Connecting MATLAB to the SMP2 Standard

Harmonizing new and traditional approaches for automatic model transfer

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Presentation overview

MOSAIC 10 activity (ESTEC / NLR / MathWorks collaboration)

- **Traditional MOSAIC approach**
  - Latest developments
  - New release of transfer tool: MOSAIC 10
- **Studying a new approach**
  - Based on Target Language Compiler technology
  - Direct configuration of code generator
  - Feasibility study
  - Prototype developed
- **Integration / harmonization of approaches: future plans**
- **Conclusions**

Introduction: automatic model transfer

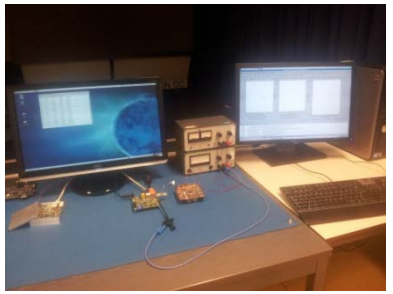
- **Purpose**
  - Re-use of models during a complete project life-cycle to reduce cost, time, effort
- **Approach**
  - Automate model transfer between COTS tools and model standards
- **Product**
  - MOSAIC

Model-Oriented Software Automatic Interface Converter

Modelling tools:
- **MATLAB**
- **EcosimPro**
- **20-sim**
- **Modelica**
- **..**

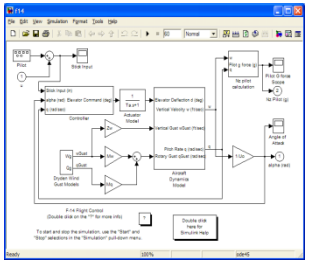
MOSAIC usage

- **Usage principles**
  - Model adaptation in originating environment
  - MOSAIC treats model as black box
  - Analyses the source code's API and adds interfacing code to it
  - End-to-end support
- **Free-of-charge license in ESA member states**
- **Used in European space industry**
  - For more than 15 years
  - In a large number of projects
- **Latest version: MOSAIC 10 (March. 2015)**



Example use case, traditional MOSAIC approach

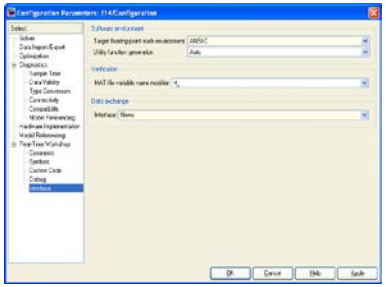
Develop spacecraft system models



Simulink

Simulink model

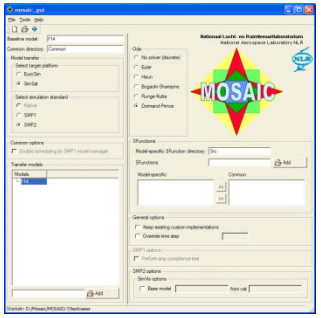
Export



Simulink Coder

C code model

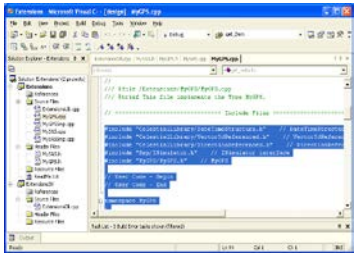
Automatic conversion



MOSAIC

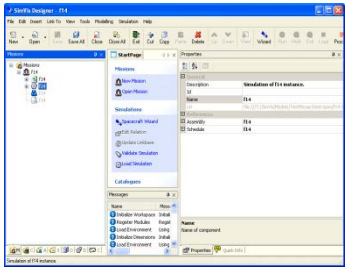
SMP2 compliant model (C, C++, catalogue, etc.)

