THE BATTERY SHOW
NORTH AMERICA

electric & hybrid vehicle technology expo | north america

Model Based Systems Engineering Approach to Battery Design

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Dassault Systemes

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MODEL BASED SYSTEMS ENGINEERING

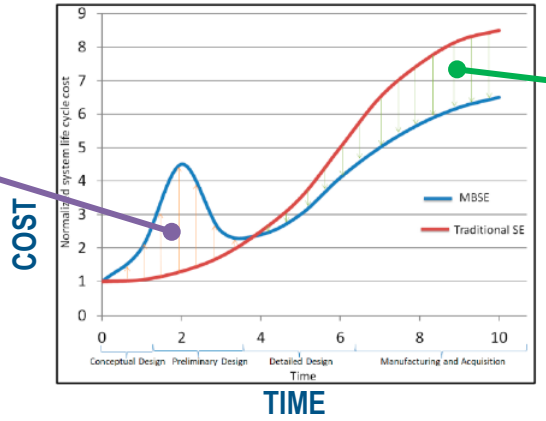
"Model-based systems engineering (MBSE) is the formalized application of modeling to support system requirements, design, analysis, verification and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle phases."

INCOSE SE Vision 2020 (INCOSE-TP-2004-004-02, Sep 2007)

- Behavioral analysis
- Systems Architecture
- Requirement Traceability
- Performance Analysis
- Simulation
- Design change impact
- Testing
- …..

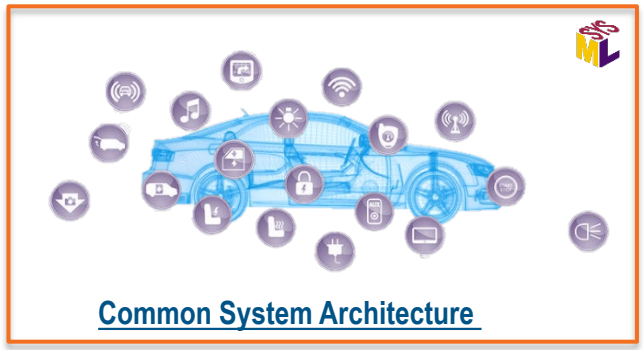
PERFORMANCE DESIGN USING AN MBSE APPROACH

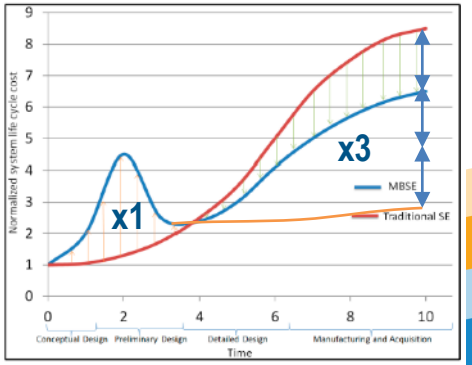
MBSE investments*
Methodology
Infrastructure
Training
Model Development



MBSE gains*
Early defect detection
Virtually predict system behavior
Continuously manage uncertainties
Standard conformance & traceability

