SESP 2010

Session:	Session: Operational Simulators (23)
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Time:	14:00 - 15:00
Room:	Newton
Chair:	
Co-chair:	
Remarks:	

Seq	Time	Title	Abs No
1	14:00	Testing and Validating Operational Spacecraft Simulators	

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The Mission Data Systems Division (OPS-GD) at the European Space Operations Centre (ESOC) is responsible for the requirements specification, development management and validation of all Mission Data Systems composed mainly by the Main Control System, the Spacecraft Operational Simulator and the Mission Planning System of each of ESA's (European Space Agency) mission. A new set of Mission Data Systems is developed for each mission based on common reusable infrastructure software.

The main user of the Mission Data Systems is the Flight Control Team (FCT) of each mission. The FCTs at ESOC start flight operations training and preparation on a specific Mission through, mainly, the preparation of flight operations procedures while the spacecraft itself is being built and is therefore unavailable for testing. The FCT's training ends just before the mission launch and has its peak during the Simulations Campaign, a specific training that starts ca. 6 months before the launch. The Operational Spacecraft(S/C) Simulator, one of the Mission Data Systems, is used by the FCT, mostly together with the Mission Control System, in order to surpass the lack of a real spacecraft with which to test procedures and train. Each Operational Spacecraft Simulator closely models one or more (in the case of constellations of satellites) S/C with its systems and subsystems mimicked to the detail, including an emulator that runs the real binary of the Onboard Software.

In particular the development, testing and validation of the complex Operational S/C Simulator poses several challenges. The first and major challenge resides in the fact that the majority of the requirements on which the development is based, must be generic enough to cope with the lack of available Spacecraft specifications and knowledge at the time of the requirements specification. However, the S/C itself, its on board software (OBSW) and database (SDB), containing all the S/C Telecommands and Telemetry, are also under development at the same time as the Operational S/C Simulator. This implies that the likely changes that might occur in either of them (the S/C systems or subsystems specification, OBSW or SDB) will result in a respective change in the Simulator models or in a new integration of the most recent OBSW and SDB. Moreover, generic requirements make it difficult to specify and execute relevant test cases. In addition, changes or new information on the S/C specification requires a consequent adaptation in the test and verification plan.

The testing and validation process of Operational Spacecraft Simulators must take into account all these dynamic aspects of modelling innovative, complex and in development Spacecrafts. This paper intends to illustrate exactly this complex process and lessons learned in testing and verifying Operational Spacecraft Simulators at ESOC, coping with the parallel development of the spacecraft being modelled and the consequences that this brings.

2 14:30 A Methodology for Effective Reuse of Design Simulators in Operational Contexts: Lessons Learned in European Space Programmes

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The development of operational simulators is commonly based on the reuse of components across different missions (e.g. standard run-time simulation infrastructures, generic models). In the last few years, specific ESA missions have implemented a complementary reuse strategy, focusing on the reuse of simulators across the mission life-cycle.

In the Automated Transfer Vehicle (ATV) mission, the design simulators of major hardware subsystems have been reused as part of the real-time ATV Test Facilities. ATV Test Facilities include, among others, the Functional Simulation Facility (FSF), the Software Validation Facility (SVF), and the ATV Ground Control Simulator (AGCS). The ATV Test Facilities have been developed by ASTRIUM ST. The first ATV, Jules Verne, was launched in March 2008 and four more ATVs will be launched until 2015.

In the Lisa Pathfinder mission, a simulator has been developed by ESA/ESOC to support spacecraft operations, leveraging from technology used in previous missions. On the other hand, in order to support science operations at ESA/ESAC, it has been chosen to reuse existing simulators developed by ASTRIUM Gmbh for the LISA Pathfinder project: the DFACS (Drag Free Attitude and Control System) design simulator and the SVF. These simulators are the core components of the LISA Pathfinder simulator for the Science Technology & Operations Centre (STOC). The STOC is currently using the DFACS to prepare and validate the science operations, and will eventually move to the SVF for a second-level validation. LISA Pathfinder is scheduled for launch in 2012.

In the near future, the simulator for the PROBA3 mission is foreseen to support a wide range of phases in the project life-cycle. It will use the Formation Flying Test Bed (FFTB), which provides the means to develop simulators addressing the specific needs of formation flying missions. FFTB also supports the reuse of Matlab/Simulink models, usually developed as part of the initial system design, towards later phases, including software validation and operations.

The paper will report on ESA experiences in the reuse of simulators across the project life-cycle. It will especially focus on the reuse of design simulators in an operational context. It will expand on the lessons learned in the past and current ESA projects.

Experience has shown that, before starting the development of the operational simulator for a given mission, a preliminary study of the existing simulators shall be performed. Guidelines have been identified, allowing understanding, at early phases, the technical implications of reuse. The applied methodology can also give indications to the management, helping assessing the actual feasibility and cost of the

reuse of the existing simulators.

Operational simulators have a different scope than design simulators. An effective reuse requires the development of adapter layers, e.g. to be able to map spacecraft TeleCommands (TCs) to their counterparts in the design simulator. It is essential that the required adapter layers are maintained up-to launch and beyond. For this purpose, the development of appropriate auxiliary tools may also be needed. Auxiliary tools typically include Man Machine Interface (MMI) editors, tools validating the adapter layers, comparison tools with data in reference databases. It is recommended to identify, at an early stage, the boundary between the legacy systems and the new operational infrastructure, taking particular care to also ensure that any inputs required by the auxiliary tools are available and will be maintained in the long-term.

An obvious technical recommendation is that coupling with reused simulators shall be minimized. The risks deriving from concurrent updates of the reused simulators shall be carefully assessed. Appropriate procedures shall be defined in order to safely incorporate the changes into the overall operational system.

In an operational context, simulators shall provide a high speed-up factor and/or the capability to save the simulation status, and restore it when requested by the users. The save-restore functionality is not commonly supported in design simulators. Guidelines have been identified to estimate the actual feasibility and the implementation effort that is required to implement the save/restore functionality on top of the existing design simulators. Procedures and tools shall be established to ensure that the save/restore implementation is thoroughly validated before embedding the reused design simulator into the operational run-time simulation infrastructure.

Reuse across the project life-cycle has been highly beneficial in the ATV and LISA Pathfinder missions. The approach has increased the coherency between the different simulation facilities. Potential pitfalls exist, and have been identified. In future missions, risks can be mitigated by applying a set of proven guidelines.