PHOENIX INTEGRATION

2018 International Users' Conference

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Annapolis, Maryland | USA

Maplesoft Engineering Solutions

A Better Design with Model-Based Systems Engineering

Functional Verification using System-Level Modeling

Paul Goossens, VP, Engineering Solutions, Maplesoft

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Andy Ko, Ph.D., Manager of Engineering Services, Phoenix Integration

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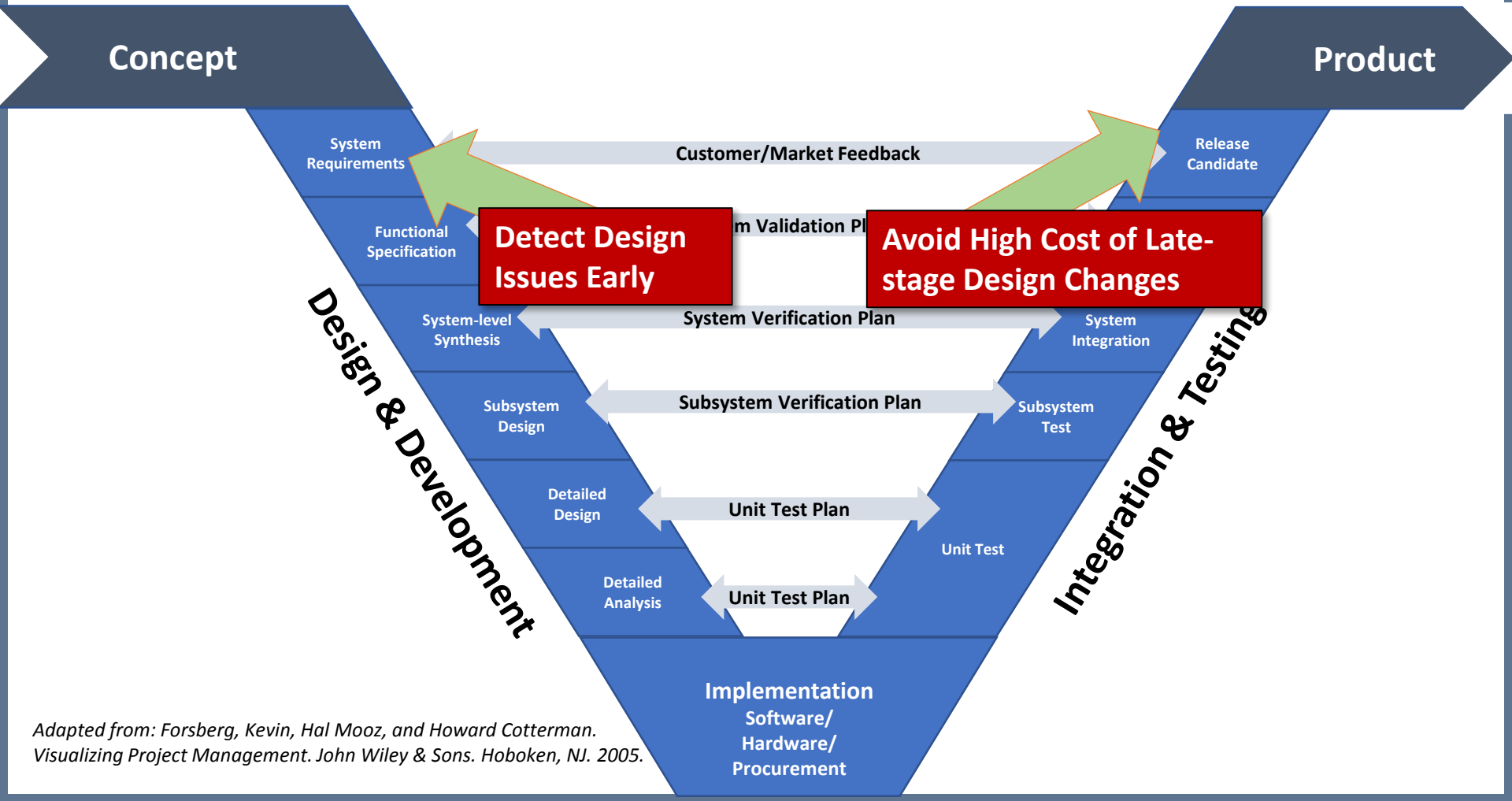
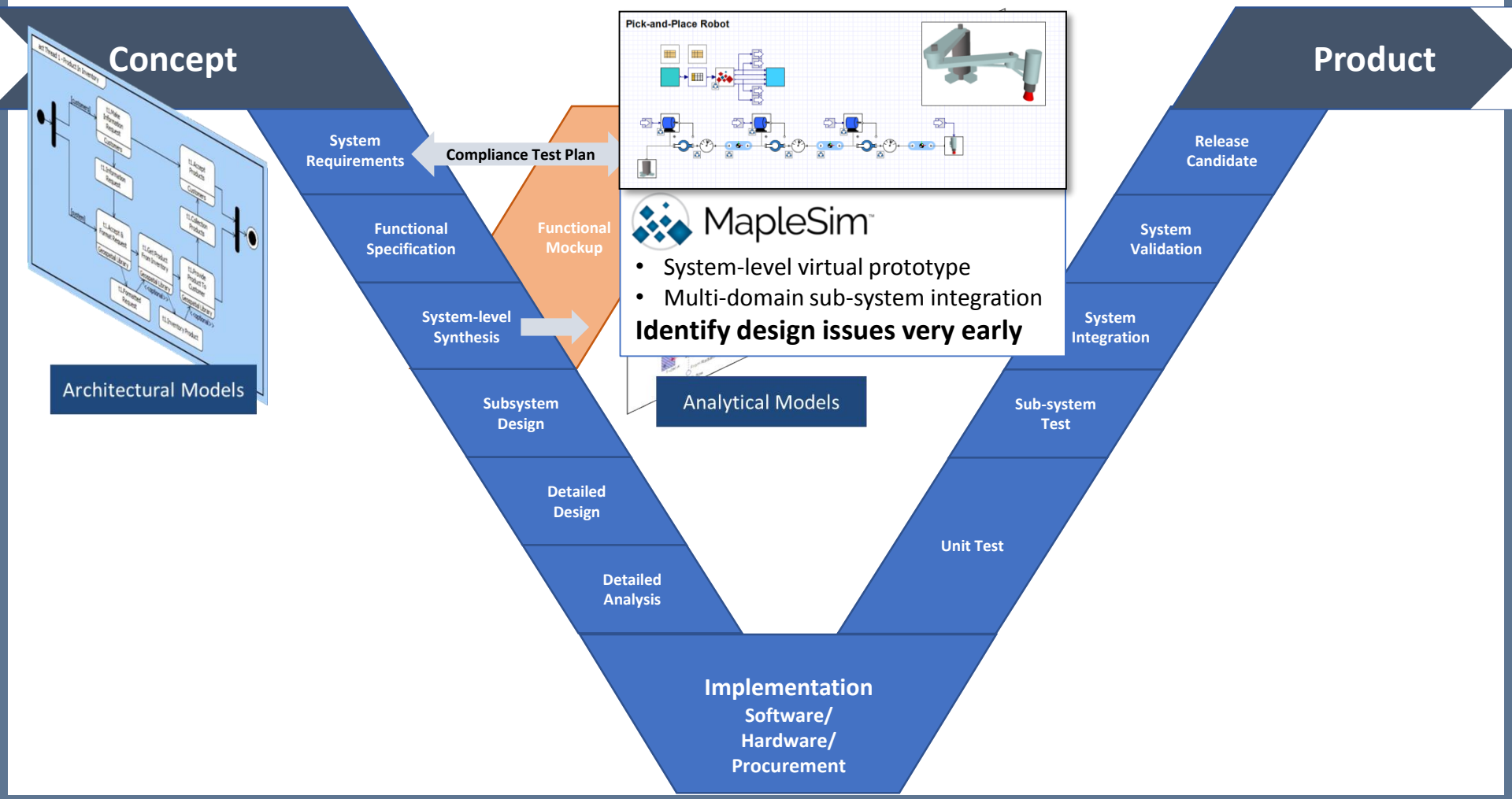
Systems Design & Development Process

