NWC 2013

NAFEMSWORLDCONGRESS

Incorporating the 1st

spdm

INTERNATIONAL CONFERENCE
Simulation Process & Data Management

SDM for Systems Simulation

Challenges and Solution Approach for Process and Data Management

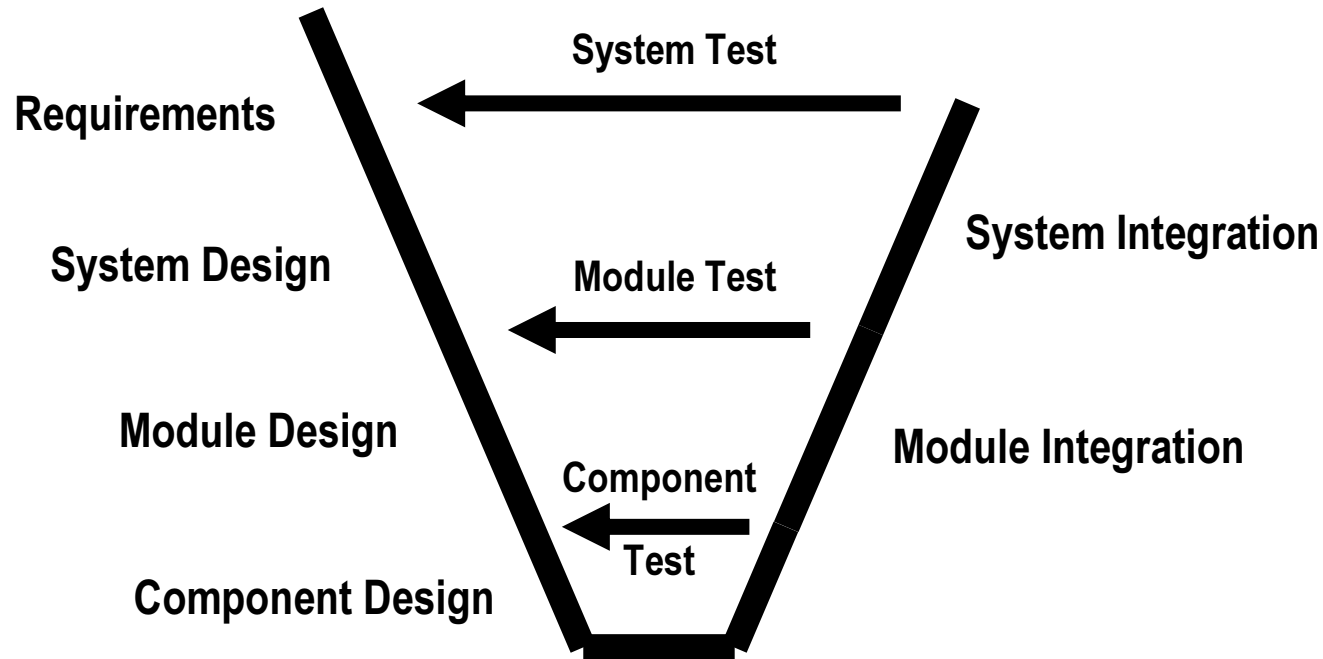## Dr. Günter Staub, PDTec AG

Contents

- Motivation

- Solution Concept: SDM for Systems Simulation

- Ongoing and next steps, Summary

Systems Simulation & Systems Engineering

- Systems Simulation is an integral part of Systems Engineering

- Systems Engineering

  - ... is an ***interdisciplinary approach*** and means to enable the realization of successful products

  - ... focuses on defining ***customer needs*** and required functionality <u>early in the development process</u> while considering the all aspects of the problem to be solved

  - ... considers both the business and the technical needs of the customers with the goal of ***providing a quality product*** that meets the user needs

