15th Modlica Conference

prostep SmartSE

Building Blocks for Simulation based Cooperation between Partners

Aachen, October 2023
Hans-Martin Heinkel, Bosch
Pierre Mai, PMSF
Martin Geissen, Unity

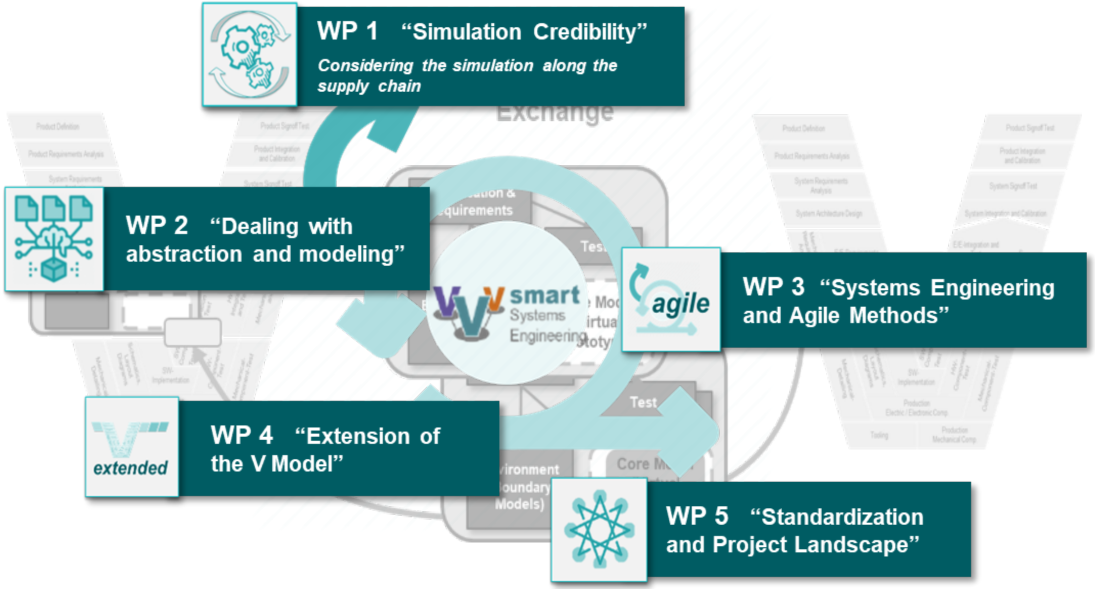
smart Systems Engineering

Prostep SmartSE Project Consortium 2023

Project phase 5: Work Packages and Fields of Action

Mission Phase 5 *(2022-2024)*

Enabling collaborative development and validation of complex products by simulation along a multi tier supply chain.



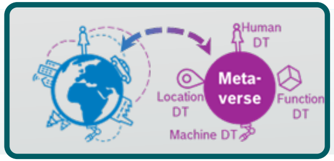
25+ project participants

Audi, AVL, BHC Consulting, BMW Group, Boeing, Bosch, Dassault Systèmes, Denso, dSPACE, :em engineering methods AG, ex|Xcellent solutions, Fraunhofer, Datenverarbeitung in der Konstruktion, Technische Universität Kaiserslautern, P|D|Tec., PROSTEP, PMSF IT Consulting, Raytheon Technologies, Siemens, Siemens PLM Software, Stellantis, Toshiba, Toyota, Unity Consulting & Innovation, virtual vehicle, VW, ZF

Prostep Smart Systems Engineering (SmartSE)

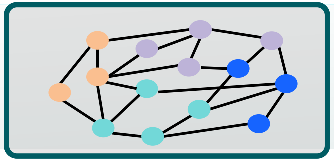
Building Blocks for Simulation based Cooperation between Partners

Metaverse



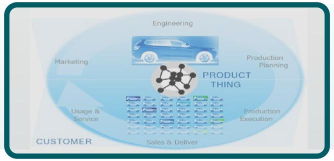
Floating transition between real and virtual world

Collaboration Networks



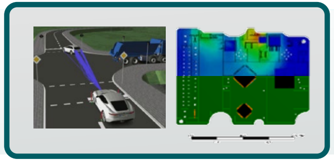
Heterogeneous changing networks, collaboration models

Company internal Digitalization, Virtualization



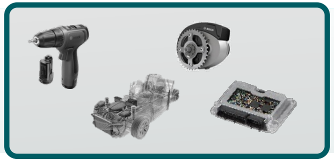
Continuous use, enrichment of information, knowledge evaluation

Simulation supported Development



Alignment with reality, prediction of reality basis for virtualization

Real Products, Components



Development of reliable and sustainable components and products

Strong involvement, interaction with users (people)

Availability of Information in heterogeneous IT environments,

Traceability, Simulation Credibility

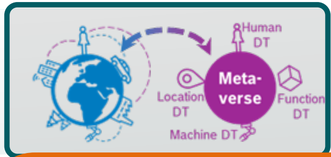
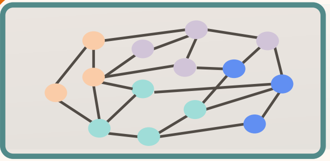
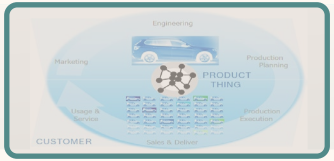
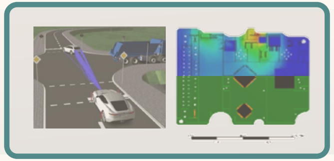
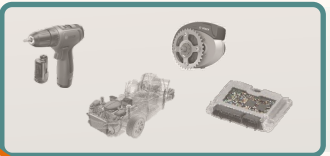
Verification Validation of Models, Parameters, Simulation

Reduced number of real prototypes

We need Building blocks to support these challenges

Prostep Smart Systems Engineering (SmartSE)

Building Blocks for Simulation based Cooperation between Partners

Metaverse		*Floating transition between real and virtual world*
Collaboration Networks		*Heterogeneous changing networks, collaboration models*
Company internal Digitalization, Virtualization		*Continuous use, enrichment of information, knowledge evaluation*
Simulation supported Development		*Alignment with reality, prediction of reality basis for virtualization*
Real Products, Components		*Development of reliable and sustainable components and products*

Focus of prostep Smart SE project

Strong involvement, interaction with users (people)

Availability of Information in heterogeneous IT environments,

Traceability, Simulation Credibility

Verification Validation of Models, Parameters, Simulation

Reduced number of real prototypes

We need Building blocks to support these challenges

Building Blocks for Simulation based Cooperation
Agenda

Process

Structuring, assignment responsibilities

Standards and Recommendations

Simulation credibility, abstraction and modeling

Information

Harmonization metadata, semantics

Data formats for exchange

heterogeneous IT environments, collaboration

smart Systems Engineering

Building Blocks for Simulation based Cooperation

Agenda

prostep IVIP

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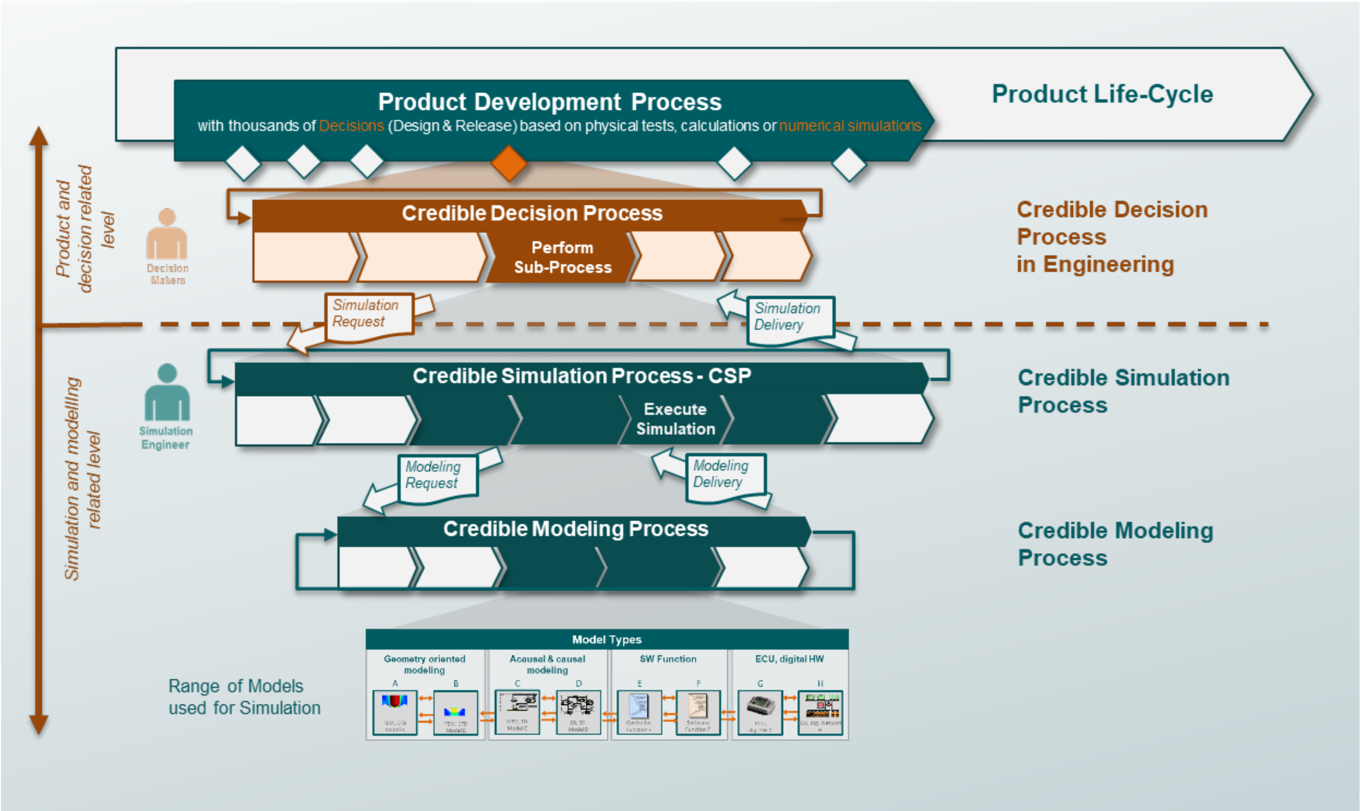
Building Blocks for Simulation based Cooperation