Leverage Gains over Multiple Programs
Quality, Cost, Schedule

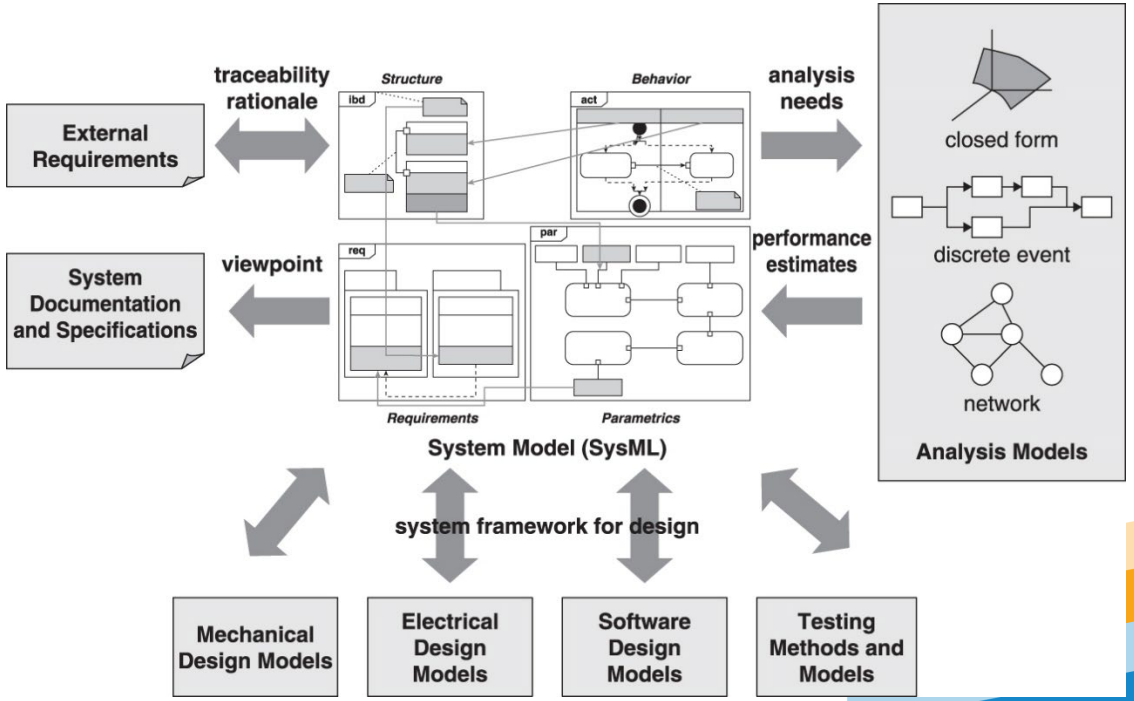




*Source: Azad M. Madni * and Shatad Purohit, "Economic Analysis of Model-Based Systems Engineering", University of Southern California, February 2019

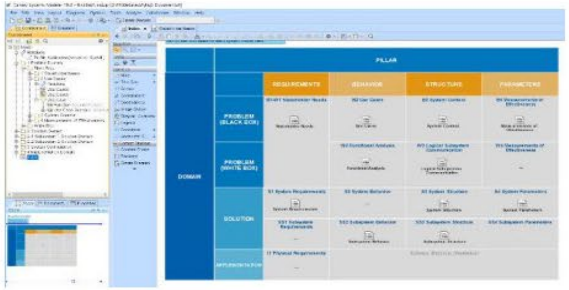
SYSTEMS MODEL AS AN INTEGRATION FRAMEWORK

Using a standard language simplifies engineering complexities between mechanical, electrical, software, and other components.