V-Model for Systems Engineering

Requirements

System Test

System Design

System Integration

Module Test

Module Design

Module Integration
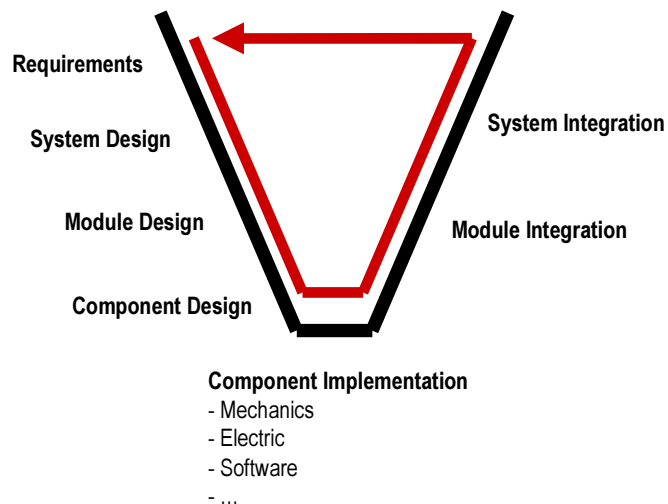
Component

Component Design

Test

Component Implementation
- Mechanics
- Electric/Electronics
- Software
- …

Motivation for Systems Simulation (1)

As Is
late system level response

Question
How to achieve an earlier system level response?

To Be
early system level response

Requirements

System Design

Module Design

Component Design

System Integration

Module Integration

Component Implementation
- Mechanics
- Electric
- Software
- ...

⇨ the later failures are found, the more expensive they are!

Answer

integrate *System Simulation* into your Development Process

V-Model for System Simulation

Requirements

System Design

Module Design

Component Design

System Integration

Module Integration

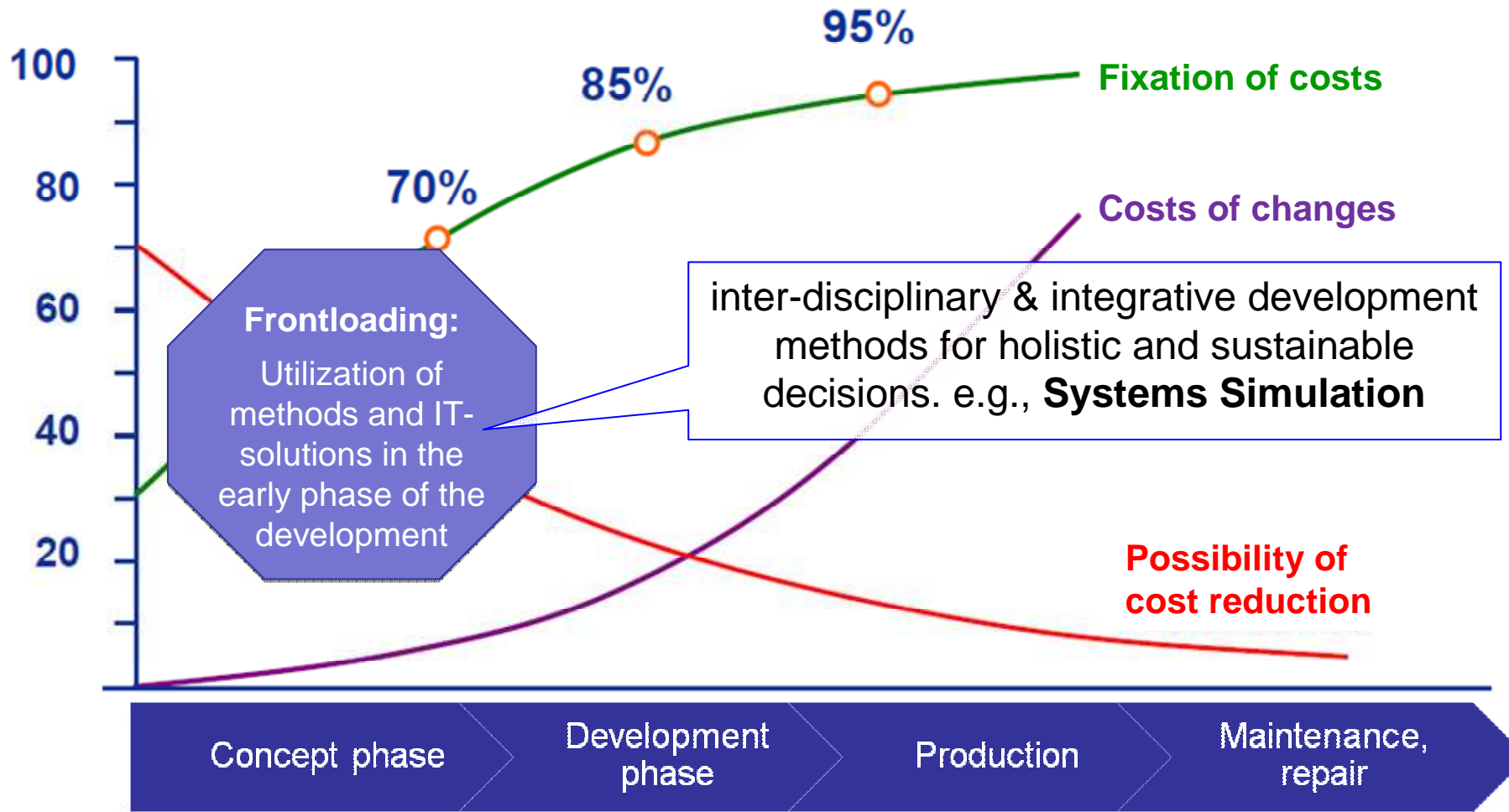**Component Implementation**
- Mechanics
- Electric
- Software
- ...