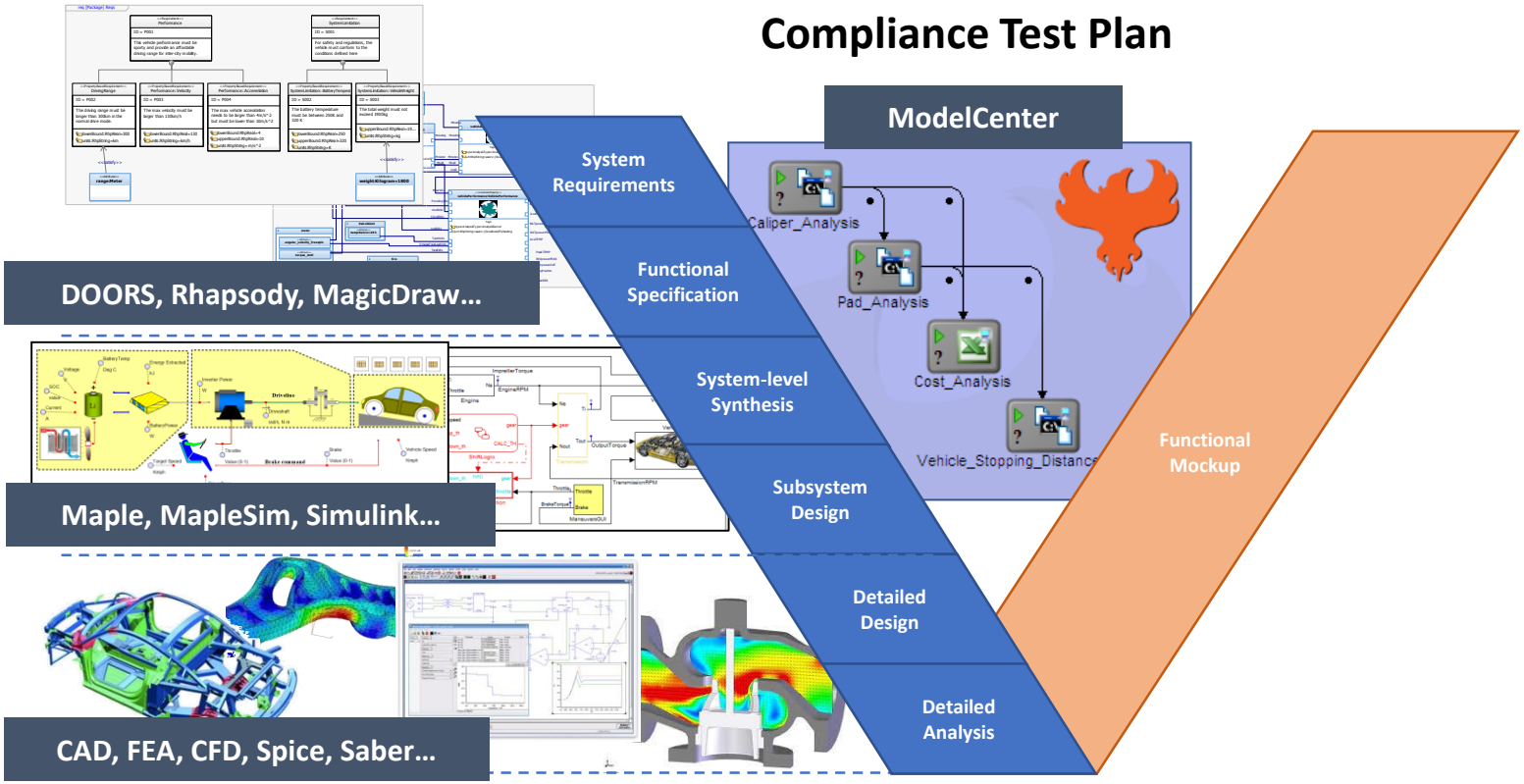


Adapted from: Forsberg, Kevin, Hal Mooz, and Howard Cotterman. Visualizing Project Management. John Wiley & Sons. Hoboken, NJ. 2005.