Hard Real-time Simulation



Visual Studio

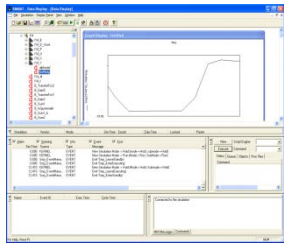
Compiled SMP2 model



SimVis Designer

(Re)connect models

SMP2 compliant simulator with integrated models

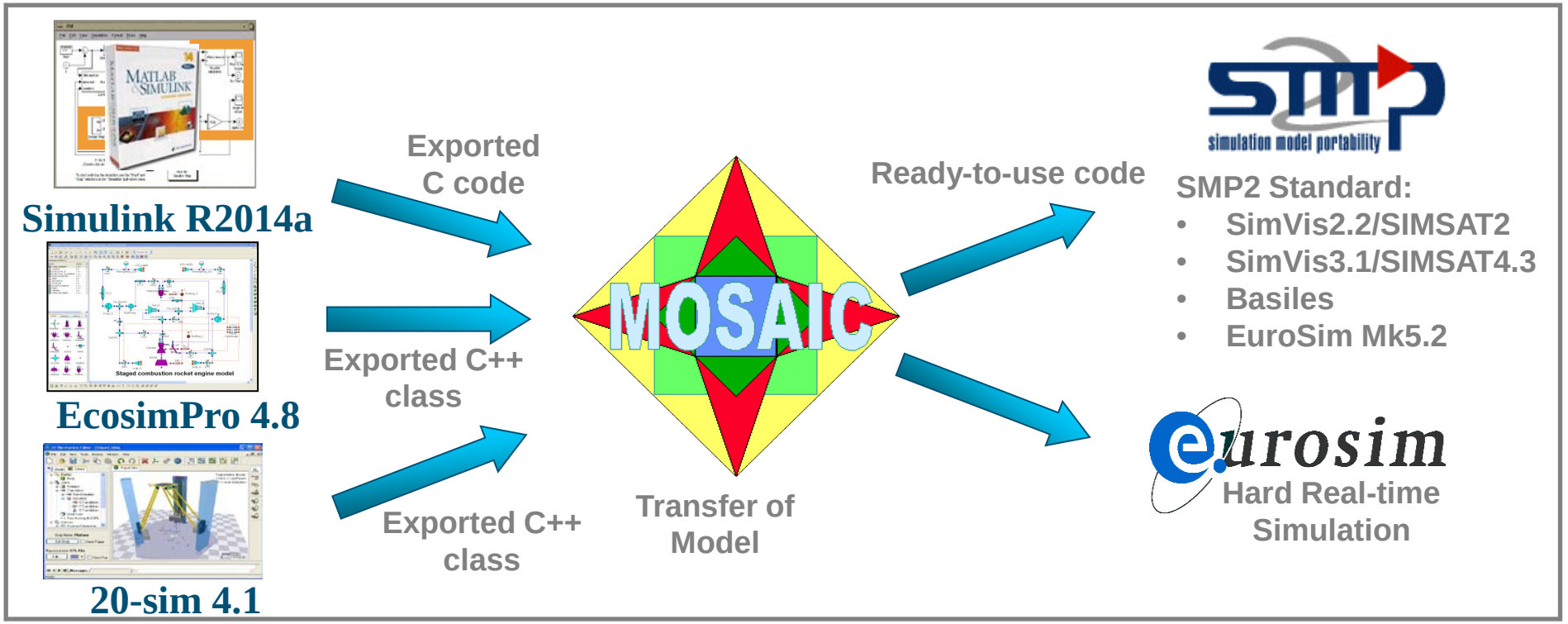


SIMSAT

Spacecraft simulation

MOSAIC 10 tool upgrade: key requirements

- Upgrade MOSAIC 9 to latest MATLAB version (R2014a at start of project)
- Maintain backward compatibility with MOSAIC 9 (e.g. EcosimPro and 20-sim support)

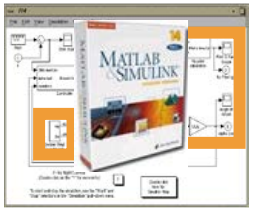


MOSAIC 10 results: Transfer combinations

- Modular architecture allows multiple transfer combinations
- Not all combinations are validated yet

MOSAIC 10 results: Transfer combinations (Simulink input)

- Modular architecture allows multiple transfer combinations
- Not all combinations are validated yet (= validated)



Simulink R2014a

C code generated

MOSAIC

Transfer of Model

SMP2 compliant code

EuroSim Mk5.2

SimVis 3.1/ SIMSAT4.3

Basiles

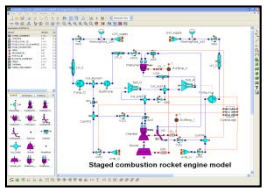
Native format

eurosim

Hard Real-time Simulation

MOSAIC 10 results: Transfer combinations (EcosimPro input, MOSAIC 9 compatibility)

- Modular architecture allows multiple transfer combinations
- Not all combinations are validated yet (= validated, → = not validated, = not yet supported)



EcosimPro 4.8

Exported C++ class

MOSAIC

Transfer of Model

SMP2 compliant code

SimVis/SIMSAT2

EuroSim Mk 5.2

SimVis 3.1/ SIMSAT4.3

Basiles

Native format

eurosim

Hard Real-time Simulation

MOSAIC 10 results: Transfer combinations (20-sim input, MOSAIC 9 compatibility)

- Modular architecture allows multiple transfer combinations
- Not all combinations are validated yet (= validated, → = not validated, □ = not yet supported)