⇨ early evaluation of systems reduce the risk of missing the "best solution"!

Source: adapted from BMW

Motivation for Systems Simulation (2)

95%
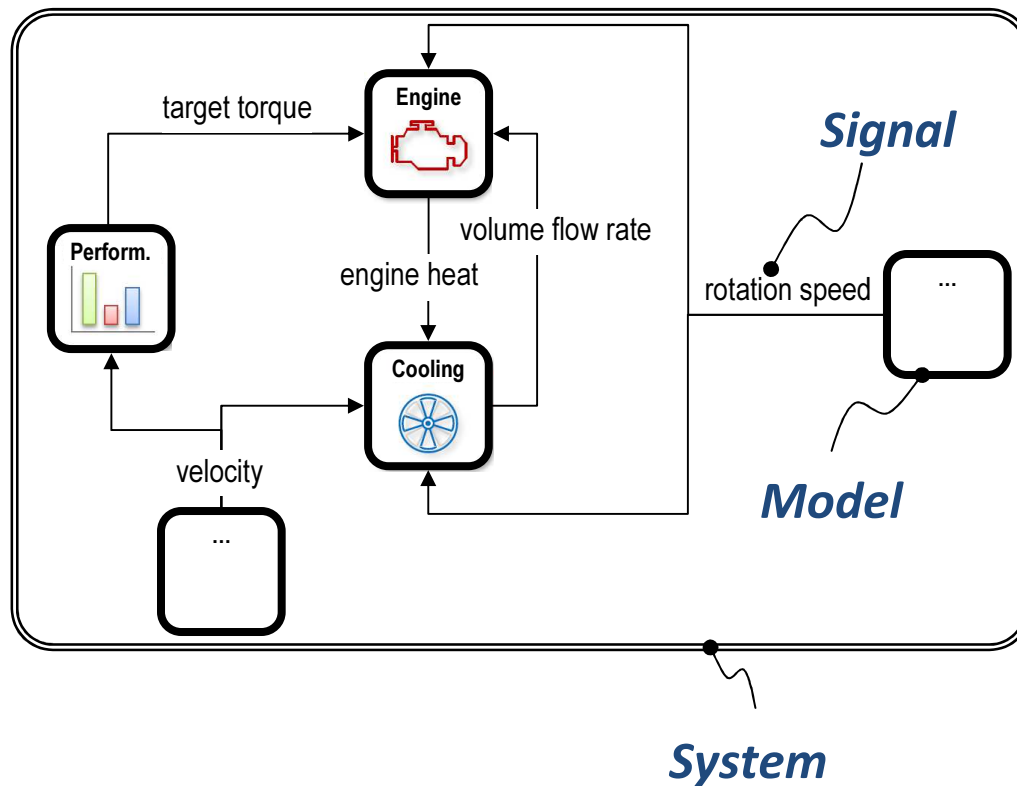
85%

Fixation of costs

70%

Costs of changes

Frontloading:

Utilization of methods and IT-solutions in the early phase of the development

inter-disciplinary & integrative development methods for holistic and sustainable decisions. e.g., **Systems Simulation**

Possibility of cost reduction

Concept phase

Development phase

Production

Maintenance, repair

Source: vif

Example of a System

target torque

Engine

volume flow rate

engine heat

Perform.

