How is PLM shaping MBSE processes?

Hari Vijay, Siemens PLM Software

Biography

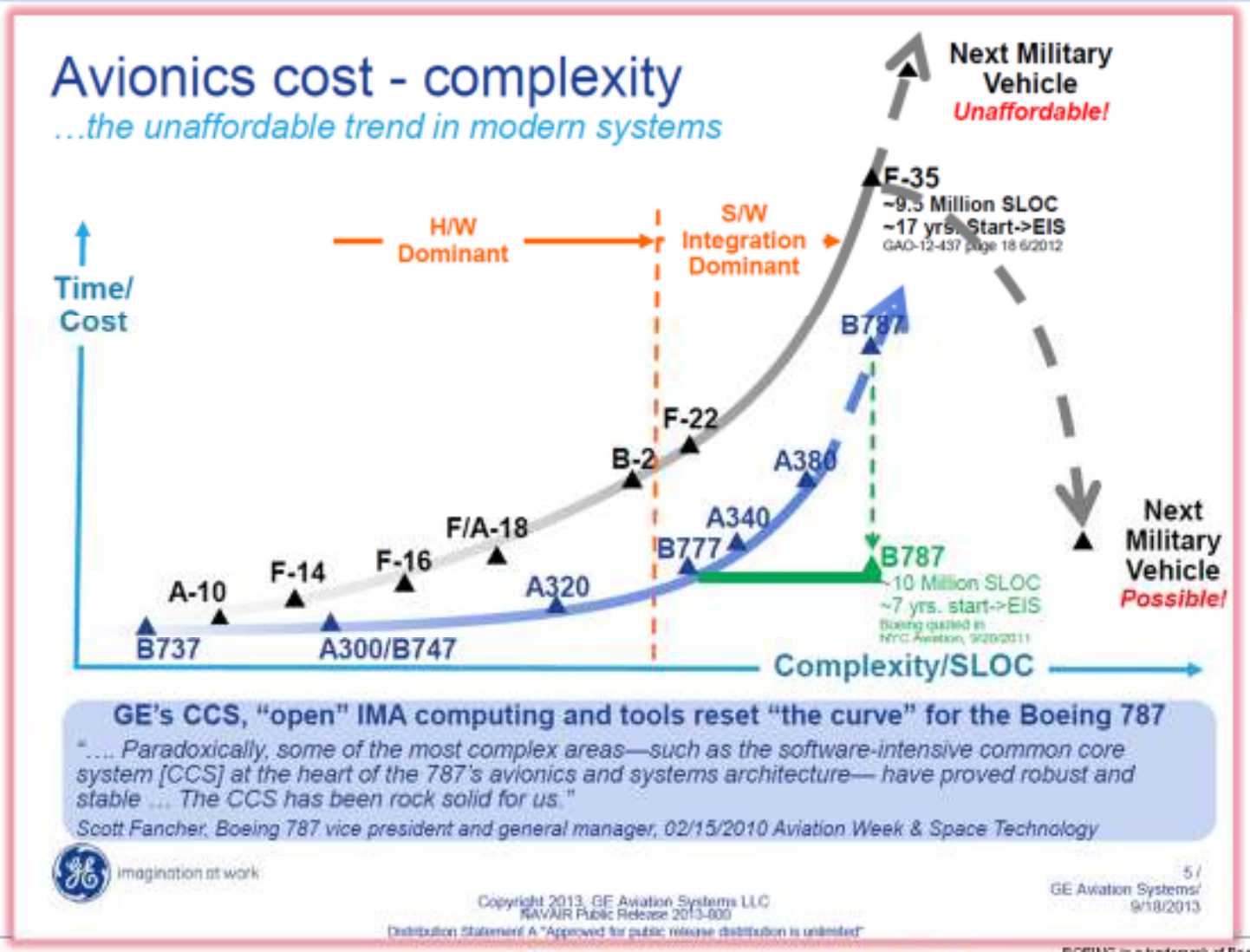
Hari Vijay has been working for Siemens PLM Software for the past 15 years with extensive experience in Model Based System Engineering tools and processes. He has worked in different capacities at Siemens as a technical support engineer, services engineer, application engineer and currently in business development.

During his tenure at Siemens, he has worked with several customers in establishing Siemens's MBSE tools as part of their simulation processes. He has worked with several automotive, aerospace and off-highway customers in auditing their respective MBSE processes so as to suggest improvements.

Hari's got an MS Automotive Systems degree from Kettering University. Prior to graduating from Kettering, he worked as a Powertrain Simulation Engineer for 3 years at t IVECO

Challenges in Aircraft industry

Global Product Data Interoperability Summit | **2015**



Challenges: Virtual Integrated Aircraft

Global Product Data Interoperability Summit | **2015**

"We've defined the **concept of the energy-optimized aircraft**, which **steps above more-electric systems and sets goals at the vehicle level**."

