E-40-07, a New Standard for Simulation Model Portability and its Implementation in SIMULUS

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→ Introduction to the E-40-07 standard

Simulation Model Portability

- Portability across missions
- Portability across phases of the same mission
- Portability of binary models

Implementation of the standard in SIMULUS

- The Model Integration environment
- The Runtime Environment

Roadmap

ECSS: European Cooperation for Space Standardisation

- Participated by ESA and the European Space Industry

E-40-07 is being drafted and promoted by the ECSS (ecss.nl)

- It is based on the existing SMP2 technical specification
- From now onwards we will only identify it with the term SMP2

The goal is to promote simulation model portability

- Portability across missions
- Portability across phases of the same mission
- Exchange of binary models

It follows a Model Driven Architecture (MDA) approach

- Platform Independent Models and mappings to C++ and Java

Introduction to the E-40-07 standard

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CENTRE NATIONAL D'ETUDES SPATIALES

ThalesAlenia Space

VEGA FINMECCANICA

DLR

logicaCMG

EADS astrium

dataspazio FINMECCANICA

NLR

SPACEBEL

scisys

TERMA

HEADWAY

Dutch Space
an EADS Astrium company

Members of the E-40-07 Working Group

SMP2 Status

E-40-07 Standard being finalised for public review (Oct 2008)

It will be the next release following SMP2 v1.2

Fully supported by SIMSAT 4 (Version 1.2)

Partially supported by Eurosim, Basiles, SimTG

Industrial validation conducted by:

CNES (Prime)

Spacebel

Thales Alenia Space

EADS Astrium

Ellidiss

A Metamodel-based representation method for reusable simulation model (Winter Simulation Conference 2007)

"*We have developed a initial CMM implementation inspired by Simulation Model Definition Language (SMDL) of Simulation Model Portability 2 (SMP2) standards*"

Yonglin Lei, Lili Song, Weiping Wang, Caiyun Jiang

School of Information System and Management

National University of Defence Technology, China

SMP2 – first interests outside Europe

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Roadmap

ESA runs a number of missions each year

Models developed for a mission can be reused and adapted for another mission

- Re-use is currently achieved by relying on the detailed knowledge of the implementer, rather than on formalised interfaces

Different kinds of simulators have to be procured for each mission at different stages (real-time, SVF, operational, etc.)

- Re-use within a mission is the exception rather than the rule, this is where significant financial gains can be made from the standard
- Terma and EADS Astrium achieved this goal in the ATV Operational Simulator (Toulouse, France) and the SVF(Les Mureaux, France)

Simulation Model Portability

By portability across missions we mean the possibility to reuse models from a simulator built for mission A in a simulator for mission B (same kind of simulator)

- Different requirements on mission B will likely require the customisation of some models.

Typically some models are more reusable “as is” than others:

- Environmental models
- Thermal models
- Electrical Network Models
- TM/TC tool-kit
- Spacecraft Dynamics Model
- Processor Emulators
- IEEE 1553 bus model
- Ground Models

Portability across missions

Portability across missions

Other models need adaptations from mission to mission

- AOCS
- Reaction Control Subsystem
- Radio Frequency Subsystem
- Data Handling Subsystem

Portability across missions requires that all missions share the same standards and architecture.

ESA/ESOC has implemented reuse across missions internally, for the Operational Simulators

- With the E-40-07 we want to enable such a reuse at a broader level, in the European industry and ecosystem of national space agencies. This will open up competition even further and drive costs down.

Along the phases of a mission different simulators are built

- Software Validation Facilities (Numerical benches)
- Real-time simulators (Avionic benches, HIL simulations, etc.)
- Precise Flight Dynamics Simulators (PFDS)
- Operational Simulators (OpSim)

PFDSs are built in parallel with the OpSims

- The AOCS is modelled very accurately
- The Environment is modelled very accurately

The AOCS and the Environment modelling of PFDSs can be reused pretty much "as is" for an OpSim.

- Typically the teams working on PFDSs and OpSims are different, but the first could work for the second.

Portability across phases of the same mission

SVFs are close to OpSims and this is where most of the intra-mission reuse is expected to happen

- An SVF is built 1 or 2 years before the OpSsim
- SVF models far from the OBSW are typically thinner, so when reused in an OpSim they need to be extended/refined
- The CDMU of an SVF is a good match for an OpSim, nowadays we have a processor emulator and an high-fidelity modelling of what is around the on-board computer in both cases

But SVFs can gain from OpSims too!

