#### The Lisa Pathfinder Simulator for the Science and Technology Operations Center: a case-study for reuse across the project life-cycle

#### 10<sup>th</sup> Workshop on Simulation for European Space Programmes 7-9 October 2008

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C. Leorato, P. van der Plas, "The Lisa Pathfinder Simulator for the Science and Technology Operations Center: a case study for reuse across the project life-cycle" 10<sup>th</sup> Workshop on Simulation for European Space Programmes, Noordwijk 2008

- Introduction
- The DFACS and SVF simulator
- Reuse approach:
  - Reuse strategy generality
  - DFACS reuse
  - SVF reuse
  - DFACS vs. SVF reuse
- Development process
  - Development iterations
  - Development approach and design guidelines
- Lessons learned and conclusions

#### Introduction

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- The Science and Technology Operations Center (STOC) will be in charge of the operations of the LPF experiments

An experiment simulator is required in order to:

- Validate the LPF Technology Package run procedures
- Provide measurements to the LPF Data Analysis tools
- Incrementally update the modelling of the LPF instrument

The main driver for the development of the STOC simulator is the reuse of simulators already existing in the LPF project: the DFACS and SVF simulators

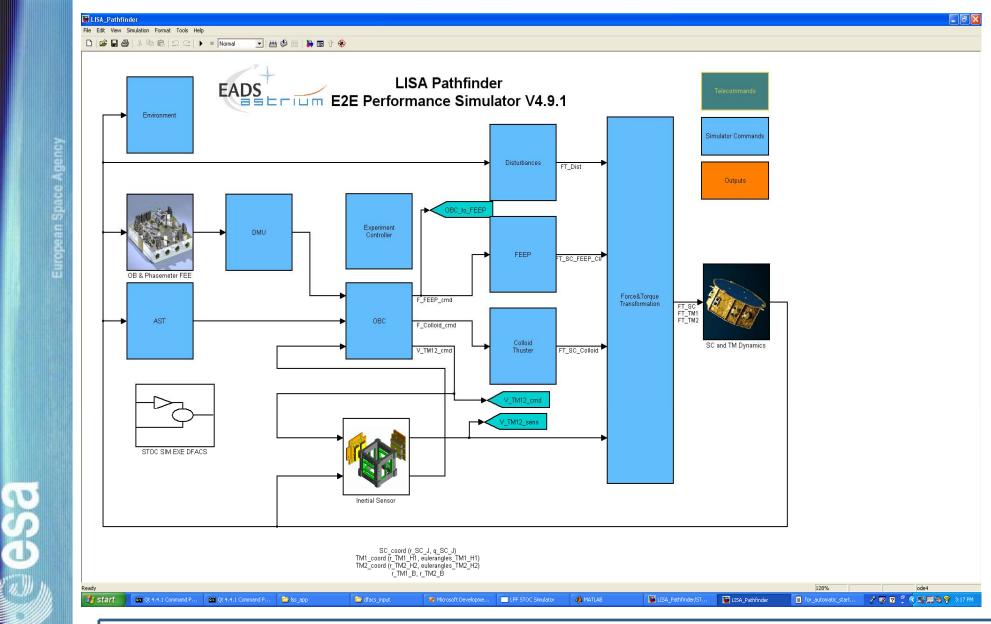
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#### **The DFACS Simulator**

- It is Matlab/Simulink based
- It is a design simulator, originally conceived for the analysis of the Drag Free and Attitude Control System performance
- It served as a prototype for the on-boad control algorithms
- It runs on Windows
- It can run faster than real-time (x30)

Most (but not all) of the STOC users are familiar with Matlab/Simulink technologies. In any case, the direct usage of the DFACS would require a deep understanding of the underlying models' implementation

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#### **The SVF Simulator**

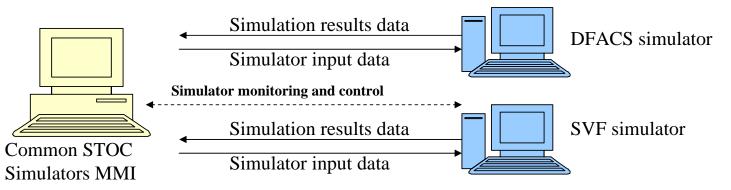
- It is part of the ASTRIUM Model Based Development and Verification Environment (MDVE)
- It is used for the integration and debugging of the on-board software
- It is conceived for AIT
- It is a run-time system
- It is interfaced by means of Open Center, supporting Elisa script language
- Runs on a Linux machine (plus an additional machine for Open Center)