Steve Iden, INVENT Program Manager

Aviation Week, Oct 27, 2008; Aviation Week, Jul 12, 2010

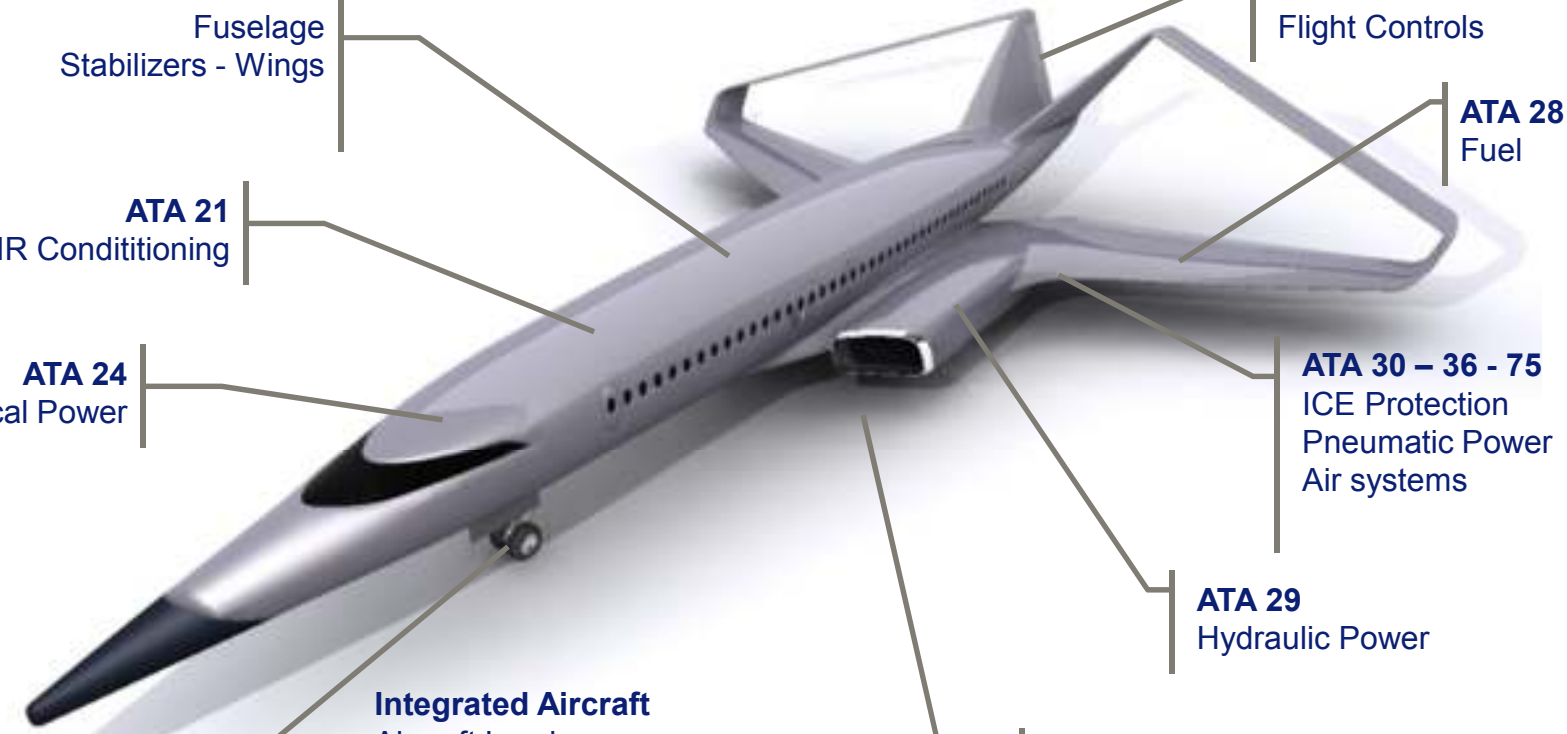
Scope

- Implement system engineering solutions for **energy-optimized design** of Vehicle & Systems
- Integrate multiple subsystems with varied **levels of fidelity**

Expectations

1. Energy optimized aircraft to have **50% increased range**
2. System engineering to delivery significant **schedule compression – up to 5x**

Challenges: Aircraft Virtual Integration



ATA 53 - 55-57
Fuselage
Stabilizers - Wings

ATA 27
Flight Controls

ATA 28
Fuel

ATA 21
AIR Condititioning

ATA 24
Electrical Power

ATA 30 – 36 - 75
ICE Protection
Pneumatic Power
Air systems

ATA 29
Hydraulic Power

ATA 32
Landing Gear

Integrated Aircraft
Aircraft Loads
Cabin Comfort & Exterior Noise
Aircraft Energy/Thermal (VIA - VTA)
Aircraft Integration Testing (VIB)
Structural Dynamics

ATA 71 – 72 - 73 – 79 – 76 - 83
Powerplant – Turbine
Engine Fuel and Control
Engine Oil
Engine Controls
Engine Accessory Gearbox

Challenges in the Automotive Market: Technology shifts

Global Product Data Interoperability Summit | **2015**

- **Electrification,**
- **CVT/DCT, ratio**
- **Regenerative braking**

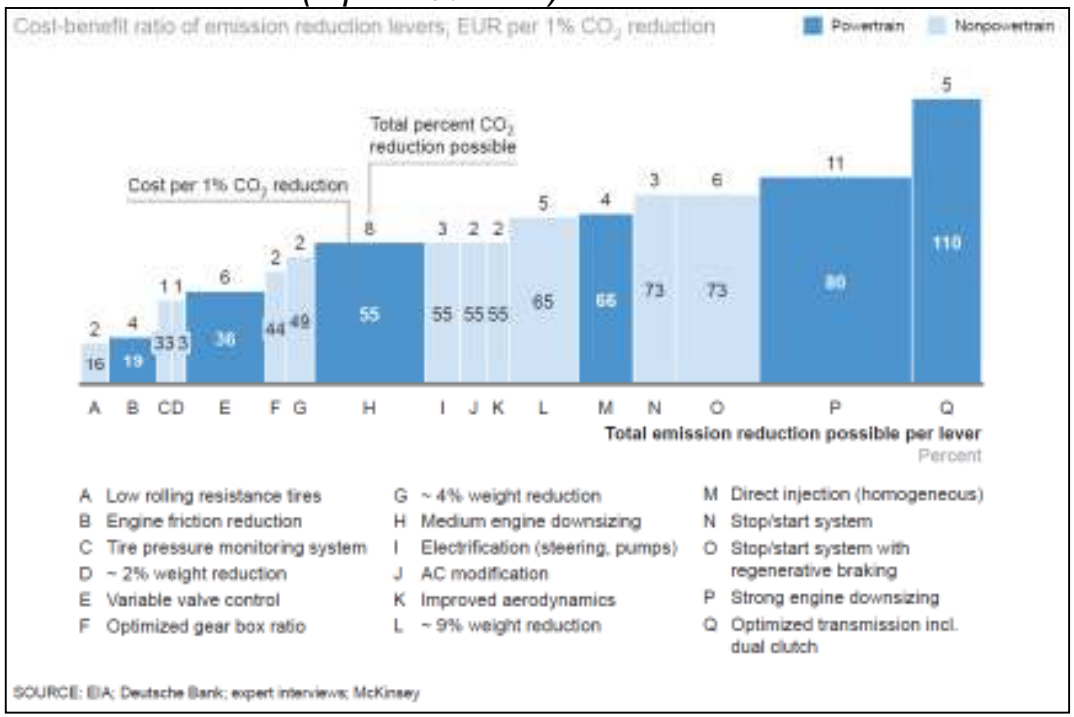
Downsizing
Stop/start…

Direct injection

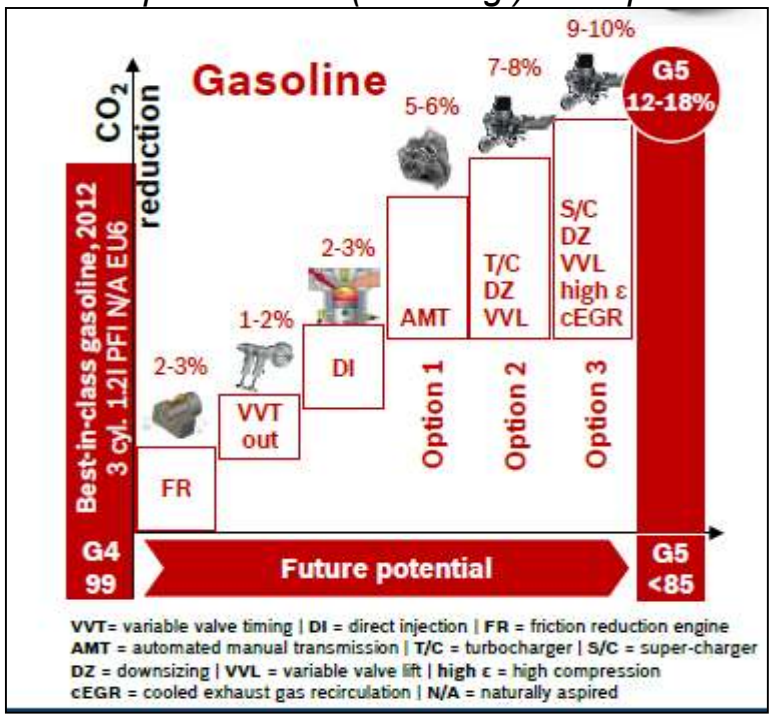
Variable Valve
Optimized gear

….