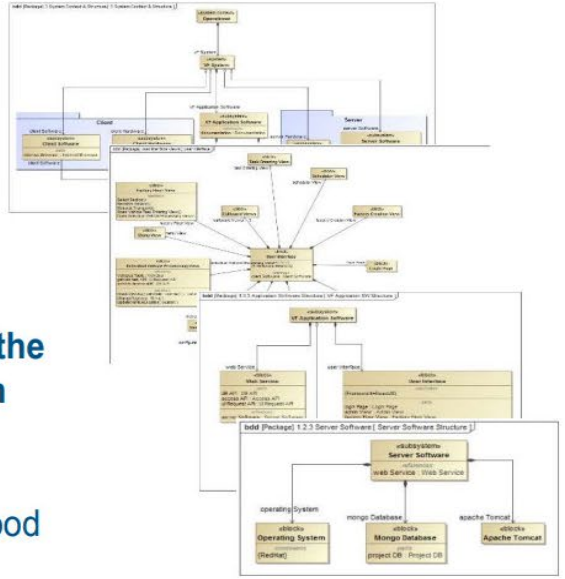


REQUIREMENTS, STRUCTURE & BEHAVIOR IN SYSML

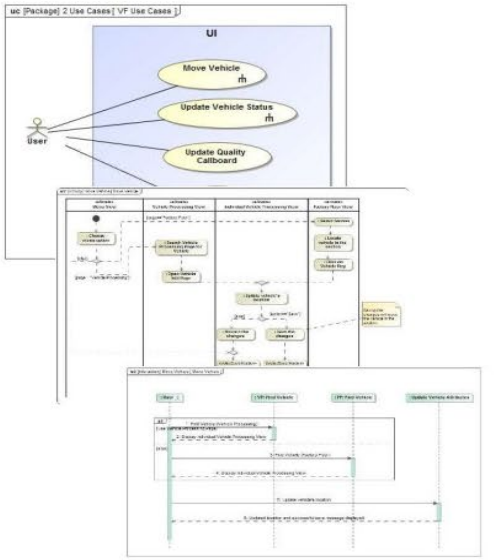
MBSE Framework



System, HW & SW Components



System Behavior, Functions



To understand a problem, understand first **the relationships** between **needs** and **system structure & behavior**.

Behavior of a system needs to be understood ***before*** requirements can be derived.

MODEL BASED SYSTEMS ENGINEERING

		PILLAR			
DOMAIN		REQUIREMENTS	BEHAVIOR	STRUCTURE	PARAMETERS
	PROBLEM (BLACK BOX)	Stakeholder Needs Stakeholder Needs	Use Cases Use Cases	System Context System Context	Measurements of Effectiveness MoEs
	PROBLEM (WHITE BOX)	Functional Analysis 1 Stakeholder Requirements	Functional Analysis Functional Analysis	Logical Subsystem Logical Subsystems Communication	Measurements of Effectiveness
	Vehicle	System Requirements Battery Requirements	System Behavior AC Charging	System Structure Vehicle Blocks Definition	System Parameters Battery Characteristic Parametric
	Pack Module	Subsystem Requirements Pack Requirements Specification Module Requirements Table	Subsystem Behavior Battery Behavior - Simulation	Subsystem Structure Battery Pack Block Definition - BDD	Subsystem Parameters Battery Characteristic Parametric
	Cell	Component Requirements Cell Requirements	Component Behavior	Component Structure Cell Configuration Block Definition - BDD	Component Parameters –
	IMPLEMENTATION	Physical Requirements –	Software, Electrical, Mechanical		

MODEL BASED SYSTEMS ENGINEERING

DOMAIN	PILLAR: REQUIREMENTS	BEHAVIOR	STRUCTURE	PARAMETERS
PROBLEM (BLACK BOX)	Stakeholder Needs Stakeholder Needs	Use Cases Use Cases	System Context System Context	Measurements of Effectiveness MoEs
PROBLEM (WHITE BOX)	Functional Analysis 1 Stakeholder Requirements	Functional Analysis Functional Analysis	Logical Subsystem Logical Subsystems Communication	Measurements of Effectiveness
Vehicle	System Requirements Battery Requirements	System Behavior AC Charging	System Structure Vehicle Blocks Definition	System Parameters Battery Characteristic Parametric
Pack Module	Subsystem Requirements Pack Requirements Specification Module Requirements Table	Subsystem Behavior Battery Behavior - Simulation	Subsystem Structure Battery Pack Block Definition - BDD	Subsystem Parameters Battery Characteristic Parametric
Cell	Component Requirements Cell Requirements	Component Behavior	Component Structure Cell Configuration Block Definition - BDD	Component Parameters –
IMPLEMENTATION	Physical Requirements –	Software, Electrical, Mechanical		

