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SATELLITE ARCHITECTURE OPTIMIZATION VIA ADAPTED RELIABILITY ANALYSES FROM COMMERCIAL AVIATION

Abstract

In course of the introduction of the world's first mega-constellations, the demand for small and high performance low-cost satellite systems manufactured in serial production is consequently increasing in modern space industry. As a result of the immense number of satellites, time- and cost-intense iteration steps in the satellite design process have to be shortened to a minimum. In order to achieve this objective, the required system reliability and system functionality of proposed satellite architectures has to be ensured in advance via new software tools and new methodological approaches in reliability and lifetime analysis.

Taking a look outside space industry, it is found that other industrial branches like aviation, automotive or nuclear industry already developed special methods for high performance system analysis and architecture optimization. In commercial airliners' airworthiness processes for instance, importance analyses are being used to identify and enhance the statistically most failure-prone elements in aircraft architectures and thus to improve aircraft's safety and reliability.

However, these methods cannot easily be applied to satellite systems for architecture optimization. Mission design and associated system requirements concerning energy and propellant budget as well as attitude control have a direct impact on a satellite's lifetime. For example, the solar arrays of a satellite system can differ in size, orientation, shading intervals, mean operating temperature and degradation progress during mission duration, making every single array unique in its importance for energy supply and mission reliability. Considering this, the combination of array failure leading to total system loss is hard to identify and additionally time-dependent, which cannot be handled by conventional importance analyses. Furthermore, a satellite component's lifetime and reliability depends on its activity during its mission. Components which are only active over short periods of time (e.g. Earth observation payloads, star trackers or propulsion systems) or designed as passive secondary systems can reach far higher lifetimes than estimated while using whole mission duration as time reference.

Considering these facts, the Institute of Space Systems (IRAS) of TU Braunschweig and safety and reliability consultant company SAREL Consult GmbH initiated the transfer project MiRel (Mission Reliability) in order to develop new methodological approaches allowing the application of current reliability analyses and optimization processes from aviation industry on satellite architectures. The paper will give an overview of the current state of the transfer project, the already adapted analysis methods and the upcoming implementation in a software tool for future application in space industry.