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UPPER-STAGE AUTONOMOUS CUBESAT PROPULSION MODULE FOR AFFORDABLE ACCESS TO EARTH ORBIT

Abstract

The overall technological advance that has been occurring in the past decades in the space domain is exponentially growing towards the direction of miniaturization. An example of very small spacecraft that still allows for development and innovation are the CubeSats, fully standardized platforms made of 100 mm3 units, eventually combined into a bigger satellite if needed. CubeSats have been flourishing in the past 15 years, allowing for dramatic reductions of the costs of missions in Low Earth Orbit from at least three points of view: standardization (including wide use of Commercial-Off-The-Shelf components), miniaturization, launch. Nevertheless, autonomy (which can be defined as the capability of executing the mission, or part of it, without active intervention of an external entity) is still a significant challenge for CubeSat developers and integrators, due to the mass, power, volume and internal computational power limitations of this class of spacecraft. Achieving autonomy requires, among other things, to include in the spacecraft design active components such as a propulsion system. This, in turn, raises issues for assuring safety to the other surrounding spacecraft in orbit. High risks are foreseen, and strict measures are expected to be applied in the future regulations, in scenarios such as a thrust-direction failure in a small spacecraft, with consequent damage to other spacecraft creating debris. This problem becomes even more critical in Low Earth Orbit operations, due to the presence of inhabited platforms such as the International Space Station. This paper presents a detailed analysis of the potential scenarios and recovery actions to be applied in the context of propulsion system failures for CubeSats operating in LEO. The analysis requires the definition of an appropriate Fault Detection Isolation and Recovery (FDIR) system, taking into consideration all failure cases at every step of the mission. All possible types of failures are identified and analysed: internal (e.g. hardware, software), external (e.g. background radiation, thermal environment) and human (e.g. wrong parameters inserted). Based on the identified failures, the corresponding recovery actions are investigated and evaluated. These investigations represent the first steps of the development of the FDIR algorithm. The development of such a FDIR system for autonomous CubeSats in LEO represents a fundamental milestone that will allow the use of such platforms in order to perform valuable research and science Earth Observation tasks in a safe and sustainable way.