20-sim 4.1

Exported C++ class

Transfer of Model

SMP2 compliant code

SimVis/SIMSAT2

EuroSim Mk5.2

SIMSAT4.2

Basiles

Native format

eurosim

Hard Real-time Simulation

MOSAIC 10 validation

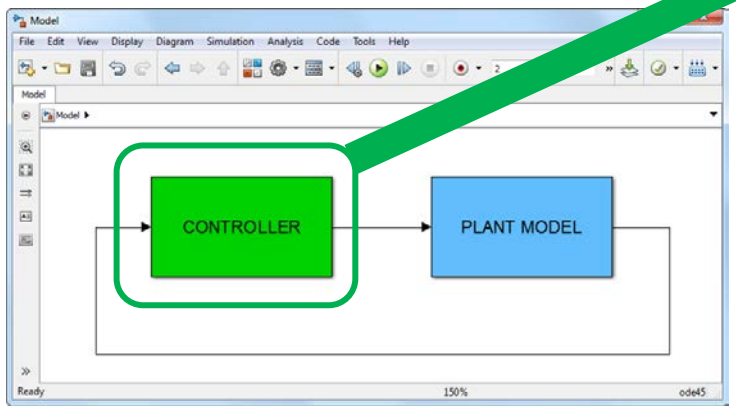
- Validated transfer combinations based on ESTEC use cases
- Other transfer combinations possible as well (at own ‘risk’)
- Tested with MOSAIC internal test suite and ESTEC acceptance models
- SMP2 Conformance suite, for compliance verification of MOSAIC 10 output SMP2 files

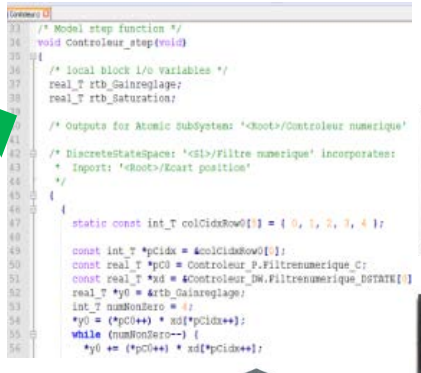
MOSAIC 10: specific user requests addressed

- Parsing of Simulink parameters with multiple comment lines in the generated code.
- The SMP2 input attribute for parameter fields has been adapted.
- SMP2 Universally Unique Identifier (UUID) issue (see paper)
  - Problem analysed and solution proposed.
  - Algorithm to be implemented in future version

Introduction to Simulink

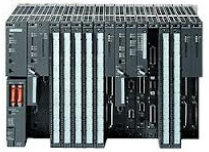
Code Generation





µ-controller / DSP
C/C++

FPGA / ASIC
VHDL/VERILOG



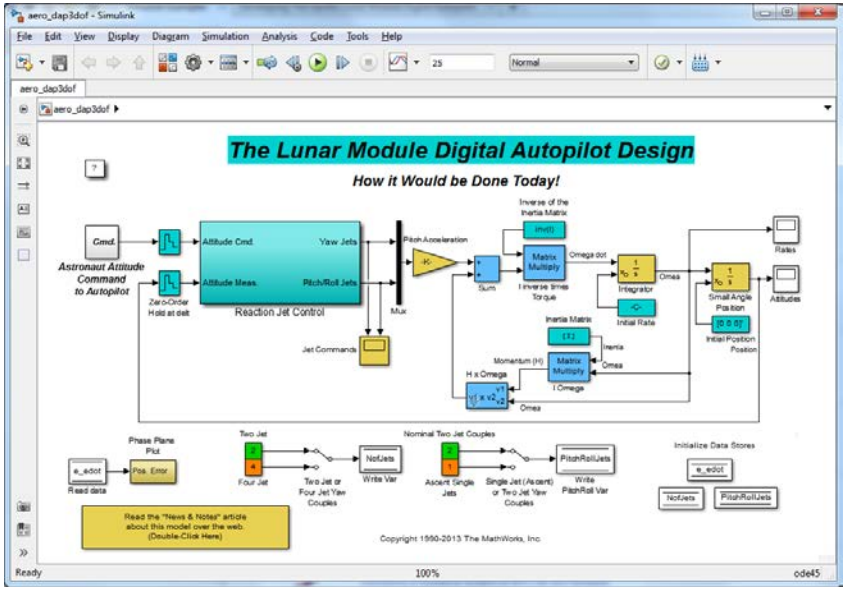
PLC / PAC
Structured Text

- **Automatic code generation from model**
- **Suitable for any embedded application**
- **Early and continuous verification**

Studying New Approach

What? Why? How?