- OpSim models are more realistic and help to validate and debug the OBSW at a later stage

Terma and EADS Astrium exercised both scenarios for ATV

Portability across phases of the same mission

All those simulators are procured by different entities and built by different teams, a common playground is needed to enable broader reuse and also to unlock some markets

Re-use of models across mission phases will be anyhow challenging

SMP2 is our first step to facilitate this process

A reference architecture for all simulators is the second step

Collaboration among vendors and sections of various organisations is the third and definitive step

Portability across phases of the same mission

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A binary model is distributed without source code, in one or more binary files

It allows third parties to provide models without giving away their IPRs (special algorithms, optimised computations, etc.)

- This is a “must have” for intra-mission reuse scenarios, where different companies are expected to exchange models.

SMP2 guarantees the portability of binary models through

- Clear packaging and boot-strapping rules
- Explicitation of all the interfaces needed to operate with the models
- Explicitation of all the interfaces consumed by the model

Portability of binary models

Roadmap

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→ Implementation of the standard in SIMULUS

- The Model Integration environment
- The Runtime Environment

SIMULUS supports the full simulation life cycle:

- MIE (Model Integration Environment), to design, assemble, code-generate and package SMP2 models and simulators
- SIMSAT, a simulation infrastructure capable of loading SMP2 models

It also provides the following generic models

- Generic models for modelling the Ground Segment elements
- Generic models for modelling the Space Segment
- Emulator for ERC32 and MIL-STD-1750

Additional generic models will be provided in the future for many spacecraft subsystems and devices, all fitting an intended Reference Architecture.

The SIMULUS framework

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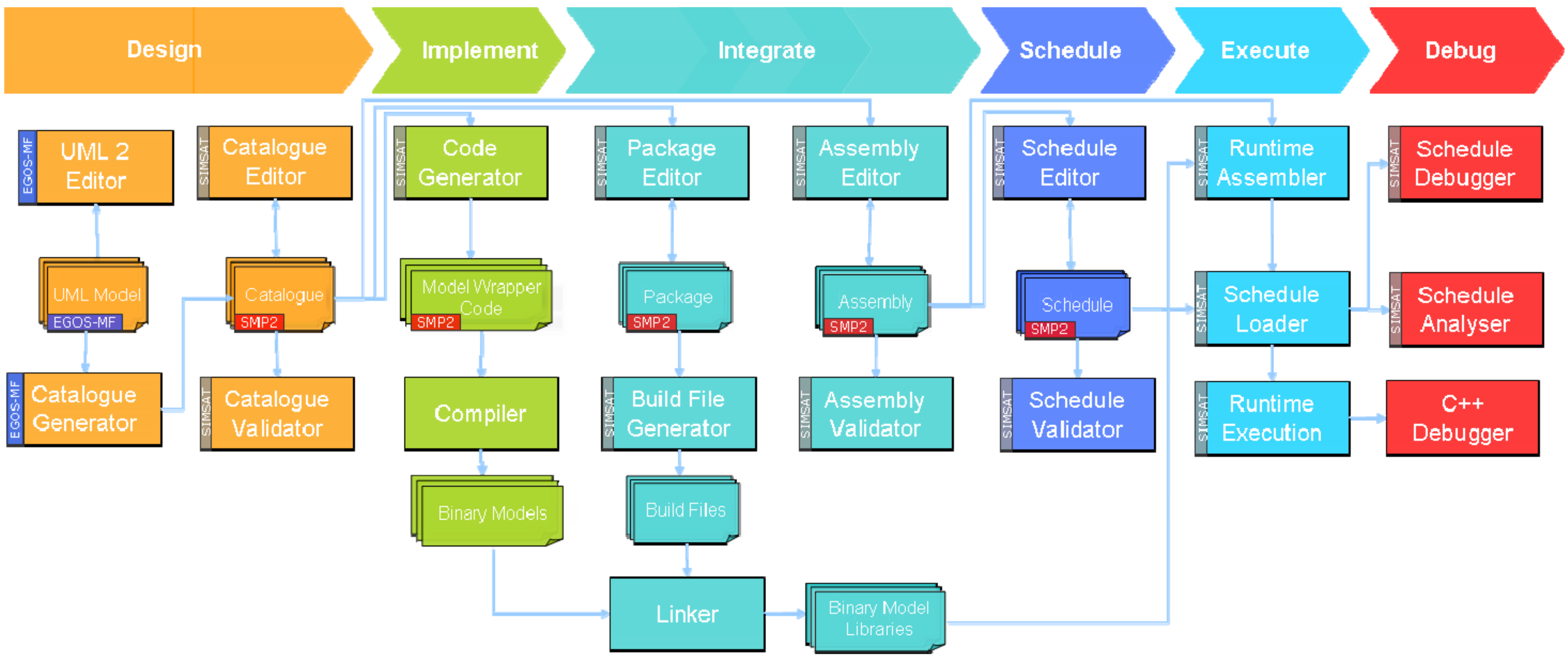
The Big picture



