquers, generating a locally underactuated system.

The analyses focuses in the pointing phase, which aims to reach and maintain a relative orientation of the main axis of inertia w.r.t. the Sun, while generating a spin around this axis to stabilize the satellite. In relation to this phase, two control approaches are explained, implemented and evaluated. The first one is based on using a linearization of the plant combined with an LQR (linear-quadratic regulator) approach. The second control approach is known as the Udwadia-Kalaba approach, and is based in the parallelism between constrained and controlled systems. This approach leads to a non-linear controller which can include complex guidance instructions.

The performance of these controllers is evaluated for the nominal case, confirming that they are able to fulfill the requirements. The difference in performance between LQR and Udwadia-Kalaba control approaches is explained, focusing on convergence time and long term error. Finally, some limitations in relation to the ADCS design are pointed out, related to control actuation limitations and to assumptions made when deriving the controllers. In relation to the control actuation, the use of magnetorquers imposes a limitation in altitude and in orbital inclination. The potential consequences of neglecting the flexibility are also addressed qualitatively.