Simulink

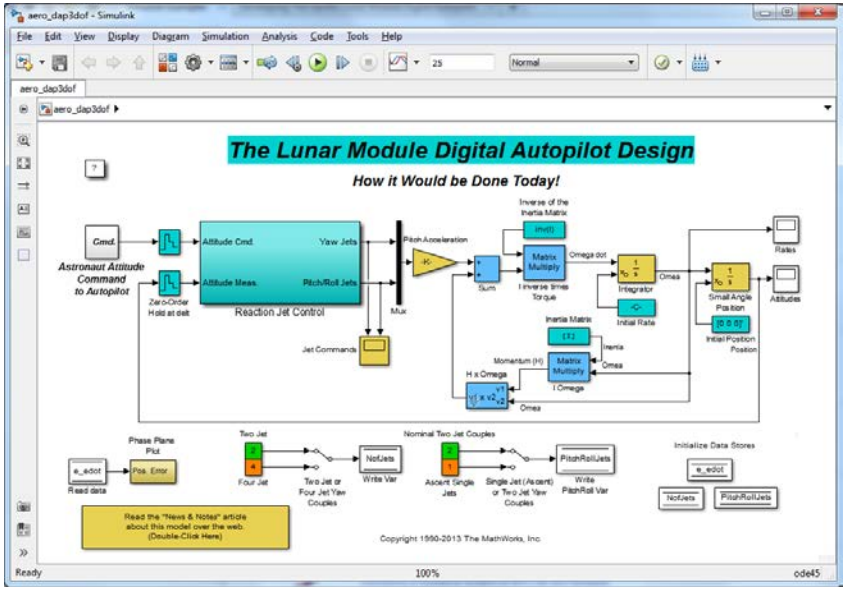


simulation model portability

Studying New Approach

What? **Why?** How?

Simulink

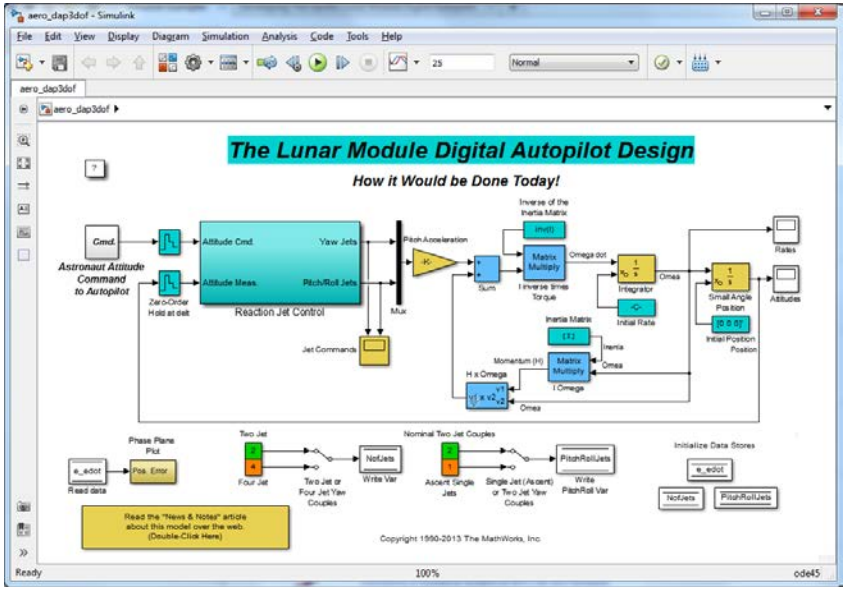


- Direct code generation
- R2010b, R2014a and +

Studying New Approach

What? Why? How?

