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# AUTONOMY FOR THE EXPLORATION: THE FLUID SCIENCE LAB (FSL) AS TESTBED FOR THE IMPLEMENTATION OF THE AUTONOMOUS PAYLOADS OPERATIONS ONBOARD THE ISS

**Abstract**

The development steps of an onboard Virtual Operator (VO) prototype is described along with a VV (Verification and Validation) platform for it. The VO is able to handle autonomously a large class of nominal operations and of anomaly recovery actions for a Columbus Payload. Currently, a majority of the ISS operations require heavy support from ground control teams even for routine onboard operations. The main feature of VO is the knowledge of specific domains and tasks that enables to support humans during the operations reducing the workload of the crew and ground operators. Several new AI technologies will be considered to develop the prototype. In many contexts such technologies have matured and been validated to the point of sufficient TRL (TRL= 3 or 4) to justify their adoption during ISS missions. The objective is to use the ISS to adequate the TRL of the new proposed technologies for a potential use to support autonomy in an exploration context. As a first step, a ground-based prototype controlling the Fluid Science Laboratory (FSL) on board the Columbus will be developed. The design approach, based on the concept of adjustable autonomy, will allow to extend the prototype use also to the other ISS experiment facilities. The prototype will be updated on the basis of the On-Board Control Procedures (OBCPs) concept and the FSL laptop system capabilities and therefore uploaded on the flight FSL . The OBCP, not linked to a specific implementation language, can be seen as a ground procedure executed onboard, autonomously capable of interacting with the payload subsystems/instruments through sending TCs and receiving TM, as if it was a ground operator controlling the payload and taking decisions. In parallel the ground prototype will provide operators with an integrated framework for the procedure preparation allowing an easier and more intuitive OBCPs development. VV will be supported by lightweight testing techniques as well as formal verification methods based on model checking techniques. This will enable design of highly reliable OBCPs, a necessary feature in order to achieve autonomy. A Failure Recovery Module (FRM) is also considered with the capability to “understand” the problems (diagnosis) and to solve them mainly giving the human operator support to decide the best recovery strategy in case of anomaly. The FRM system should integrate the traditional, well established in the space context, FDIR methodologies and innovative technologies, such as AI and model checking, taken directly from research context.