INCREASING RAMS FOR NOVEL LOW COST AND COMPLEX MISSIONS BASED ON CUBESATS TECHNOLOGIES

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ABSTRACT

"Increasing RAMS for Small Satellites" is an activity under the ESA umbrella whose main objective is to specify and design a FDIR system by making use of relevant RAMS analyses for missions in non-deterministic environment with limited resources. The project is being conducted by a consortium formed by Deimos (prime contractor), Politecnico di Milano and Delft University of Technology.

Small Satellite/CubeSat missions were born primarily for educational or demonstration purposes, reason why their driver was the cost reduction and lead time. COTS standard assemblies and components were chosen as baseline, coupled with a shortening of the design, analysis, and testing phases. This led to a failure rate of CubeSats quite high compared to conventional satellites, implying reduced reliability and lifetime, trend that continues to date.

The rationale for this study is the increasingly consideration of small satellites for more demanding missions, involving complex spacecraft and mission architectures in situations where high levels of autonomy are expected. This makes essential to focus on achieving a significant degree of reliability in accordance with the CubeSat philosophy. Therefore, the solution should not rely on traditional space market way out, which is related to the use of space-grade components, conservative designs, or physical redundancies implementation. Alternatively, engineering practices adapted to small satellites on an appropriate scale are proposed. The objective is to ensure that COTS reliability data and CubeSats limitations do not jeopardize the missions.

Implementation of reliability engineering approaches based on RAMS analysis allows early identification of risks in the design phase, finding the root causes and hence developing strategies to correct or mitigate them at little or no cost. That is, a risk management system applied from the beginning of the program enables prioritization of analyses, tests, reviews, and activities, without too much impact on budget and planning. The "robustness" of the system is achieved through a risk mitigation strategy, ensuring the best price-quality ratio in missions with low resources. The aim is to understand how missions can be resilient to failure, and thus apply design practices to achieve a robust system. Rather than trying to do everything, identify what are the most important things to do and make sure those things get done.

Analysis, tests, processes, etc. shall be selected based on the programmatic risk (cost, schedule) and the technical risk (risk of in-orbit failure).

Fault tolerance methods, such as the FDIR architecture, appears as the enabler for future complex CubeSat missions. It ensures functional redundancy and proper fault detection and recovery without impacting cost, planning or system budgets, providing added value to CubeSats missions in terms of safety, performance, and reliability. For the missions of interest in this study, e.g., deep-space missions, the benefits of this tool are highlighted; considering that ground contact frequencies are limited, an autonomous system with high availability is required to solve in-flight issues. However, during the development of the FDIR concept, the limited resources available on CubeSats shall be considered. At this point the importance of the RAMS analyses is highlighted as, considering their findings, the FDIR can be formulated focusing on the most critical aspects.

To date, the first part of the project has been completed, encompassing a wide investigation within existing databases of the failures and issues arising in SmallSats/CubeSats. A review of the state of the art has led to a better understanding of the reasons for the failure rates of small satellites, mainly occurred during early phases of their lifetime. In particular, information such as which subsystems are associated with the highest failure rate has offered valuable data to identify the critical areas that need to be especially addressed during the reliability improvement process.

The conference will guide the audience through the specificities of the RAMS analysis and FDIR concept applied to a use-case of a small satellite deep-space mission. The conclusions obtained during the first phase of the study will be presented with the intention of providing a view of how Systems Engineering must work in tandem with RAMS analyses and FDIR concept to achieve a more robust and functional mission architecture.