Open Center is a complete EGSE system. As such, it is quite complex to be used directly by the STOC users

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## **Reuse approach (I)**

- Simulation execution on DFACS or SVF
- Common STOC Simulators MMI
  - Definition of experiments and configurations
  - Management of simulations
    - Preparation of run-time data for DFACS and SVF
  - Collection of result data
    - Provide post-processing options



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## **Reuse approach (II)**

The configuration of each experiment is determined by a certain number of artefacts, defining:

- Initialisation values of the simulation models
- Other initialisation conditions (e.g. DFACS mode)
- The run procedure (TC sequence)
- Out-of-limit conditions (monitoring)
- TMs to be recorded for further data analysis
- External stimuli
- Predefined plots

Those artefacts are defined by means of a common MMI (for each artefact, the same editors applies to DFACS and SVF)

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25.09.2008 14.54.04 (INFO) Lisa Pathfinder STOC Simulator started (session logs on lss\_logfile.txt)

science\_mode

25.09.2008 14.54.50 (INFO) Database=..\def\_files\user\db\mim\_db.xml was set successfully

25.09.2008 15.05.21 (INFO) Database=..\conf\obs\_def.xml was set successfully

StartUp Mode

External stimuli

Monitoring

Initialisation TC Sequen...

TC Simulator Timeline

25.09.2008 15.05.31 (INFO) Database=..\conf\obs\_def.xml was set successfully

25.09.2008 15.05.41 (INFO) Start parsing file C:\OSE\_v491\OSE\_v491\LSS\ss\_app\def\_files\user\timelines\tcmd\_exec\_SVS\_DFACS\_STANDBY\SVS\_DFACS\_STANDBY\Ipf

25.09.2008 15.06.33 (INFO) Database=..\conf\obs\_def.xml was set successfully

### **DFACS** simulator reuse (I)

Analysis of the legacy system and compatibility with the existing DFACS interfaces

- Initialisation of parameters using Matlab scripts, generated from the common model initialisation artefacts, based on XML (and RTS DB)
- Definition of TC sequences interfacing the text format expected by the DFACS simulator

Need to adapt the DFACS TC layer, in order to accept SCOS-2000 TCs

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#### **DFACS** simulator reuse (II)

Potential configuration control issues because of possible concurrent DFACS updates from the industry

Encapsulate STOC extensions requiring modifications to the DFACS (e.g. monitoring and recording artefacts) in S-functions or library blocks, in order to:

- support encapsulation automation
- Enhance flexibility (it easily allow chages in the set of observable TMs)

#### Reuse of Simulink built-in features (plots)

#### **SVF** simulator reuse

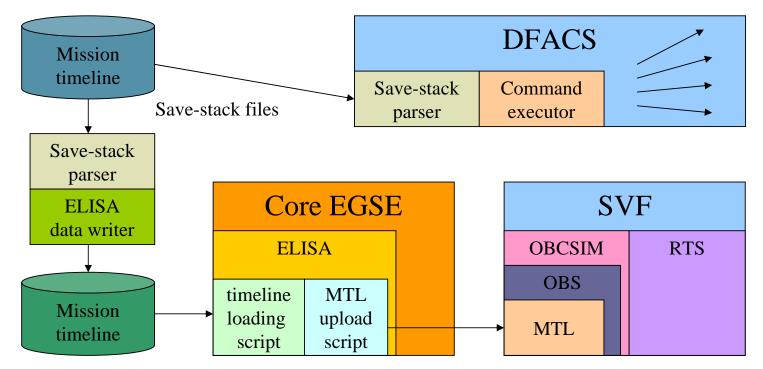
- SVF infrastructure will be used as black-box
  - Monitoring and control of the SVF via core EGSE
  - Will require manual interaction (start, monitoring, etc)
- Input data will be transformed into EGSE data
  - Model initialisation data by means of the common artefacts (and RTS DB)
  - Mission timeline and init TC sequence execution
    - Create generic ELISA scripts to load save-stack data and send to the OBS as MTL commands
  - Stimuli, monitors and recorders
    - Activated by generic ELISA scripts loading definition data (reuse XML format or use specific format for scripting)