Structuring, Assignment Responsibilities

Process hierarchy with clear information structuring

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



Building Blocks for Simulation based Cooperation
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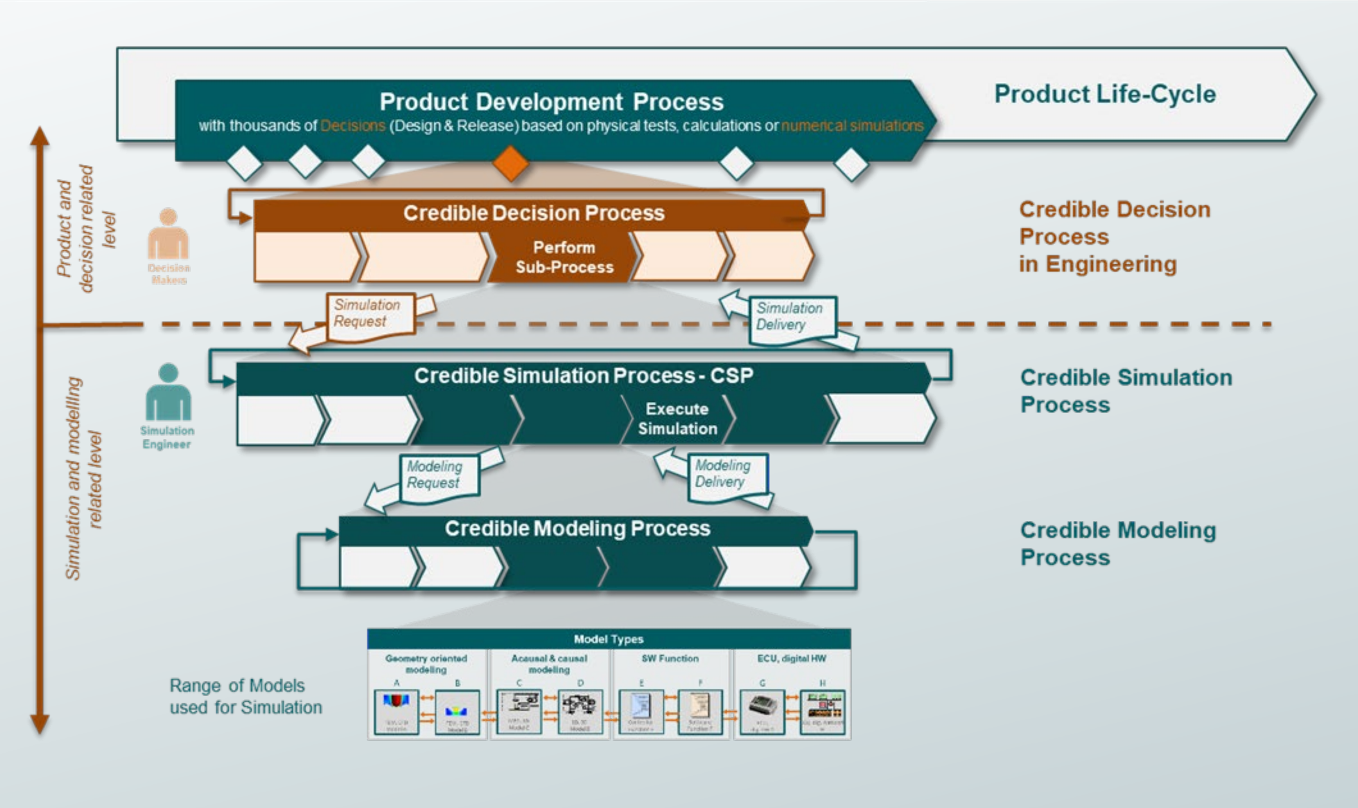
Building Blocks for Simulation based Cooperation

Standards and Recommendations for Simulation Credibility

Currently meetings for alignment "Big Picture and core terms" for Credible Decision Process Framework in Engineering with

as basis for domain specific credibility standards.



Building Blocks for Simulation based Cooperation
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prostep ivip

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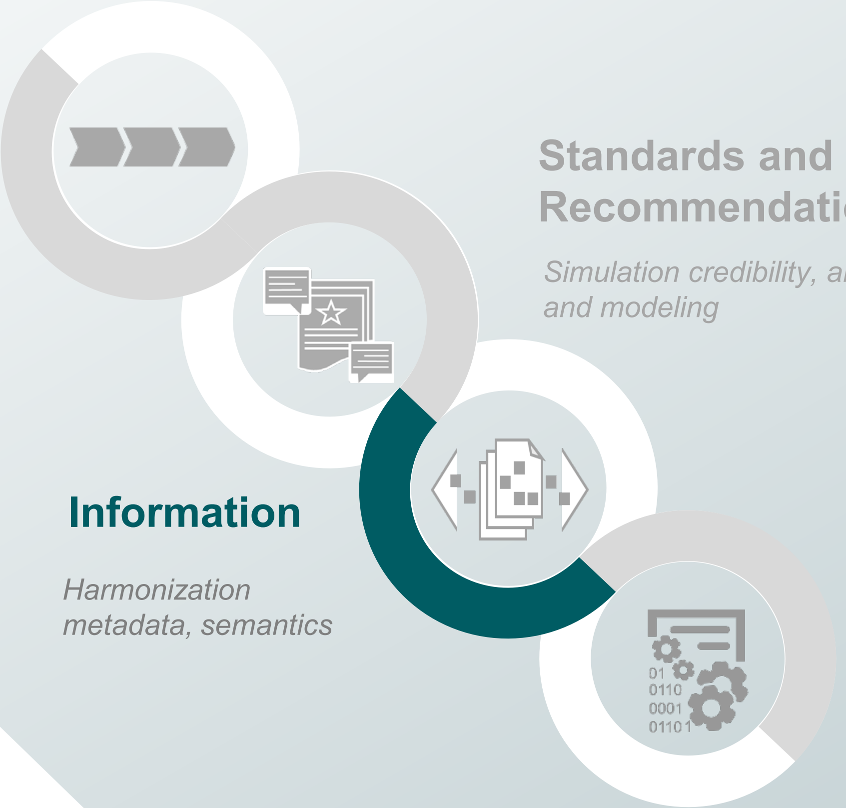


smart Systems Engineering

Building Blocks for Simulation based Cooperation

Harmonization Metadata, Semantics

Alignment of Model Metadata for Simulation and Traceability

The exchange and reuse of simulation models within the company and with external partners is becoming increasingly important.

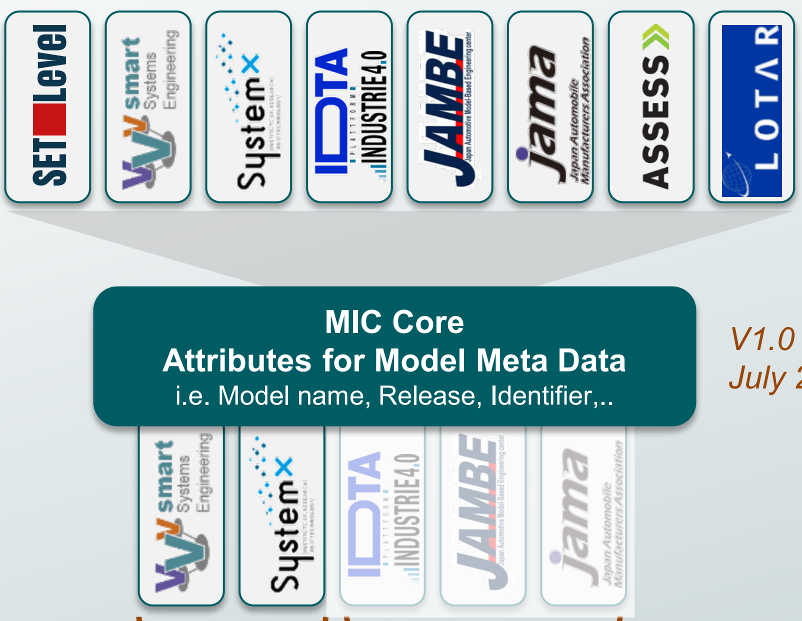
For efficient exchange and reuse

- Information, metadata about the properties of the models is required (what does the model represent, which effects are implemented)
- as well as administrative information (name, owner, version,...).

Currently there are several standards for model metadata, or they are being developed from these organisations

Building Blocks for Simulation based Cooperation

Alignment of Model Metadata for Simulation and Traceability



The standards from these organizations are input for alignment

V1.0 release July 2023

Fully aligned

Alignment ongoing

Goal: not to have one standard

But:

- to identify and harmonize the overlapping attributes
- so, there will be a common aligned part of attributes in every standard
- also, standard specific attributes according to the different use cases, domains

The standards will stay independent but will have aligned parts

Building Blocks for Simulation based Cooperation

SRMD Data Format and MIC Core Standard for Model Metadata

Contents

SystemX INSTITUT DE RECHERCHE TECHNOLOGIQUE

prostep IVIP

MIC Core Specification

Version 4528536, 2023-06-29

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 ambuity and incompatibility in common attributes across domains and standards. It is maintained as a joint undertaking of IRT SystemX and prostep ivip. Releases and issues can be found on github.com/MIC-Core/MIC-Core.

1. Introduction

1.1. Why MIC Core

The exchange and reuse of simulation models within the company and with external partners is becoming increasingly important.

For efficient exchange and reuse

- Information, metadata about the properties of the models is required (what does the model represent, which effects are implemented)
- as well as administrative information (name, owner, version,…).

Currently there are several standards for model meta data, or they are being developed from several organisations

1.2. What is MIC Core

Link to MIC Core specification

https://mic-core.github.io/MIC-Core/main/

Building Blocks for Simulation based Cooperation

SRMD Data Format and MIC Core Standard for Model Metadata

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

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

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 Resoure 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).

Maping of MIC-Core attributes to the SRMD format

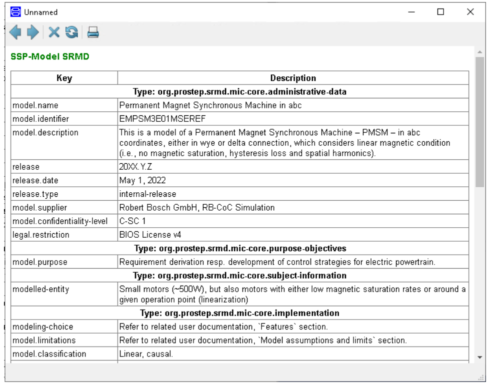
The following table shows the implementation. In the first column the attributes defined in the MIC core are listed. The second column lists the conversion of the attribute names to SRMD. For easier machine processability, clustering via presented terms separated by period is used here. No spaces are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

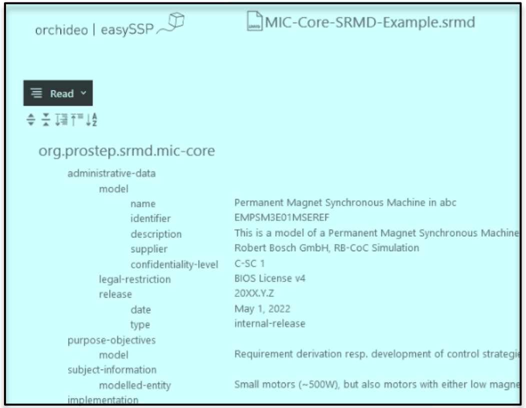
MIC-Core Name	SRMD Mapping	Short Explanation
Model name	administrative-data.model.name	Human-readable way of referring to the model. Usually short and clear. Not necessarily unique
Model identifier	administrative-data.model.identifier	Unique identifier for the model.
Model description	administrative-data.model.description	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.

