IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
Technologies for Future Space Transportation Systems (5)

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ARCHITECTURES OF HYBRID NAVIGATION SYSTEMS (HNS) FOR REUSABLE SPACE TRANSPORTATION SYSTEMS

Abstract

In order to bring reusable space transportation systems back to Earth, determining and actively controlling the flight state (that is, position and attitude) is essential. These capabilities are usually provided by Guidance, Navigation, and Control (GNC) systems implemented aboard the spacecraft. One of the functions required and provided by GNC systems is the *navigation function*, which is responsible for estimating position, velocity, attitude, angular velocity, and other parameters of the flight state. Especially the final flight phase of reusable space transportation systems with approach to and landing in/on a predefined area or platform demands a challenging navigation accuracy, which cannot be achieved by conventional navigation systems. The navigation of launch systems worldwide mostly still relies on pure inertial navigation, i. e., the propagation of acceleration and rotation rate measurements. The accuracy of this navigation method is rapidly decreasing with the flight duration as the process is subject to integration drift.

The GNC Systems Department of the DLR Institute of Space Systems in Bremen is developing novel,

autonomous Hybrid Navigation Systems (HNS), which overcome the limitations of conventional navigation systems by combining measurements of inertial and non-inertial sensors by methods of data fusion. They provide a long-term accurate navigation solution suitable for reusable space transportation systems. HNS are currently being developed in the frame of two Reusable Launch Vehicle (RLV) missions with different landing approaches: ReFEx (Reusability Flight Experiment), which is a DLR technology demonstrator for the development of key technologies for winged Vertical Take-Off, Horizontal Landing (VTHL) RLV, and CALLISTO, a joint project of CNES, DLR, and JAXA for the development of a Vertical Take-Off, Vertical Landing (VTVL) RLV.

This paper takes the developments in both of these missions as an example and describes the challenges faced for the development of navigation systems for VTHL and VTVL RLV. It provides an overview of the principal HNS architecture, which is commonly developed for both missions, and presents the selected sensor suites with differential GNSS, Sun sensors, laser and radar altimeters, and flush air data systems as non-inertial sensors including the required ground-based means and infrastructure. The paper concludes with an analysis of the achievable navigation performance for each of these missions.