Supporting the full simulation life cycle

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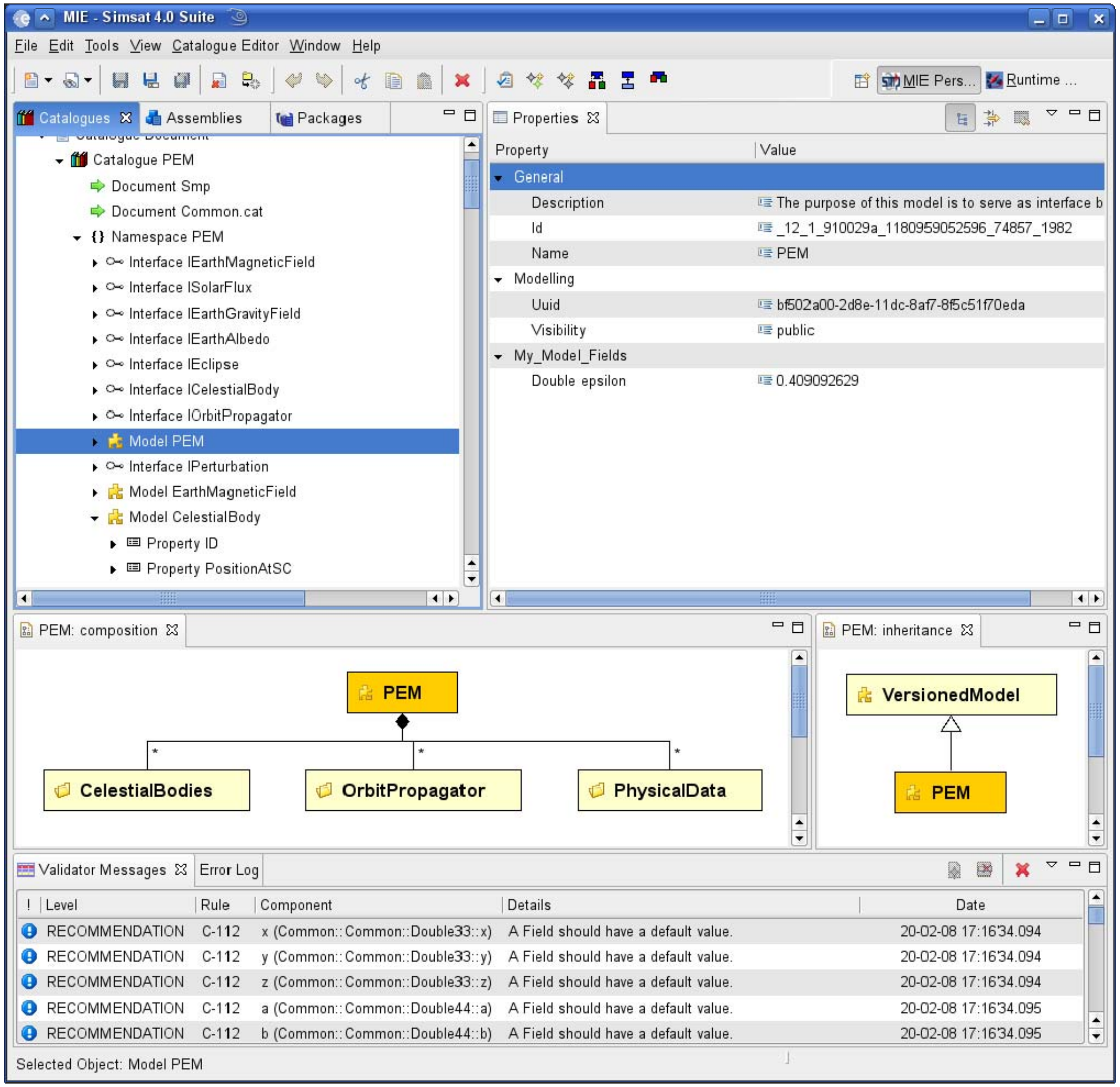
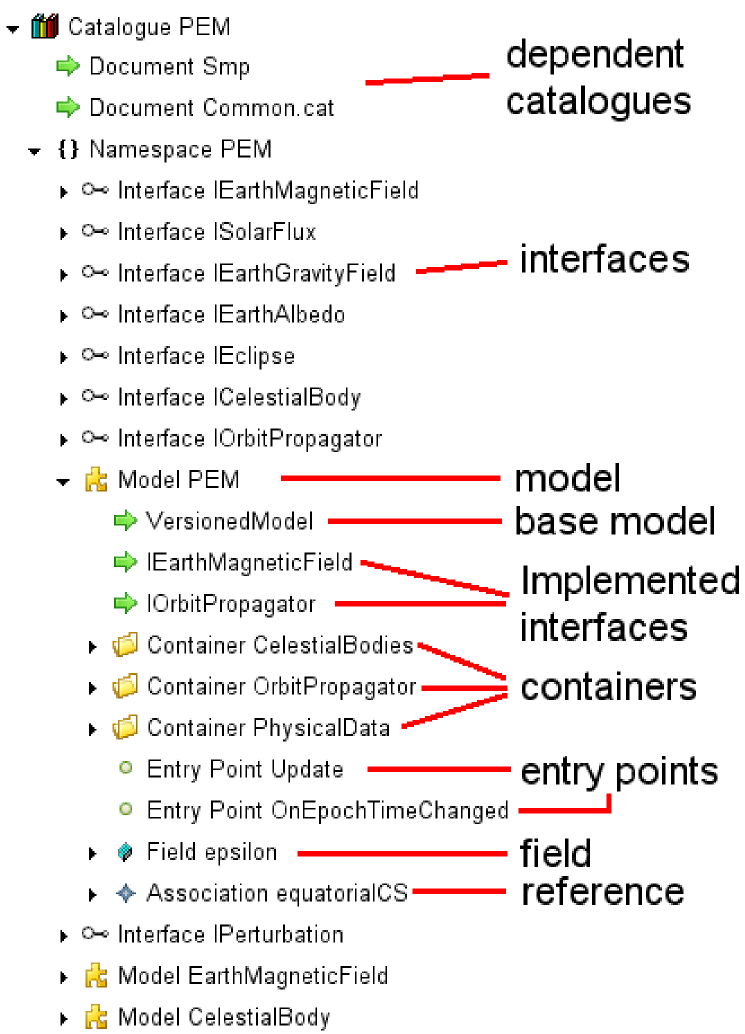