Cost-benefit ratio (€ per 1% CO2)



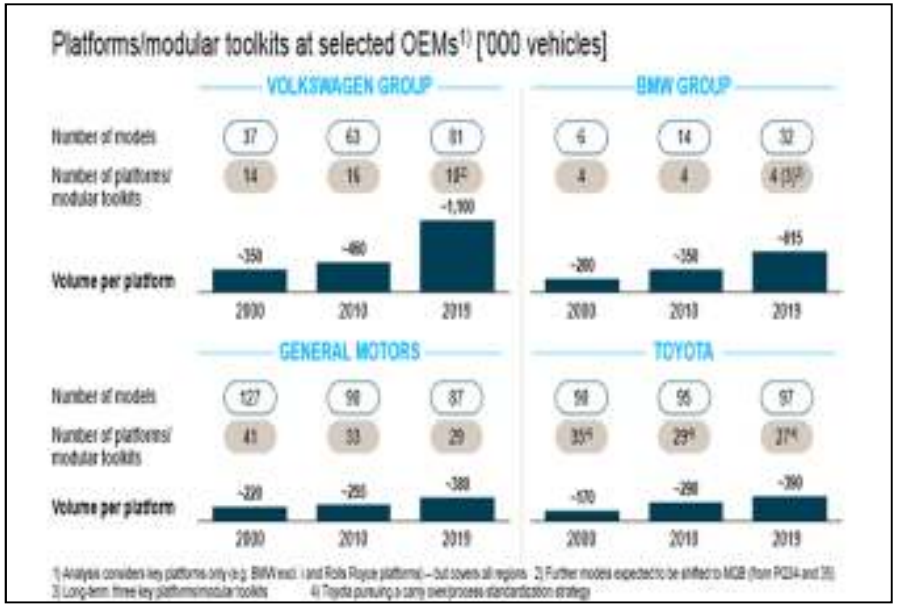
Subcompact vehicle (<1100kg) example



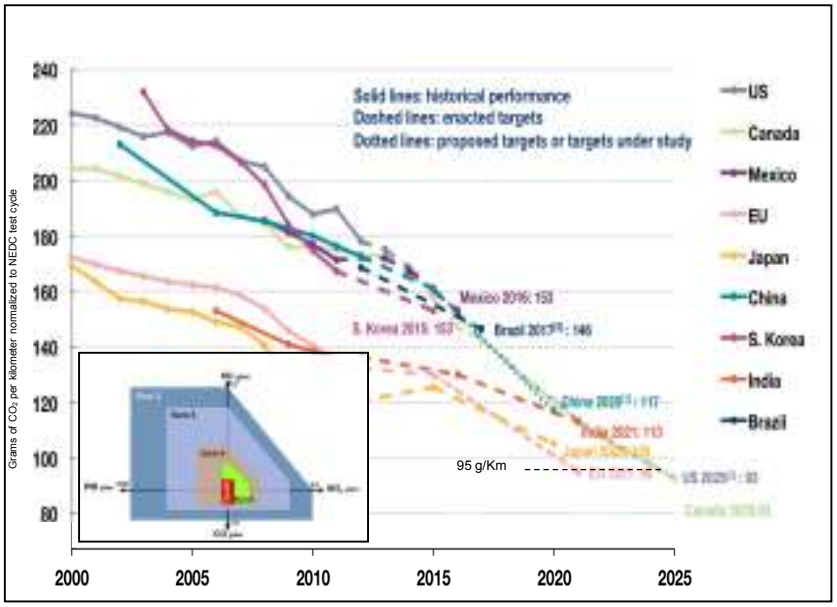
Challenges in the Automotive market: Growing variety

- **Multiple variants and vehicle systems architectures**
- **X engine times Y transmission times Z standards times ….**
- **= Growing variety of vehicle models**

Variety of vehicle model based on less platforms



Fuel eco & pollutant emission standards



Definition of MBSE

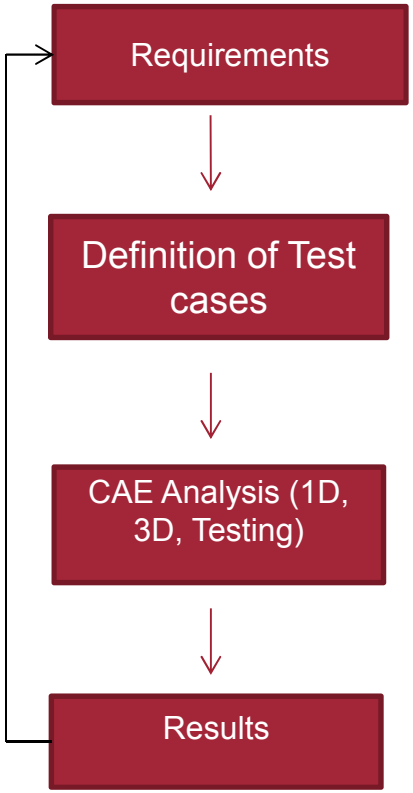
Model Based Systems Engineering is a Systems Engineering paradigm that emphasizes on the activities like:

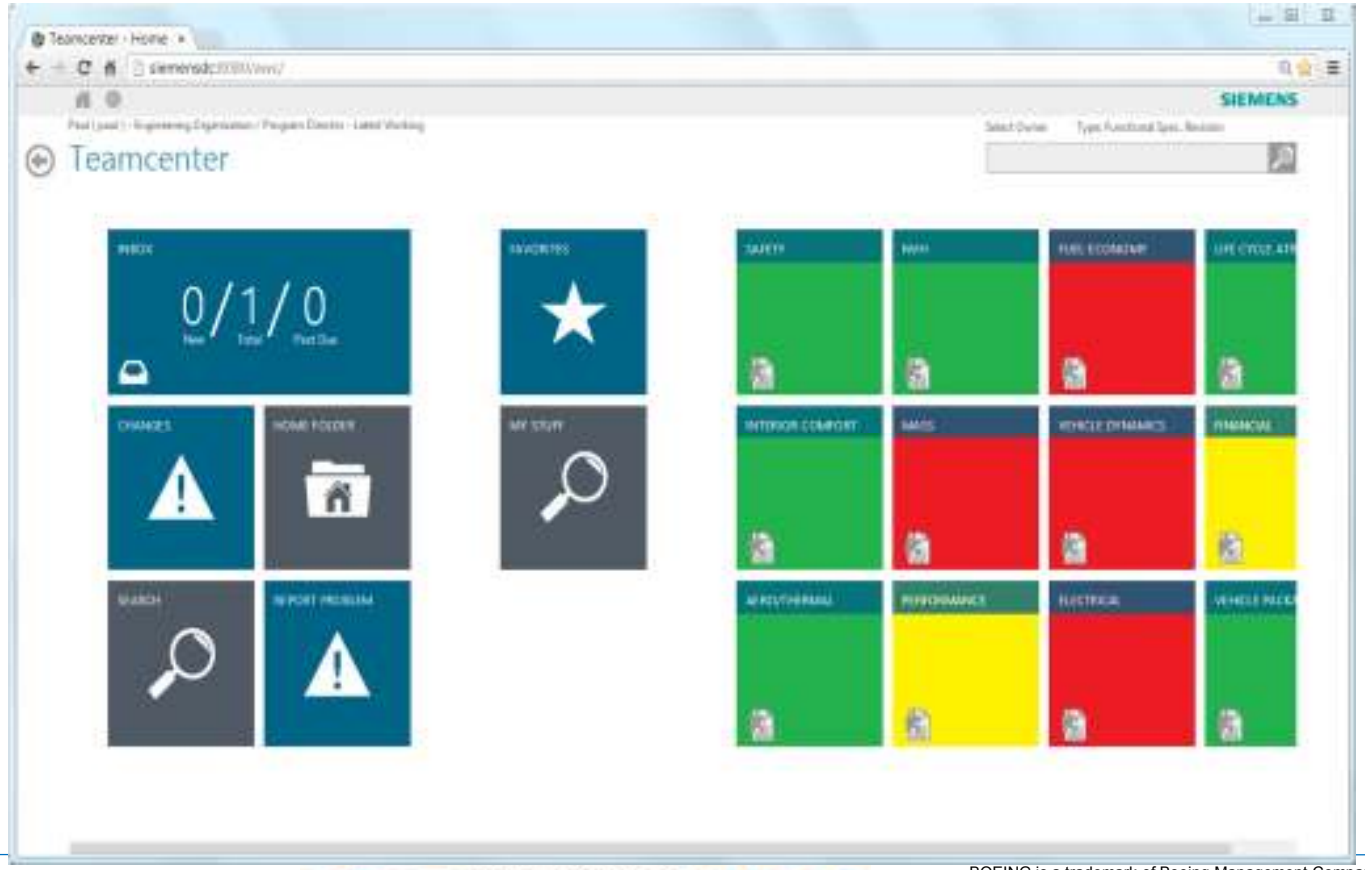
- **Requirements Analysis**
- **Validation and Verification**
- **Functional Analysis**
- **Performance Analysis & Trade studies**
- **System Architecture specification**