Problem

Solution

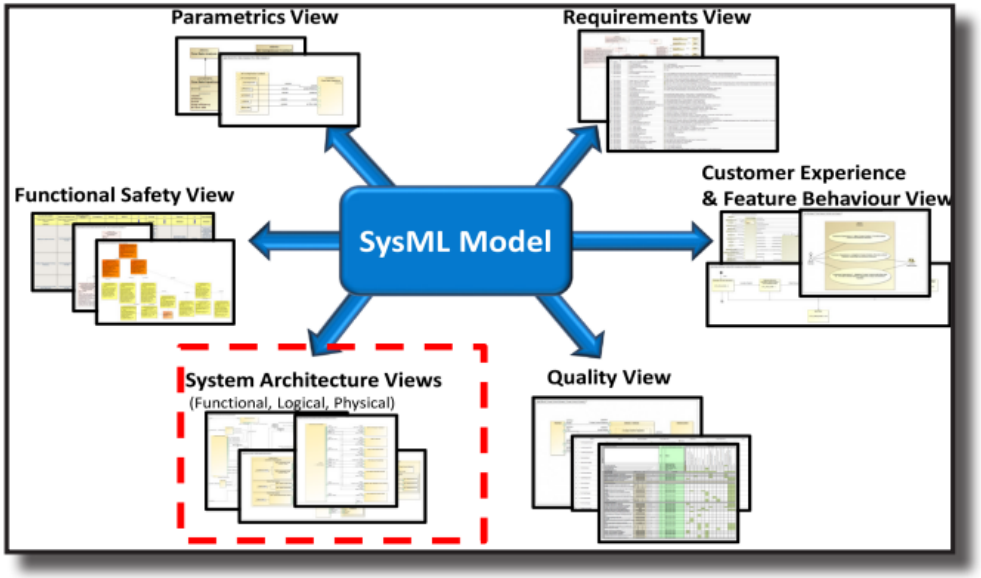
Design

DEMO

DEMO

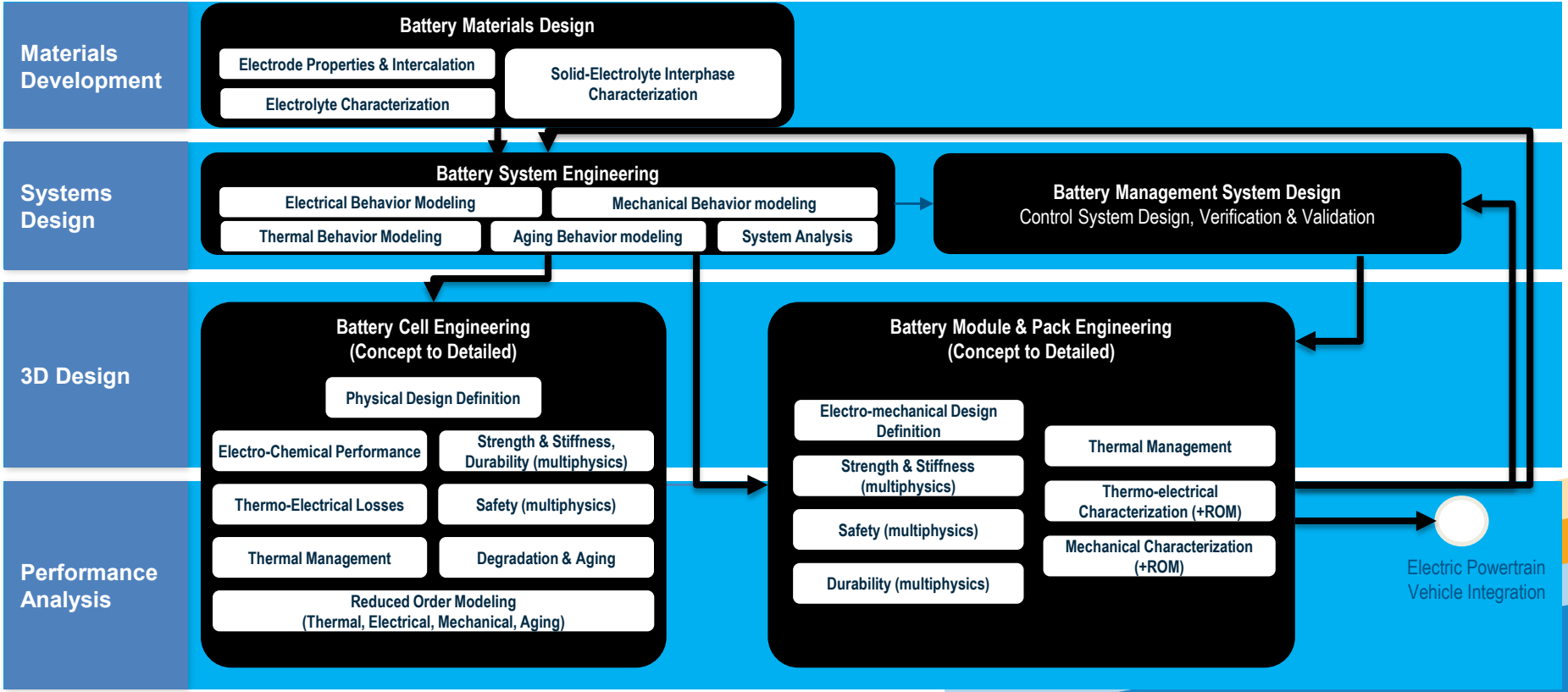
DASSAULT SYSTÈMES MBSE

MBSE with SysML is developed and extended to manage the engineer's ability to model and analyze complex Systems of Systems (SOS).



