SPACE OPERATIONS SYMPOSIUM (B6)
Mission Operations, Validation, Simulation and Training (3)

Author: Mr. Andrea Campa
GMV-Insyen for German Space Operations Center (DLR/GSOC), Germany

Mr. Giuseppe Albini
RHEA for European Space Operations Centre (ESA/ESOC), Germany

REACTION TO ANOMALIES IN SPACE: HUMAN SPACEFLIGHT AND UNMANNED MISSIONS MUTUAL LESSON LEARNT AND OPTIMISATION CONCEPTS

Abstract

Since the beginning of the space era, engineers designing manned spaceships, unmanned satellites and space probes got the challenge of developing advanced tools to monitor and control critical and complex on-board space systems in order to detect and react to failures.

This concept, implemented under the name of FDIR (Failure Detection, Isolation and Recovery) has evolved alongside with the degree of autonomy of spacecrafts up to becoming the core of human life and systems safety in space.

The need of a robust FDIR logic is now unavoidable and stressed to maximum efficiency in two environments almost at the antipodes of contemporary space missions: the International Space Station - where the safety of the crew has the highest priority - and the satellites in LEO, whose safety and mission goals have to be ensured with a high reliable level of autonomy by the FDIR itself.

In essence, on board the manned ISS, priority is given - in decreasing order - to Crew, Vehicle and Mission. This is similarly reflected on the contingencies annunciations hierarchy, i.e. Emergencies, Warnings and Cautions. For each of those criticality levels, a combination of On-board and Flight Controllers reactions is necessary, together with crew involvement in case of life danger, need to support ground or loss of communication.

The ISS module *Columbus* bases its failure and contingency response on two different levels, a nominal one, for efficient reconfigurations of systems and software, and a vital one, where an immediate high-priority reaction is needed.

On the other side, the FDIR algorithms of LEO spacecrafts base their reactions on the monitoring of parameters and events performed by the On-Board software. This service triggers, in case of violation, a set of implemented and patchable instructions to be executed mostly in autonomy, called On-Board Control Procedure (OBCP), used intensively also during the mission nominal day-to-day life, such as activate transponders before ground coverage.

In this paper, the basics of FDIR architecture definition and implementation are described by the Authors, together with several practical examples, both for the European laboratory Columbus and the Earth Observation satellite *CryoSat-2*, ESA's ice explorer.

The Authors will then identify the similarities and underline the main space operations philosophies of both architectures, with the aim of offering interesting inputs to improve one another domain, focusing on the safety and mission hierarchies for those two very similar but different realities of space exploration and science exploitation.