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ADIA: A NOVEL ONBOARD FAILURE DIAGNOSTIC SYSTEM FOR NANOSATELLITES

Abstract

Spacecraft failure analysis is often a time-consuming process which requires increased attention from ground personnel. Since operations expenditures represent a major part of overall satellite mission cost, efficient assignment of resources, especially when it comes to as weighty a cost factor as manpower, is critical. This is especially true for small-scale satellites which are often operated by research groups with limited means. Also, ground-based error source isolation by operators implies that due to limited contact windows, real-time diagnosis is usually out of the question, hence losing valuable time when quick reactions to critical failures are necessary. Moreover, the onset of failures looming for several days or weeks cannot be easily predicted by human operators who are by and large not good at trend-analyzing large amounts of data, especially if mutually interdependent time series are involved. Thus, the capability to analyze errors in real-time onboard a satellite is desirable as it can help cut costs and reduce mission failure risk.

In order to provide such capabilities, the development of a new autonomous failure diagnostic system called ADIA (Autonomous Diagnostic System for Satellites) has started at the University of Würzburg which is funded through the German Aerospace Center (FKZ 50RM1231) by the Federal Ministry of Economics and Technology (BMWi). The goal is to develop an onboard diagnostic software which is capable of detecting errors, isolating them with respect to their cause as well as trend analysis of spacecraft telemetry data for the prediction of future subsystem malfunctions.

The system consists of two functionally intertwined components. One is a set of diagnostic algorithms with an interface to the satellite's TTC system. The second is a satellite simulator software which has two functions: on the one hand, it serves as a "telemetry generator" in the context of ADIA's development process, providing the diagnostic core with raw data during system testing and fine-tuning. On the other hand, the simulator can itself be integrated into the diagnostic component, thus making ADIA a model-based analysis tool. Internal states of the simulator can be compared with the state of the actual satellite in order to derive hypotheses on the nature of an emerging error.

The focus of this paper lies on the discussion of ADIA's requirements, the basic functional concept as well as the workings of the diagnostic core. Additionally, a brief discussion of the nanosatellite to be modeled as part of the development process is included.