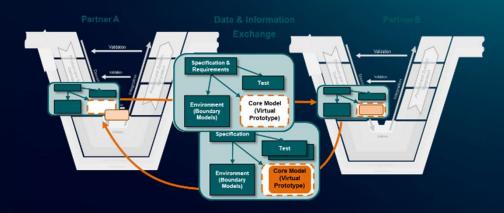# 16th Modelica & FMI Conference

prostep SmartSE

Traceability and Support of Simulation & Modeling using
SSP-Traceability Layered Standard

September 2025

Hans-Martin Heinkel, Robert Bosch GmbH
Antoine Vandamme, Robert Bosch GmbH
Peter Lobner, eXXcellent solutions
Dag Brück, Dassault Systèmes
Pierre Mai, PMSF

Traceability and Support of Simulation & Modeling using SSP
Agenda

- Overview prostep SmartSE project

- Building Blocks GlueParticle SmartSE

- Credible Modeling using SSP-Traceability Layered Standard

- Example with Demo

- Status of standardisation of metadata for modeling & simulation (M&S)

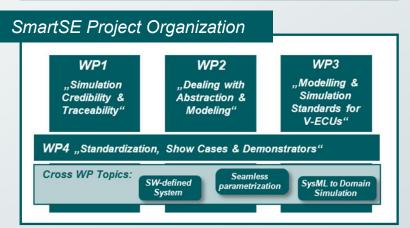- Usage of metadata and SSP-traceability for traceability and reuse

- Summary

Overview SmartSE Project
Project phase 6: Mission and Work Packages

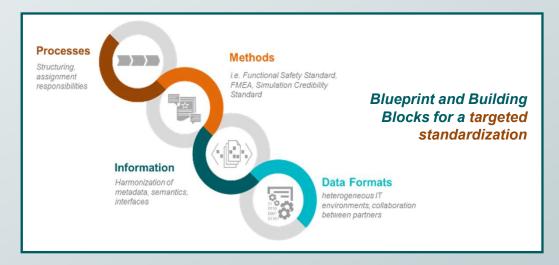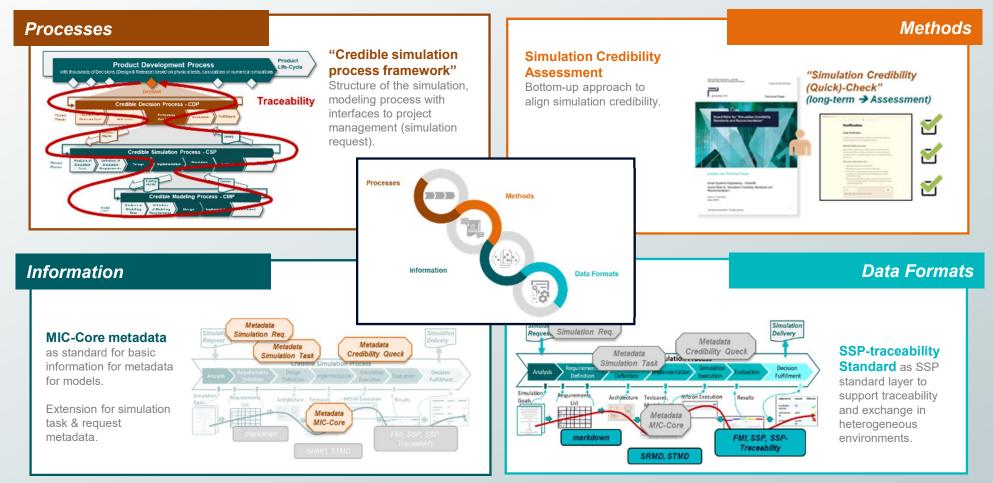**25+ project participants**

Stand: 2025

Mission Phase 6 (2025-2027)

Enabling collaborative development and validation of complex products by simulation in networks and along multi-tier supply chains.

SmartSE Project Organization

WP1 "Simulation Credibility & Traceability"	WP2 "Dealing with Abstraction & Modeling"	WP3 "Modelling & Simulation Standards for V-ECUs"

WP4 "Standardization, Show Cases & Demonstrators"

Cross WP Topics: SW-defined System | Seamless parametrization | SysML to Domain Simulation

Processes — Structuring, assignment responsibilities

Methods — i.e. Functional Safety Standard, FMEA, Simulation Credibility Standard

Information — Harmonization of metadata, semantics, interfaces

Data Formats — heterogeneous IT environments, collaboration between partners

Blueprint and Building Blocks for a targeted standardization

The initiation, development and industrialization of standards in the field of model-based and cross-company development is an important part of the work of the SmartSE project group.

Traceability and Support of Simulation & Modeling using SSP-Traceability
Building blocks to support Credibility and Traceability of Simulation & Modeling

Processes

"Credible simulation process framework"
Structure of the simulation, modeling process with interfaces to project management (simulation request).

Methods

Simulation Credibility Assessment
Bottom-up approach to align simulation credibility.

Information

MIC-Core metadata as standard for basic information for metadata for models.

Extension for simulation task & request metadata.

Data Formats

SSP-traceability Standard as SSP standard layer to support traceability and exchange in heterogeneous environments.

