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Author: Dr. Juan Luis Gonzalo
Politecnico di Milano, Italy

Prof. Camilla Colombo
Politecnico di Milano, Italy

AUTONOMOUS COLLISION AVOIDANCE ON-ORBIT EXPERIMENT IN THE E.CUBE MISSION

Abstract

The increasing satellite traffic in the low Earth orbit region has spurred multiple initiatives to advance Space Traffic Management (STM) systems and in-orbit autonomy, to ensure the safe and sustainable utilization of space. This includes private initiatives, like the automated collision avoidance system in Starlink satellites, and others promoted by space agencies and governments, such as ESA's CREAM, NASA's proposal for an STM architecture, or the EUSTM and Spaceways projects funded by the European Commission. Within these efforts, one key goal is increasing the automation of collision avoidance (COLA) activities, both on-ground and in-orbit.

Developing and testing an on-board autonomous COLA system is one of the mission goals of e.Cube - The environmental CubeSat. This 12U CubeSat mission, currently in Phase A, is being developed by an Italian team from industry and academia, formed by D-Orbit, Politecnico di Milano, Temis, Università di Padova and Intelligentia. It is funded by the Italian Space Agency as part of its Alcor program, which aims to position Italy as an international leader in the nanosatellites field. e.Cube will carry out three scientific experiments related to the sustainability of space operations: autonomous on-board COLA; in-orbit characterization of non-trackable debris, to support space debris modelling; and atmospheric and thermomechanical measurements during re-entry, to inform the improvement of re-entry models.

The autonomous on-board COLA architecture in e.Cube assumes that the spacecraft receives a sequence of Conjunction Data Messages (CDM), to make it as compatible as possible with current operations. This data is processed by the dedicated on-board computer in two stages. First, a machine learning (ML) component decides if a Collision Avoidance Manoeuvre (CAM) is required. Secondly, a quasi-optimal manoeuvre is computed on-board using analytical models. For the in-orbit experiment, a sequence of synthetic CDMs will be uploaded from ground, and the outcome of the decision process and CAM monitored. This work will present the current development of these building blocks, including the generation of synthetic CDM datasets for both ML training and experiment execution, the selection and training of the ML component, and the analytical models for on-board CAM computation. Furthermore, the structure for the complete COLA framework is presented, and the requirements in terms of data input, combination with other data sources and possible federation of CDM uploading to the satellite discussed.