Building Blocks for Simulation based Cooperation

SRMD Data Format and MIC Core Standard for Model Metadata

Dymola

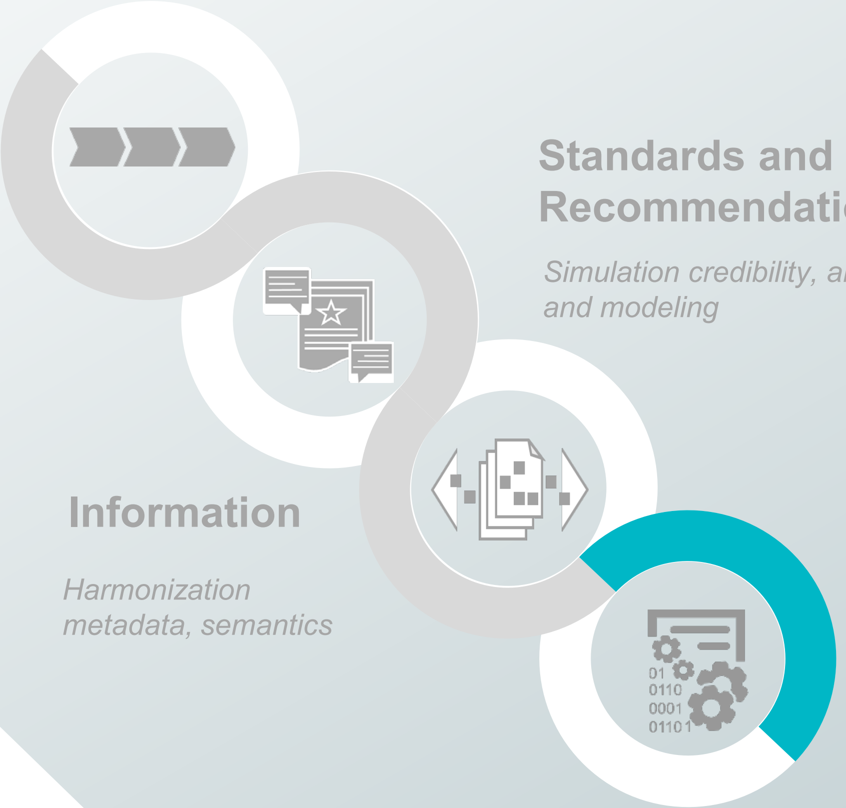




easySSP

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

Building Blocks for Simulation based Cooperation
Agenda



Process
Structuring, assignment responsibilities

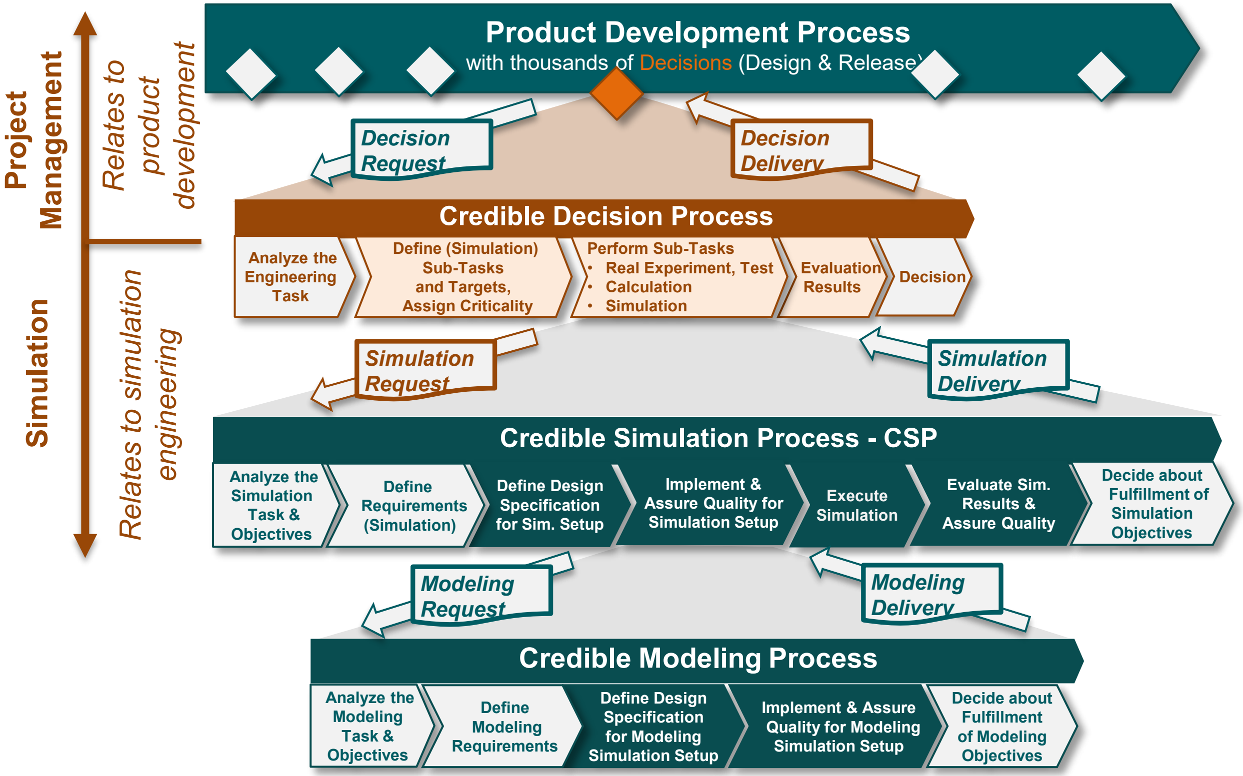
Standards and Recommendations
Simulation credibility, abstraction and modeling

Information
Harmonization metadata, semantics

Data formats for exchange
heterogeneous IT environments, collaboration

Building Blocks for Simulation based Collaboration

Data Formats & Processes for Exchange: Heterogeneous IT Environments, Collaboration

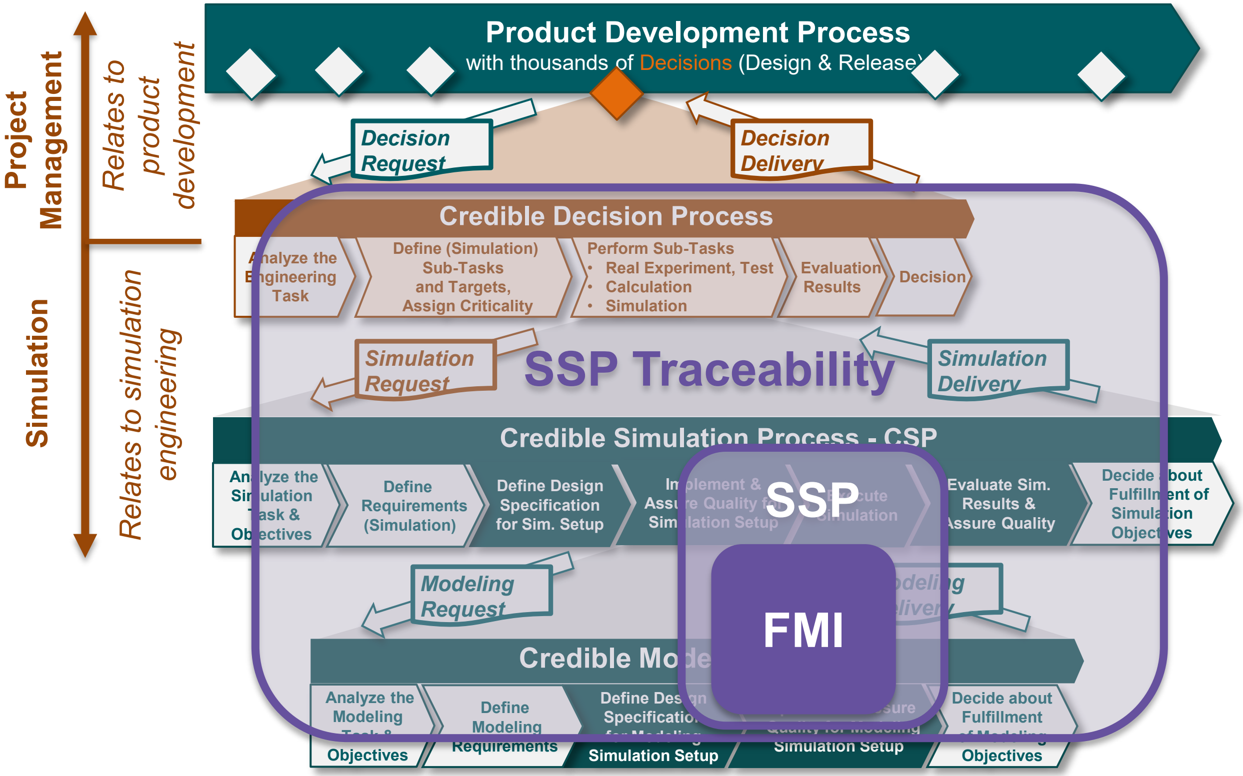


Credible Simulation Process Framework

- Process hierarchy with clear information structuring
- Sub-processes can be integrated into specific company processes

Building Blocks for Simulation based Cooperation

Data Formats for Exchange: Heterogeneous IT Environments, Collaboration



Within the Modelica Association, data standards for the exchange of simulation artifacts between tools are developed and supported.

- **FMI project**:
  - Exchange of models on system level → (FMI3.0)
- **SSP project**
  - Exchange of model architectures and parameter sets.
    → SSP1.0 with standard layer SSP Traceability (GlueParticle)

Building Blocks for Simulation based Cooperation

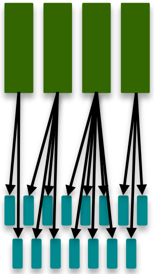
From Process to Traceability in Heterogeneous IT Environments, Collaboration

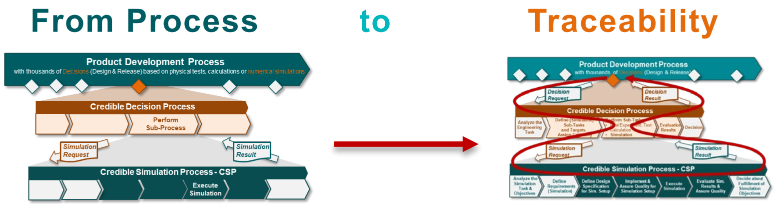
Process
- Reproducibility
- Traceability

Workflow
- Concrete implemented process
- Repeatability

Information Chain
- Process-data-modell
- **GlueParticle**

Information Artefacts
- Artefacts linked to information chain
- For traceability, reuse



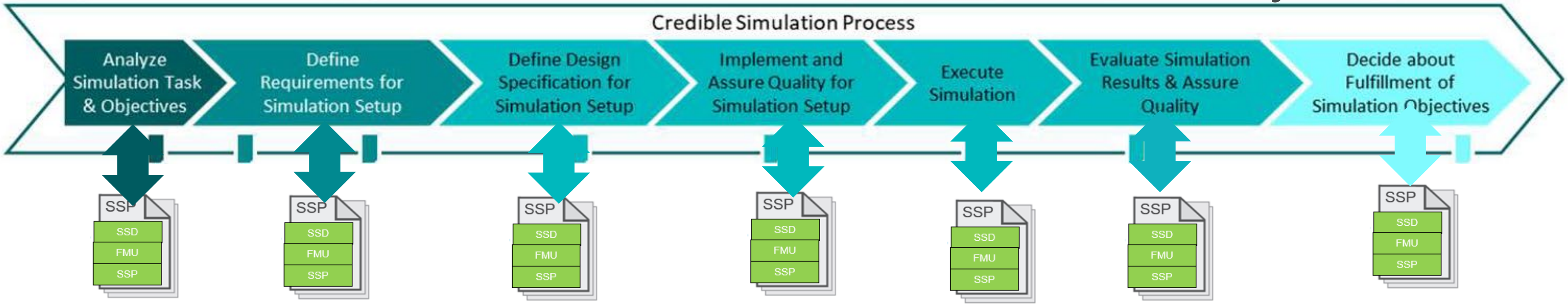


- Clear structuring of information

- Transparency of the information linkage of workflows, processes
- **With GlueParticle Approach**
  - Consistency of process chain and information chain
  - Is integrated part in workflow
  - After the workflow run, a filled information chain is available, no post documentation