Credibility and Traceability of Simulation as an Enabler for Virtualization
Process framework for Support of Simulation & Modeling

Process hierarchy with clear information structuring

- *Sub-processes can be integrated into specific company processes*
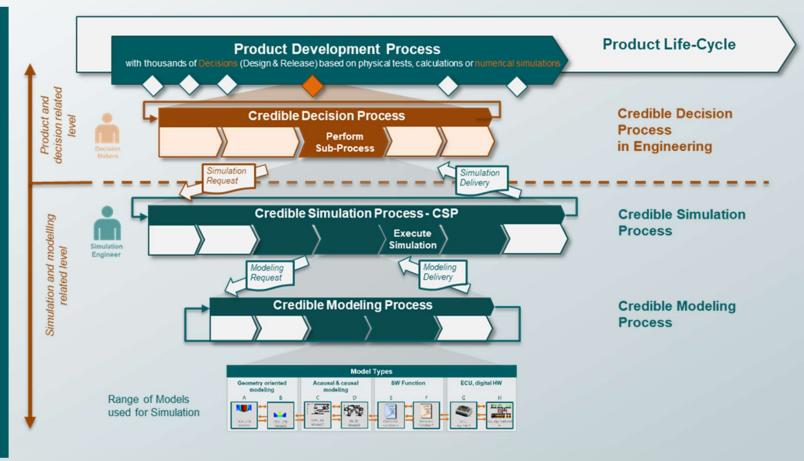
- *Clear assignment of responsibilities*

Meetings for alignment "Big Picture and core terms"

as basis for domain specific credibility standards.

Credibility and Traceability of Simulation as an Enabler for Virtualization
Process framework for Support of Simulation & Modeling

Process hierarchy with clear information structuring

- Sub-processes can be integrated into specific company processes
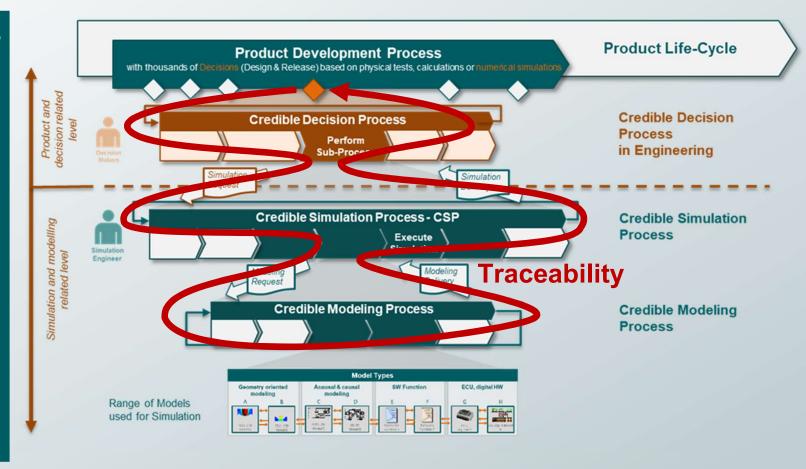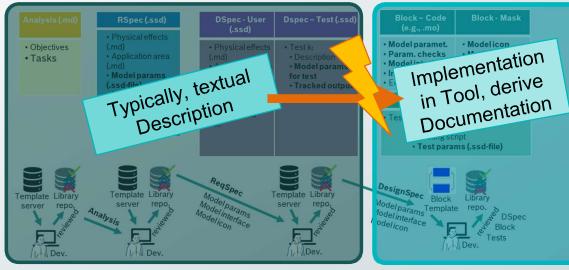- Clear assignment of responsibilities

Meetings for alignment "Big Picture and core terms"

ASME · INCOSE · NAFEMS

as basis for domain specific credibility standards.

Product Development Process
with thousands of Decisions (Design & Release) based on physical tests, calculations or numerical simulations

Product Life-Cycle

Credible Decision Process
Perform Sub-Process

Credible Decision Process in Engineering

Product and decision related level

Decision Makers

Simulation Request

Simulation

Credible Simulation Process - CSP
Execute Simulation

Credible Simulation Process

Simulation and modelling related level

Simulation Engineer

Modeling Request

Modeling Delivery

Traceability

Credible Modeling Process

Credible Modeling Process

Model Types
- Geometry oriented modeling (A, B)
- Acausal & causal modeling (C, D)
- SW Function (E, F)
- ECU, digital HW (G, H)

Range of Models used for Simulation

Traceability and Support of Simulation & Modeling using SSP
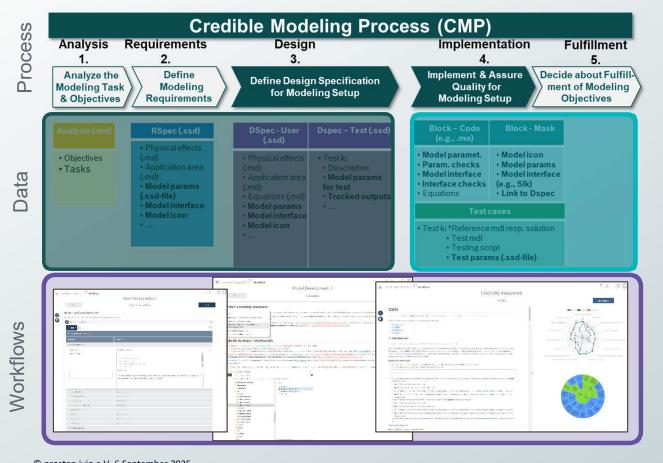## Modeling Process (Status quo)

Weak Points

- Mismatch of interface, parameter specification to implementation in simulation tool

- Copy / Paste errors

- Inconsistent versions, content of requirement & design specification and documentation