Delivered as a set of Eclipse RCP plug-ins

Catalogue Editor
Assembly Editor
Schedule Editor
Package Editor
Semantical Validator
Code Generator

The Model Integration Environment

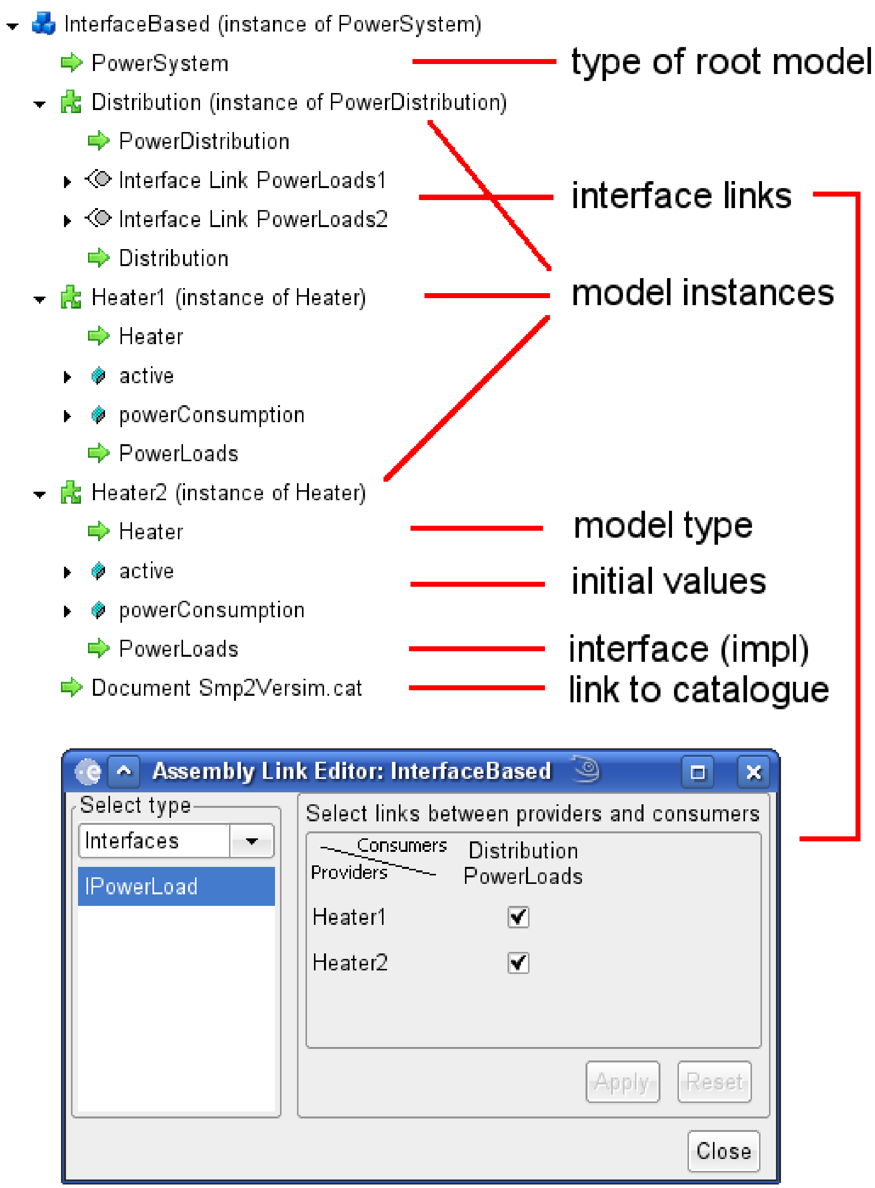
Catalogue Editor



A Catalogue is a collection of models and types

Skeleton models can be generated from their catalogue description

You only need the catalogue description along a third party binary model to be able to integrate and use it in your own simulator.