Credible Simulation Process (CSP) + SSP-Traceability (GlueParticle)
The CSP is a Documentation Standard to establish Traceability

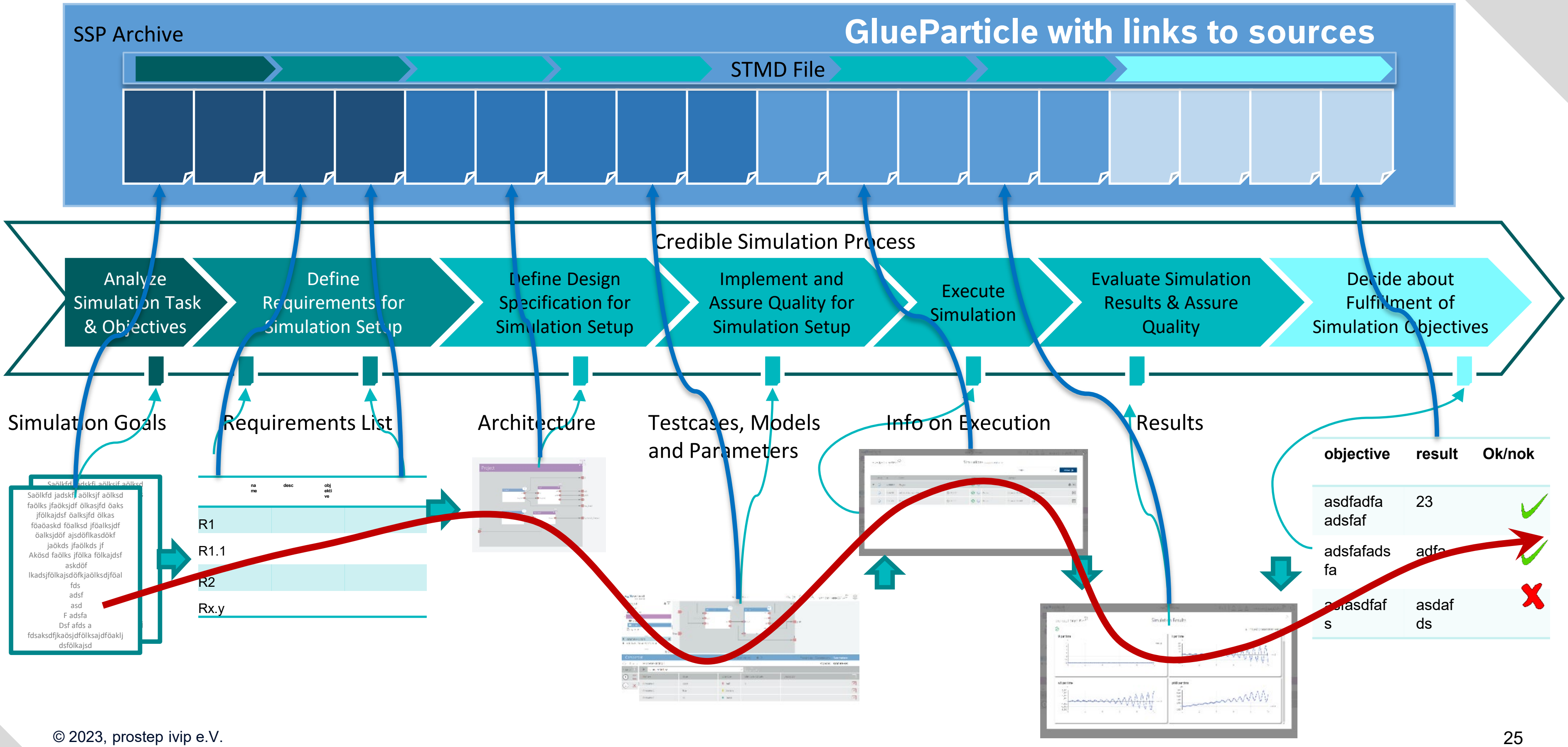
How it is documented in a traceable and standardized way...



What really happened during Development...

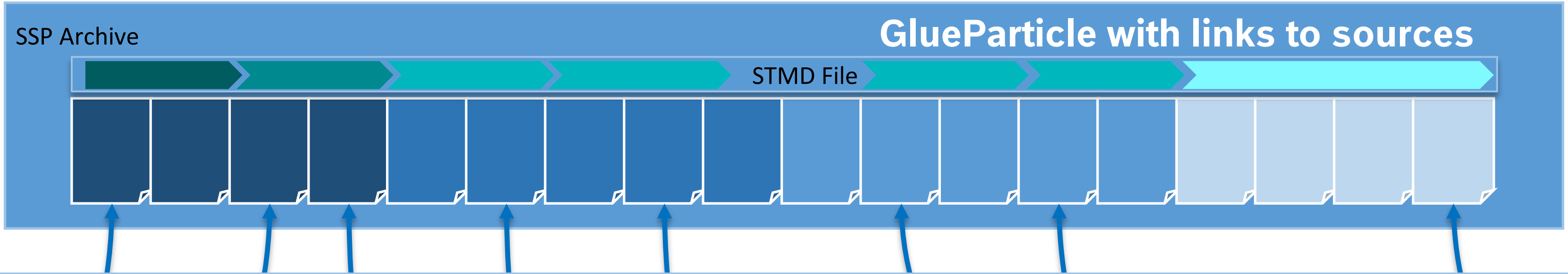
Building Blocks for Simulation based Cooperation

Traceability from Requirements to Simulation Result



Building Blocks for Simulation based Cooperation

Traceability from Requirements to Simulation Result



SSP Traceability Specification

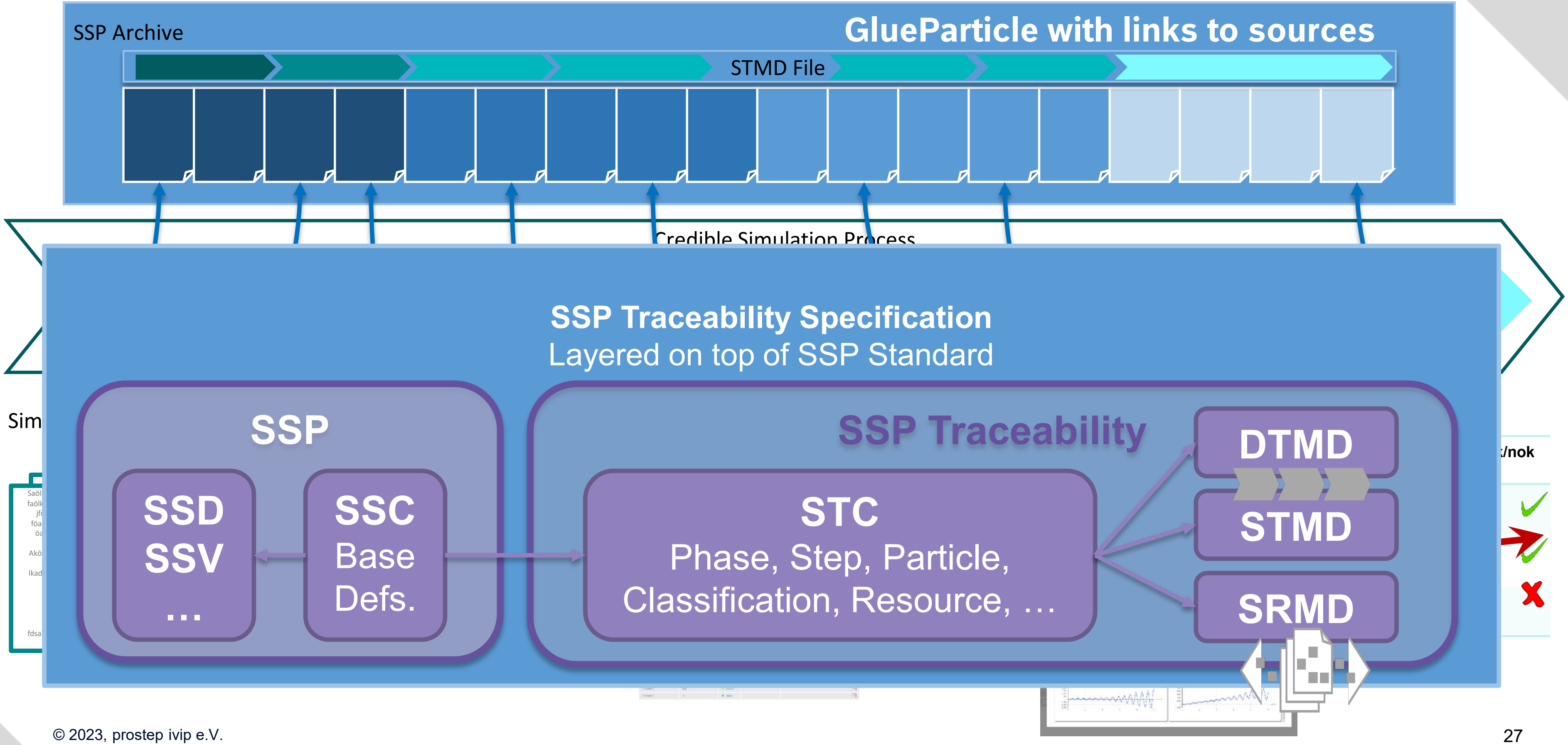
Layered on top of SSP Standard

- Based on SSP formats and principles
- Generic approach of phases and steps
- Instantiated for CSP as STMD format
- Each step contains Input, Procedure, Output, Rationale information, referencing Resources
- Additional Linking, Life Cycle & Classification

- SSP ZIP packaging
- (Relative) URI references to resources
- Multi-format support for resources
- Common XML schema components
- Extensibility via annotations
- Devolves into pure SSP for pure SSP tools

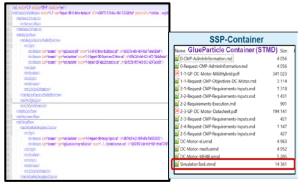
Building Blocks for Simulation based Cooperation

Traceability from Requirements to Simulation Result

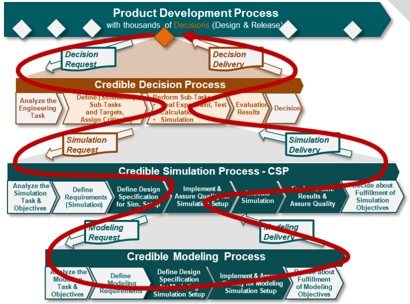


Building Blocks for Simulation based Cooperation
Data formats for exchange, heterogeneous IT Environments, Collaboration

Consistent data formats (SSP Traceability) for the Credible Simulation Framework are available. They support the cooperation between partners in heterogenous environments.

