SESP 2010

Session:	Session: Modelling and Simulation Standards (15)
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Date:	Wednesday, September 29, 2010
Time:	15:00 - 16:30
Room:	Newton
Chair:	
Co-chair:	
Remarks:	

Seq	Time	Title	Abs No
1	15:00	An SMP Conformance Verification Suite	

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Following the establishment of the Simulation Modelling Platform standard (E40-07), it will be necessary to have the means to verify the conformance of simulation artefacts, models and infrastructures with this standard. This enables the certification of suppliers of models and environments for the space market.

The SMP Conformance Suite (SMP-CS) activity has established a test harness and the associated environment allowing a standalone verification of this conformance. The project was led by ESA with the contribution of Spacebel and VEGA.

The SMP-CS activity has been split into two phases. During the first phase, a set of conformance criteria has been specified, which now forms the basis for the conformance verification process. That is, the verification process performed for an item under test aims at verifying whether the item under test satisfies or not the related conformance criteria. During the second phase, the SMP-CS tool has been developed upon that basis. An ECSS compliant software development process has been applied, including the user requirements specification, the software requirements specification, the architectural design, the implementation, the test specification and the test reports. For each item under test, the tool is able to generate a human readable conformance report (in HTML and PDF format). The tool has been tested with two SMP compliant infrastructures: SIMSAT4.0 (ESOC) and BASILES (CNES). The conformance criteria provided by SMP-CS cover both the SMP2 1.2 standard and the E40-07 standard (draft). The SMP-CS tool implementation is generic and allows for the verification of arbitrary conformance criteria. Initially, all conformance criteria covering the SMP2 1.2 standard have been implemented. For future evolution (e.g. to cover E40-07) criteria implementations can be added or updated via a plug-in mechanism.

During this activity, the technologies and tools of the Eclipse framework as well as UML, XML design artefacts have been used. The main programming language is Java, together with SMP C++ models where required.

The conformance criteria specification is based on an UML profile, which is fed as input to the Eclipse Modeling Framework (EMF) to produce XML files directly workable by rendering tools and by software.

The SMDL artefacts verification is based on EMF. The SMP models verification allows to perform run time and compile time tests on the input models. The SMP infrastructures verification provides a set of SMP test simulators, which are loaded and started in the real infrastructure by using an infrastructure specific interface for conformance verification. In all cases, the process output is correlated with the corresponding conformance criteria to produce the conformance report.

The SMP-CS product is deployed as an Eclipse Rich Client Platform (RCP) application. This can be used as a standalone application or can be, thanks to the Eclipse plug-in concept, integrated into the Eclipse IDE or other Eclipse based applications (such as the SIMSAT MIE, the UMF, ...). It is also possible to support verification of a new simulation infrastructure by providing a plug-in that implements an infrastructure specific interface for conformance verification.

This paper will describe the project in more detail as well as the experiences and lessons learned by Spacebel and VEGA.

2 15:30 SWARMSIM - The first fully SMP2 based Simulator for ESOC

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Summary
ESOC has started the deployment of a new generation of operational simulators in the context of the Swarm mission, a constellation of three satellites planned to be launched at the end of 2011. Compared to previous simulators developed by ESA, it is unique in a number of ways:

- It natively implements the Simulation Model Portability 2 (SMP2) Standard;
- It is the first simulator based on the ESOC Spacecraft Simulator Reference Architecture (REFA);
- It has been produced using a model driven development process using the EGOS Modelling Framework (EGOS-MF).

SMP2
In October 2005, Issue 1.2 of SMP2 was released. For an application in ESOC simulators, the SIMSAT simulation infrastructure was enhanced to support SMP2 (in addition to SMI). Then, the ESOC Generic Models were ported from SMI to SMP2. These models are reused across operational simulators for thermal and electrical modelling, environment and dynamics, and for TM/TC encoding and decoding. Before starting with the development of an operational simulator, an SMP2 based reference architecture for spacecraft simulators was designed (making use of the Generic Models). Finally, the Swarm Simulator was developed using all these technologies provided by ESOC.

In the Swarm Simulator, most models are native SMP2 models, i.e. they have been designed and implemented starting from a complete design in an SMP2 Catalogue. This approach is different from a porting of existing models as e.g. done for the generic models. The only Swarm Simulator models that wrap existing models are the Emulator (native Ada with C wrapper) and TTC Streams (CORBA based interface to the Ground Models).

Reference Architecture
The objective of the Spacecraft Simulator Reference Architecture (REFA) is to identify and integrate, using SMP2, a reference spacecraft

simulator architecture which can be used as the basis for future operational simulators. This is essential to achieve shorter (and therefore more cost-efficient) spacecraft simulator development cycles by means of extensive reuse by relying on a common architecture. This relies on the specification of interfaces between the various spacecraft subsystems and on the identification of models which can be developed in a generic fashion (e.g. on board software emulation), thus providing the start of the actual development of an operational simulator.