Simulink

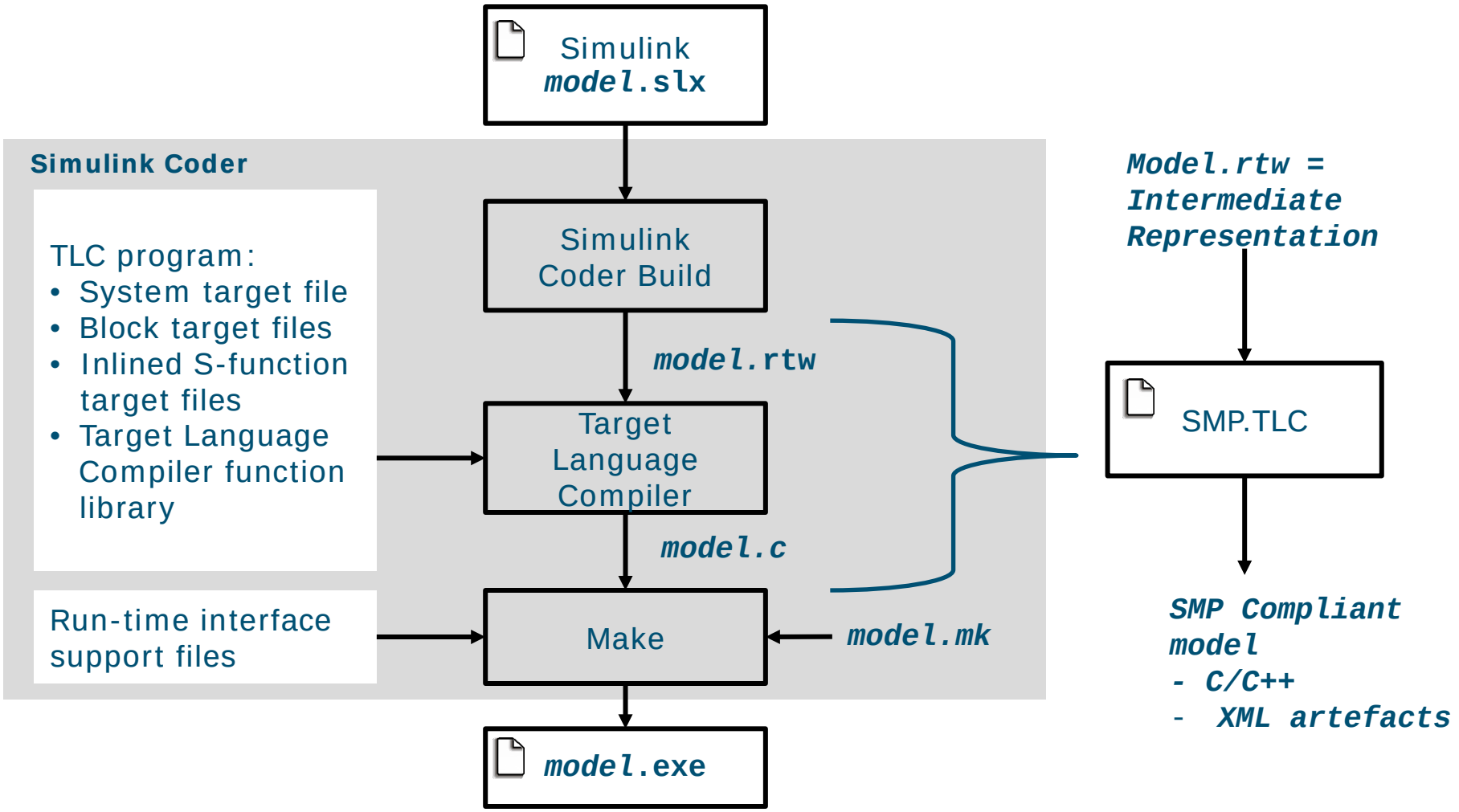


STF, TLC

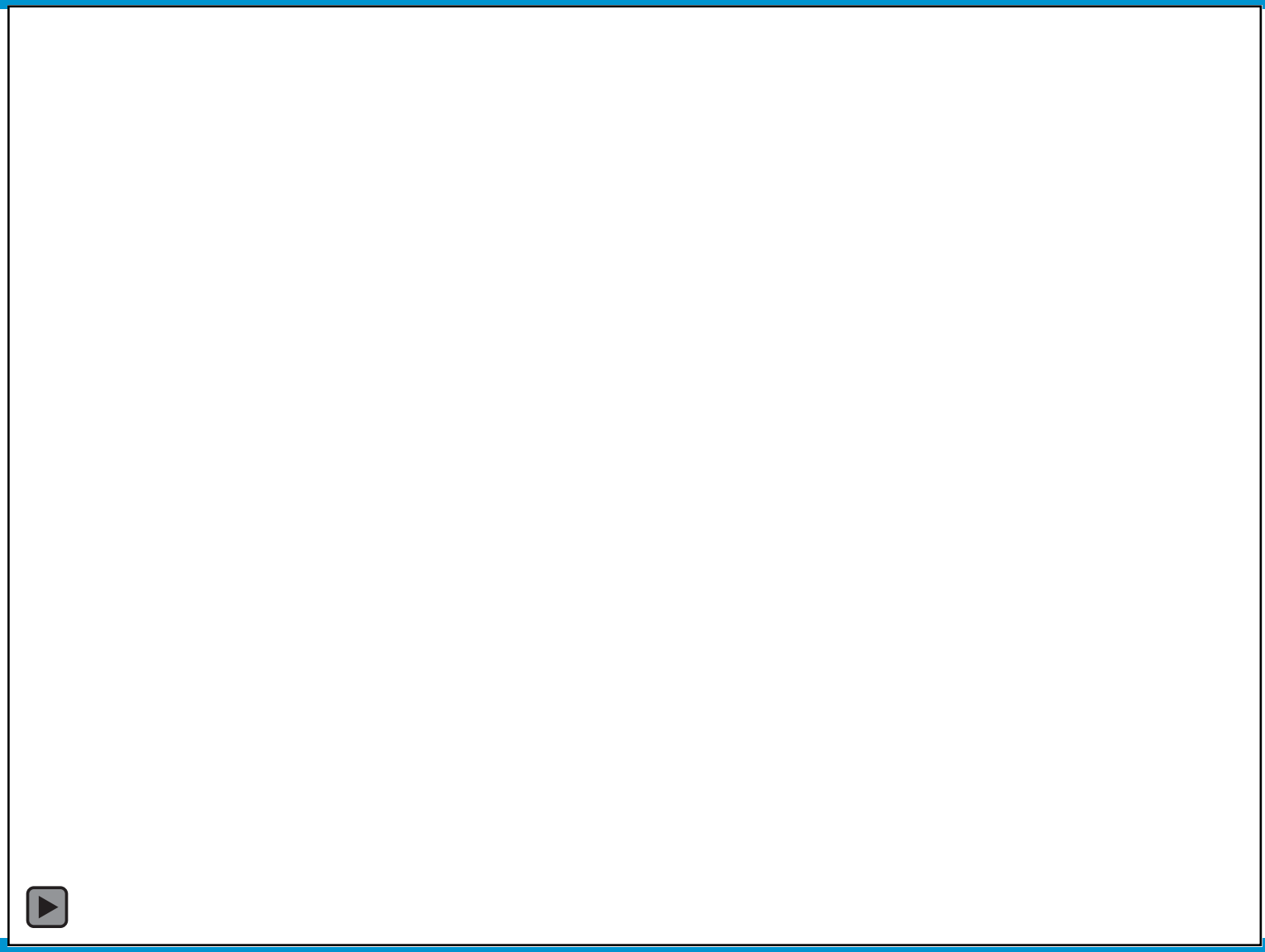
simulation model portability

- STF: Custom System Target File
- TLC: Target Language Compiler File

Embedded Coder
Generate custom C/C++ code with TLC



Validation of the SMP.tlc prototype

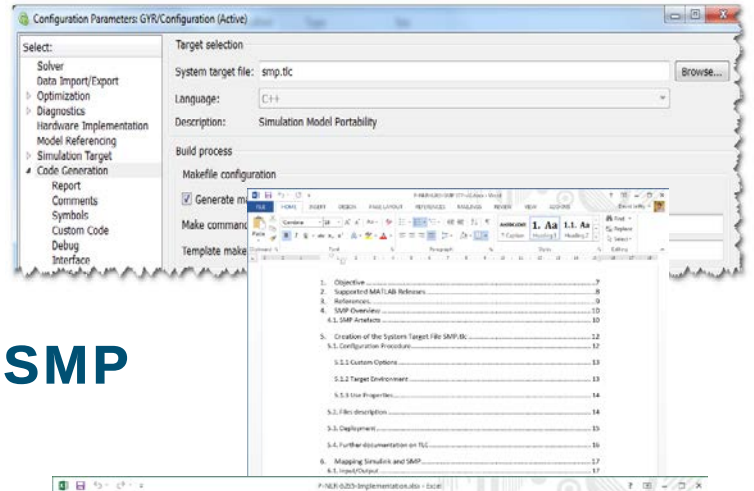


