Enhancing the Model Integration Workflow in Aircraft System Simulation using FMI & SSP

Industrial User Presentations
Modelica Conference 2019, Regensburg

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Background: Current way of working at Saab
Model-Based Development of Aircraft Vehicle Systems

1. Design & Implementation of S/W
2. M&S of physical systems
3. Test A/C

Test rigs & simulators
Future Needs in System Development

- Enhanced connection of modeling domains, e.g., 3D CAD - system simulation, or system architecture - system simulation, 7%
- More formal and objective modeling of system requirements enabling connection of requirements to simulation models, to check compliance directly during simulation, 8%
- Optional needs: i) Utilize models enabling simulation on overall desing level, capability to quickly model large systems, ii) Enhanced cooperation between Model Responsible and Model Integration Responsible, iii) Open-source and tools that lasts, etc., 11%
- More efficient and automated methods & tools for export and integration of simulation models, 13%
- Capability to simulate larger part of a complete aircraft using more detailed models of interconnected subsystems, 13%
- More structured and automated model validation enabling objective assessment of test station credibility and test worthiness, 22%
- Enhanced methodology and tool support for product line management, e.g., handling of variants, versions, multi-customer, multi-fidelity models, 14%
- Capability to move testing from Msysm, T-rig, and subsystem physical test rigs to desktop environments available earlier in the development process, 14%
COLLABORATIVE R&D ON METHODS, STANDARDS & OPEN SOURCE TOOLS FOR EFFICIENT DEVELOPMENT OF CYBER-PHYSICAL SYSTEMS

Duration: December 2015 to December 2018
4 countries: Sweden, France, Finland, Hungary
Current status: 46.5 person-years, 6.5 M€, 18 partners
Project coordinator: Saab
Project Consortium & Industry Domains

- Sweden
  - Ericsson
  - SKF
  - EQUA
  - ICT
  - SICS
  - SIEMENS

- Finland
  - VTT

- France
  - CEA
  - EDF
  - Inria
  - ENSA
  - Sirehna

- Hungary
  - INQL

- Naval
- Automotive
- Aeronautics
- Mechanics
- Energy
- Gas turbines
- Building
Innovation Areas & Industrial Demonstrators

Overall aim: Increase **front loading** capability in development of cyber-physical systems by enabling **large-scale simulation**

- FMI Master Simulation Tool including UML/Modelica Interoperability
- State Machine and Real-Time Debugging & Validation
- Efficient Multi-Core Simulation

Vehicle energy management
Sherpa, CEA

Aircraft Vehicle Systems
Saab AB, LIU

Ship Decision Support System
Sirehna

Joint Energy Demonstrator
Siemens, EDF, KTH, EQUA

Tunnel ventilation HIL and SIL
EQUA

Mechanical Bearing-related demonstrator using FMI TLM
SKF, LIU
FMI Master Simulation Tool: OMSimulator

- Open source tool for **standardized, numerically robust**, and **efficient distributed (co-)simulation**
  - Functional Mock-up Interface (FMI) 2.0 CS & ME
  - System, Structure & Parameterization (SSP)
  - Transmission Line Method (TLM)
- Scripting support in Lua & Python, GUI support for composite model editing and simulation in OpenModelica & Papyrus
- FMUs and external tool integration, e.g. Simulink, Adams, Hopsan, Dymola
- Standalone: Open for integration into scripting frameworks, third-party tools, and specialized applications, e.g. flight simulators, optimization tasks

\[
p_1(t) = Z_c \left[ q_1(t) + q_2(t - \Delta t) \right] + p_2(t - \Delta t)
\]
\[
p_2(t) = Z_c \left[ q_2(t) + q_1(t - \Delta t) \right] + p_1(t - \Delta t)
\]
FMI Master Simulation Tool: OMSimulator

OMSimulator.exe

OMSimulator.lib/dll

OMTLMSimulator
• Physical connections
• Delayed connections
• Distributed processes

OMFMISimulator
• Signal connections
• Non-delayed connections
• Single process

Standalone: https://github.com/OpenModelica/OMSimulator
Integrated in OpenModelica tool suite: https://openmodelica.org
Saab Aeronautics Demonstrator
FMI-based co-simulation of Aircraft Vehicle Systems

- **Demonstrate**
  - Standardized model export and integration into desktop simulators
  - Interoperability between different modeling tools/domains
  - Expansion in M&S of aircraft vehicle systems at Saab, increased scope, availability, and utilization of “high fidelity” simulations

- **OMSimulator development**
  - Input to requirement specification
  - Aid in development prioritization
  - Verification in an industrial setting

- **Multiple languages/tools involved**
  - Modelica (OpenModelica, Dymola)
  - xtUML (Bridgepoint)
  - SysML (Papyrus)
  - Simulink
Updated way of working
Model-Based Development of Aircraft Vehicle Systems

Design & Implementation of S/W
Test rigs & simulators
OMSimulator
Test A/C

M&S of physical systems

OMSimulator
SSP
FMI-based digital twin

M&S
UML
OMSimulator
SSP
FMI
Summary & Conclusions

• **Open and transparent integration tools make sense**

• Enabling easy setup of FMI & SSP-based simulator applications at Saab

• FMI for increased efficiency in Saab’s model integration workflow

• Workflow and tool support for FMI & SSP-based interoperability between system architecture (e.g. SysML) & system simulation (e.g. Modelica, Simulink)

• Industrial needs on standardization:
  • FMI: Provide means to improve **numerical robustness** and **simulation speed**: FMI Change Proposals (FCPs) #015, #010, #012, #013
  • SSP: Manage **simulation settings** and **external models**

• More info on OMSimulator: **Tuesday 11:00, Session 1C: FMI 1**
Questions?