Systems Design & Development Process
Functional Verification



Systems Design & Development Process
Functional Verification



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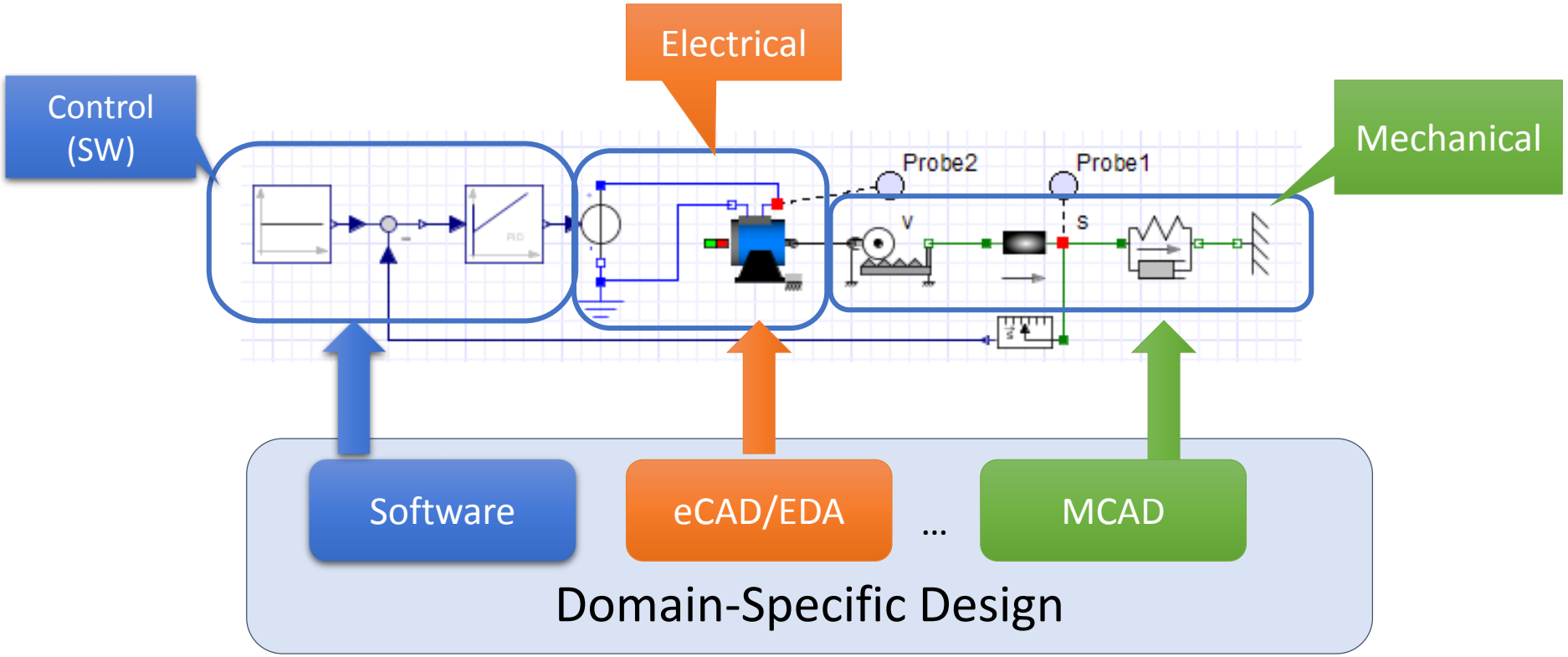

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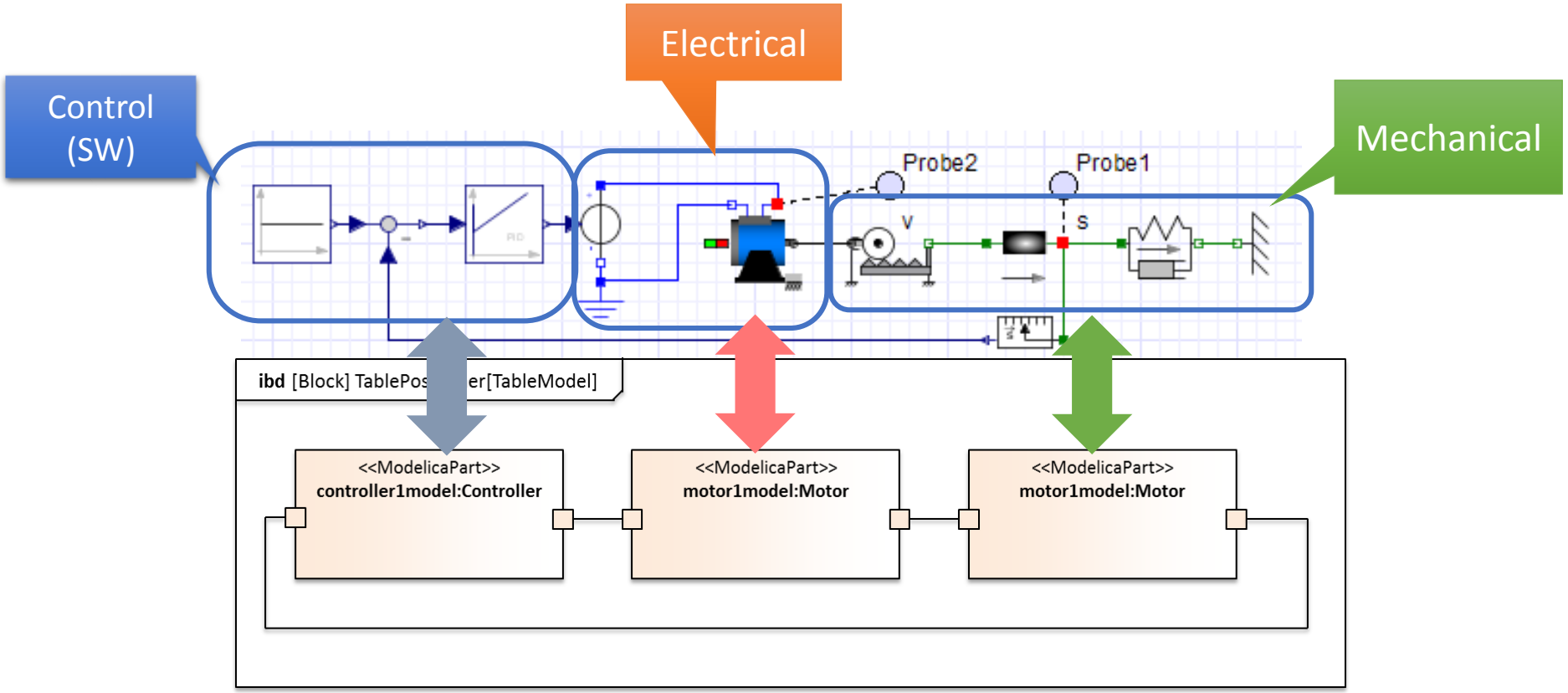
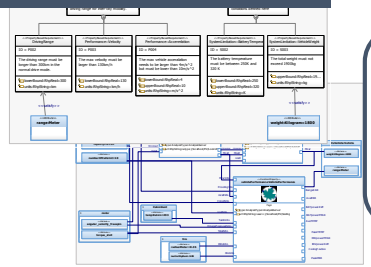