Validation of the SMP.tlc prototype

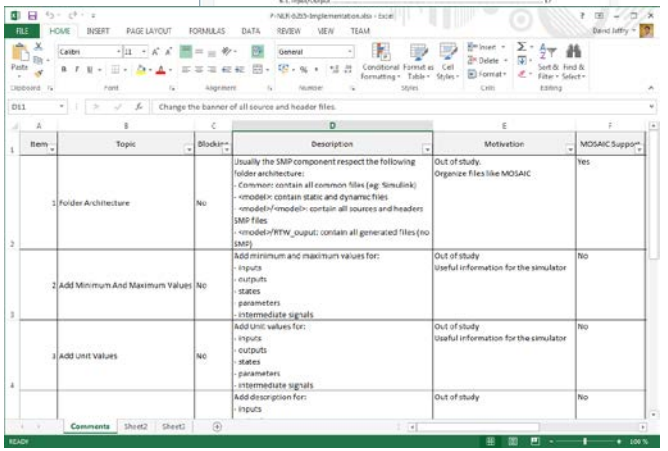
- **Tested with ESA Gyroscope Simulink model**
- **Validation:**
  - Inspection of the generated SMP artefacts and source code, comparison with MOSAIC generated output
  - Check with SMP2 Conformance Suite
  - Successful load in EuroSim Mk5 on a 32-bits Linux platform