INCOSE Automotive Vision 2025 - 65

BATTERY ENGINEERING PROCESS

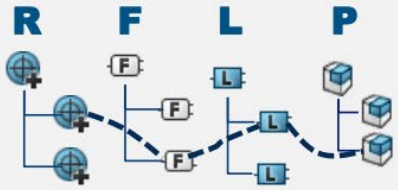


MBSE PILLARS

1

Multi-scale systems Experience

2



Digital Continuity

3

Standard Support & Openness

3DEXPERIENCE Twin = Disciplines Federation + Agile Collaboration + Virtual Trust

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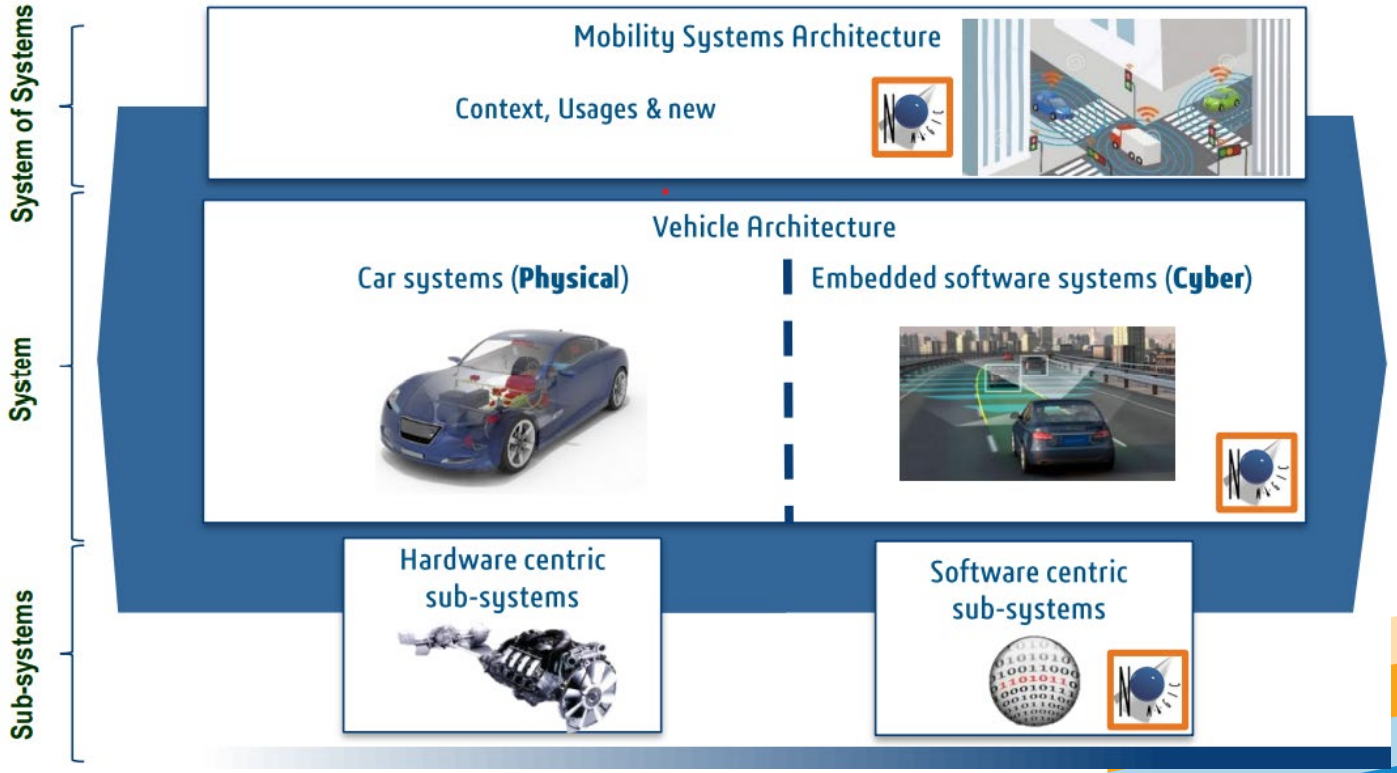
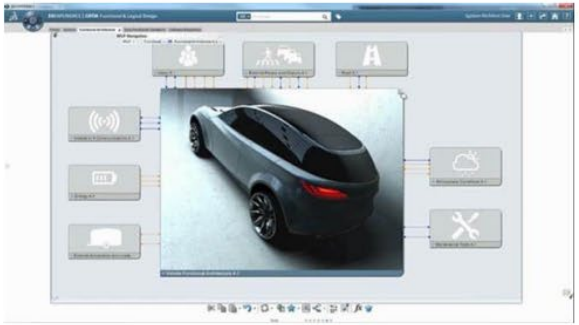
DESIGN “MULTI-SCALES” CYBER-PHYSICAL SYSTEMS