MBSE Process in reality
Customer pain 1

Traceability to Requirements

- Requirements based Analysis





MBSE Process in reality
Customer pain 2

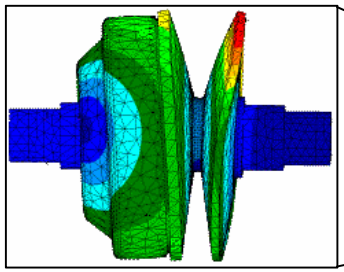
Traceability to Requirements	• Requirements based Analysis
Multi-level approach	• How to switch behavior models easily from one fidelity to another one?

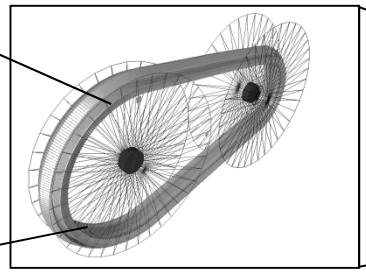
Goal
Fuel economy, vehicle performance, pre-sizing

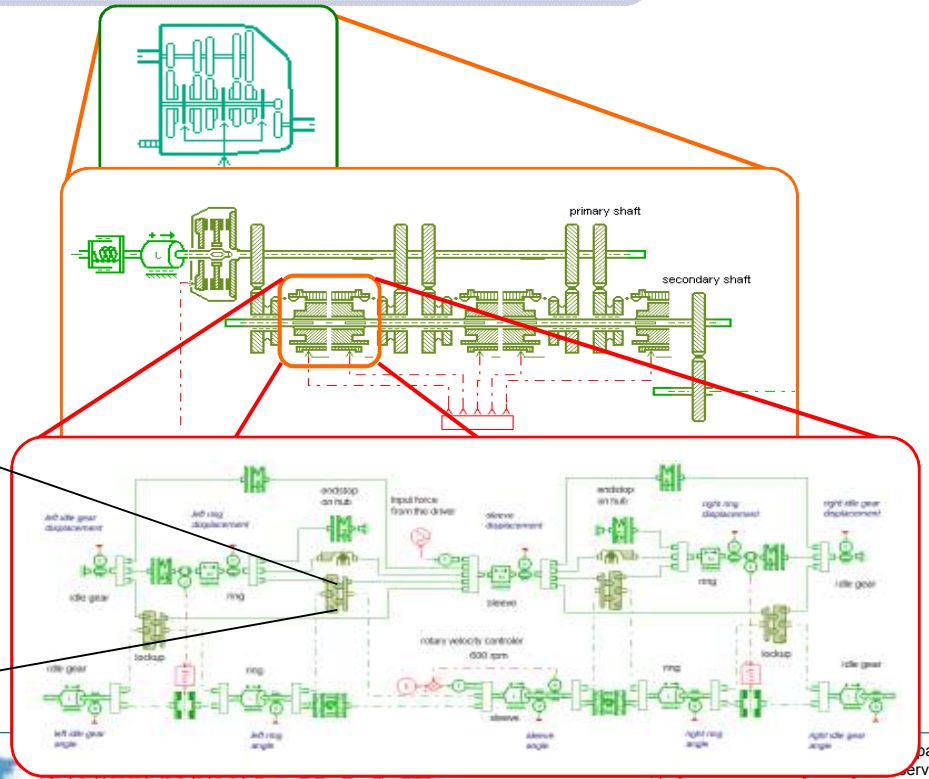
Goal
System sizing, performance

FE

MBS



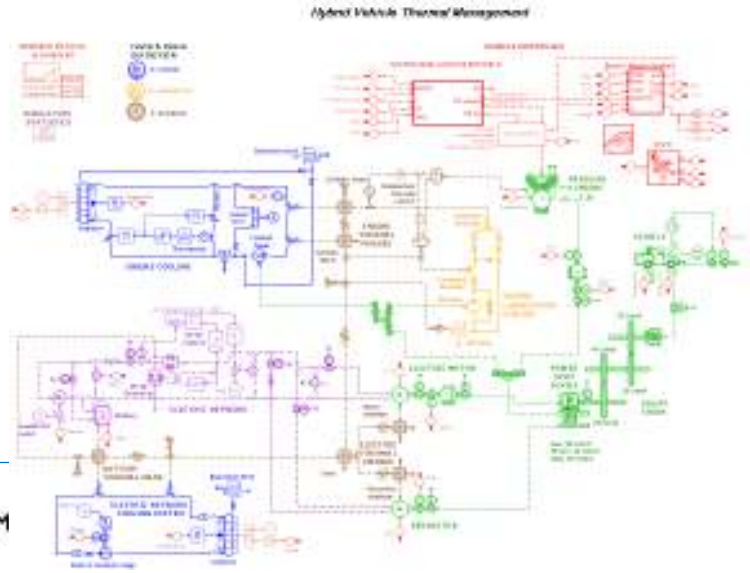


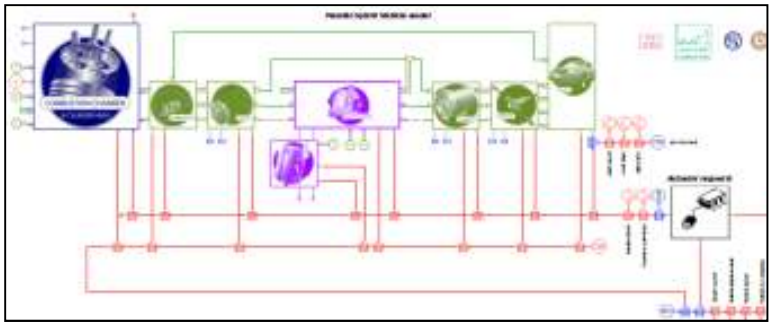


Goal
Component optimization

MBSE Process in reality
Customer pain 3

Traceability to Requirements	• Requirements based Analysis
Multi-level approach	• How to switch easily from one fidelity to another one?
Parameters and Test methods	• What type of analysis and where are the parameters available? • How do we manage the process flow?