Study Results

- **STF supporting main features of modeling and Embedded Coder options**



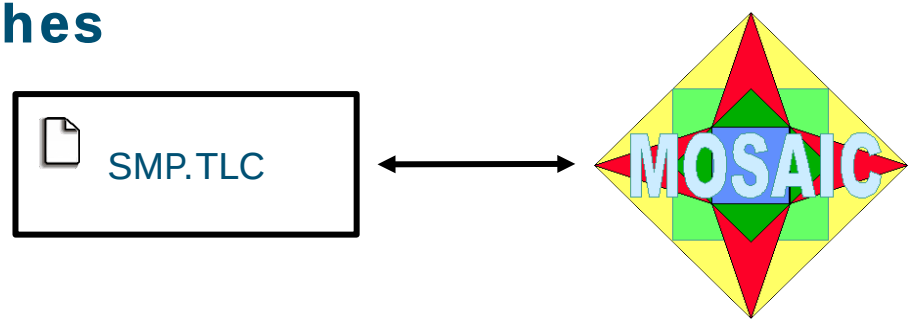
- **Mapping doc between Simulink and SMP**



- **Identification of new features or evolutions**

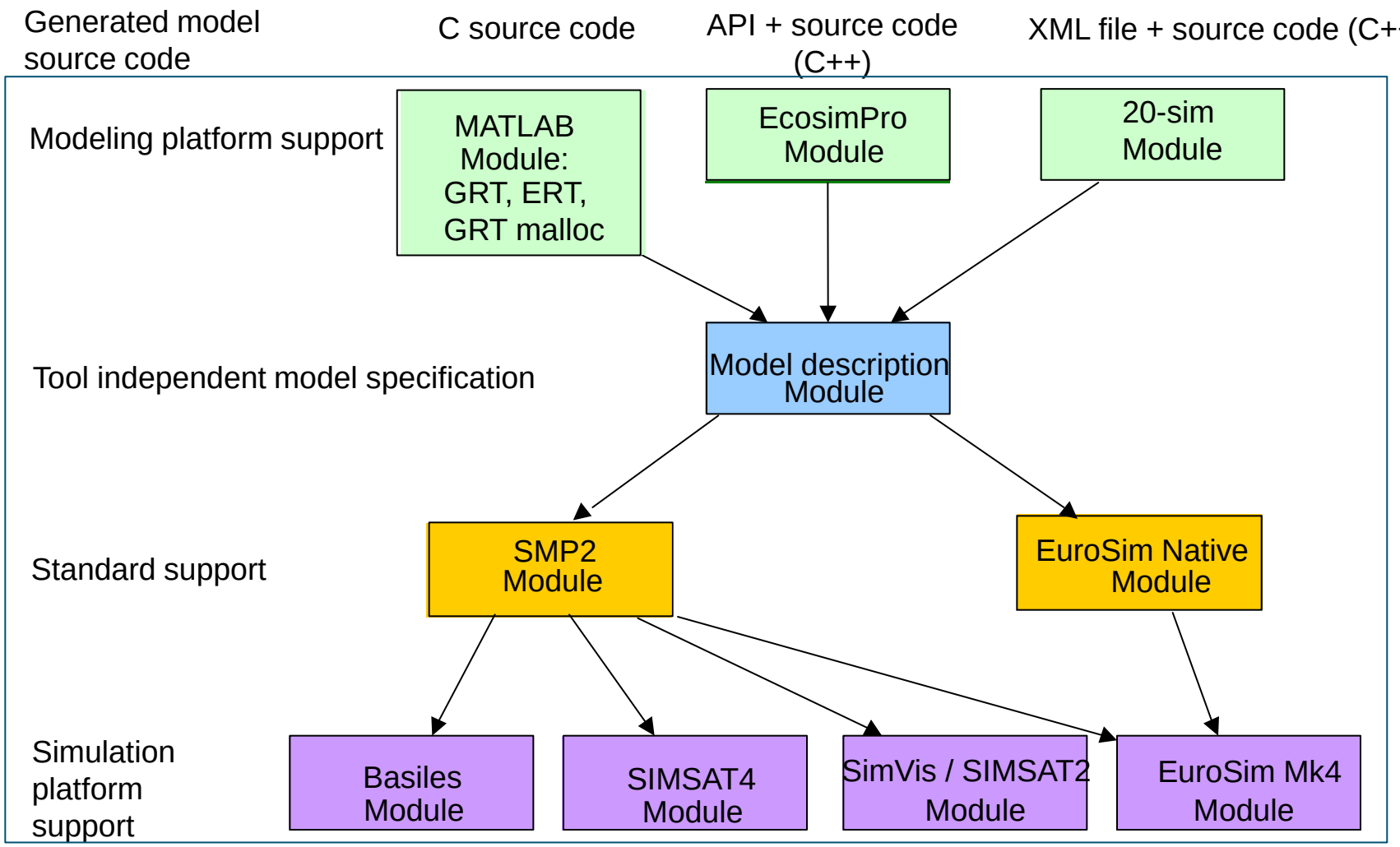
Integrating SMP.tlc with MOSAIC

- **Future work: Further harmonize new and traditional model transfer approaches**