- High review efforts

- Often no single source of truth

- No Traceability => No Credibility

Traceability and Support of Simulation & Modeling using SSP
Approach for Credible Modeling

Credible Modeling Process (CMP) diagram with Process, Data, and Workflows levels

Three level approach
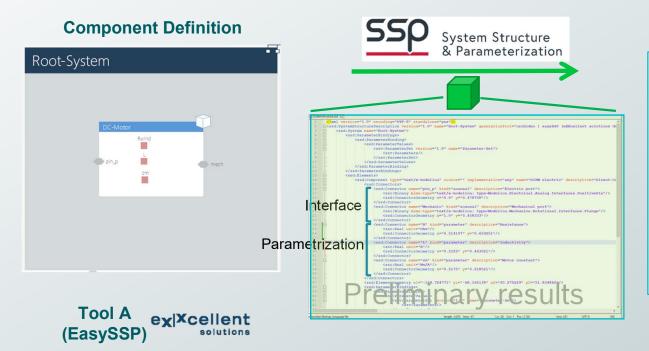- **Process**
- **Data**
- **Workflows**

Benefits

- Well-defined process to convey information in a structured manner

- Use of SSP for efficient model exchange

- Use of SSP Traceability to store and exchange process information in a standardized form

- Easy to use via workflows based on common formats (Markdown, YAML)

- Automatic process & model documentation

- Data exchange via SSP package

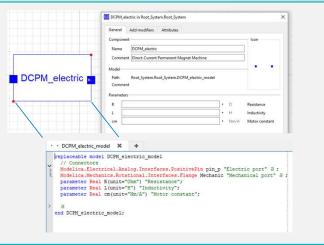# Traceability and Support of Simulation & Modeling using SSP
Open Standards for Efficient Data Exchange

Use of SSP 2.0, SSP Traceability and Modelica enables efficient data exchange and development, e.g. via automatic interface and parameter propagation (investigations with easySSP & Dymola, prototypical release E.2024)
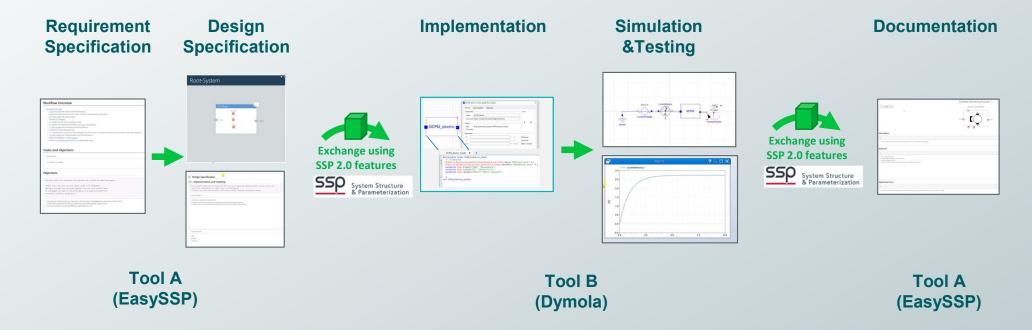
Component Definition

Component Implementation

Interface

Parametrization

Tool A (EasySSP)

Tool B (Dymola)

Traceability and Support of Simulation & Modeling using SSP
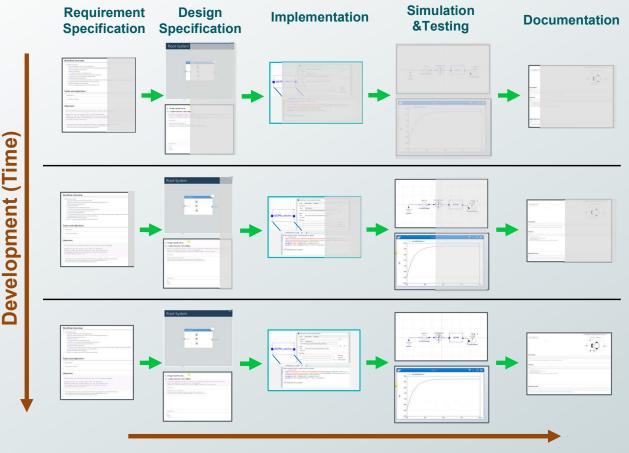## Open Standards for Efficient Data Exchange

Use of SSP 2.0, SSP Traceability and Modelica enables efficient data exchange and development, e.g. via automatic interface and parameter propagation (investigations with easySSP & Dymola in progress)

| Requirement Specification | Design Specification | Implementation | Simulation &Testing | Documentation |

Exchange using SSP 2.0 features

SSP System Structure & Parameterization

Exchange using SSP 2.0 features

SSP System Structure & Parameterization

Tool A (EasySSP)

Tool B (Dymola)

Tool A (EasySSP)

Traceability and Support of Simulation & Modeling using SSP
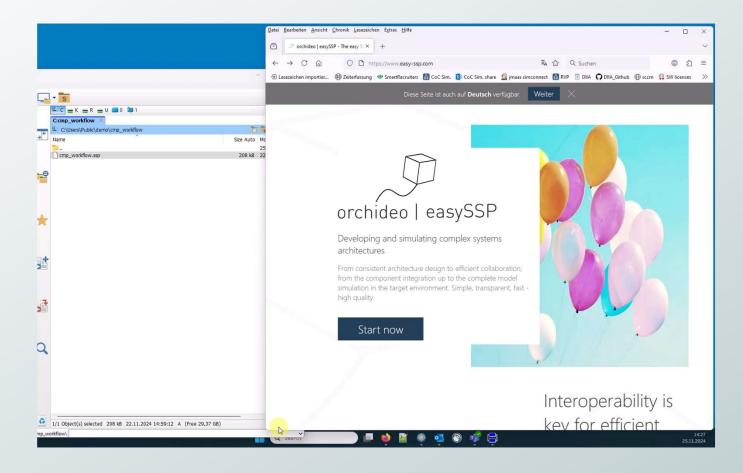## Open Standards for Efficient Data Exchange