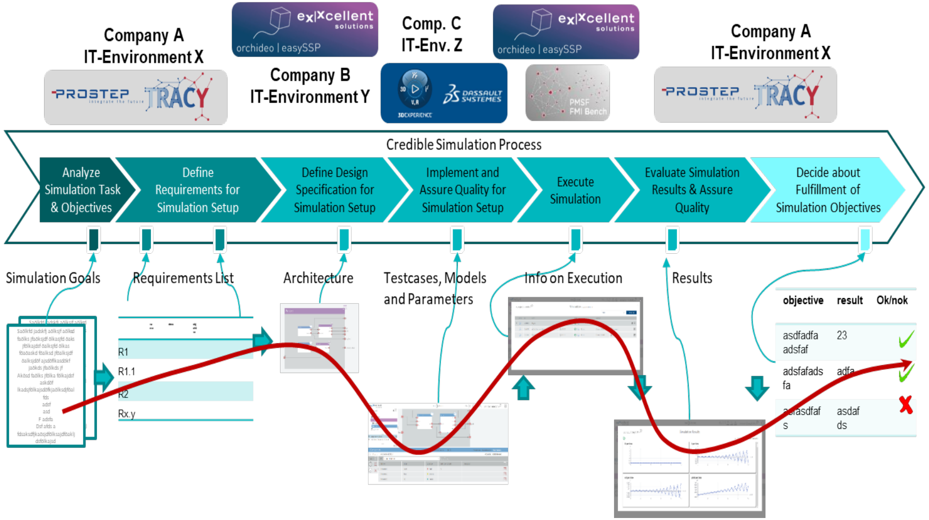


Tool support is already available.



2023-24: Establish realistic automotive use cases for SSP, CSP, traceability, meta data management

- Open to SmartSE partners to facilitate the collaborative development among us and along the value chain
- A communication medium between SmartSE and other consortia, e.g. JAMBE or CATENA-x



Building Blocks for Simulation based Cooperation

Data Formats for Exchange: Heterogeneous IT Environments, Collaboration

Consistent data formats (SSP-Traceability) for the Credible Simulation Framework are available.

They support the cooperation between partners in heterogenous environments

SmartSE Use Case Proposal 2022 - 2024

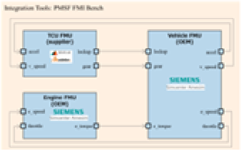
CONFIDENTIAL

Collaborative Development and Engineering Data Management of a Transmission Control Unit (TCU) Design based on FMI/SSP

2021

FMI/SSP proof of concept for TCU development

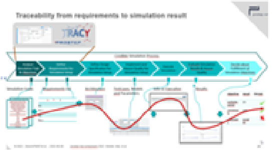
DENSO, PMSF, em engineering methods



+ realistic example
- part of value chain
- no traceability

Traceability, Exchange of Simulation Tasks based on Glue Particle

BOSCH, Dassault Systèmes, PROSTEP, PMSF, ex-cellent solutions



+ traceability
- part of value chain
- simple example

2022-2024

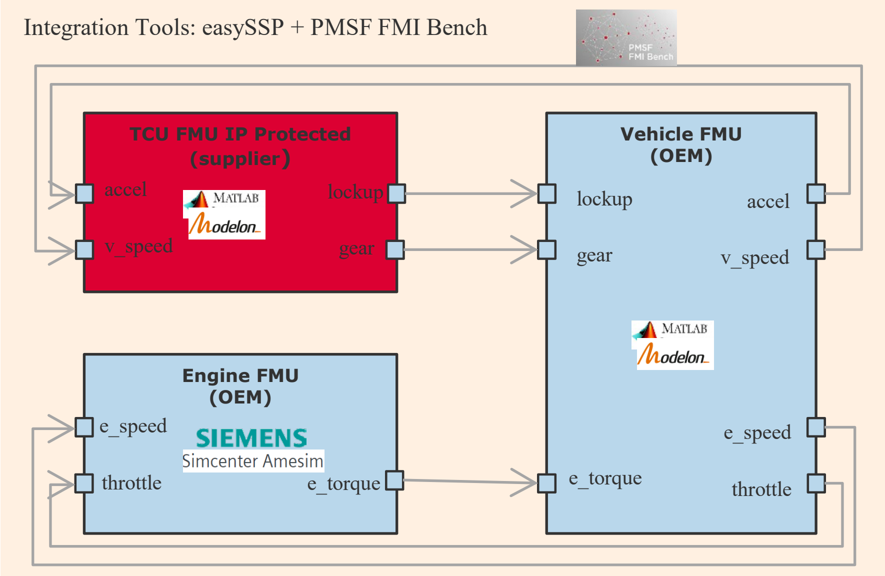
Establish a **realistic automotive use case** for **ssp, csp, traceability, meta data management**

- Open to SmartSE partners to facilitate the collaborative development among us and along the value chain
- A communication medium between SmartSE and other consortia, e.g. JAMBE or CATENA-x

DENSO Crafting the Core

Collaborative Simulation-based Engineering

Use Case*: Collaborative Transmission Control Unit (TCU) Design



This is an example use case. It does not represent any real business case.

Showcase

Supplier to design, test and calibrate TCU based on OEM specs and requests.

Fokus

Usage of Credible Simulation Process (CSP), SSP-Traceability, MIC-Core Metadata

Engine Model →

Internal combustion engine

Vehicle model →

rest of the vehicle. Maintains the engine state, vehicle state; provides accelerator and throttle positions

TCU model →

provides transmission lockup and gear ratio information, based on the vehicle speed / accelaration information.

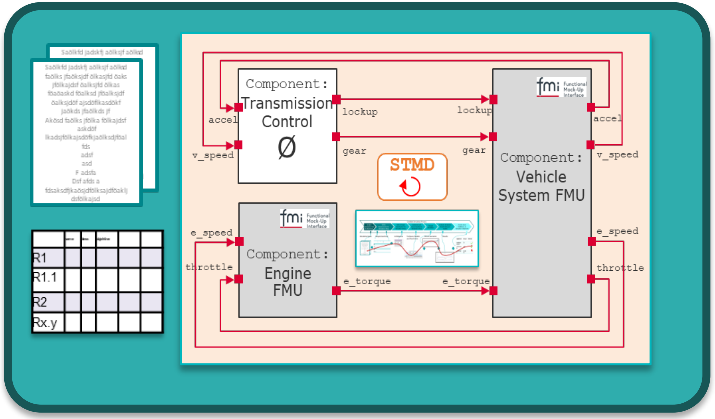
In Scope: Exchange of all artefacts required for an efficient, cross-company simulation-based engineering like specifications, requirements, test cases, simulation models and model meta data.

Collaborative Simulation-based Engineering

Use Case*: Collaborative Transmission Control Unit (TCU) Design

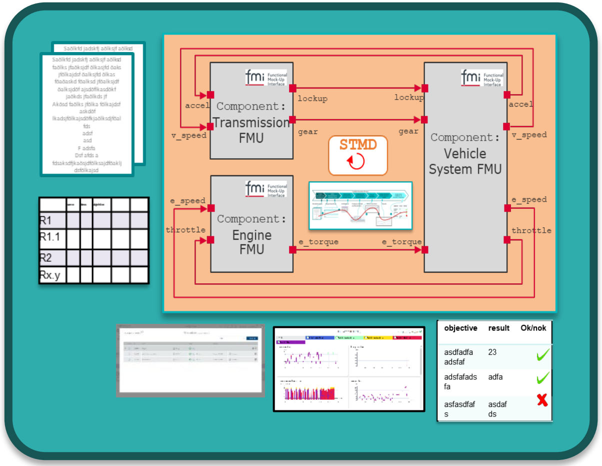
Story: Supplier to design, test and calibrate TCU based on OEM specs and requests.

Request Package



The OEM submits the TCU specification as an envelope specification, as well as the other documents as an SSP container.

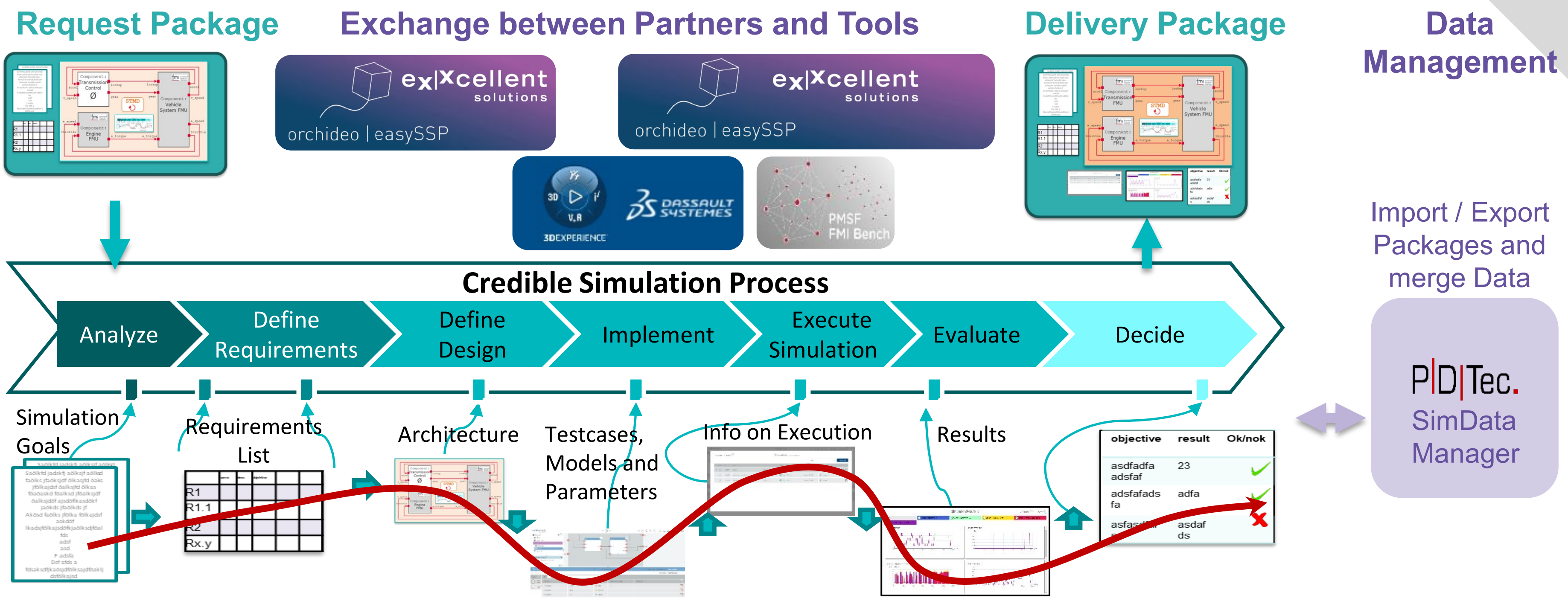
Delivery Package



The supplier transfers the TCU model and the results as an SSP container. Here the SSP standard layer SSP-traceability (STMD format) is used.