MBSE Process in reality
Customer pain 4

Traceability to Requirements	• Requirements based Analysis
Multi-level approach	• How to switch easily from one level to another one?
Parameters and Test methods	• What type of analysis and where are the parameters available? • How do we manage the process flow?
Multiple authors	• How engineers can share/store models/data from other departments?

Multiple departments: engine, T/M, chassis, controls

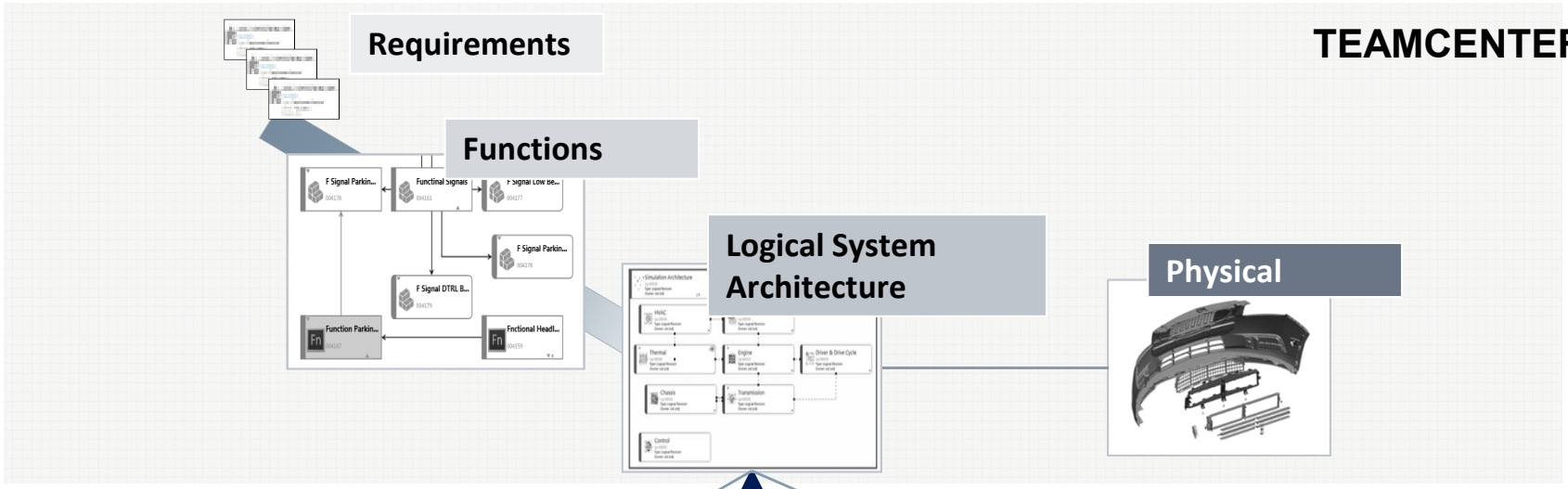
Multiple sites: US, India, Europe…

Multiple authors

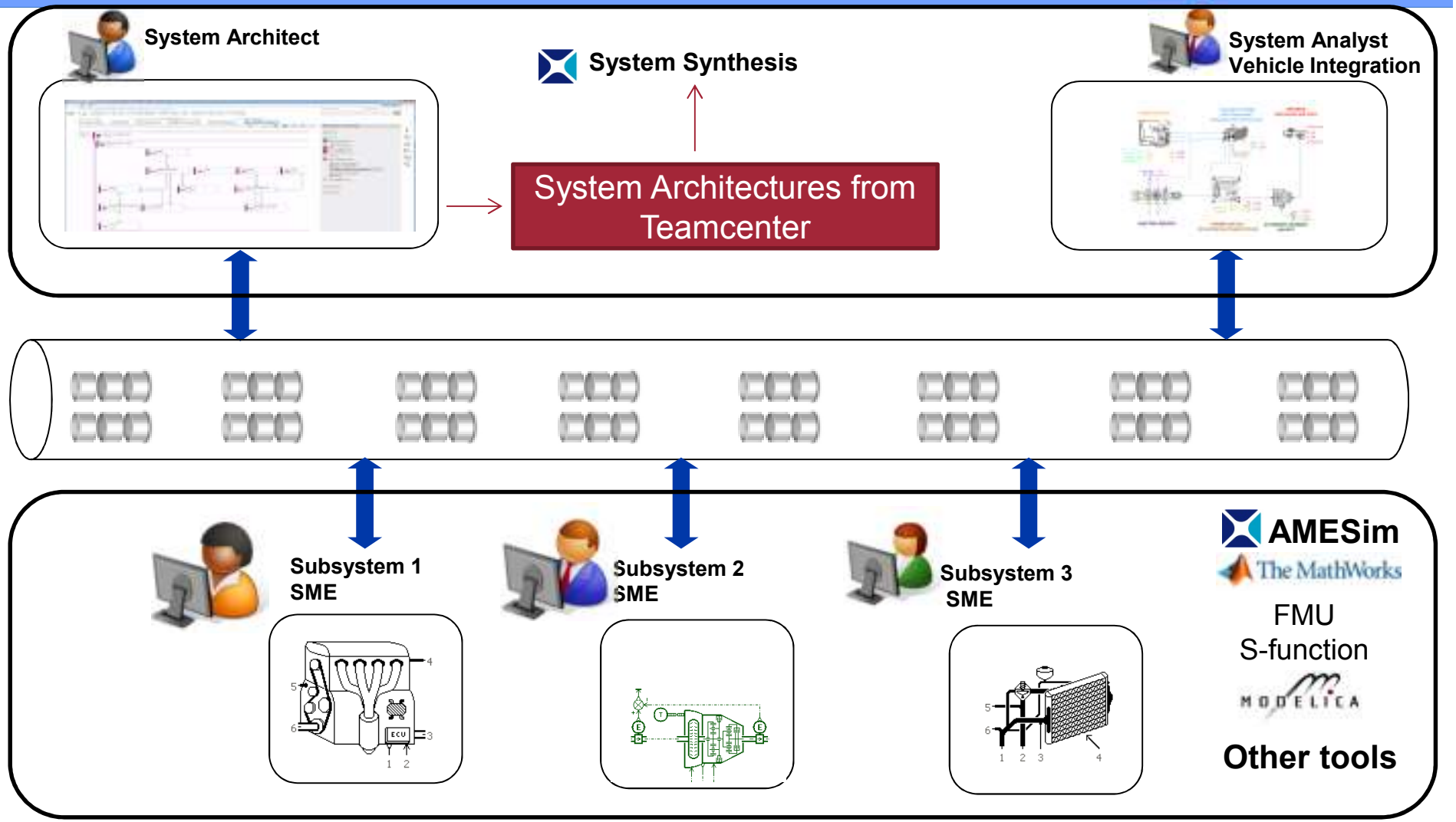
MBSE Process in reality
Customer pain 5

Traceability to Requirements	• Requirements based Analysis
Multi-level approach	• How to switch easily from one level to another one?
Parameters and Test methods	• What type of analysis and where are the parameters available? • How do we manage the process flow?
Multiple authors	• How customer can share/store models/data from other departments?
Heterogeneous cosimulation	• How to capitalize and integrate the “right” models from various vendor and in-house tools?