Development Process

- It is not a waterfall

- It is an iterative process over time

- All the process phases gain more information in parallel with feedback

- There is a logical ordering i.e. design specification is based on requirements

These must be supported by tools and standards

Traceability and Support of Simulation & Modeling using SSP
Demo of Current Status
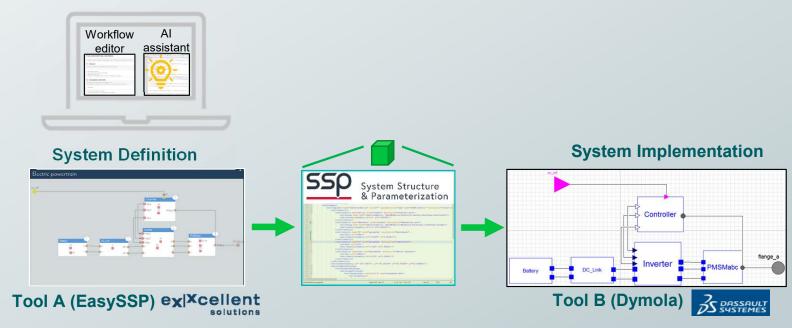
Traceability and Support of Simulation & Modeling using SSP
Outlook

- Credible Modeling Process (CMP) with credibility assessment

- AI for CMP

- CMP for System

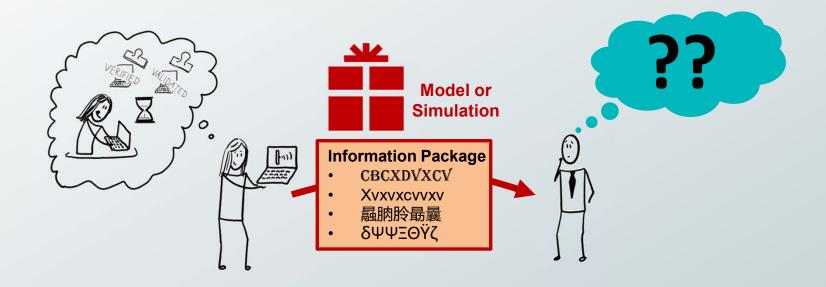**Traceability and Support of Simulation & Modeling using SSP**
Agenda

- Overview prostep SmartSE project

- Building Blocks GlueParticle SmartSE

- Credible Modeling using SSP-Traceability Layered Standard

- Example with Demo

- Status of standardisation of metadata for modeling & simulation

- Usage of metadata and SSP-traceability for traceability and reuse

- Summary

Traceability and Support of Simulation & Modeling using SSP
Need of Standards for Model & Simulation Meta Data

Model or Simulation

Information Package
- CBCXDVXCV
- Xvxvxcvvxv
- 蟲胂肹晜曩
- δΨΨΞΘŸζ

??

▶ **For the exchange, collaboration, traceability we need standardized information, metadata**

Traceability and Support of Simulation & Modeling using SSP
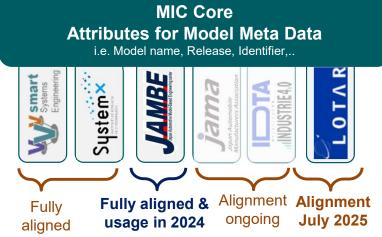## Standard for Model Meta Data

MIC-Core Standard for Model Meta Data

"Model Identity Card (MIC)"

The MIC-Core specification is a free standard that defines a set of harmonized model meta data attributes. It is developed by IRT SystemX & prostep SmartSE.

The standards from these organizations are input for alignment

MIC Core
Attributes for Model Meta Data
i.e. Model name, Release, Identifier,..

V1.0 released July 2023

Fully aligned

Fully aligned & usage in 2024

Alignment ongoing

Alignment July 2025

Examples of JAMBE Generic Vehicle Models

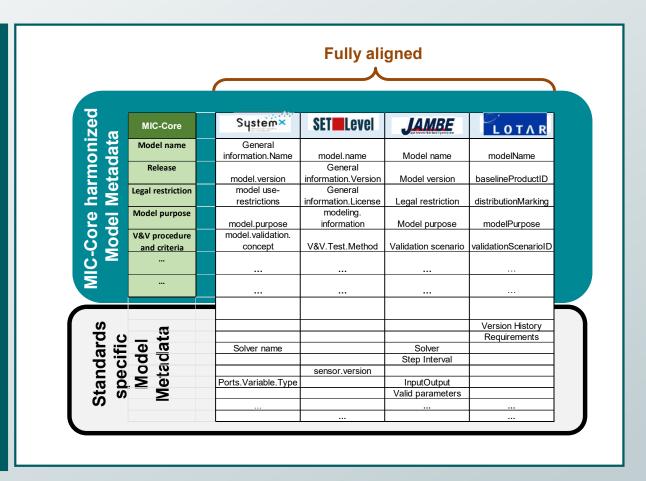| No.	Sub system	Functions
A	Driver	Accelerator/brake opening calculation
B10C	Engine control ECU	· Throttle Opening calculation · Idle stop command · Fuel injection cut command · Ignition Timing command · Starter motor drive command · Engine speed calculation
B20C	Transmission control ECU	· Clutch engagement command · Slip RPM calculation · CVT ratio calculation
B30C	Alternator control ECU	Target generation voltage calculation
B40C	Brake control ECU	Brake opening calculation
B10P	Engine	Engine torque generation
B12P	Transmission	· clutch engagement · Reduction (gear ratio)
B21P	Differential gear	· Final reduction (gear ratio)
B30P	Alternator	· Generation torque generation · current calculation
B31P	Starter motor	· Motor torque generation · Current calculation
B40P	Low voltage battery	Voltage supply according to SOC
B50P	Low-voltage electrical component	Calculation of (equivalent) power consumption of low-voltage electrical equipment
B51P	Brake	Brake torque generation
B60P	Tire	Torque to driving force conversion

