A Testing Time

Columbus Payload Testing in the RLTF

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Introduction

ESA's Biolab, Fluid Science Laboratory (FSL), European Drawer Rack (EDR) and European Physiology Modules (EPM) racks will be launched inside Columbus on Mission 1E, together with the EuTEF and SOLAR external payload platforms. These complex internal payloads have completed their thorough testing in the Rack Level Test Facility (RLTF), so that can now become part of Columbus, where another campaign will soon begin to show that the module works as a whole.

The Columbus payload facilities have successfully completed a major part of their testing ...

The experiments inside Columbus are accommodated in International Standard Payload Racks (ISPRs). In the RLTF, the ISPRs were supplied with the same resources they can expect in orbit: power, data (low, medium and high rate), video, water cooling, nitrogen gas and vacuum/venting. The external experiments are housed on standardised Columbus External Payload Adapters (CEPAs). In the RLTF, these CEPA payloads are provided with the power and data interfaces they will have in space.

The Fluid Science Laboratory undergoes testing in the RLTF.

In order to provide maximum confidence that the Columbus payloads will work properly in orbit, their integration and test programme is divided into two phases in a classical test approach: the RLTF acted as the Columbus Engineering Model before the payloads are tested in the Columbus Flight Model. In both test phases, the payload Flight Models are used.

During the second phase, the RLTF itself has to show compatibility with the data/video interfaces of the Columbus FM. Once Columbus is in orbit, the RLTF will be used as the Columbus reference model for integrating future payloads.

EADS Space Transportation in Bremen (D), with subcontractor Alenia (I), is the Columbus Payload Integrator (CPI) and thus responsible for conducting both test phases. This article covers the first test phase; the four racks are now being integrated into Columbus for the second phase.

Test Objectives

Experience shows that verifying the operational procedures and the software interfaces (telemetry packets and telecommands) between the racks and Columbus is the most time-consuming and complex part of the tests. Testing the hardware interfaces is limited to verifying the connections.

Payload telemetry and telecommands are divided into two groups: system-level parameters and commands that have to be available to Columbus and its control centre, and payload-specific parameters and commands of interest to the experimenters in the User Support Operations Centres (USOCs) or astronauts operating the payload. In the RLTF, the Columbus electrical ground support equipment (EGSE) plays the role of the control centre, while the payload EGSE represents the USOC.

The RLTF verified that data packets are forwarded to their correct destinations, and that parameters and commands unique to a payload are correct and satisfy the system requirements. This has verified all the software elements – the Mission Database (containing all packet definitions and routing information), the payload software and the payload EGSE database. Discrepancies were resolved by modifying the software.

RLTF Capabilities

The RLTF was conceived as a faithful representation of the Columbus interfaces without the actual module. It has three major elements: Electrical Test Model (ETM) with payload power and data interfaces; ETM EGSE with payload EGSE interfaces; payload adapters with utility interface panel connector, water services, vacuum and nitrogen gas connections.

The ETM provides power to the payloads via the Power Distribution Unit, it reads caution and warning signals from payloads and provides them to the Vital Telemetry and Command Controller, it sends and receives low-rate data on the MIL-STD-1553 bus through the Payload Control Unit, it sends and receives medium-rate data of up to 10 Mbit/s on the Ethernet LAN, and it receives and processes high-rate data and video images through a serial line at up to 30 Mbit/s. It can also receive and process video from an NTSC analogue video line.

The ETM is functionally identical to the Columbus module. The Columbus avionics are represented by their engineering models. Power comes from commercial supplies configured to match the power characteristics of Columbus. Payload simulators generate a realistic scenario for the rack under test.

The software running on the ETM Data Management System (DMS) is identical to the software on the Columbus DMS. The same is true for the Video/Data Processing Unit. The Mission Database (MDB) that contains the telemetry/telecommand definitions for the entire Columbus system (including all payloads and other software) is also identical to that used on the Columbus flight model.