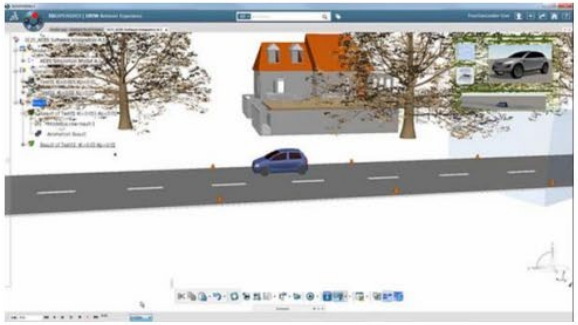


DIGITAL PROCESSES CONTINUITY TO DESIGN, VALIDATE & EXPERIENCE

Systems **Design**



Virtual **Validation**



Usage **Experience**

Virtual System Mockup = Disciplines Federation + Agile Collaboration + Virtual Trust

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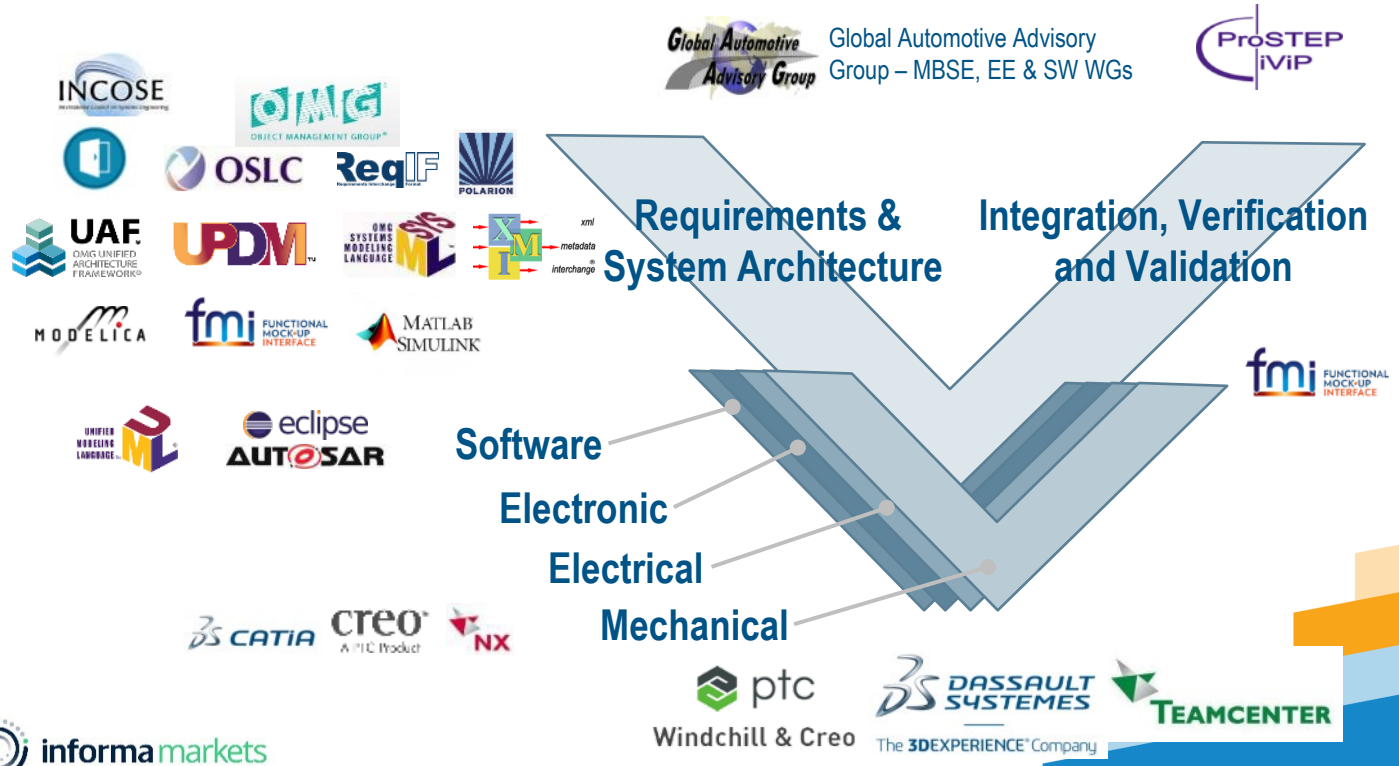
OPENNESS