Assemblies are organised in a hierarchical fashion

- tree of model instances

Assemblies define

- models instances
- interface links
- inter-model events links
- field links
- initial values for fields

The Link Editor helps connecting models through the various kinds of links

Assembly Editor

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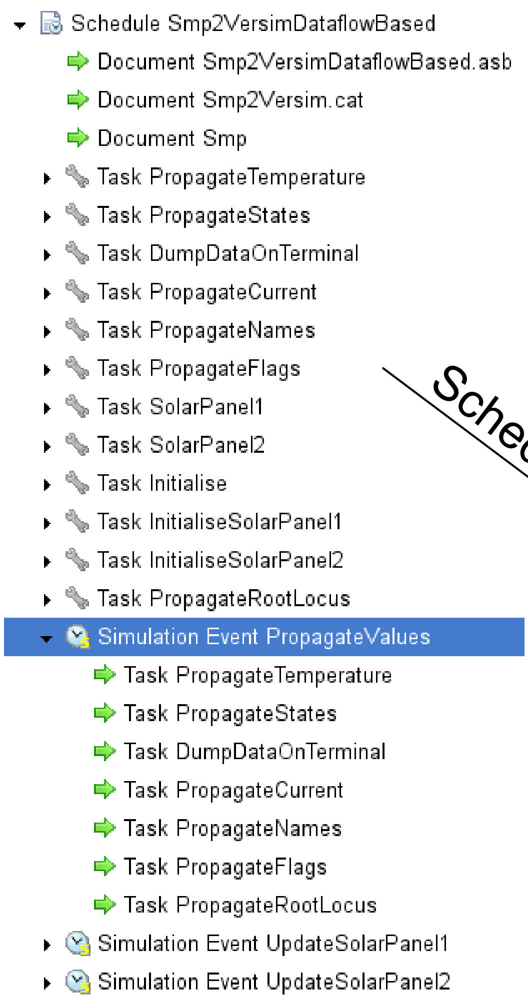
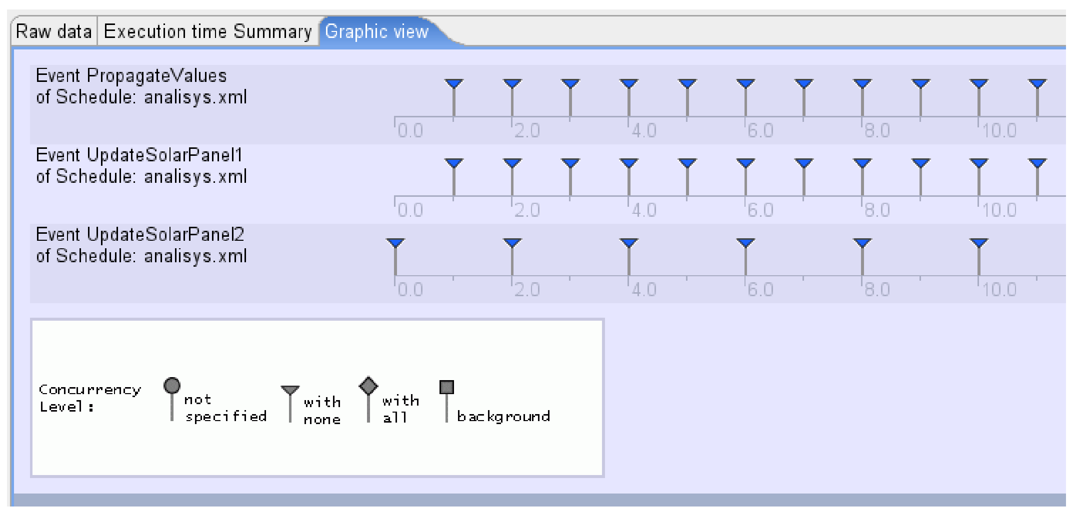