Siemens MBSE Solution Landscape

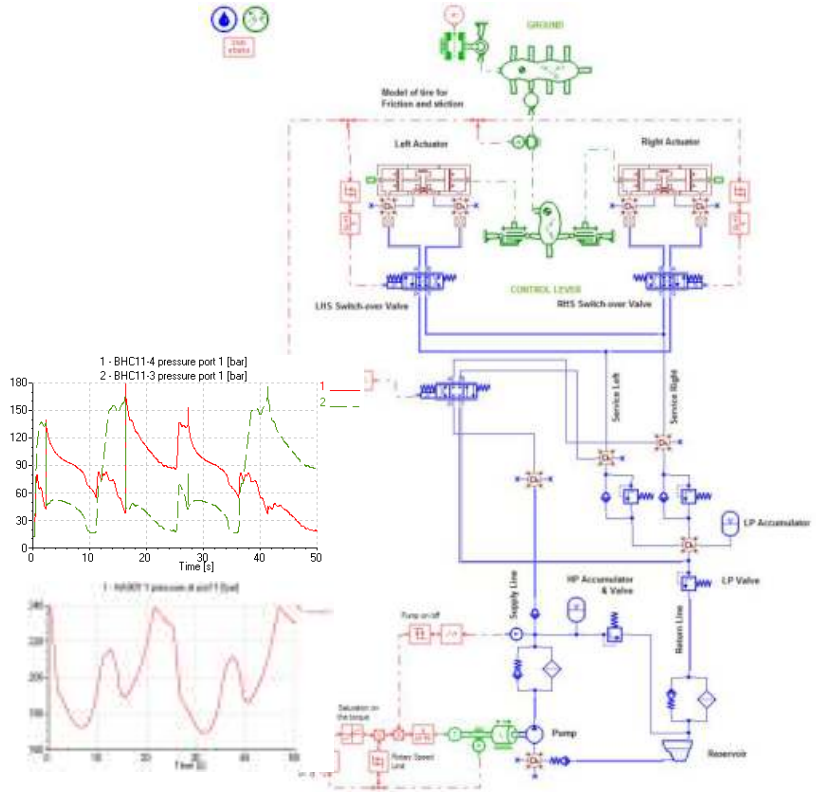


Architecture Driven MBSE process



AMESim: Multi-Functional (Plant) System simulation

CREATING MODELS



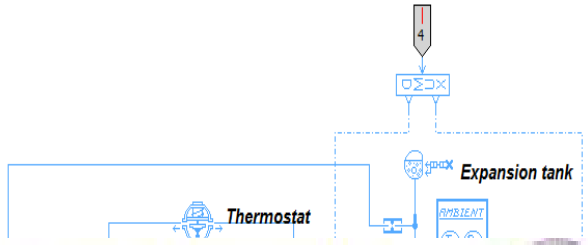
- **Integrated platform for Multi-Functional & Multi-Disciplinary System simulation**
  - **36 libraries & 5000 models/equations**
  - **Scalability of models (high / low fidelity)**
  - **Integration with FEA, CFD, Simulink, Modelica**
  - **Support FMI standard FMI1.0, FMI2.0**
  - **Efficient solver, Parallel processing, Partitioning of models**
  - **Transient & Steady-state simulations**
  - **Optimization, DOE and Monte-carlo analysis**

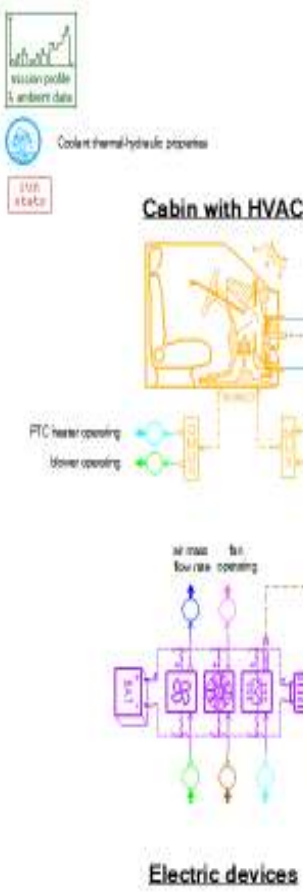
Diversitied AMESim Application Domain

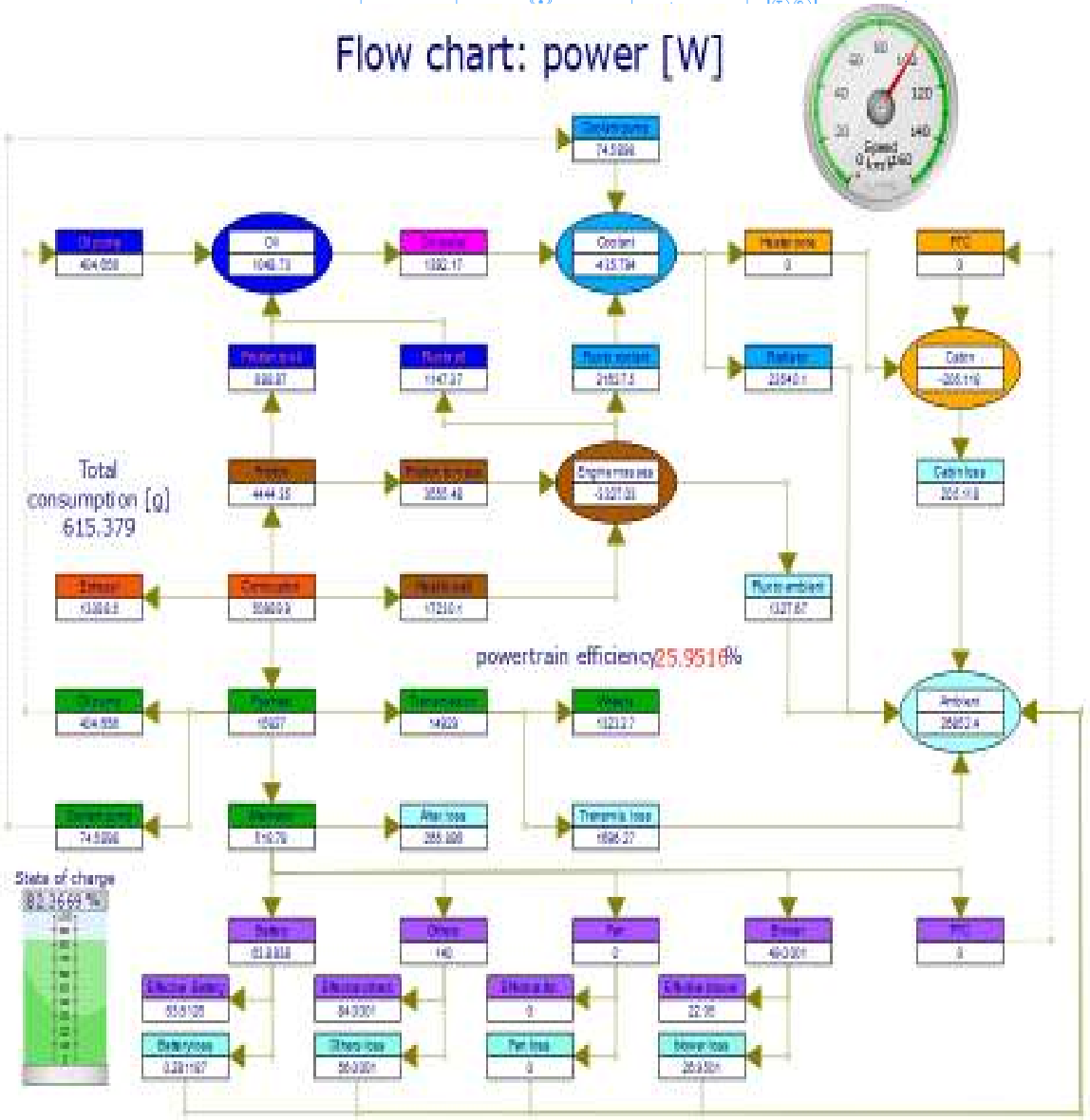
- Hydraulics
- Pneumatics
- 1D/2D/3D Mechanical systems
- Two-phase flow and HVAC
- Batteries and Fuel cells
- Electric motors and Drives
- Engine analysis
- Gearbox/Drivetrain analysis
- Energy / thermal mgmt
- Heat exchangers
- Performance analysis
- NVH analysis