- An Opened Platform for Systems Engineering



Adopt and Drive **Standardization initiatives** with **Industry Communities: OMG, INCOSE**

Support **Industry Standards** and Provide **Connectors** to external legacy tools used by our Customers, **power' by** **3D**Experience Platform, Siemens TC, PTC Windchill

DIGITAL CONTINUITY HUB FOR MBSE

End-to-End Traceability

Project, Configuration and Change Management

Requirements Management

Quality Analysis
Design Failure Modes & Effects Analysis

Operational Vision

Mission modeling, simulation and optimization

Multi-systems contractual architecture and services models

Functional View

Functional modeling simulation and optimization

System Architecture & Functions models

Constructional View

Solution modeling simulation and optimization

Solution Architecture models and 3D outfitting model

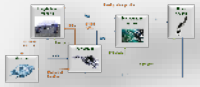
Mechanical

Fluid

Electrical

…

Electronics/Embedded Software



Hardware architecture

Software architecture

Hardware

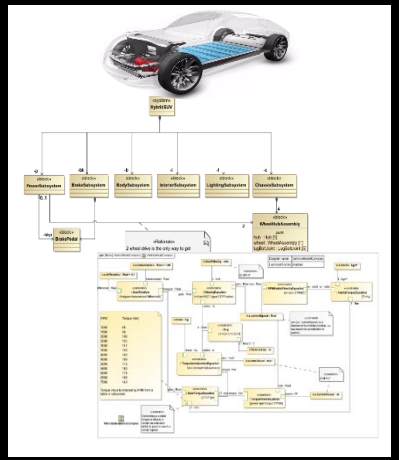
Software

Test Management

OSLC · PDF · UAF · UPDM · modaf · AUTOSAR · ReqIF · STEP · ReqIF · BPMN · fmi

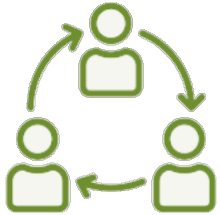
MODEL BASED SYSTEM ENGINEERING VALUES

Modeling



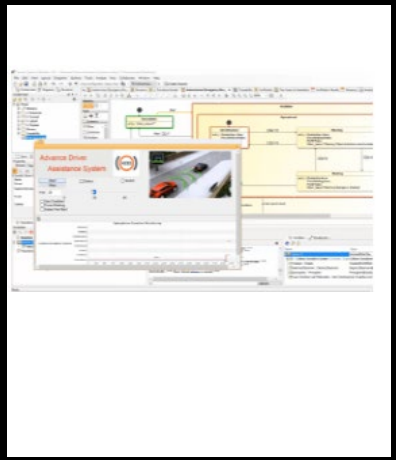
- Components attributes
- Hierarchical architecture
- Modification propagation
- Standard modeling rules (SysML,…)
- Automatic architecture checks Traceability
- Query capability