Schedule analysis

Schedule events against

- Simulation Time
- Epoch Time
- Mission Time
- Zulu Time

Analyse time-slips with the Schedule Analyser



Schedule Editor

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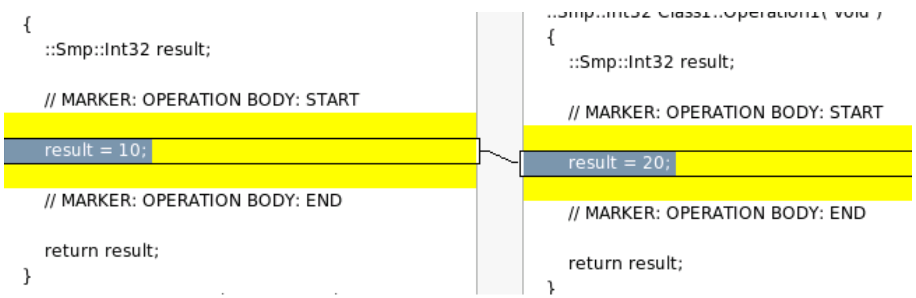
```
class SolarPanel:
      virtual public ::Smp::IDynamicInvocation,
      virtual public ::Smp::Mdk::Management::ManagedModel,
      virtual public ::Smp::Mdk::Management::EntryPointPublisher
{

    // ---------------------------------------------------------
    // ------------------------- Constructors/Destructor ------
    // ---------------------------------------------------------

    public:

        // Default constructor.
        SolarPanel();

        // Constructor setting name, description and parent.
        SolarPanel( ::Smp::String8 name, ::Smp::String8 descript

        // Virtual destructor that is called by inherited classe
        virtual ~SolarPanel();


    // ---------------------------------------------------------
    // ---------------------------------- IModel --------------
    // ---------------------------------------------------------

    public:
        // Request for publication.
        void Publish( ::Smp::IPublication *receiver ) throw ( ::

        // Perform custom configuration steps
        void Configure( ::Smp::Services::ILogger* logger ) throw

        // Connect model to simulator.
        void Connect( ::Smp::ISimulator *simulator ) throw ( ::S
```

SMP2 Model → C++ Code

Code Merging

- Model updates are fed back into customised code
- User-friendly conflict management



Code Generation and Merging

The SIMSAT runtime is delivered in two parts

- C++ Kernel where the models are executed
- MMI that is used to control the Kernel

Multiple users can connect to a simulation

- The MMI and the Kernel communicate through CORBA

The SIMSAT Kernel is simulation standard agnostic

- Supports native SIMSAT models and services
- Supports SMP1 models (SMI)
- Supports SMP2 models (v1.2)
- Any new standard that the future will bring us ...