Traceability and Support of Simulation & Modeling using SSP
Standard for Model Meta Data

The MIC Core specification is a free standard that defines a set of harmonized model meta data attributes that meta-data standards can adopt to avoid ambiguity and incompatibility in common attributes across domains and standards.

The focus is on a core set of metadata required for traceability and basic information on whether the model is usable for the intended application

Fully aligned

MIC-Core harmonized Model Metadata

MIC-Core	System×	SET Level	JAMBE	LOTAR
Model name	General information.Name	model.name	Model name	modelName
Release	model.version	General information.Version	Model version	baselineProductID
Legal restriction	model use-restrictions	General information.License	Legal restriction	distributionMarking
Model purpose	model.purpose	modeling. information	Model purpose	modelPurpose
V&V procedure and criteria	model.validation. concept	V&V.Test.Method	Validation scenario	validationScenarioID
...	...	...	...	...
...	...	...	...	...

Standards specific Model Metadata

				Version History
				Requirements
	Solver name		Solver	
			Step Interval	
		sensor.version		
	Ports.Variable.Type		InputOutput	
			Valid parameters	
	...	...	...	...

Core Metadata for Simulation Task & Request
SRMD Data Format and MIC Core Standard for Model Metadata

An implementation of the MIC-Core Specification in the SRMD Standard is already available.

Metadata
MIC-Core

Simulation Resource Meta Data (SRMD) format is part of the Modelica SSP-Traceability standard

Now same approach for Metadata for

Metadata
Simulation Req.

Metadata
Simulation Task

Collection and aligning Metadata

Implementation of MIC-Core in the SRMD metadata format

Introduction

In the following, an exemplary implementation of the MIC-Core standard into the SRMD metadata format will be shown. The SRMD (Simulation Resource Meta Data) metadata format is a subset of the SSP traceability STMD (Simulation Task Meta Data) format. These formats are part of the Modelica Association Project SSP (System Structuring and Parametrization). The SRMD format allows to specify any metadata, attributes in the form of key value pairs. The format description also specifies where this metadata file should be stored in an FMU or SSP (link to SSP traceability).
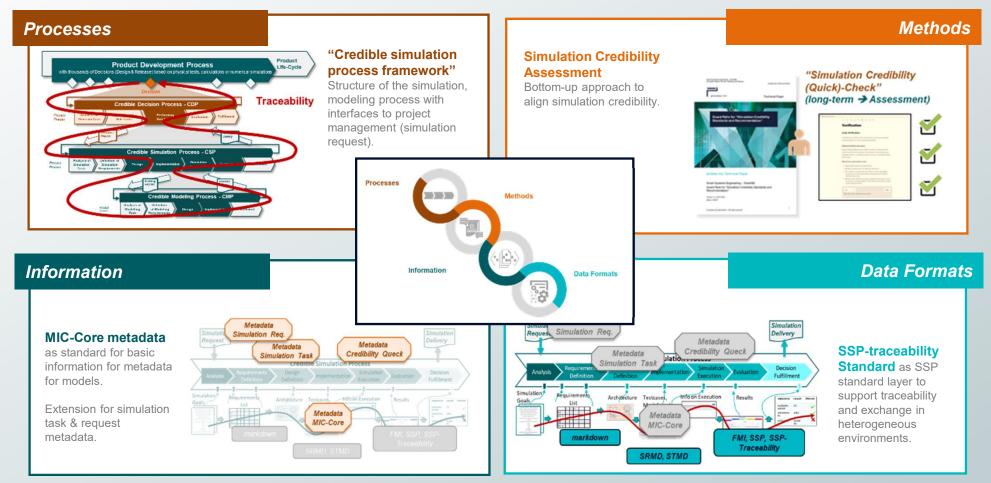
Mapping of MIC-Core attributes to the SRMD format

The following table shows the implementation. In the first column the attributes defined in the MIC core are listed. The second column lists the conversion of the attribute names to SRMD. For easier machine processability, clustering via presented terms separated by period is used here. No spaces are used. In column 3 an abbreviated explanation of the attributes is listed

