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Author: Mr. Tiago Nogueira
Zentrum für Telematik, Germany

Mr. Slavi Dombrovski
Zentrum für Telematik, Germany
Dr. Stephan Busch
Zentrum für Telematik, Germany
Mr. Artur Gasparyan
University of Würzburg, Germany
Prof. Klaus Schilling
Zentrum für Telematik, Germany

MONITORING AND CONTROL OF THE NETSAT FORMATION: CONCEPTS AND TOOLS FOR OPERATIONS OF MULTI-SATELLITE SYSTEMS

Abstract

The NetSat formation flying mission, with a tentative launch in early 2018, will demonstrate in orbit the autonomous control of a formation of four pico-satellites. The development and in-orbit demonstration of such a system will make contributions in the areas of onboard autonomy, distributed formation control, relative navigation, inter-satellite communications and protocols, and miniaturised attitude and orbit determination and control. Development of such systems will pave the way for new scientific and commercial applications based on fractionated satellite architectures.

With NetSat, we build on the design and operational experience gained at the University of Wüzburg with the UWE pico-satellite program and take the step towards multi-satellite systems and operations. Managing the ground-station contacts when several satellites, flying close together, need to share a single ground-station; efficiently maintaining an overview of the overall mission status without being overwhelmed by the amount of telemetry; or quickly identifying and recovering from failures, are some of the new challenges we need to manage. Typically, the answer implies extending existing tools, adding extra personal and ground-stations without rethinking the overall approach. On a tight budget, we take an approach towards more onboard autonomy, goal-based operations and model-based monitoring and FDIR. On NetSat the operator should be able to monitor and control the formation as if it were a single satellite.

This contribution starts by introducing the NetSat mission objectives and requirements, and the mission's high-level system design and constraints. We look briefly at some existing and planned multi-satellite missions, including ESA's Swarm and the OneWeb's constellation, and review their approaches and operational tools. We introduce then our goal-based operations and autonomy concept, design and implementation, grounded on a redundant onboard computer, an automated timeline-based onboard planner, a model-based robust executive and a protocol stack for ground-space and space-space communications. Finally, we introduce our goal-based multi-satellite Mission Control System (MCS). This new system is an extension of our current MCS, updated to tackle many of the problems that arise when moving to multi-satellite operations. The MCS places special focus on ease of operations and automation, trying to reduce the complexity displayed to the operator and simplify his role. We describe the MCS's new goal management system and a model-based monitoring system to ease failure identification, isolation and recovery.