In the Swarm Simulator, all models are derived from models defined by REFA. As a minimum, models reuse generic concepts for logging, tracing, failures, events and TM/TC parameters. This ensures consistency of such mechanisms across all subsystems of the simulator. Most models are derived from subsystem specific models, and implement interfaces defined by the Reference Architecture. In a few cases, these interfaces have been extended for mission specific needs. Only in exceptional cases, Swarm specific interfaces had to be defined.

Modelling Framework

The SMP2 standard has been developed with a model driven development process in mind. The Simulation Model Definition Language (SMDL) allows implementation of a process where models are fully designed in UML, and skeleton source code can be generated from this design. Such a process has been implemented by ESOC in the EGOS Modelling Framework (EGOS-MF) and the SIMSAT Model Integration Environment (MIE), which are currently merged into the Universal Modelling Framework (UMF). This process not only generates skeleton source code for the model operations defined in the design, it as well auto-generates SMP2 compliant C++ code for e.g. for publication and dynamic invocation. Further, from the same source, documentation can be generated, which is hence guaranteed to be consistent with the source code.

In the Swarm Simulator, the existing process has been tailored to project specific needs: The C++ code templates have been updated to generate code compliant with the BSSC Coding Standards, and the document templates have been updated to comply with the applicable ECSS standard. While the high-level summary of the design is written by hand, detailed design documentation, interface control documents and reference sections of the user manual are generated from the UML design. This has not only significantly reduced time and effort to write and update documentation, it as well improved the quality, completeness and consistency of the relevant documents.

Conclusion

The Swarm mission is the first demonstrator of the power of the SMP2, REFA and EGOS-MF technologies. The presentation will further illustrate the three above aspects and clearly prove how the REFA applied in simulators reduces development effort & cost and offers a strictly identical interface to users, hence creating beneficial synergy across operations teams, regardless of the satellite being simulated. The presentation will be concluded with lessons learned and some proposals for future improvements.

3 16:00 The Spacecraft Simulator Reference Architecture

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This paper presents an overview of the Spacecraft Simulator Reference Architecture study, which is being performed by VEGA Deutschland and Astrium Satellites within ESA's Technology Research Programme (TRP).

Simulation has become more and more a crucial activity in the support of a wide range of engineering and operational activities during the lifecycle of a space programme. Considerable effort is currently invested by programmes in the development of simulation and test facilities. Although it is widely recognised that simulation now forms a crucial part of the system engineering process, there has been a tendency until recently to treat simulation as a supporting activity. The application of simulation by the different disciplines and across project phases is often uncoordinated with facility specific solutions being developed to address particular needs.

It is nowadays recognised that a more coordinated and consistent approach to the development of simulation products across project phases would bring substantial benefits. This would promote the most effective use of simulation within the system engineering process to minimise the overall space programme risk and cost. The industrial experience has shown that a number of simulation and test facilities are procured which are common across all space programmes. Experience has also shown that there is much commonality between the infrastructure and models developed for each of these facilities. This experience has been captured in the ECSS ETM-10-21 "System Modelling and Simulation" Technical Memorandum which provides guidance to system engineers on how to use system simulation to support their system engineering tasks. This Technical Memorandum identifies the typical facilities that can be procured and their associated high level requirements. It also identifies possible model reuse across simulation facilities. However, it does not specify which enabling simulation technology should be used to achieve this.

The objective of the Spacecraft Simulator Reference Architecture study is to define and validate a reference architecture which is aligned with the ETM-10-21 that promotes model reuse and maximises the benefits of modelling ad simulation in support of the Systems Engineering function. It is based on the use of the SMP2 specification as the simulation technology to enable the reuse of model implementations across simulation facilities. The reference architecture can be considered to serve as a template which can be applied and extended for simulator developments in space programmes. The reference architecture captures the semantics of the space system simulation problem domain. For example, the language of the reference architecture includes as first order concepts such items as Equipment Models or System Level Interfaces (e.g. power lines, bus lines, etc) using a terminology which is natural to a system engineer. This language is independent of the underlying simulation technology. This domain specific language is then mapped to the SMP2 platform by a set of mapping rules which describe how model elements in this language are represented by SMP2 models and interfaces. The separation of the domain semantics from the target platform allows the underlying simulation technology to evolve without having major impacts on the reference architecture. For example, future evolutions of SMP would have a minimal impact on the reference architecture. As the scope of the reference architecture is to support simulation model reuse across the full project life-cycle, there are a number of important constraints which have been considered in its design, in particular:

- the efficient evolution of models across the project life-cycle
- support for hardware-in-the-loop and hard real-time
- the configuration of simulation benches from engineering databases

Tooling is required in-order to support the application of the reference architecture on a project. A modelling approach based on the use of

UML profiles has been applied in the study in order to take advantage of existing UML tools. This approach was adopted in-order to minimise the effort spent in the study on tooling development. However this is not mandated by the reference architecture and an approach using a domain specific language modelling environment can also be considered.

The Primarily Design Review of the reference architecture has recently been completed and the validation phase of the project is currently on-going. However the definition of a reference architecture which is widely accepted within the spacecraft simulator community is a long process and the results of this study are just a first step in achieving this ultimate goal.