Cooling

velocity

rotation speed

Signal

Model

...

...

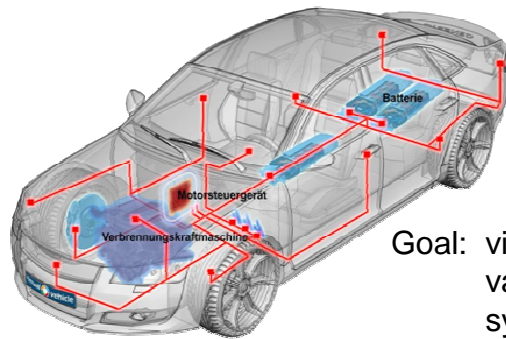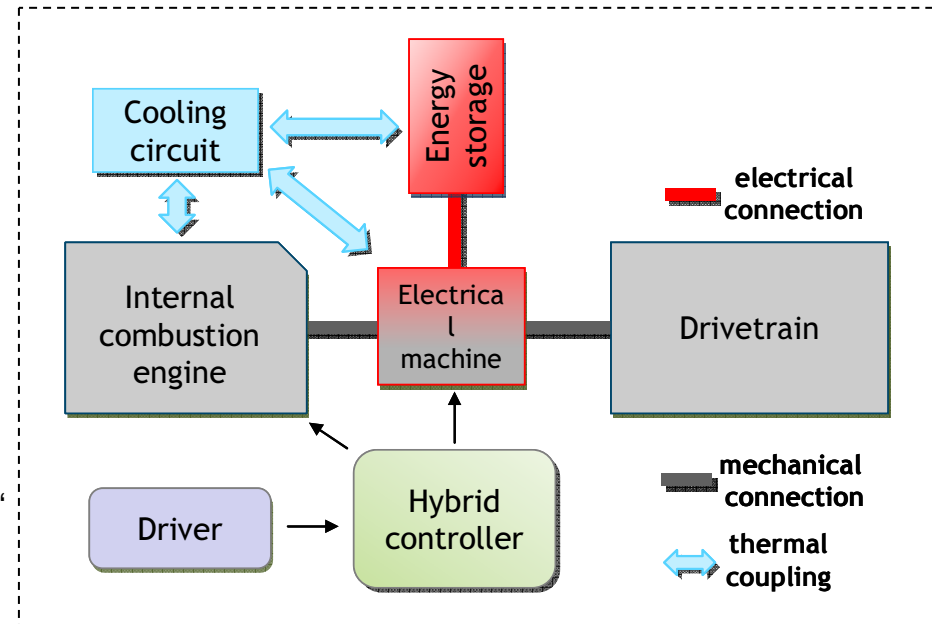**System**

- A System represents an abstraction model of e.g. a car or sub-systems of it
- it consists of a set of models that are connected by input and output signals
- It supports the reasoning about its behavior by determining the behavior of its components (models) and their interactions
- A Model represent a function that delivers output signals based on its input signals and its internal behavior

Source: adapted from VW

Example of a System
(Parallel Electric Hybrid Vehicle)

Goal: virtual design and validation of the system „full vehicle"

