Applying Digital Risk Twin & Causation-Based AI for Space Assets

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1 ABSTRACT

Now days, more and more space exploration missions (such as Europa Clipper mission or JUICE spacecraft; JUpiter ICy moons Explorer) are taking place to explore our solar system, and even beyond (outer solar system and interstellar space beyond the Sun's heliosphere). Due to space rough environment (solar winds, coronal mass ejection, etc.), failures are common to occur. As an improvement of technology in the past couple of years, assets are becoming more and more complex and defining root causes of failures & applying proper control measures is becoming a real challenge. In addition to that, every space mission is facing "ground-control / asset" communication time delay (deepest it gets, longer it takes to get the info). For critical missions, this delay can be fatal to the asset if failure occurs during time essential phases - ground-control won't have the information on time to react accordingly. There is a need for automating either failure identification on-board the asset & mitigation actions.

During this presentation, we'll show how a Digital Risk Twin (MADe; Maintenance Aware Design Environment) can be leveraged to define the design and capture syndromes of failure in the early stages of the satellite conception. The Digital Risk Twin can assess where to allocate sensors to have the best failure coverage in the system. Coupling the Digital Risk Twin syndromes of failures with a causation-based AI tool (Syndrome Diagnostic) will allow the asset to provide real-time Fault Detection and Isolation of critical failures (on the edge fault Detection and Isolation).

Identifying the failure is only half of the work - as maintenance actions can't yet be conducted in space, there is a need to identifying alternate pathways (Workarounds) for a function to be successfully executed by a system if a critical component experiences a Functional Failure. To do so, Fall-Back Analysis (FBA) will demonstrate how it increases the likelihood of mission success by using another planned pathway (or solution) to ensure the same function is achievable, even if the primary functional pathway fails to operate.