27th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Small Satellite Operations (3)

Author: Mr. Ricardo Silva
VisionSpace Technologies, Germany, ricardo.silva@visionspace.com

Mr. João Guerreiro
VisionSpace Technologies, Germany, joao.guerreiro@visionspace.com
Dr. Simone Fratini
ESOC - European Space Agency, Germany, simone.fratini@esa.int
Mr. Nicola Policella
ESA, Germany, nicola.policella@esa.int
Mr. Tiago Nogueira
VisionSpace Technologies, Germany, tiago.nogueira@visionspace.com

GOAL-ORIENTED ONBOARD AUTONOMOUS OPERATIONS: AN OPS-SAT EXPERIMENT

Abstract

New space missions will require a higher degree of onboard autonomy operations to increase the quality of the returned science, to shorten the space-ground decision-making loop, and to enable new mission scenarios. This is particularly true for small satellite platforms, which tend to be much more limited in terms of storage, power, thermal and downlink capacity, for example. This class of missions has much to benefit from an onboard autonomy system that can help mitigate these constraints on the onboard resources to boost overall mission return.

The possibility to combine Artificial Intelligence technologies like Machine Learning and Automated Planning on board a satellite is now slowly becoming feasible and appealing. This offers a satellite system the capability to use the output of automated data analytics mechanisms as input for decision-making processes that autonomously generate and execute activity plans, all this on board.

This contribution describes the experimental onboard autonomy system developed for the ESA OPS-SAT nanosatellite mission, detailing the overall architectural design and interfaces, the verification and validation activities and the first results. The autonomy system consists of three main components: (a) an image processing and classification component that autonomously identifies and classifies Areas Of Interest; (b) a domain-independent timeline-based constructive planner that autonomously generates executable schedules from user-defined goals; and (c) a platform-agnostic executive that executes time-flexible schedules.

This experiment constitutes the first attempt to apply Artificial Intelligence for onboard autonomy on an ESA flying mission. Initial steps were taken in the past to validate, on the ground, the building blocks and technologies of this system, such as diagnostics and automated planning. This experiment moves forward the state-of-the-art at ESA and takes inspiration from previous NASA-JPL missions that have pioneered and proven the value of AI planning and scheduling for autonomy in space applications. The Remote Agent Experiment on Deep Space 1 and the Autonomous Sciencecraft Experiment on Earth Observing 1, are the two most notable examples.

This paper starts by introducing the mission scenario and the overall objectives of the autonomy experiment. It then describes its architecture and interfaces, detailing each of its three key components. Afterwards, it details the VV activities performed, together with some first results from simulations and in-flight demonstration. The paper closes with a proposed roadmap to promote the adoption of more onboard autonomy functions for future small satellite platforms.