abstraction model of a parallel electric hybrid vehicle concept
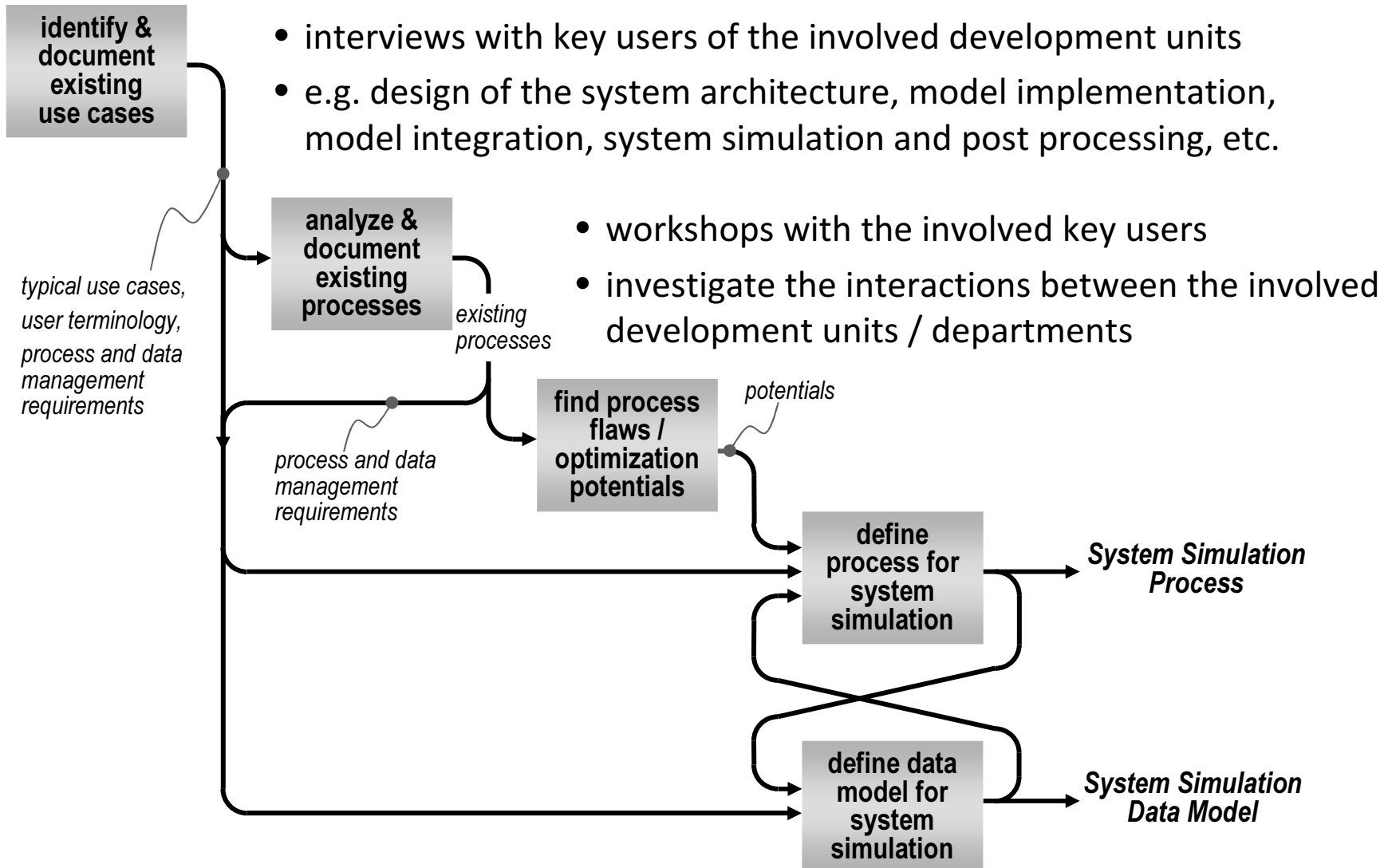
Source: vif

Contents

- Motivation

- **SDM for Systems Simulation**

  – **Approach for the development of a SDM Solution**

  – **Challenges / Overall Requirements**

  – **Results**

    - **Reference Process for Systems Simulation**

    - **Resulting Requirements for SDM for Systems Simulation**

    - **Data Model for Systems Simulation**

    - **SDM Solution for Systems Simulation**

- Ongoing and next steps, Summary

Illustration of the Approach for the development of a SDM Solution for Systems Simulation

identify & document existing use cases

- interviews with key users of the involved development units
- e.g. design of the system architecture, model implementation, model integration, system simulation and post processing, etc.

typical use cases, user terminology, process and data management requirements

analyze & document existing processes

- workshops with the involved key users
- investigate the interactions between the involved development units / departments

existing processes

process and data management requirements

find process flaws / optimization potentials

potentials

define process for system simulation

System Simulation Process

define data model for system simulation

System Simulation Data Model

Challenges / Overall Requirements (Excerpt)

- A SDM solution should support the whole process of system simulation
  - system design, model design, model implementation, system integration, job submit & monitoring, post processing and reporting
- Multiple development units shall use the SDM solution in order to manage their models and their simulations
  - independently as well as in a collaborative way
  - different processes and different tools
- A SDM solution should support all kinds of simulations
  - one simulation model, one solver (classical simulation)
  - multiple homogenous simulation models, one solver
  - multiple simulation models, multiple solvers (co-simulation)