Typical Amesim r

Global Product Data Interoperability S







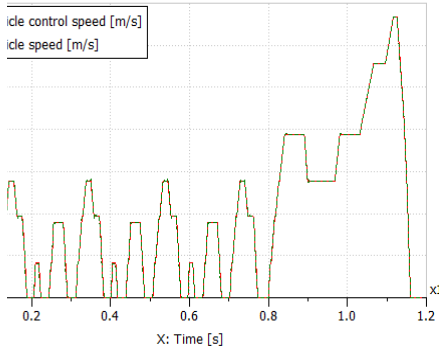


Figure 8: Driving cycle

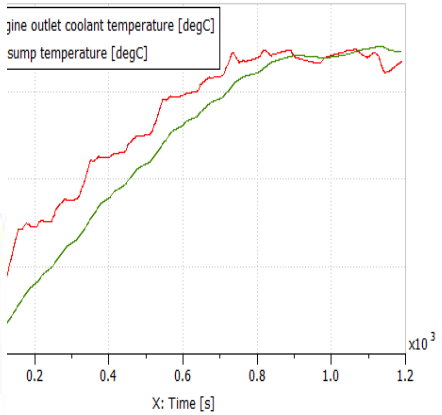


Figure 9: Temperatures of the system

ELYSIUM

System Synthesis: System Architecture and Configuration Tool

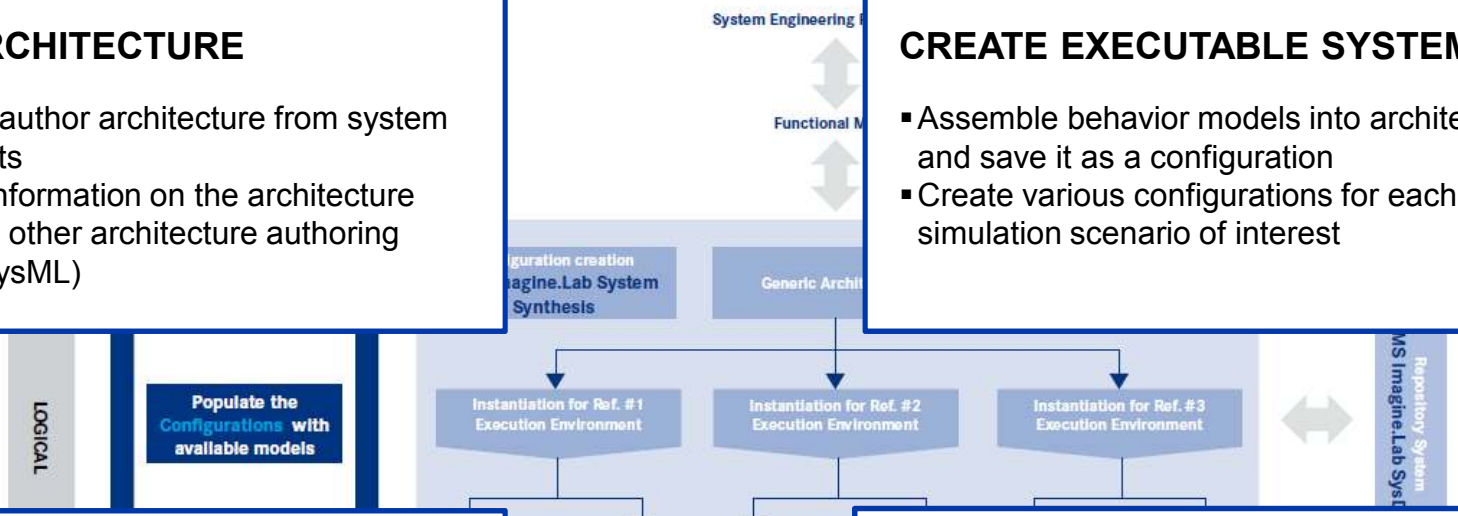
INTEGRATING MODELS

BUILD ARCHITECTURE

- Define and author architecture from system requirements
- Add meta-information on the architecture
- Import from other architecture authoring systems (SysML)

CREATE EXECUTABLE SYSTEMS

- Assemble behavior models into architecture and save it as a configuration
- Create various configurations for each simulation scenario of interest



RUN SYSTEM SIMULATIONS

- Select target simulation platform preference (Amesim, Simulink, Cosimate)
- Apply configurations and start simulation in target simulation platform (AMESim or Simulink®)

POST-PROCESS RESULTS

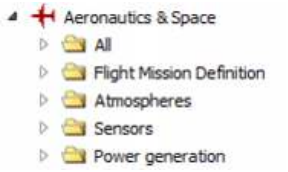
- Analyze simulation results
- Confront architecture choices