- Recording data
  - Get SVF output data and store in results directory
    - Optionally post-process the data for STOC simulators use

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#### **DFACS vs. SVF reuse (I)**

## Mission timeline loading and execution



ELISA compatible data files

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#### **DFACS vs. SVF reuse (II)**

Common Topic	DFACS envisaged implementation	SVF/OpenCenter envisaged implementation
Platform start	Automated start of the platform. Automated (or manual) start of the simulation	Manual start of the platform (first-time only) Manual start of the simulation.
Model initialisation (XML definition files)	Generation of M-files from the common XML	Generation of SVF XML ModelCharacFile,to be loaded via Elisa
TC sequences (saved-stack files)	Generation of DFACS text files.	Automated generation and up-load via a common Elisa script
Recording (XML definition files)	STOC extension in the Simulink environment.	Automated triggering of TM acquisition. Retrieval via "Manual ParamProduction" GUI" or Elisa
Monitoring (XML definition files)	STOC extension in the Simulink environment.	Elisa plug-ins into the OC monitoring feature. Possible manual initial selection.
Stimuli (SVF-based format)	STOC extension in the Simulink environment.	Direct reuse of the dedicated SVF stimuli feature.
Plots (XML files)	Simulink-based (link to external library).	Automated opening via Elisa.

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#### **Development iterations**

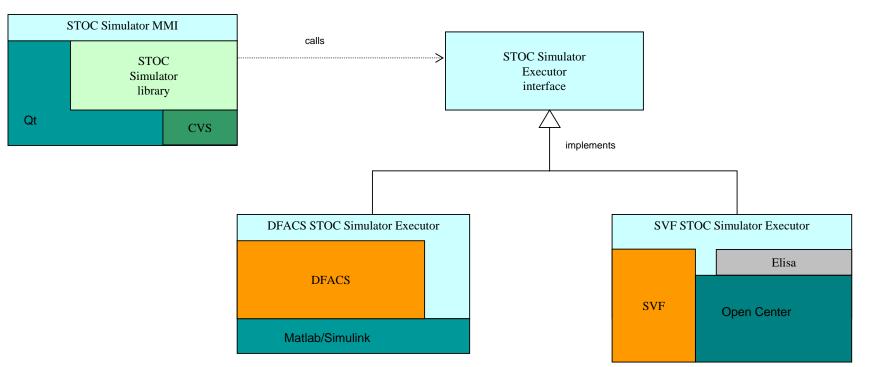
- Follows the ECSS-E-40 standard
- Helpful usage of prototypes to support the discussion on:
  - MMI aspects
  - Complex use cases
- Intermediate informal deliveries are also foreseen to:
  - Familiarise the final users of the system
  - Get early feed-back
  - Facilitate further refinements
  - Avoid Big-Bang integrations
- A first version was delivered in September 2008 and contains most of the common parts of the STOC simulator and of the DFACS interface
- Two more major deliveries are foreseen this year

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#### **Development approach (I)**



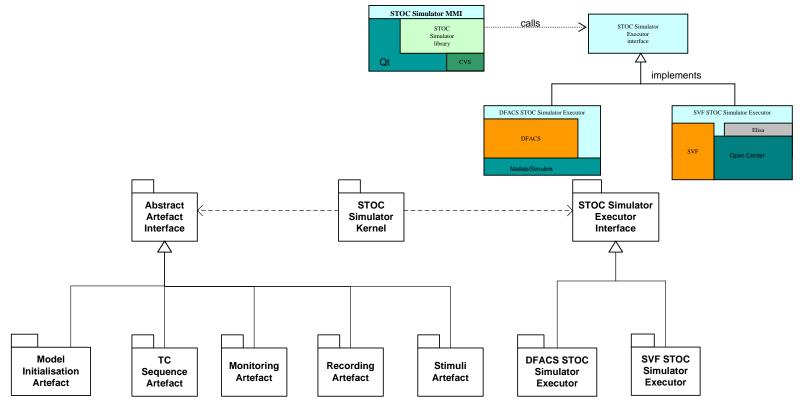
C++/Qt and CVS complete the run-time environment:

- Cross-platform tools and easy deployment (no VM)
- Mature products and wide user community
- STOC preferences

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#### **Development approach (II)**

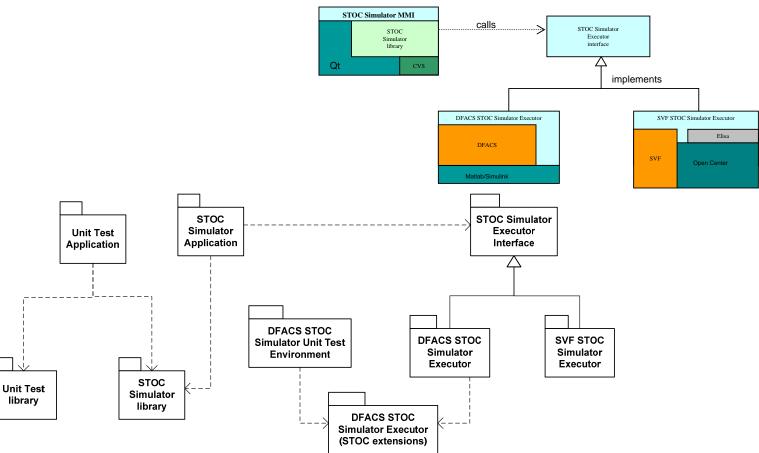
- Moderate usage of patterns and upfront design
- Automated documentation by means of Doxygen



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#### **Development approach (III)**

#### Emphasis on unit test automation



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#### **Conclusions**

## Main objective: Reuse of design and AIT simulators in an operational context

#### Main issues

- Different scope of the design simulator (TC adapter)
- Management of the concurrent development in the industry
- Difficulties to hide the full complexity of AIT simulators ("black-box" approach)

#### So far, satisfactory solutions were identified for all main issues

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#### **Conclusions**

#### First indications:

- Significant reduction of the development cost
- Moderate encapsulation of the underlying simulations (userfriendly environment)
- Availability of complementary simulation strategies (fidelity vs. performance)
- Minimisation of the typical risks of completely new developments (uncertainty on the level of fidelity, heavy cross-validation w.r.t. validated platforms,...)
- Increased coherency of the simulation facilities across the project lifecycle

#### Any questions?

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#### **Requirements gathering (I)**

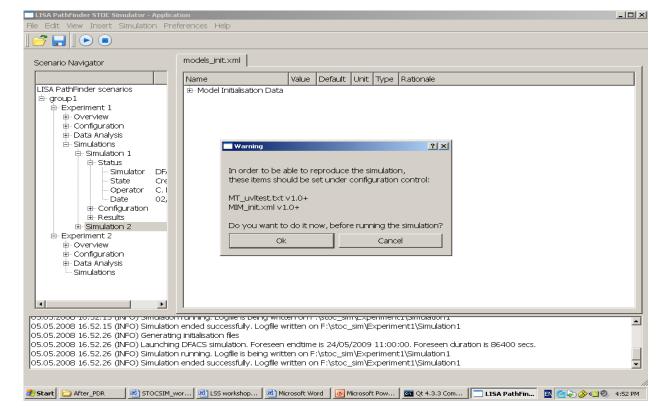
- Reuse of the DFACS and SVF is the main driver for the technical requirements (need to privilege cross-platform frameworks)
- The content of the artefacts is expected to evolve during the preparation of the LPF mission (and during the mission itself). A user-friendly configuration control of the artefacts shall be provided by the STOC Simulator

Requirements were gathered with several interviews with the different stakeholders. A more structured meeting was organised before the PDR to discuss and refine the understanding of the requirements

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## **Requirements gathering (II)**

Prototyping proved useful to discuss:MMI aspectsComplex case studies



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