This is an example use case. It does not represent any real business case.

Collaborative Simulation-based Engineering
Traceability from requirements to simulation result



This approach is based on the Credible Simulation Process Framework and open standards like FMI, SSP, SSP-Traceability

fmi Functional Mock-up Interface

ssp System Structure & Parameterization

Building Blocks for Simulation based Cooperation
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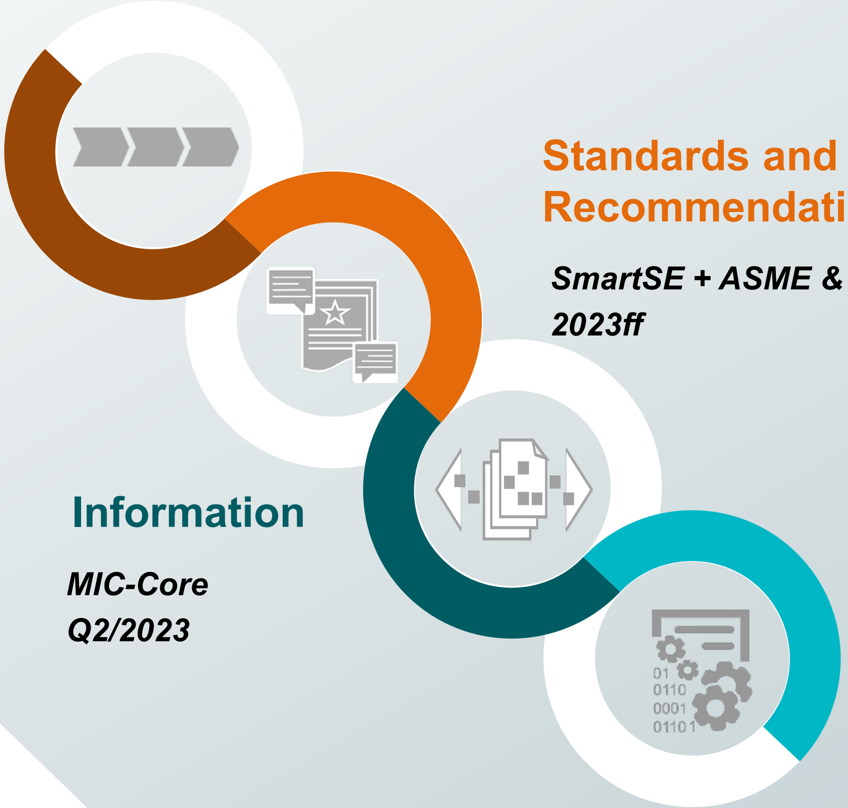
heterogeneous IT environments, collaboration

smart Systems Engineering

Building Blocks for Simulation based Cooperation
Where does it go?



Process

SmartSE
2023/24

Standards and Recommendations

SmartSE + ASME & INCOSE & NAFEMS
2023ff

Information

MIC-Core
Q2/2023

Data formats for exchange

Modellica Assocation Prj. SSP
SSP Traceability 1.0 Q4/2023
SSP 2.0 Q4/2023

smart Systems Engineering

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prostep ivip SmartSE Phase V

Mission Phase 5
(2022-2024)

Enabling collaborative development and validation of complex products by simulation along a multi tier supply chain.

If you are interested in these topics: Get in contact with us during the conference

Hans-Martin Heinkel
Robert Bosch GmbH

Pierre Mai
PMSF

Peter Lobner
eXXcellent solutions

Dag Brück
Dassault Systèmes

Or Contact

Melanie Kluge, melanie.kluge@b-h-c.de
Tel.: +49 7031 2050002

prostep IVIP

Thank you

for your attention

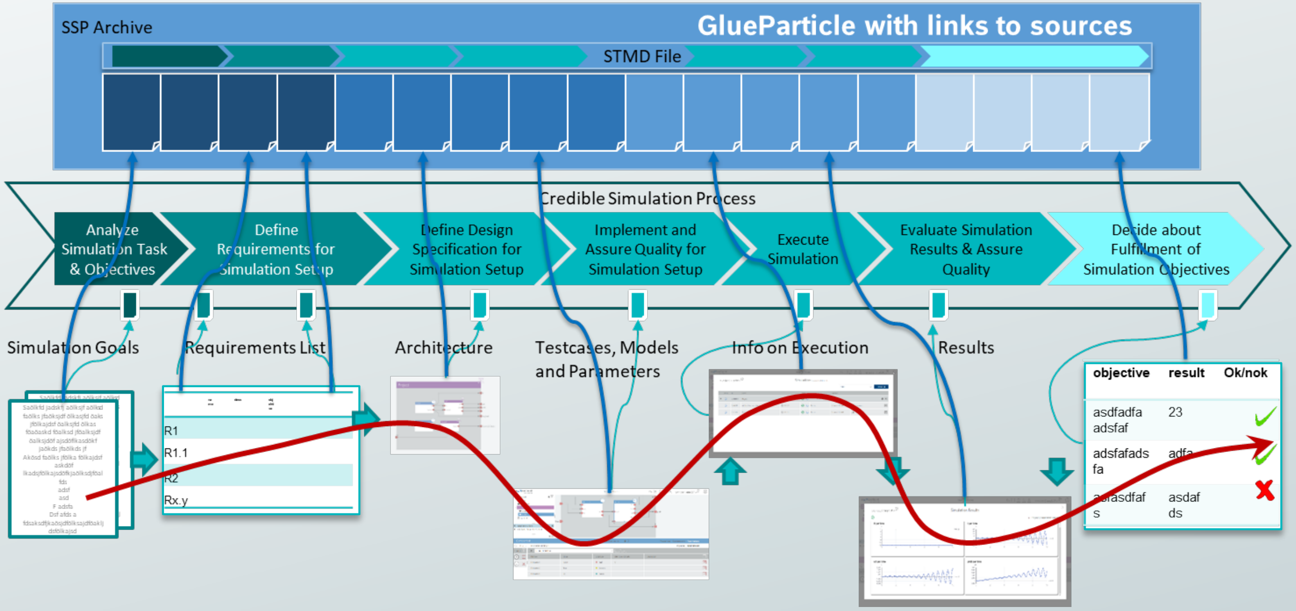
UNITY BOSCH PMSF IT Consulting

Building Blocks for Simulation based Cooperation

Data Formats for Exchange: Heterogeneous IT Environments, Collaboration

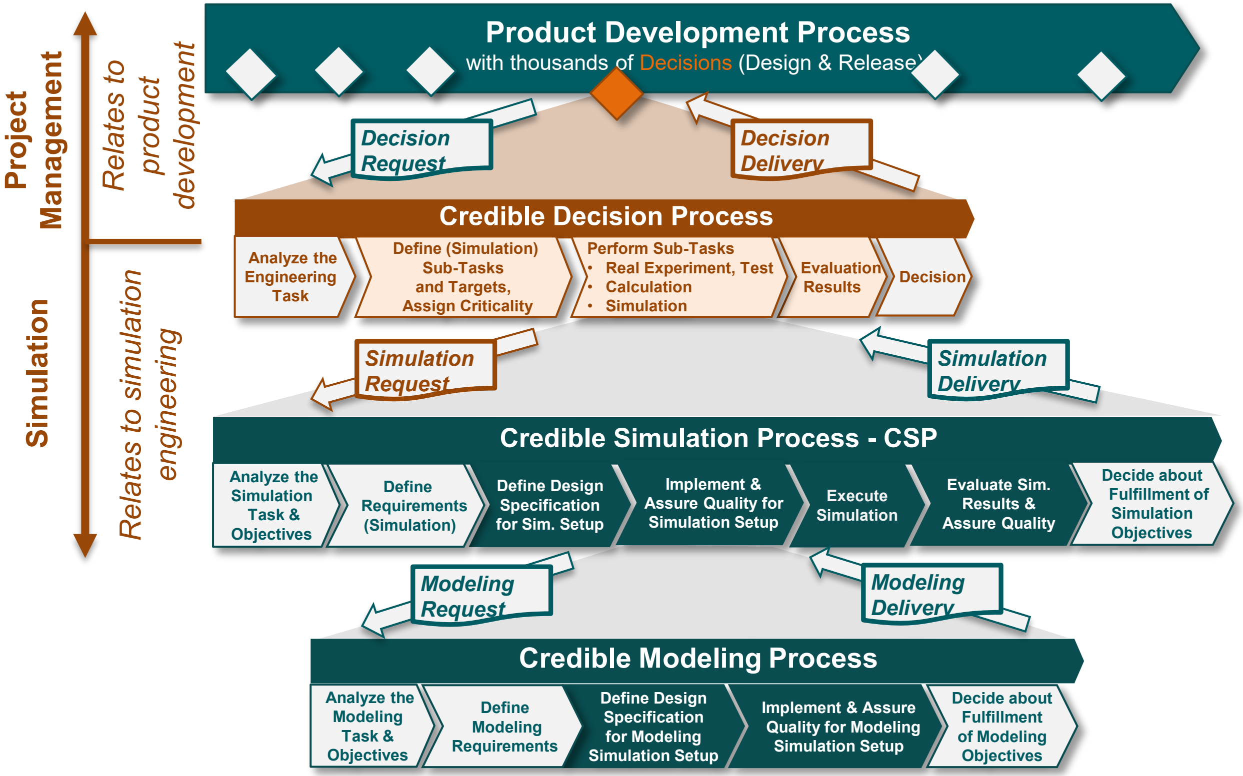
Traceability supported by GlueParticle Approach

Traceability from requirements to simulation result



Building Blocks for Simulation based Collaboration

Data Formats & Processes for Exchange: Heterogeneous IT Environments, Collaboration

