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PRELIMINARY GUIDANCE AND NAVIGATION DESIGN FOR THE UPCOMING DLR REUSABILITY FLIGHT EXPERIMENT (REFEX)

Abstract

The experience of SpaceX's Falcon 9 and Blue Origin's New Shepard shows that reusability is becoming an important feature for the sustainability of future space missions. The German Aerospace Center (DLR) is developing the Reusability Flight Experiment (ReFEx), which is scheduled for launch on a Brazilian VSB-30 sounding rocket in 2021. The mission shall enable the development of key technologies necessary for future reusable launch vehicle applications, culminating in their demonstration with a controlled autonomous return flight in a representative regime.

Two critical elements for the success of the mission are the guidance and the navigation subsystems. In order to meet the desired landing performance, the guidance needs to steer the vehicle to the desired landing zone with reduced dispersion despite limited control authority and the presence of strong uncertainties and disturbances like wind gusts, atmospheric density variations, and aerodynamic modeling errors. Moreover, strict vehicle integrity and flight safety requirements have to be satisfied. This challenging task requires a highly accurate estimation of the vehicle state during the entire mission, which is realized by a hybrid navigation subsystem architecture. This approach overcomes limitations of conventional navigation based on purely inertial solutions by fusion of measurements from different sensors. In order to command, monitor, and trigger sensors as well as to filter and process the measurements, to calculate the navigation solution, and to provide it to the guidance, the navigation subsystem comprises a fault-tolerant, high-reliable on-board computer system, which is vital for the operation of the navigation subsystem and hence to the entire vehicle.

This paper presents the proposed architecture for the two subsystems. We show the guidance analysis of the reference optimal trajectory and the controls to track it, together with a flight safety assessment. We study different sensor configurations and their achievable performances through covariance analysis. Finally, we describe the preliminary functional and algorithmic structure of the navigation process as well as the fault detection, isolation, and recovery strategy.