ProSTEP iViP Project

Smart Systems Engineering (SmartSE)

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project chairman

Emre Nalbant (PROSTEP AG)
project coordinator

ProSTEP iViP Symposium | May 18th, 2017
Collaborative system development with simulations

1. Create business requirements / technical specification for functional models, which have to be delivered by the supplying partner

2. Behaviour model documentation for exchange of the relevant model functions and properties for example via a Functional Mockup Unit (FMU)

3. Check the model quality, for example proof the correct model validation; „Q-Checker“ for functional / behaviour models
Vision and Mission of SmartSE

**Vision**

Establish best practices for distributed collaborative system development between partners using existing Systems Engineering methods and standards

**Mission (2012-2015)**

Investigation of the use and best practices of the “Functional Mock-up Interface” (FMI) for the neutral behavior model exchange

**Mission (2016-2017)**

Investigation of the use of Systems Engineering methods for collaborative system development and its necessary core technologies as IP protection and data handling
Smart Systems Engineering (SmartSE)
Phase 3: Robust collaborative behavior modeling

• Aims:
  – Intensify the cooperation activities with other projects and further focus on enhancements to the recommendations

• Envisioned Results:
  – Enhanced SmartSE use case descriptions
  – Report on standard model architectures and model elements for mechatronic systems
  – Documented Business Case for SysML Industrialization
  – Annex to recommendation on SE Data Management Integration and a FMI-Requirements- Specification Template
  – Report on technical measurements for IP Protection in collaborative behavior modeling

• Duration:
  – 01/2016 – 12/2018

• Participants:
SmartSE project consortium

>25 project participants from industry

- 38% User (OEM & Supplier)
- 38% Service Provider
- 14% IT Vendor
- 10% Academics

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Project planning 2016-2018: SmartSE Phase 3 – Robust collaborative behavior modeling

WP 1
Project Management
Networking with other organizations and projects
• VDA, Modelica Association, FMI Steering Committee, INCOSE, GfSE, ISO, OMG
• AGESYS, MoSSEC, mecPro², etc.

Dissemination of project results and roadmap in:
• Publications: Produkt Daten Journal, Recommendation
• Conferences & congresses: ProSTEP iViP Symposium, SIA Congress 2016, …
• Newsletter: ProSTEP iViP

WP 2
Industrial Building Blocks in Simulation Architectures
• Identification of standardization potentials in the area of mechatronic systems
• Differentiation between IP Protection or Standardization relevance of building blocks in vehicle simulation infrastructures
• Conceptualize an industrial building block system for vehicle simulation infrastructures
## Project planning 2016-2018: SmartSE Phase 3 – Robust collaborative behavior modeling

<table>
<thead>
<tr>
<th>WP 3</th>
<th>FMI Industrialization</th>
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<tbody>
<tr>
<td></td>
<td>• Business Case for FMI Industrialization</td>
</tr>
<tr>
<td></td>
<td>• Support the collaboration process between SmartSE and MAP FMI</td>
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<tr>
<td></td>
<td>• Prepare FMI Specification Issues: Compatibility, IP Protection, Interconnection of different FMUs etc.</td>
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<table>
<thead>
<tr>
<th>WP 4</th>
<th>Challenges of Interdisciplinary Collaboration</th>
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<tbody>
<tr>
<td></td>
<td>• Business Case/ Potentials for SysML Industrialization</td>
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<td>• Model-Based Traceability</td>
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<td>• Human Factors</td>
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<table>
<thead>
<tr>
<th>WP 5</th>
<th>Behavior models and Data Management Integration</th>
</tr>
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<tr>
<td></td>
<td>• Enhance the concept for the PDM Integration of SE objects</td>
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<tr>
<td></td>
<td>• Enhance the behavior model exchange process with a FMI-Requirements-Specification Template</td>
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<th>WP 6</th>
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<tr>
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<td>• Analysis and proposal of technical measurements for an IP-secured collaborative behavior modeling</td>
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</table>
**SmartSE – current work packages**

[Diagram showing the current work packages for SmartSE, including Partner A and Partner B, with work packages WP 2, WP 4, WP 5, and WP 6 highlighted. The diagram illustrates the sharing of model use and model data management between the partners, with standardized architecture and artifacts, and standardized processes and formats.]
# Actual Work Package Mentors

<table>
<thead>
<tr>
<th>Work Package</th>
<th>WP Mentor*</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP 1 Project Management and Public Relations</td>
<td>BMW AG</td>
</tr>
<tr>
<td>WP 2 Industrial Building Blocks in Simulation</td>
<td>Robert Bosch GmbH</td>
</tr>
<tr>
<td>Architectures</td>
<td></td>
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<tr>
<td>WP 3 FMI Industrialization</td>
<td>Project Group</td>
</tr>
<tr>
<td>WP 4 Challenges of Interdisciplinary Collaboration</td>
<td>Ford-Werke GmbH</td>
</tr>
<tr>
<td>WP 5 Behaviour models and Data Management Integration</td>
<td>ETAS GmbH / dSPACE GmbH</td>
</tr>
<tr>
<td>WP 6 IP Protection in Collaborative Behavior Modeling</td>
<td>ZF Friedrichshafen AG</td>
</tr>
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* As partner in the topics there is also a second mentor as advisor / discussion partner for the first possible
Basis: Systems Engineering
Collaborative System Development Between Partners

- Distributed model based development between partners
  - What needs to be exchanged?
  - Which approaches and methods do exist (Viewing: Consistency, IP-Protection,..)
  - What is missing, what can SmartSE do?
SmartSE – current focus

Current focus of SmartSE project

- Geometrical Part of Physic JT
- Requirements ReqIF
- Geometrical Part of Physic JT
- Data Management Integration for Behavior Models
- IP Protection for Models
- Business Model for Standardized Models
- Reference Process (incl. Templates) for Collaborative Model Development using FMI
- Challenges of Interdisciplinary Collaboration. SysML and Architectures
- Requirements ReqIF

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## SmartSE Results - Highlights

<table>
<thead>
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<th>Work Package</th>
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<tbody>
<tr>
<td>WP 2 Industrial Building Blocks in Simulation</td>
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<tr>
<td>Architectures</td>
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* WP4 Results are part of the next presentation
## SmartSE Results - Highlights

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SmartSE – WP2
Results of SmartSE Check

What kind of models (A-H) we have to simulate together?