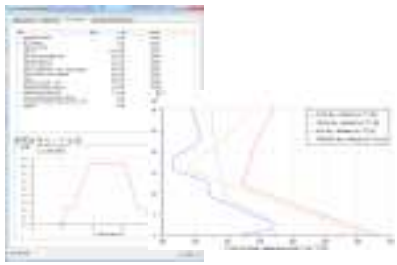
Virtual Integrated Aircraft Analysis

Global Product Data Interoperability Summit | **2015**

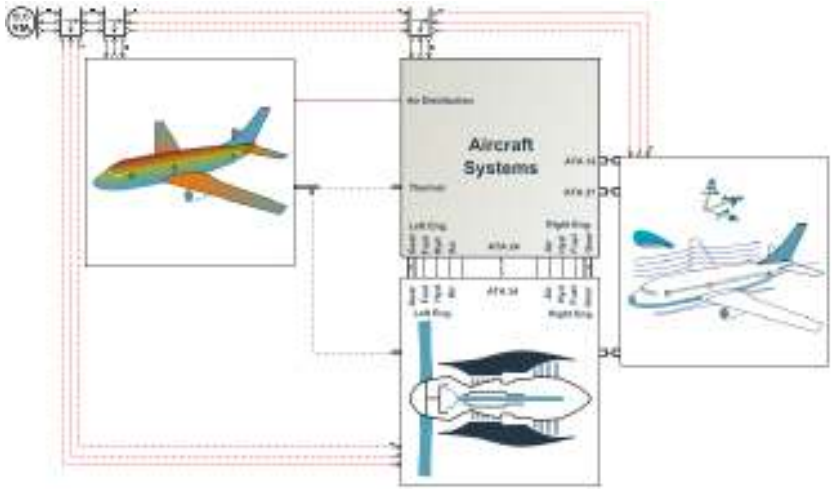
A

Scenarios

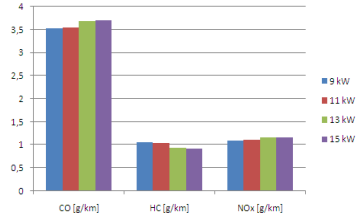




System model – Synthesis & analysis



Performance



Sub-Systems Models & Tools

Landing Gear

Flight Control

Engine Equipment

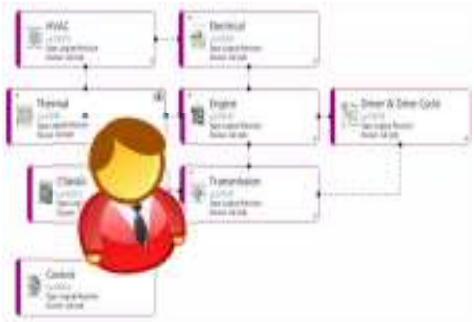
Fuel Systems

Environm. Control System

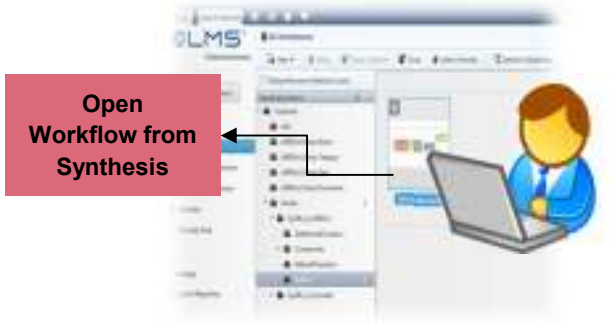
Aircraft Engine

Electrical Aircraft

Typical Use case



Attribute Owner



MBSE Simulation Engineer

Open Workflow from Synthesis

Create Validation Package

Define Analysis Request

- System Architecture
- Input Parameters
- Targets
- Test Cases

Workflow

Retrieve Validation Package

Create from Logical or Reuse Simulation Architecture

Configure Architecture with validated models and simulation settings

Define and Execute Simulation Models

Test Reports, Attributes, and Sim App

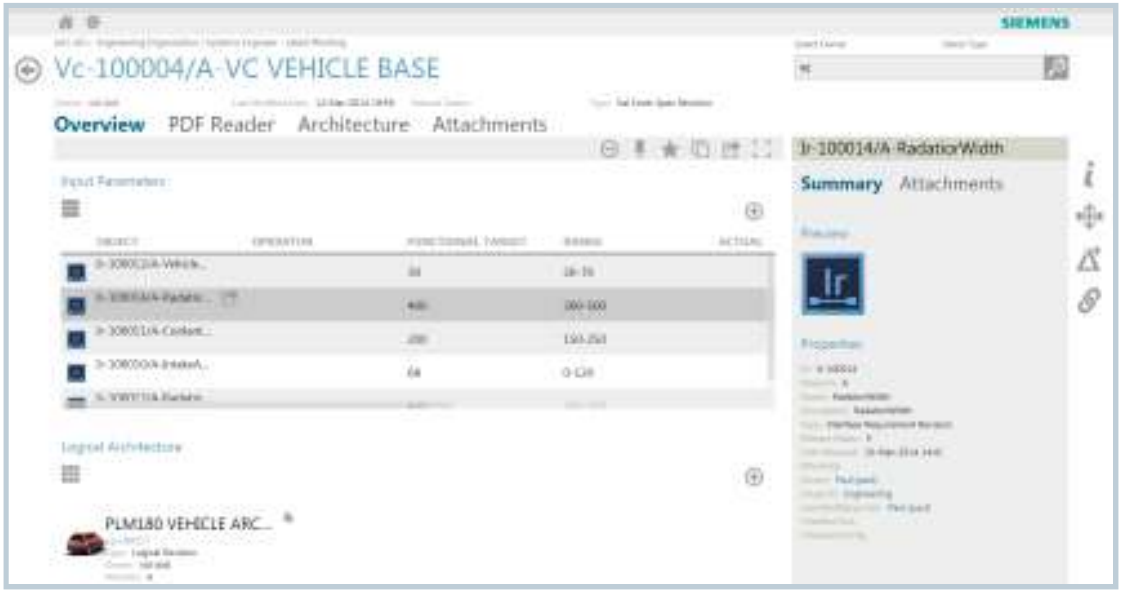
Simulation Configuration

Simulation Results, Attribute Values, Validated Simulation Architecture and Configuration

TEAMCENTER ⟷ **Traceability** ⟷ **System Synthesis**

Analysis Request: Definition

- **Defines a Analysis Request between vehicle engineer and an SME from 1D-3D-Test domain**
- **Holds information to be exchanged back and forth between users including…**
  - **Test Cases (Methods)**
  - **System Requirements**
  - **Interface Requirements**
  - **Target Attributes**
  - **Input Parameters**
  - **Test Results**
  - **Output Parameters**
- Can be accessed by both the vehicle and simulation / test engineer through workflow and change management



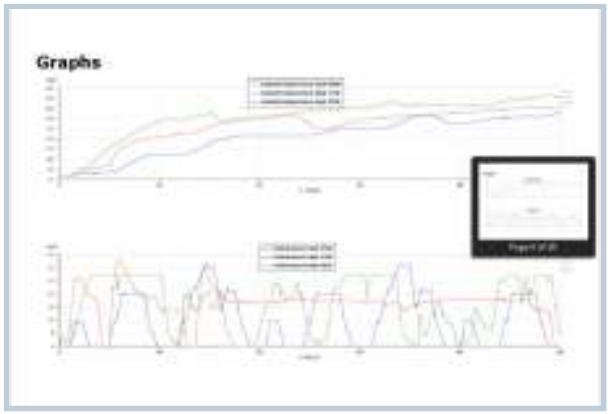
Validation of Requirements

Challenges

- Capturing decisions and lessons learned for future projects
- Confirming simulation results
- Complex simulations are difficult to convey non-experts

Benefits

- Framework for capturing and correlating decisions, while enabling reuse
- Continuous insight on status of key architecture and integration parameters
- Ability for non-experts to leverage simulation models to evaluate alternatives upfront



Simulation Results

Application Dashboard

Conclusion

Traceability to Requirements	• Requirements based Analysis
Multi-level approach	• How to switch easily from one level to another one?
More and more details	• What's about the visibility of the sketch?
Multiple authors	• How customer can get models/data from other departments?
Heterogeneous cosimulation	• How to capitalize the "right" models and cosimulate them?

Q & A