SIMSAT – the runtime environment

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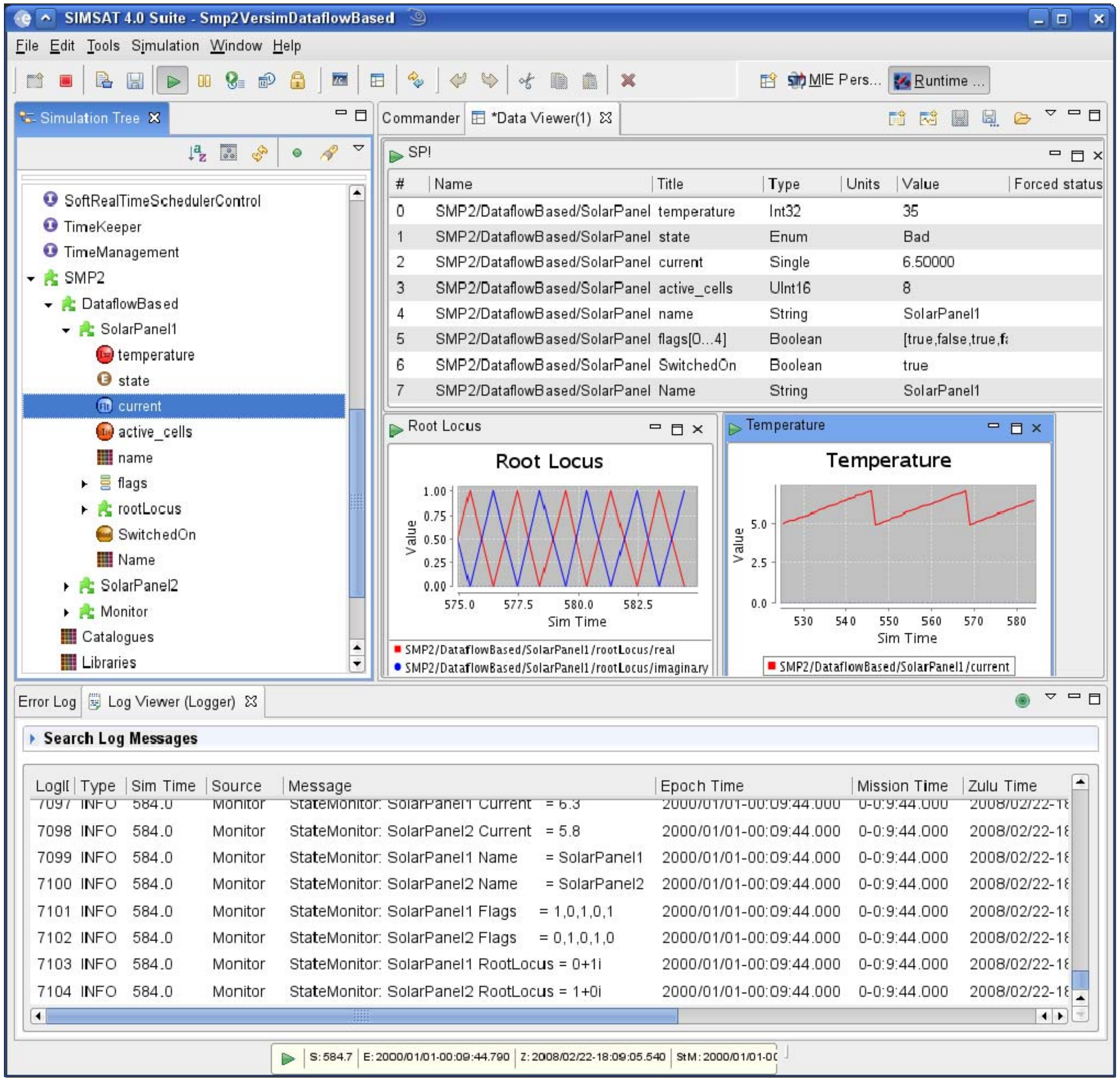

The MMI is delivered as a set of Eclipse RCP plug-ins

- Data Display
- Logger Viewer
- Commander
- Schedule Viewer
- Schedule Analyser
- Property Grid
- Recorder
- Simulation Tree
- Status Viewer

SIMSAT – the runtime environment

SMP2 Specifications
https://projects.de.terma.com/simsat40/docs/EXT/SMP2/smp2-12/

ECSS – European Cooperation for Space Standardisation
http://ecss.nl

Winter Simulation Conference
http://www.wintersim.org

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References

Q & A