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HARDWARE-IN-THE-LOOP TESTS OF COMPLEX CONTROL SOFTWARE FOR ROCKET PROPULSION SYSTEMS

Abstract

Software of rocket propulsion systems exhibit very high complexity and nevertheless must guarantee an extremely high reliability. Therefore, extensive test procedures are foreseen in the development process. In ground tests often only specific features from the complete scenario can be addressed by specific hardware equipment.

In the future adaptive/reconfigurable control algorithms for the propulsion system will become increasingly important. Adaptive control algorithms can identify specific characteristic parameters during operation and use the gained information to optimize related control actions. One essential parameter of the propulsion system is the resulting thrust vector, which should be identified very accurately. In addition, coupling the control algorithms to suitable anomaly detection systems allows the safe reaction to unforeseen events, which further improves the reliability of the propulsion system.

The DLR-Institute of Space Propulsion operates extensive test facilities for developing propulsion system technologies to operational maturity and ensuring their quality. A major focus of the ongoing research is the detailed characterization of the combustion process within rocket engines, which determines thrust and efficiency. This contribution addresses hardware-in- the-loop methods for associated anomaly detection and control systems.

Specific attitude pointing aspects of the propulsion system software can be simulated by high precision turntables of Zentrum for Telematics (ZfT). Within the cooperation between the DLR-Institute and the ZfT, different aspects of complex control software for propulsion systems are analyzed and tested using the available facilities. A roadmap surveying a step-by-step approach related to hardware-in-the-loop tests of these advanced algorithms is presented.