Reference Process for Systems Simulation incl. Roles and Results of each Phase

Roles   **Process Phases**   **Results**

Roles	Process Phase	Result
System Responsible	**System Design**	**System Architecture** (abstract)
Model Responsible / Model Implementer	**Model Design and Implement.**	**(Alternative) Realizations** of models
System Responsible	**System/ Model Integration**	**Configurable System** (n x 100%)
CAE Engineer	**Config. and Parameterization**	**Configured and Parameterized System**
CAE Engineer	**Simulation Execution**	**Raw Simulation Results**
CAE Engineer	**Post Processing and Reporting**	**Final Simulation Results**
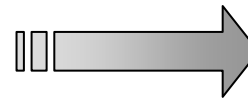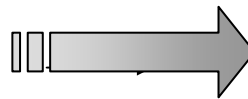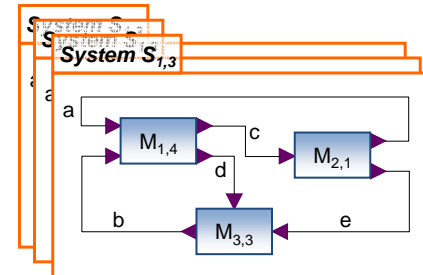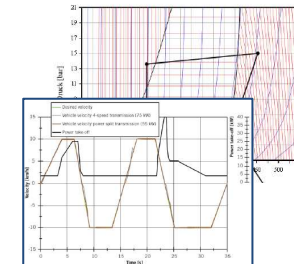
Input deck = ($S_{1,3}$(step :=0.1, ...),
$M_{1,4}$(a:= 3 m/s, ...), $M_{2,1}$(...), $M_{3,3}$(...))

Resulting Requirements for the SDM Data Model (1)

- from System Design Phase
    - representation of systems and their decomposition
    - models as components of systems
    - might be occurrences of models within a library
    - connection of models by input and output signals
    - versioning of systems and models
    - representation of the lifecycle of systems and models
    - release status / workflows for systems
    - associated car project
    - milestone within the PEP
    - creator and approval information
    - ...

Resulting Requirements for the SDM Data Model (2)

- from Model Design and Implementation Phase
  - representation of models
  - functions as components of models
  - model components are occurrences of functions within a library
  - versioning of models and functions
  - functions are connected by input and output signals
  - discipline (e.g. thermal management, electrical system, driving performance & consumption)
  - model granularity and scope of validity
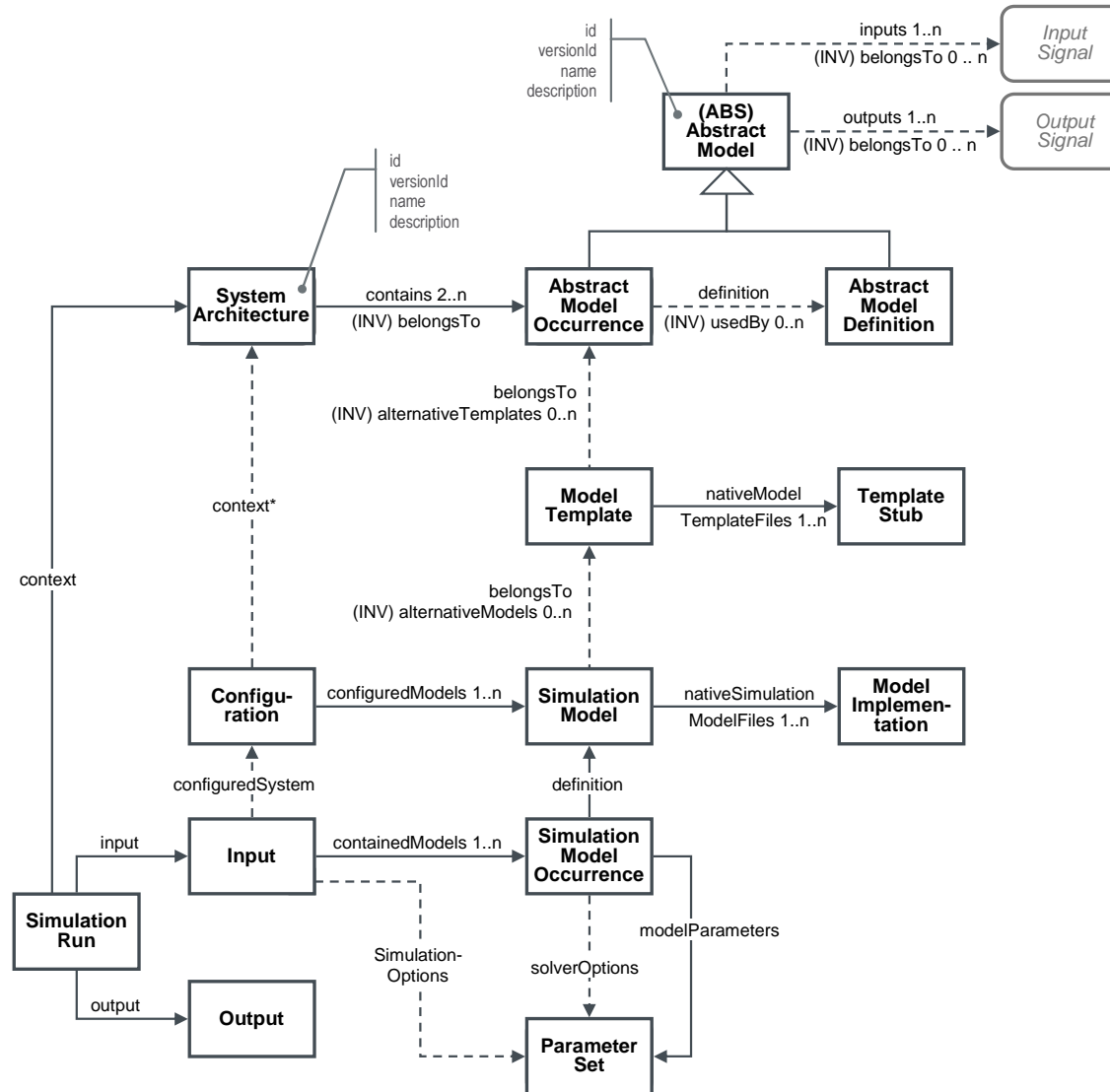 - creator and approval information
  - ...