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SmartSE Results – WP 2
Application for Autonomous Driving

Environment

3D Road Network & Infrastructure
- Freeway, rural & urban roads, buildings
- Traffic signs, traffic lights
- Street markings

Traffic
- Vehicles, pedestrians
- Objects

Environmental Conditions
- Weather, lighting
- Friction coefficient

Sensors

System Fct

Server, Cloud

Connectivity

HAD System Functional Chain

Environment Perception

Decision Making

Motion Planning & Control

Actuator Management

Vehicle Motion Control

HAD: Highly Automated Driving

Test Scenarios

Simulation Environment

Environment Sensors System Fct Connectivity Server, Cloud

Environment

Vehicle Model

Driver

Actuation

Brake

Steering

Power Train

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## SmartSE Results - Highlights

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SmartSE WP3
Best Practice Guide for FMI Users

• Motivation:
  – Provide condensed recommendations based on current industry experience, processes and best practices
  – Supplement FMI standards with background information, do not supersede standards (enhancement/clarification requests are forwarded to FMI WG)

• Best Practice Guide for Users (FMI Key Users at OEMs & Suppliers)
  – Necessary modeling decisions, their impact and background information
  – Integration testing, documentation of exchanged models, unit testing
  – Common pitfalls to avoid based on observed project practice
SmartSE WP3  
Driver Model as Example

- FMUs from 5 different companies combined to “System Model”
- For each FMU different variants used (6 cycle-, 4 driver-, 3 vehicle-FMU variants)
- In sum 72 FMU-combinations created and simulated on the platform of a partner
- Results:
  - All FMU combinations can be simulated
  - All driver FMUs allow to follow velocity profiles like WLTP, …
  - For seamless exchange between companies, FMU interface specification must be very accurate and ideally machine readable
  - Template FMUs according to proposal from Modelica SSP project could be helpful:
    - Template FMUs could be generated from “System Model”
    - Template FMUs should be importable in modelling tools to transport interface
## SmartSE Results - Highlights

### Work Package

| WP 2 Industrial Building Blocks in Simulation Architectures |
| WP 3 FMI Industrialization |
| WP 4 Challenges of Interdisciplinary Collaboration* |
| WP 5 Behaviour models and Data Management Integration |
| WP 6 IP Protection in Collaborative Behavior Modeling |
SmartSE WP5
Accompanying Templates

• Administrative & organizational aspects
  – General organization
  – Project plan
  – General regulations

• Classification of behavior model
  – General description
  – General properties
  – Additional IT requirements
  – Model description
SmartSE WP5
Template Description

Document Purpose:
• Specification
• Documentation
• Validation

Criteria:
• Model Content
• Model Validation
• Real Time Usage
• Validity Range
• etc.

Criteria Description
# SmartSE Results - Highlights

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SmartSE WP6
Process to select protective measures

1. Identify intellectual property (IP)
2. Classify security level
   - Classify usage
3. Identify threats
4. Apply measures
5. Review applied measures
6. Monitoring
SmartSE WP6
IP Protection in Collaborative Behavior Modeling

• Example FMU:
  • Identify IP, classify confidentially and classify usage
  • Identify threats for every artefact

Example CoupledClutches.fmu*

1. Identify IP
   • Model Function (system structure, algorithm)
   • Model Parameter (force limits, friction etc.)
   Stored in:
     - modelDescription.xml (Model Parameter and structured variable names i.e. system structure)
     - Source code (Model Function, Model Parameter)
     - Compiled dll (Model Function, Model Parameter)
     - Documentation (no IP)

2. Classify confidentially and usage
   • Security level - Model Function: → FOR INTERNAL USE
   • Security level - Model Parameter: → CONFIDENTIAL
   • Usage:
     → Simulate/Execute

Example CoupledClutches.fmu*

3. Identify threats

<table>
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<th>IP Protection</th>
<th>Source Code</th>
<th>Compiled dll</th>
<th>Documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited visibility of models</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Unauthorized modifications of models</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Severe internal or sandbagged dissemination of models</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Escaping into model structure</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Restricted access to input and output behavior</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Reverse Engineering</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Overcoming terms of use</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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SmartSE WP6
IP Protection in Collaborative Behavior Modeling

- Example FMU:
  - Identify IP, classify confidentially and classify usage
  - Identify threats for every artefact
Big Picture SmartSE - Model Based

Interaction scenarios

SmartSE Use Cases

Simulation Tasks

SmartSE Reference Process

Requirements for cross domain SE data management

Abbreviation:
SE-DM Systems Engineering Data Management

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Big Picture SmartSE – Formats and Standards

Abbreviation:
SE-DM Systems Engineering Data Management

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Big Picture SmartSE – Cross Domain Data Management

Requirements for Cross Domain Data Management:

I. SE model data management
II. SE configuration management
III. Tool & data integration
IV. SE model exchange
V. Project & workflow management
VI. Traceability
VII. Simulation & test data management
SmartSE Use Cases

SmartSE Formats and Standards

Requirements for cross domain SE data management

Abbreviation:
SE-DM Systems Engineering Data Management

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Thank you!

Questions?