Payload Test Experience

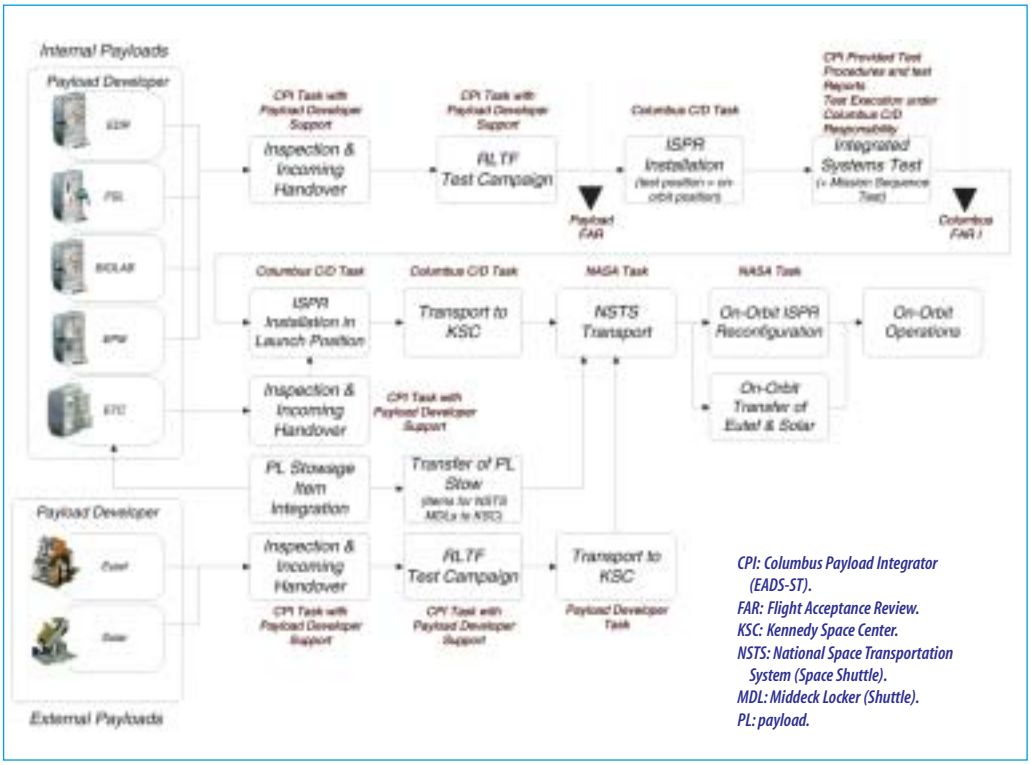
So far, all four active payload racks (Biolab, EPM, FSL, EDR) have been successfully tested on the RLTF (see box). The EuTEF and SOLAR external platforms will follow by the end of 2004.

Time constraints during development meant that the payloads entered RLTF testing without completing their Preliminary Acceptance Reviews (PARs) at their contractors, which would have been standard procedure. This was allowed assuming that they completed RLTF testing showing full conformance with the Columbus interfaces. This approach initially caused additional work for EADS but ultimately proved successful and time-saving.

Some software discrepancies were found (and corrected) on the payloads and the MDB. For the hardware, interface problems included payload LAN connector wiring. The high-rate demultiplexer in the Columbus EGSE did not behave as expected by the payload contractors. Instead of a continuous stream, it sends out data in short bursts of 100 Mbit/s, which cannot be processed by the payload EGSEs. Since the demultiplexer is a commercial product that cannot be modified, the problem had to be solved by adding a converter to smooth the bursts into a continuous bit-stream of 30 Mbit/s.

Conclusions and Lessons Learned

Testing the four payload racks in the RLTF before moving into Columbus itself now was clearly the correct choice. Having standard equipment such as the ISPR, Standard Payload Computer (SPLC), Remote Power Distribution Assembly and Avionics Air Assembly in the racks proved to be an advantage. It should be emphasised that all the Columbus and payload software protocols (as part of SPLC) worked flawlessly. The cycle for updating software in the Mission Data Base needs to be shortened from the current months to weeks. ■



CPI: Columbus Payload Integrator (EADS-ST).
FAR: Flight Acceptance Review.
KSC: Kennedy Space Center.
NSTS: National Space Transportation System (Space Shuttle).
MDL: Middeck Locker (Shuttle).
PL: payload.

The Columbus payload integration flow for the 1E mission. A fifth ESA rack, the European Transport Carrier (ETC), will also be launched inside Columbus, but it is a passive carrier and did not need RLTF testing.

Completed RLTF Testing

Biolab
TRR: 14 May 2003
RLTF Test:15-28 May
PTR: 6 Jun

EPM
TRR: 8 Jul 2003
RLTF Test: 11-31 Jul
PTR: 28 Aug

FSL
TRR: 12 Sep 2003
RLTF Test: 18 Sep - 2 Oct
PTR: 17 Oct

EDR
TRR: 6 Feb 2004
RLTF Test: 10-27 Feb
PTR: 11 Mar

PTR: Post Test Review
TRR: Test Readiness Review