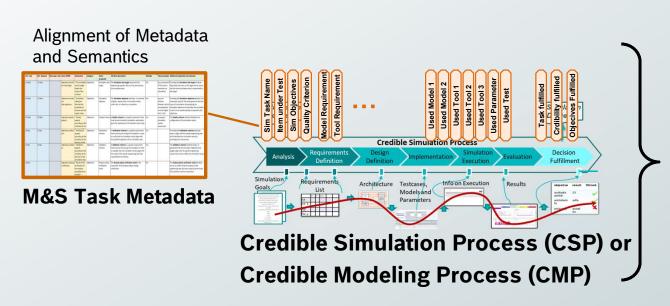| MIC-Core Name	SRMD Mapping	Short Explanation
Model name	administrative-data.model.name	Human-readable way of referring to the model. Usually short and clear. Not necessarily unique
Model identifier	administrative-data.model.identifier	Unique identifier for the model.
Model description	administrative-data.model.description	Human-readable, textual, general overview. Highlights important information about the model.
Model supplier	administrative-data.model.supplier	The responsible body and, if applicable, organizational unit within the body, that is responsible for supplying the model.
Model confidentiality level	administrative-data.model.confidentiality-level	Protection level to apply to the model.
Legal restriction	administrative-data.legal-restriction	Defines the rules governing the distribution and usage of the simulation model, including licensing,
Release	administrative-data.release	Unique identifier, preferably human-readable (i.e. semantically meaningfull), for the release of a particular simulation model.
Release date	administrative-data.release.date	Date, and possibly time and timezone, of the release of a simulation model. Must respect ISO 8601.
Release type	administrative-data.release.type	Relates to the maturity of the model.

Traceability and Support of Simulation & Modeling using SSP-Traceability
Building blocks to support Credibility and Traceability of Simulation & Modeling

prostep IVIP

Processes

"Credible simulation process framework"
Structure of the simulation, modeling process with interfaces to project management (simulation request).

Methods

Simulation Credibility Assessment
Bottom-up approach to align simulation credibility.

"Simulation Credibility (Quick)-Check"
(long-term → Assessment)

Information

MIC-Core metadata
as standard for basic information for metadata for models.

Extension for simulation task & request metadata.

Data Formats

SSP-traceability Standard as SSP standard layer to support traceability and exchange in heterogeneous environments.

Traceability of Simulation & Modeling as an Enabler for Virtualization
Usage of aligned Metadata for M&S Tasks and Requests

Alignment of Metadata and Semantics

M&S Task Metadata

Credible Simulation Process (CSP) or
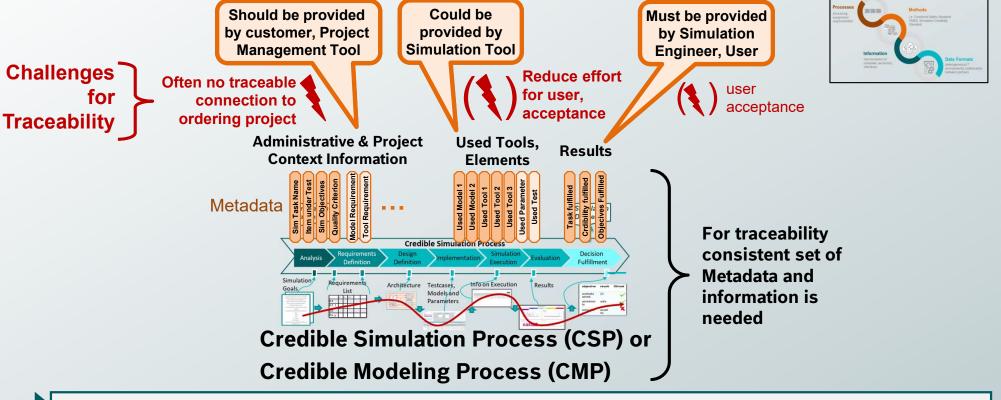
Credible Modeling Process (CMP)

Building Blocks for cross-company simulation-based engineering

One consistent set of Metadata and information

> ▶ **The M&S Metadata together with the CSP gives a structured, standardized set of Metadata for simulation and modeling tasks**

Traceability of Simulation & Modeling as an Enabler for Virtualization
Metadata needed for basic Traceability

Should be provided by customer, Project Management Tool

Could be provided by Simulation Tool

Must be provided by Simulation Engineer, User

Challenges for Traceability

Often no traceable connection to ordering project

Reduce effort for user, acceptance

user acceptance

Administrative & Project Context Information

Used Tools, Elements

Results

Metadata

Sim Task Name | Item under Test | Sim Objectives | Quality Criterion | Model Requirement | Tool Requirement

Used Model 1 | Used Model 2 | Used Tool 1 | Used Tool 2 | Used Tool 3 | Used Parameter | Used Test

Task fulfilled | Credibility fulfilled | Objectives Fulfilled

Credible Simulation Process

Analysis → Requirements Definition → Design Definition → Implementation → Simulation Execution → Evaluation → Decision Fulfillment

Simulation Goals | Requirements List | Architecture | Testcases, Models and Parameters | Info on Execution | Results

For traceability consistent set of Metadata and information is needed

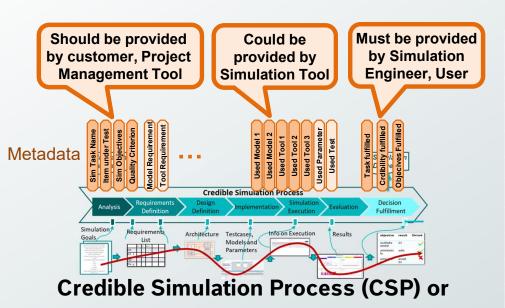## Credible Simulation Process (CSP) or
Credible Modeling Process (CMP)