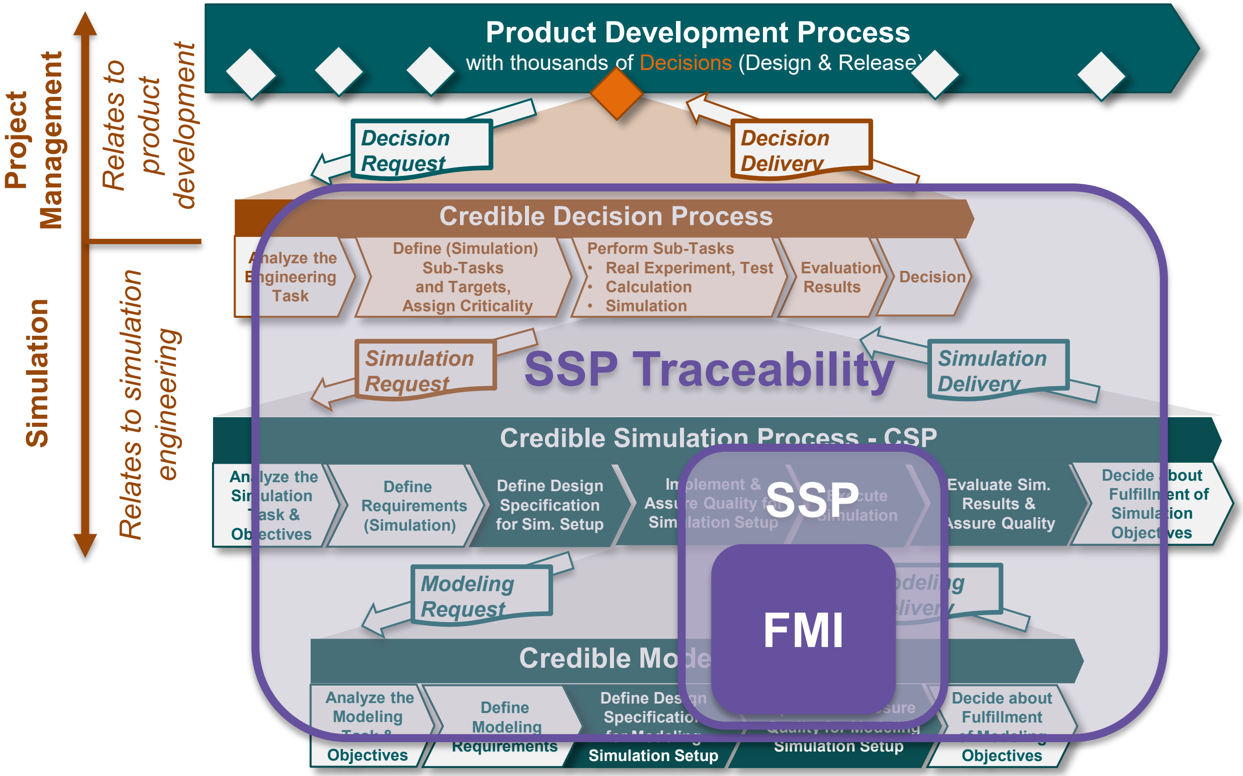


Credible Simulation Process Framework

- Process hierarchy with clear information structuring
- Sub-processes can be integrated into specific company processes

Building Blocks for Simulation based Collaboration

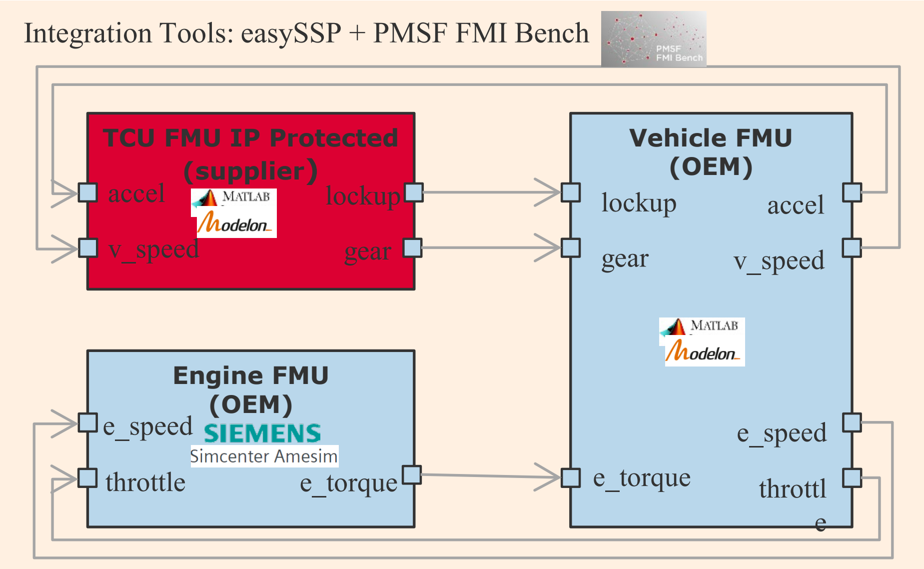
Data Formats for Exchange: Heterogeneous IT Environments, Collaboration



Within the Modelica Association, data standards for the exchange of simulation artifacts between tools are developed and supported.

- **FMI project**:
  - Exchange of models on system level → (FMI3.0)

Motivation Smart Systems Engineering (SmartSE)
Collaborative Simulation-based Engineering



Showcase 1

Supplier to design, test and calibrate TCU based on OEM specs and requests.

Fokus

Usage of CSP, SSP-Traceability, MIC-Core Metadata

Engine Model →

Internal combustion engine

Vehicle model →

rest of the vehicle. Maintains the engine state, vehicle state; provides accelerator and throttle positions

TCU model →

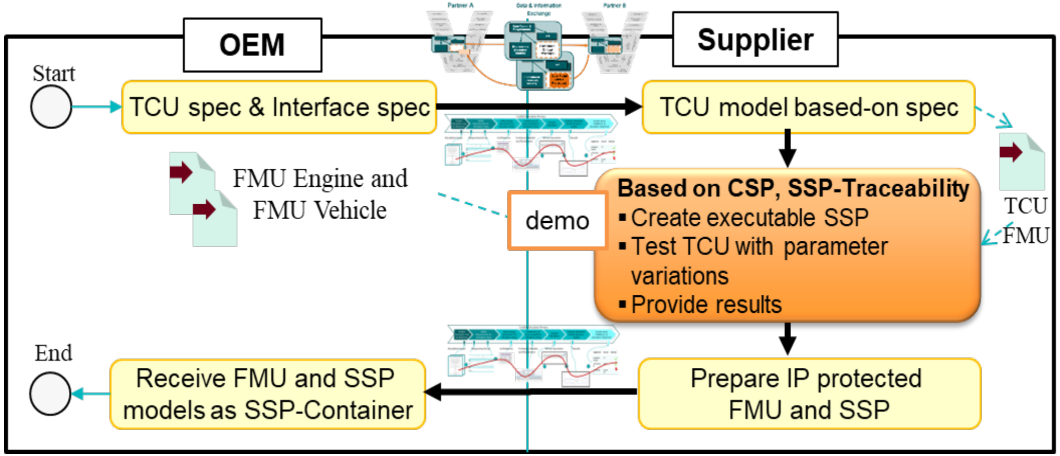
provides transmission lockup and gear ratio information, based on the vehicle speed / accelaration information.

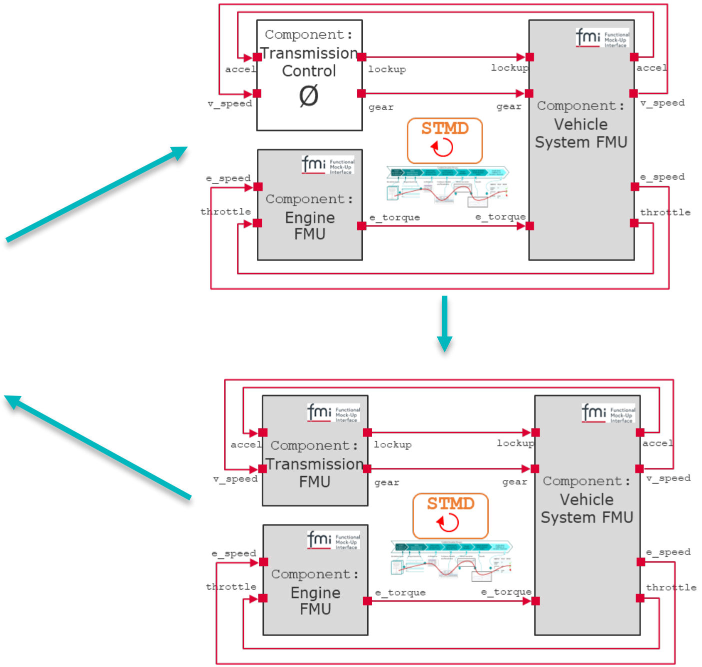
In Scope: Exchange of all artefacts required for an efficient, cross-company simulation-based engineering like specifications, requirements, test cases, simulation models and model meta data.

Use Case*: Collaborative Transmission Control Unit (TCU) Design

<u>Story:</u> Supplier to design, test and calibrate TCU based on OEM specs and requests.

The OEM submits the TCU specification as an envelope specification, as well as the other documents as an SSP container.

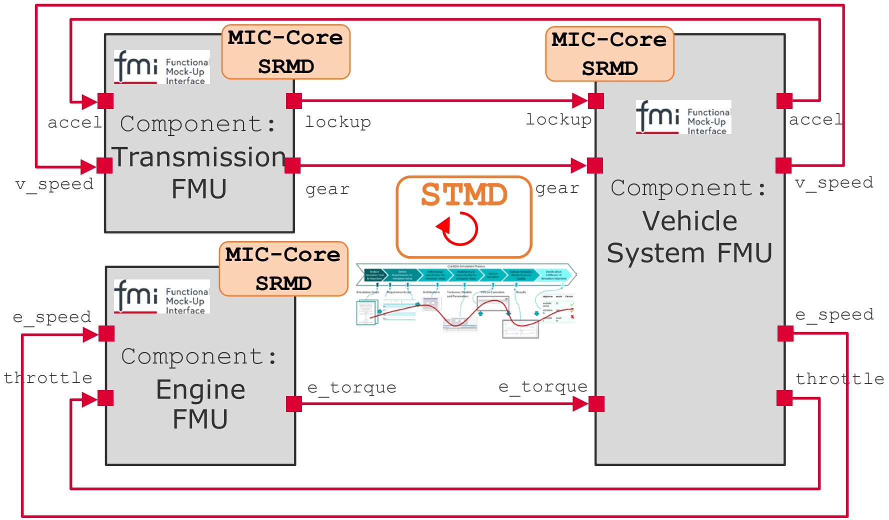


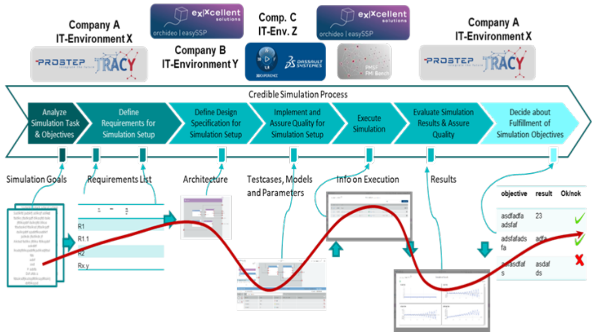


The supplier transfers the TCU model and the results as an SSP container. Here the SSP standard layer SSP-traceability (STMD format) is used.

This is an example use case. It does not represent any real business case.

Motivation Smart Systems Engineering (SmartSE)
Collaborative Simulation-based Engineering





- Usage of STMD-format (GlueParticle SSP-Traceability) for collecting data in walkthrough simulation process
- Usage of SRMD-format and MIC-Core model Metadata as leaflet for simulation models
- → structured information and metadata

In Scope: Exchange of all artefacts required for an efficient, cross-company simulation-based engineering like specifications, requirements, test cases, simulation models and model meta data.

