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METHODOLOGY FOR HEALTH MONITORING OF SPACECRAFT FOR A HIGHLY AUTONOMOUS ASTEROID MISSION

Abstract

With the vision of future deep space missions and the increasing interest of private industries worldwide on a profitable resource extraction from bodies in space, the need for the development of sophisticated autonomous systems rises. With more and more complex mission operations, the operational costs could be reduced as well as the mission success increased by investigating the possibilities that stand-alone systems can offer. Especially in the field of fault management, an implementation of higher autonomy could improve mission safety and support human monitoring. One of the challenges in safety management is the detection and identification of faults using the limited parameters available that spacecraft provide. In this paper, a new methodology for health monitoring on complex spacecraft is presented on the example of an asteroid characterization mission in the main belt.

First, the mission and system design as well as the operational timeline is introduced. The mission is planning a spacecraft departure from a parking orbit in the main belt at 2.8 AU to a sequence of asteroids. During asteroid proximity operations, the asteroid is characterized thoroughly. The spacecraft is realized with an orbiter / lander architecture to be able to provide detailed information on the surface properties. Amongst others, the proximity operations envisage a global and local characterization, the selection of several landing sites and a joint experimental phase during the surface operations of the lander.

Next, a hazard analysis is performed to name mission critical failure cases using the system design described as baseline. A fault tree analysis traces the failure pathways from these cases to the failure or faults on system level. The main potential causes of the mission critical cases are named. As a final step, a new methodology to intercept the procreation of failures in a complex system is presented. The so-called Failure Symptom Analysis (FSA) highlights the system elements that show symptomatic deviations of the norm due to a certain event. Thus, it is possible to define Failure Detection Gates (FDG) that allow the purposeful monitoring of parameters. The list of FDGs that are activated due to an event show a symptomatic scheme that constrain the origin and type of error and are displayed in a Failure Pattern Matrix (FPM).