The M&S Metadata together with the CSP/CMP gives a structured, standardized set of Metadata for simulation and modeling tasks

Traceability of Simulation & Modeling as an Enabler for Virtualization
Metadata needed for basic Traceability

Should be provided by customer, Project Management Tool

Could be provided by Simulation Tool

Must be provided by Simulation Engineer, User

Metadata

Sim Task Name · Item under Test · Sim Objectives · Quality Criterion · Model Requirement · Tool Requirement · · · Used Model 1 · Used Model 2 · Used Tool 1 · Used Tool 2 · Used Tool 3 · Used Parameter · Used Test · Task fulfilled · Credibility fulfilled · Objectives Fulfilled

Credible Simulation Process

Analysis → Requirements Definition → Design Definition → Implementation → Simulation Execution → Evaluation → Decision Fulfillment

Simulation Goals · Requirements List · Architecture · Testcases, Models and Parameters · Info on Execution · Results · objective result Ok/nok

Credible Simulation Process (CSP) or Credible Modeling Process (CMP)

Set of Metadata for basic Traceability

| Metadata	Sim.Task Phase	Source	Provided by
Ordering Project	Administration (Data)	Project Management Tool	Tool
Simulation Task Name			Tool
Item under Test	Analysis	Project Management Tool	Tool
Simulation Objective			User
Quality/Cred. Criterion			User
Used Model, Version	Execution	Simulation Tool	Tool
Used Tool, Version			Tool
Task fulfilled	Fulfillment	Simulation/ Modeling Task supporting Tool	User
Credibility fulfilled			User
Objectives fulfilled			User

Tools that already or in 2026 will support:
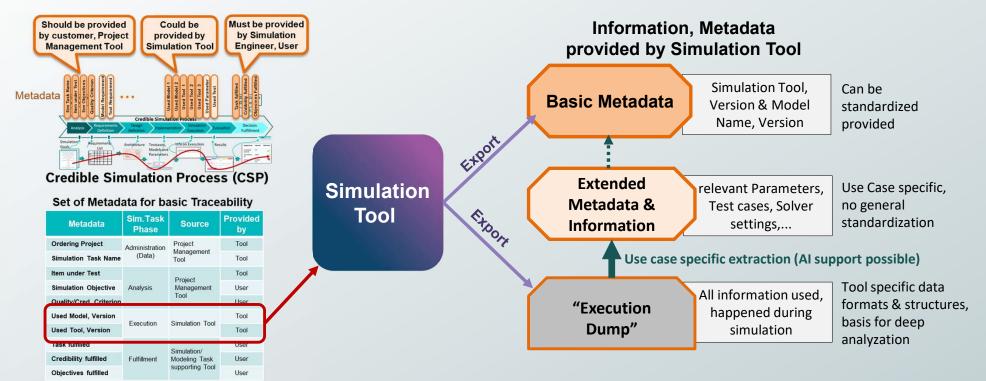
Dymola, easySSP, Model.CONNECT, FMI Bench, IPG CarMaker,...

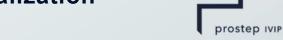> **Minimal set of Metadata that is needed for basic traceability, search and reuse**
> - Can be used as a starting point for implementation of these funcionalities
>
> **Important in this approach:** Availability of data and user acceptance

Traceability of Simulation & Modeling as an Enabler for Virtualization
Metadata needed for (basic) Traceability

Information, Metadata provided by Simulation Tool

Basic Metadata — Simulation Tool, Version & Model Name, Version — Can be standardized provided

Extended Metadata & Information — relevant Parameters, Test cases, Solver settings,... — Use Case specific, no general standardization

Use case specific extraction (AI support possible)

"Execution Dump" — All information used, happened during simulation — Tool specific data formats & structures, basis for deep analyzation

**Basic Metadata can be standardized and provided by Simulation Tools
Extended Metadata are Usecase specific, only support in generation possible**

Traceability of Simulation & Modeling as an Enabler for Virtualization
Metadata needed for basic Traceability

Use cases for basic Traceability

- I am looking for the corresponding simulations for a project

- For which applications was Model Z used?

- In which simulations was a tool used in Version X with models of Version Y

- Which existing simulation settings can possibly be used as a template for a new simulation task?

- …

Set of Metadata for basic Traceability

Metadata	Sim. Task Phase	Source	Provided by
Ordering Project	Administration (Data)	Project Management Tool	Tool
Simulation Task Name			Tool
Item under Test	Analysis	Project Management Tool	Tool
Simulation Objective			User
Quality/Cred. Criterion			User
Used Model, Version	Execution	Simulation Tool	Tool
Used Tool, Version			Tool
Task fulfilled	Fulfillment	Simulation/ Modeling Task supporting Tool	User
Credibility fulfilled			User
Objectives fulfilled			User

Should be provided by customer, Project Management Tool

Could be provided by Simulation Tool

Must be provided by Simulation Engineer, User

Metadata

Credible Simulation Process (CSP)

Basic traceability use cases are applications that serve for basic search, pre-selection, overview, and narrowing.