Collaboration



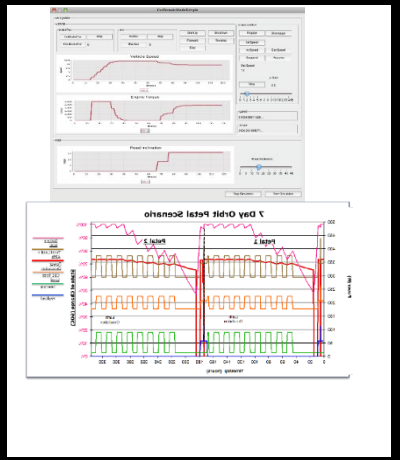
- Reuse of models Models versioning
- Centralized models management for concurrent engineering (availability, visibility, concurrent modifications,…)
- Collaborative reviews

Simulation



- Models validation through simulation
- Requirements verification
- Co-simulation with 3rd party models (FMI) for early virtual systems integration & early global evaluation

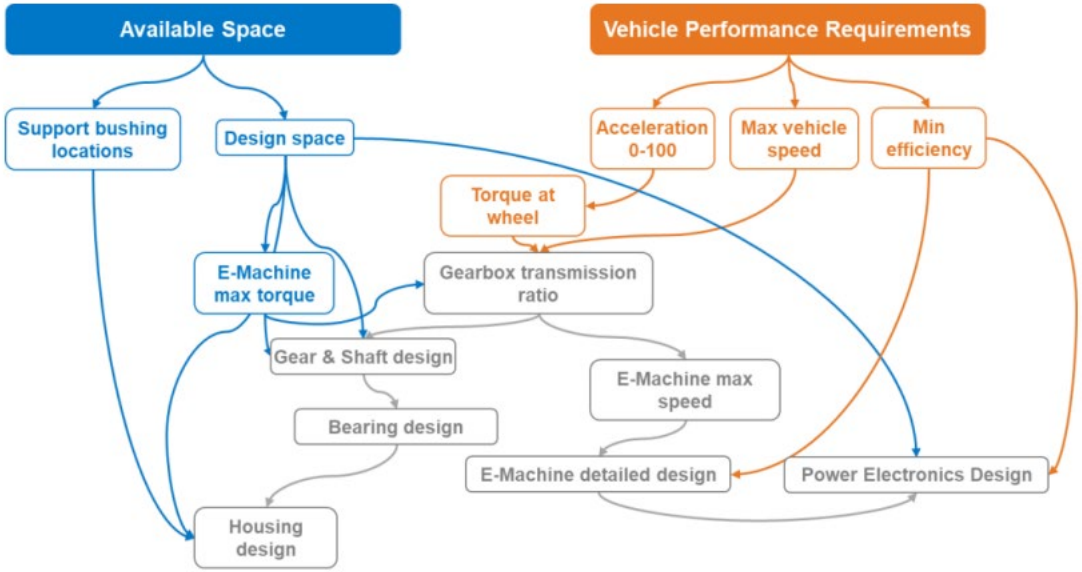
Analysis



- System trade-off analysis
- System optimization

MBSE METHODOLOGY BENEFITS

1. Development time & cost reduced by as much as **1/3**
2. Accurate prediction of **multidisciplinary KPIs** and opportunity for **multidisciplinary design optimization**
3. **Integrated systems engineering** approach to minimize complexity and ensure compliance with requirements
4. **Reduced risk** of warranty costs and recalls



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SUMMARY

- Model Based Systems Engineering (MBSE) , descriptive language and tools providing a single source of truth for complex systems

- Industry-proven simulation technologies and best practices methods enabling high confidence in system validation early insights into system inter-dependencies using MBSE approach

- MBSE provides integration with solutions for quality planning and verification & Validation for test strategy management

Thank you!

Questions?

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