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INNOVATIONS AND RELIABILITY IN MINICOR: HOW FMEA AND ARCHITECTURE RELIABILITY ANALYSIS CAN IMPACT A MISSION POTENTIAL SUCCESS

Abstract

Over the last several decades, NASA and NOAA have spearheaded various scientific missions within the field of heliophysics. Among them, coronagraphic missions stand out for their key contribution to enhance our comprehension of Solar phenomena. In particular, Coronal Mass Ejections (CMEs) are crucial for space weather forecasting. These missions have always been carried out by conventional large-scale instruments, but now the Miniature Coronagraph (MiniCOR) emerges as a pioneering CubeSat initiative. However, almost half of all CubeSats in the last decade have faced partial or complete failures. For this reason, addressing these issues swiftly not only boosts the possibility of mission success, but also supports sustainable space utilization. Scheduled for a 2027 launch, MiniCOR is a 6U CubeSat designed to observe the CME's kinematics and shocks in the Sun's corona. The spacecraft is equipped with a deployable solar occulter and a telescope. As part of the NASA H-FORT program, the mission involves a team from the Applied Physics Laboratory (APL), the Naval Research Laboratory (NRL) and Argotec. Leveraging heritage from the LICIACube and ArgoMoon missions, the MiniCOR design philosophy is based on an incremental reliability approach, with the application of a rigorous Failure Mode and Effects Analysis (FMEA) strategy, that will be used from the very first stages of development. This systematic approach helps identify and mitigate potential failures across all mission phases, while also implementing the lessons learned from prior design and operations of CubeSat platforms. The information highlighted by these analyses will aid in the definition of the elements of the spacecraft architecture, weighing in on the platform tradeoffs. Furthermore, this analysis may surface potential needs for critical redundancies, reliable interfaces definition, and possible improvements in the mission ConOps that could lead to an increase in robustness and reliability once in orbit. The level of detail of this FMEA will increase alongside the platform, leading to a robust architecture and Failure Detection, Isolation and Recovery (FDIR). The increased complexity of CubeSat missions is impacting reliability and sustainability. High-profile failures can erode trust in these types of missions, thus reducing support and funding. The methodology proposed here ensures that MiniCOR's mission will advance our understanding of the heliosphere and improve space weather forecasting. It will also establish new benchmarks in CubeSat reliability for future explorations around and beyond the Earth.