Traceability of Simulation & Modeling as an Enabler for Virtualization
Usage of Meta Data of Simulation & Modeling Task
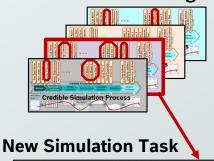

Search

Metadata Sets of Simulation & Modeling Tasks

Evaluation

- in which simulation/modeling tasks was element used
- is the same or similar context of use

Reuse

Metadata Sets of Simulation & Modeling Tasks

New Simulation Task

Evaluation for Reuse of similar Simulation & Modeling Task

- Evaluation for best mapping
- Evaluation of differences, missing aspects

Building Blocks for cross-company simulation-based engineering

---

▶ **Usage of aligned Building Blocks allows search and supports reuse without further effort and minimal maintenance**
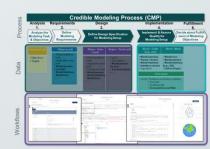
Traceability and Support of Simulation & Modeling using SSP
Summary

- Importance of the alignment of the SmartSE GlueParticle Building Blocks
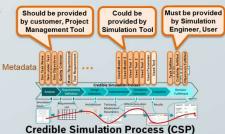

- Credible Modeling using Credible Modeling Process + SSP-Traceability Layered Standard

  - Achieve traceability, seamless documentation, model exchange

- Importance of process structures and aligned metadata for implementation of traceability, search and reuse

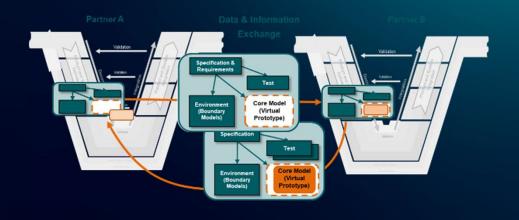 - Usage of Modelica SSP-standard and the SSP-traceability layered standard

Credible Simulation Process (CSP)

Set of Metadata for basic Traceability

Metadata	Sim.Task Phase	Source	Provided by
Ordering Project	Administration (Data)	Project Management Tool	Tool
Simulation Task Name			Tool
Item under Test	Analysis	Project Management Tool	Tool
Simulation Objective			User
Quality/Cred. Criterion			User
Used Model, Version	Execution	Simulation Tool	Tool
Used Tool, Version			Tool
Task fulfilled	Fulfillment	Simulation/ Modeling Task supporting Tool	User
Credibility fulfilled			User
Objectives fulfilled			User

- **Already tool support available and industrial application**

Thank you

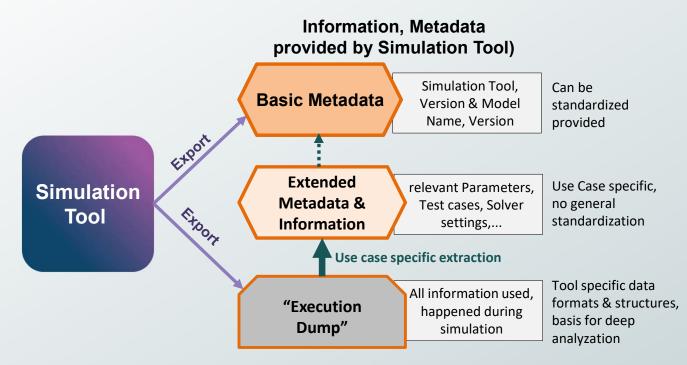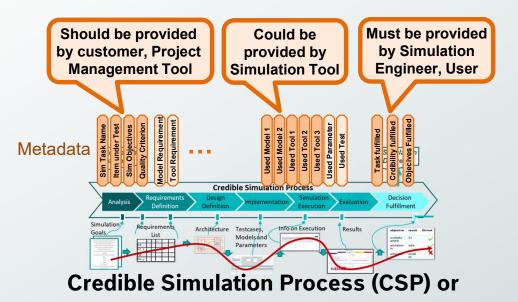**for your attention**

Traceability of Simulation& Modeling as an Enabler for Virtualization
Metadata needed for (basic) Traceability

Information, Metadata provided by Simulation Tool)

Simulation Tool

Export

Export

Basic Metadata

Simulation Tool, Version & Model Name, Version

Can be standardized provided

Extended Metadata & Information

relevant Parameters, Test cases, Solver settings,...

Use Case specific, no general standardization

Use case specific extraction

"Execution Dump"

All information used, happened during simulation

Tool specific data formats & structures, basis for deep analyzation

**Basic Metadata can be standardized and provided by Simulation Tools
Extended Metadata are Usecase specific, only support in generation possible**

Traceability of Simulation& Modeling as an Enabler for Virtualization
Metadata needed for basic Traceability

Should be provided by customer, Project Management Tool

Could be provided by Simulation Tool

Must be provided by Simulation Engineer, User

Metadata

**Credible Simulation Process (CSP) or
Credible Modeling Process (CMP)**

Set of Metadata for basic Traceability

Metadata Simulation	Metadata Modeling	Sim.Task Phase	Source	Provided by
Ordering Project	Ordering Project	Administration (Data)	Project Management Tool	Tool
Simulation Task Name	Modeling Task Name			Tool
Item under Test	Item Modeled	Analysis	Project Management Tool	Tool
Simulation Objective	Modeling Objective			User
Quality/Cred. Criterion	Quality/Cred. Criterion			User
Used Model, Version	Used Model, Version	Execution	Simulation Tool	Tool
Used Tool, Version	Used Tool, Version			Tool
Task fulfilled	Task fulfilled	Fulfillment	Simulation/ Modeling Task supporting Tool	User
Credibility fulfilled	Credibility fulfilled			User
Objectives fulfilled	Objectives fulfilled			User

Minimal set of Metadata that is needed for basic traceability, search and reuse
- Can be used as a starting point for implementation of these functionalities
Important in this approach: Availability of data and user acceptance