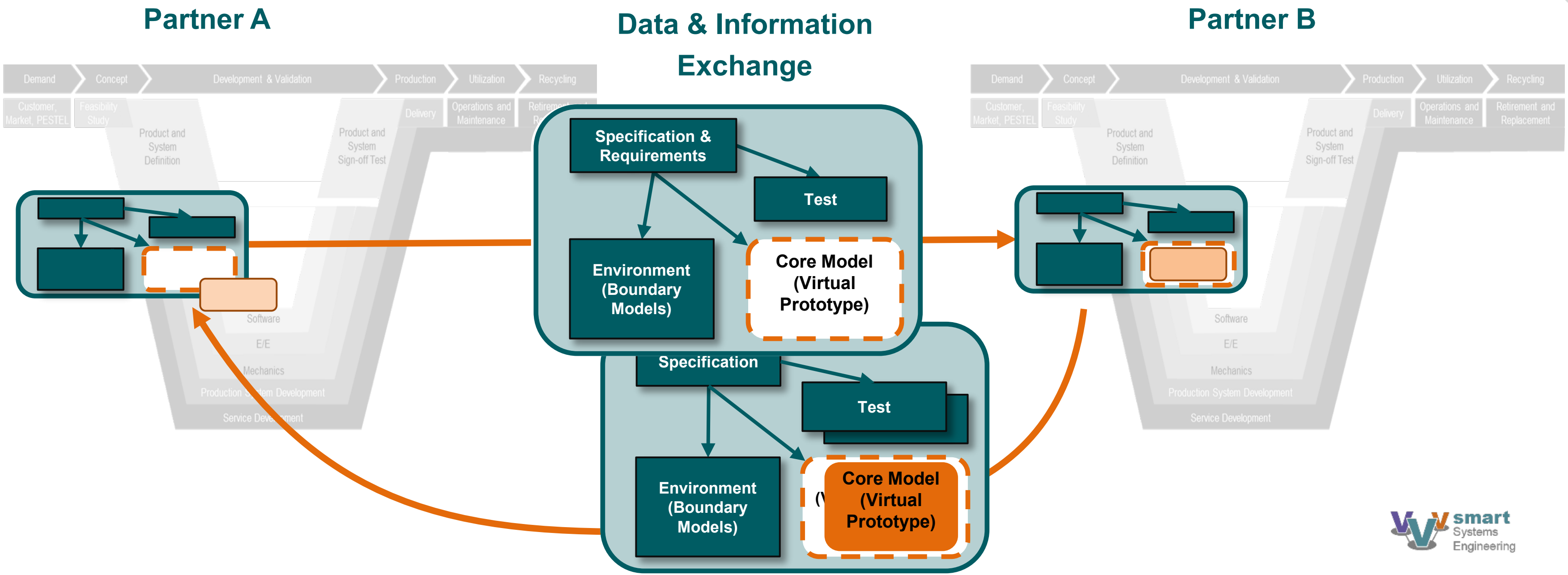
Agenda

prostep ivip

SmartSE Showcase

Collaboration of Partners using Exchange Packages in heterogeneous IT-Environments

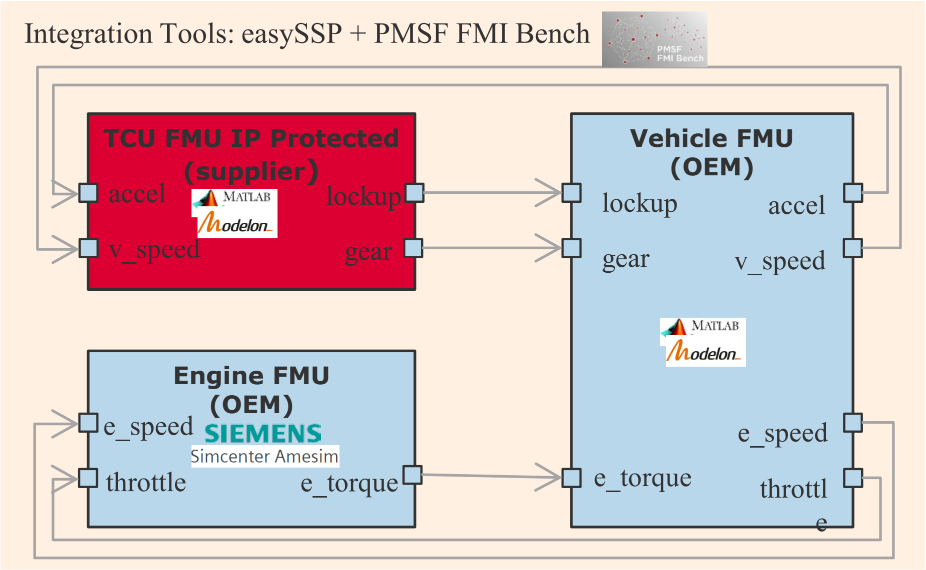
Motivation Smart Systems Engineering (SmartSE)
Collaborative Simulation-based Engineering



In Scope: Exchange of all artefacts required for an efficient, cross-company simulation-based engineering like specifications, requirements, test cases, simulation models and model meta data.

Collaborative Simulation-based Engineering

Use Case*: Collaborative Transmission Control Unit (TCU) Design



This is an example use case. It does not represent any real business case.

Showcase 1
Supplier to design, test and calibrate TCU based on OEM specs and requests.

Fokus
Usage of Credible Simulation Process (CSP), SSP-Traceability, MIC-Core Metadata

Engine Model →
Internal combustion engine

Vehicle model →
rest of the vehicle. Maintains the engine state, vehicle state; provides accelerator and throttle positions

TCU model →
provides transmission lockup and gear ratio information, based on the vehicle speed / accelaration information.

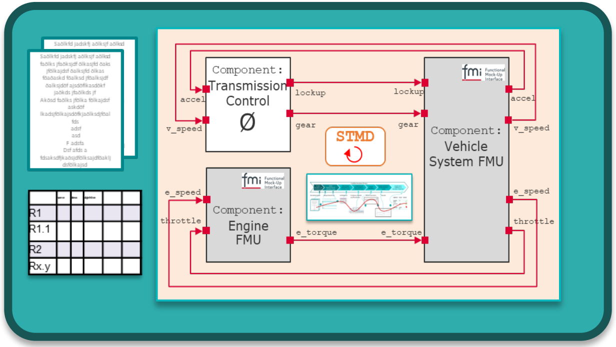
In Scope: Exchange of all artefacts required for an efficient, cross-company simulation-based engineering like specifications, requirements, test cases, simulation models and model meta data.

Collaborative Simulation-based Engineering

Use Case*: Collaborative Transmission Control Unit (TCU) Design

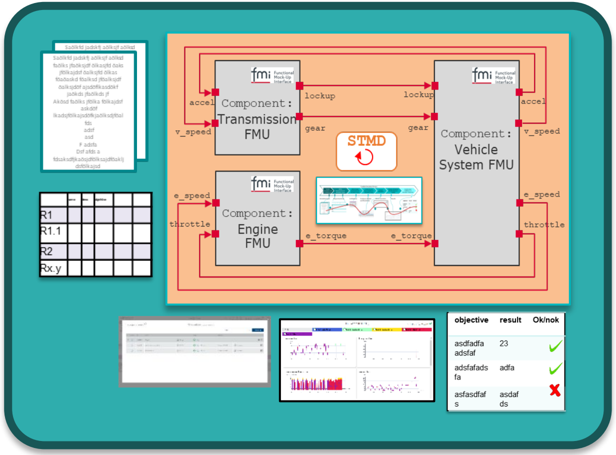
Story: Supplier to design, test and calibrate TCU based on OEM specs and requests.

Request Package



The OEM submits the TCU specification as an envelope specification, as well as the other documents as an SSP container.

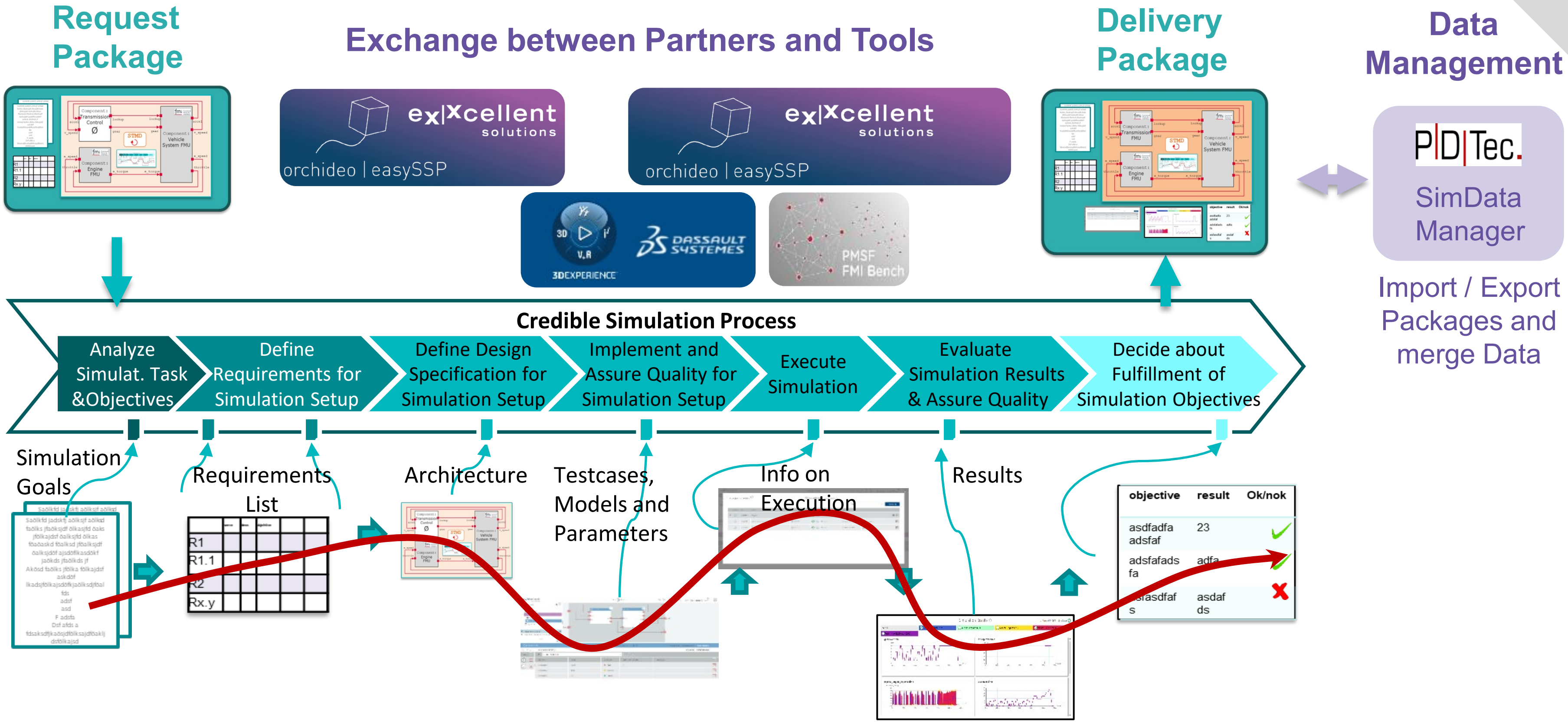
Delivery Package



The supplier transfers the TCU model and the results as an SSP container. Here the SSP standard layer SSP-traceability (STMD format) is used.

**This is an example use case. It does not represent any real business case.*

Collaborative Simulation-based Engineering
Traceability from requirements to simulation result



Theme

1 Overview SmartSE project

2 New V-Model

3 Simulation Model Meta Data MIC-Core

4 **Showcase using Exchange Packages in heterogeneous IT-Environments**

5 “Guard rails for Simulation credibility standards and recommendations””

6 New approach “Simulation credibility standards and recommendations “