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FLUID SCIENCE LABORATORY ON-ORBIT OPERATIONS ON THE ISS COLUMBUS MODULE: FIRST EXPERIENCES AND LESSONS LEARNED

Abstract

In early February 2008 the Fluid Science Laboratory (FSL), after 9 years of development carried out at Thales Alenia Space Italia, was successfully launched; FSL Commissioning has been completed and now is fully supporting microgravity sciences. The overall experience built supporting this first part of the FSL on-orbit operations generates lessons learned to be implemented into a design and development phase as well as in the operations phase. Experience gathered allowed to learn how to better face the mission preparation phase in the analytical processes, in the operations products development and in the on-orbit activities follow-on. Special attention was given to aspects relevant to the validation of the operations products and to the consistency of the flight execution approach versus the flight preparation.

A lot of advantages have been gathered by the remote monitoring and commanding from ground (telescience approach), so local monitoring and control by astronaut is not a frequent event. In addition, the full automatic experiment conduction has saved crew time and has given the scientists the possibility to keep under direct control the experiment execution.

Other important feature is the exploitation of the Experiment Procedures to control, modify, start and stop the experiment during its execution. Thanks to FSL modular philosophy and the decentralized approach to operations, a number of scientists, from all over the world can perform experiments, sending commands and receiving data directly in their laboratories. It is possible, through this approach, to maximize as much as possible the scientific results expected by the Fluid Science scientific community.

On the other hand, FSL has experienced some unexpected problems during the first part of the on-orbit commissioning. Also, those are an important source for planning the future FSL on-orbit operations.

The most considerable one was the rip from the Columbus Utility Interface Panel connectors of the Ethernet and Mil-Bus-1553 cables. During the FSL mechanical setup, the crew did not perform the removal of the rear launch fixation bolts as required. To remove the bolts, the FSL rack has been tilted again. This operation has caused the damage to the umbilicals mated between FSL and Columbus (Ethernet Mil-Bus-1553).

Other issue was relevant to telemetry errors detected on the ODM laser safety switch. Also in this case the cause was human error: the FCE drawers were not correctly installed during mechanical setup (rear blind connectors were not well engaged and drawer's rubber seals were protruding).

Further anomaly was a self-generated error message when running the FSL automatic test on the CEM lamps. The CEM-U lamp not correctly connected during mechanical setup was identified as the source of the issue.

Then, most of the troubles detected until now was related to the FSL mechanical setup executed on-orbit. Hence, it has been learned that operations not correctly performed may prevent the execution of the most part of the FSL experiments.

As a consequence, a large amount of extra crew time has been used to troubleshoot the issues and to repair the failures, and this was not taken into account in the FSL commissioning plan. In addition, part of the FSL planned operations has been skipped to recover the crew time lost in the repair activity. In

particular, the number of FSL Optical checkouts has been reduced, focusing only on the optical modes strictly related to the first experiment execution.

Also, ground activities related to the troubleshooting were slown down by the Col-CC command channel and telemetry feedback authorizations.

As recommendations, particular and additional attention may be given to the crew preparation, since most of the FSL related mechanical activities are very complex and delicate. It is necessary to refine and verify procedures on the FSL Ground Model and improve crew training.

In addition it is recommended to streamline the command/telemetry chain during FSL troubleshooting (i.e. command channel and telemetry feedback enabled over adequate time).

Even though those issues, the FSL on-orbit activities are now proceeding as planned, exploiting the FSL scientific performances for the running experiment. The TAS-I FSL engineering support team is playing a fundamental role in supporting troubleshooting, solving issues and fixing anomalies.

The FSL represents one of the most sophisticated and complex space facility ever developed and we may be proud to currently be the only Columbus internal facility fully operative and providing scientific returns. A new era of science opportunities has started.