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HIGH-LEVEL MODELLING OF THE RELIABILITY AND MISSION FAULT TOLERANCE OF MULTI- SATELLITE SYSTEMS

Abstract

Increasing number of present and future space missions heavily relay on the operation of multi-satellite systems generating, transmitting and processing heterogeneous, multidimensional 'big data' in real time. A major challenge becomes the space segment, mission objectives driven, data management and data quality assurance of the entire system,linked down to the physical performance and the reliability of the individual standalone satellite platforms and their specific payloads. This paper presents an approach for high-level modelling, at three levels of hierarchy, of the performance of multi-satellite systems of any size, with respect to the user-driven objectives and requirements on the specific space mission. We define three hierarchical levels for high-level modelling of the reliability performance of a multi-satellite system: 1.Individual payload functional behaviour and own state, including the input/output data communication stream related to the payload functionality as needed for the implementation of the specific individual satellite mission; 2.Standalone satellite platform functional behaviour and state,including the related to it in/out data communication stream representing the platform functionality (excluding payload) for implementing the mission goal(s); 3.Multi-satellite system behaviour as a whole, including the related to it in/out data communication stream related to implementing the overall space mission (or specific task) objectives(s). In this work, as a specific example not limiting the applicability of the suggested approach to other classes of multi-satellite missions, we address the specific case of a multi-satellite system dedicated to remote sensing tasks (e.g. EO, Moon/Mars exploration).The disruption/failures of the system individual elements (sub-systems of a stand-alone platform, or whole stand-alone platforms in a multi-satellite system) change the overall functionality and affect the quality of data and service. Changes in the functionality of the individual payloads depend on both their own functional condition (e.g. level of performance degradation due to e.g. aging), as well as on the state of platform sub-systems which ensure the payload reliable operation during the designed lifetime. The developed modelling and simulation tools are portable to various missions and individual tasks (e.g. science experiments). The presented approach naturally incorporates high-level modelling of the information flow in such space systems, and the assessment of the mission reliability in an analytical way. New data recovery algorithms are developed to improve the space systems mission fault tolerance. In result, optimal fulfillment of various possible objectives can be achieved in a cost-efficient manner for the present and future multi-satellite missions.