Resulting Requirements for the SDM Data Model (3)

- **from other phases**

    - representation of configuration information (expressions)

    - parameter sets and their association to simulation models

    - job submit and monitoring

    - storage of raw / key results and simulation reports

    - …

- **other requirements**

    - audit-trail and traceability

    - integration of modeling tools and external partners

    - discipline specific views
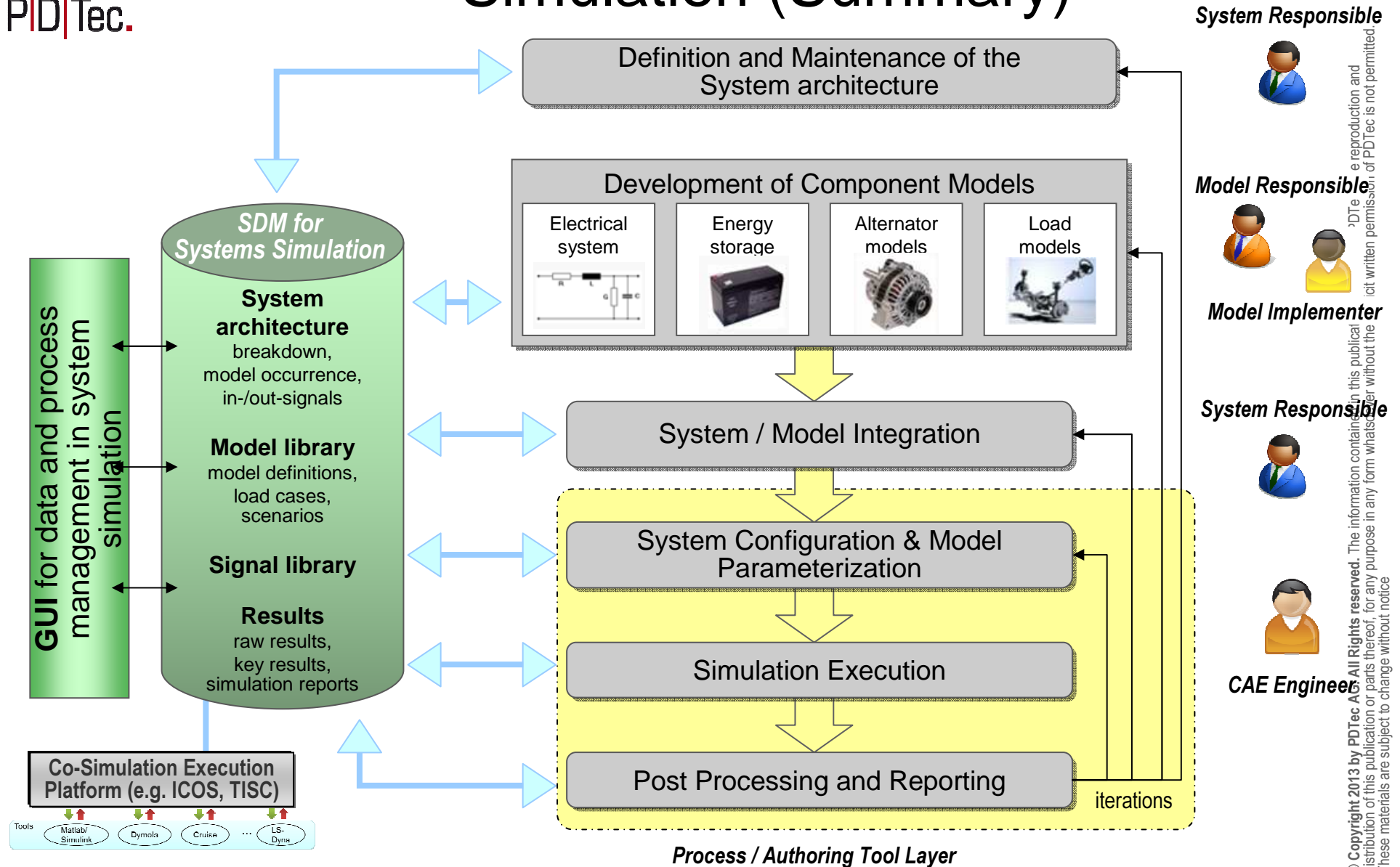
    - filtering & search mechanisms

    - ...

Resulting Data Model for Systems Simulation (excerpt, simplified)

Solution Concept for SDM for Systems Simulation (Summary)

System Responsible

Definition and Maintenance of the System architecture

SDM for Systems Simulation

System architecture
breakdown, model occurrence, in-/out-signals

Model library
model definitions, load cases, scenarios

Signal library

Results
raw results, key results, simulation reports

GUI for data and process management in system simulation

Development of Component Models

| Electrical system | Energy storage | Alternator models | Load models |

Model Responsible

Model Implementer

System / Model Integration

System Responsible

System Configuration & Model Parameterization

Simulation Execution

CAE Engineer

Post Processing and Reporting

iterations

Co-Simulation Execution Platform (e.g. ICOS, TISC)

Tools
Matlab/ Simulink   Dymola   Cruise   ...   LS-Dyna

