SPACE OPERATIONS SYMPOSIUM (B6)
New Operations Concepts, Advanced Systems and Commercial Space Operations (2)

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ADIA: AUTONOMOUS DETECTION, ANALYSIS AND PREDICTION OF ON-ORBIT SPACECRAFT FAILURES

Abstract

Spacecraft ground operations require increased attention from engineering staff during on-orbit failures. The process of anomaly identification, isolation and recovery is especially costly in terms of man-hours and – potentially – the risk of total loss for small research groups at universities operating their own satellites. Also, unavailability of extended coverage for independent operator entities due to a lack of ground station networks or interplanetary distances of probes may worsen situations where causal analysis of existing errors is a time-critical matter. Simultaneously, future failures "creeping" into subsystem components over time might announce themselves early on but in ways not obvious to human operators.

ADIA (Autonomous Diagnostic System for Nanosatellites) is a software system which has been funded by the DLR (FKZ 50RM1231) and developed at the University of Würzburg to tackle several of the problems mentioned. Its task is the detection and causal analysis of on-orbit failures and anomalies of small satellites while running either on the latter's onboard computer (OBC) or on a separate hardware unit. Furthermore, ADIA performs early prediction of future failures through trend detection. A first version has been finalized through the joint efforts of the Chairs of Computer Science VIII and VI. Both a desktop PC version with a graphical user interface for use during everyday ground operations and an embedded version for the DLR's satellite middleware RODOS for deployment onboard the satellite itself are available.

At the heart of ADIA's diagnostic core, a heuristic reasoning engine is at work. It uses the following pipeline: 1. The spacecraft's OBC sends telemetry frames to ADIA. 2. ADIA preprocesses the data by computing various derived parameters (symptoms). 3. Possible diagnoses are ranked with a heuristic score to identify the most probable cause for the symptoms. In the same way, the software executes the prediction of trends in various figures of interest describing spacecraft status. For this purpose, it relies on a locally stored history of telemetry parameters from which to extrapolate, hence forecasting possible future anomalies.

Furthermore, verification and testing of ADIA by means of a satellite simulator software are discussed in this paper as well as future deployment options on one or more nanosatellites. Additionally, improvements to ADIA by means of ADIA++, the successor version of the original software currently under development are shortly outlined together with the latter's updated concept.