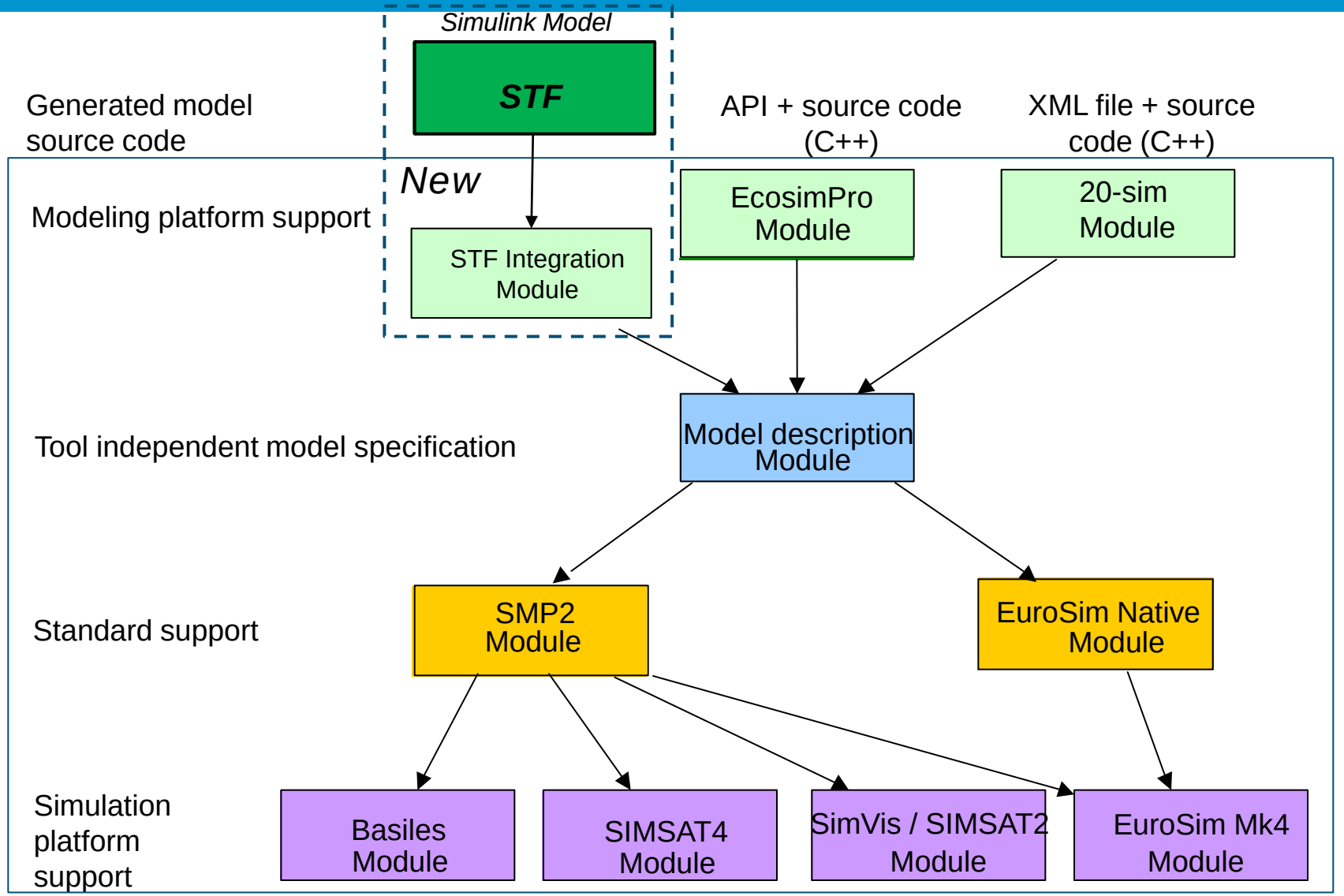


- **Ensure efficient maintainability**
- **Avoid duplication of functionality**
- **Several options:**
  - Stand-alone STF from end-to-end (target environment support to be added)
  - STF connects to MOSAIC modular architecture

Traditional MOSAIC architecture



Possible MOSAIC architecture with STF



Conclusions

- **MOSAIC 10**
  - Free-of-charge in ESA member states (license request: **mosaic@nlr.nl**)
  - Supports recent updates to corresponding simulation environments
- **System Target File**
  - Effective collaboration between NLR/ESA/MathWorks
  - Complementary approach
    - Meta data of Simulink model accessed directly
    - Less development effort expected
- **Integration of approaches**
  - New and traditional transfer approach fit well together
  - Integration activity planned ->MOSAIC 11
  - Contribute to high-level objective
    - Cost reduction of space system development
    - Efficient harmonization of System Modelling & Simulation (SM&S)