Process / Authoring Tool Layer

Contents

- Motivation

- SDM for Systems Simulation

- **Ongoing and next steps, Summary**

Ongoing and Next steps

- Demonstrator based on PDTec's SimData Manager
  - Mapping of the resulting data model to the SimData Manager data model
    - some extensions of the data model were required
    - CAD/PDM data is not needed for Systems Simulation!
  - existing generic functionality is used to allow a basic way of working
- Extend the demonstrator to a fully functional prototype
  - e.g. deeper integration of the tool chain (Dymola, Simulink, Kuli, Adams, SimXpert, …)
  - authoring tool for the development and maintenance of the System Architecture
  - add convenience functionality
- Validation of the prototype in a pilot project

Summary

- A more holistic approach in the development of mechatronic systems, e.g. cars, is necessary
  - Systems Engineering and Systems Simulation
- Simulation process and data management is one important ingredient for an optimal IT-support within a systems engineering based development process
  - in addition: for ISO 26262 („Road vehicles – Functional safety") compliance a SDM system for system simulation is required
- Within a project with an automotive OEM, the solution concept (reference process, data model, architecture, etc) was elaborated

**Thank you
for your attention**

Dr.-Ing. Günter Staub

NAFEMS World Congress 2013 – Salzburg, Austria
June 9-12 2013