How to scale MBSE beyond “Expert use”?

MagicDraw, Rhapsody…



MBSE Experts

Architecture

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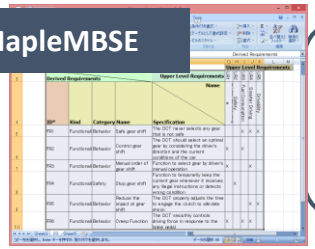


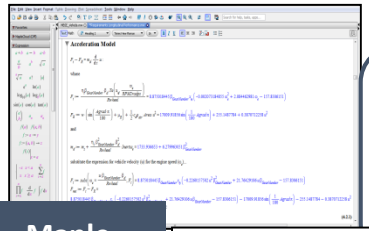
Design Stakeholders
Engineering, UX, Software, Business process etc

Detailed Architecture

Impact Analysis

System Architecture (SysML)
Structure
Behavior
Requirements
Parametric Constraints

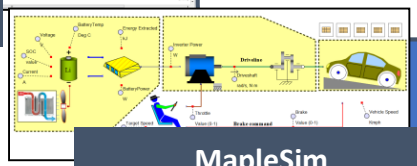
Maple



Engineering Analysts

Compliance Tests

Trade studies, etc



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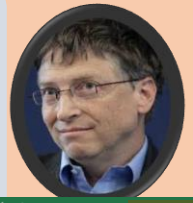
…many stakeholders need to do “modeling”

The aim of Systems Engineering is for many stakeholders to collaborate across many disciplines, so modeling tools for non-experts are vital

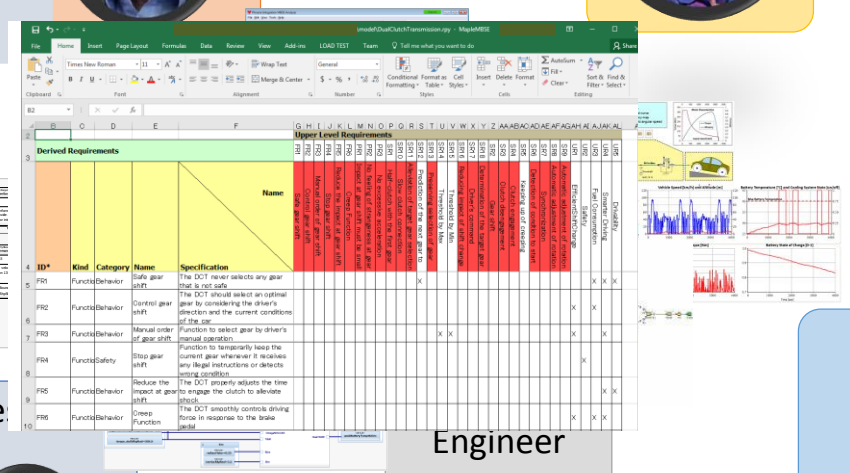
Integrate models with commonly used spreadsheet interface

Req. Analysts



Electronics Engineer

Project Manager



De

Engineer

Software Engineer

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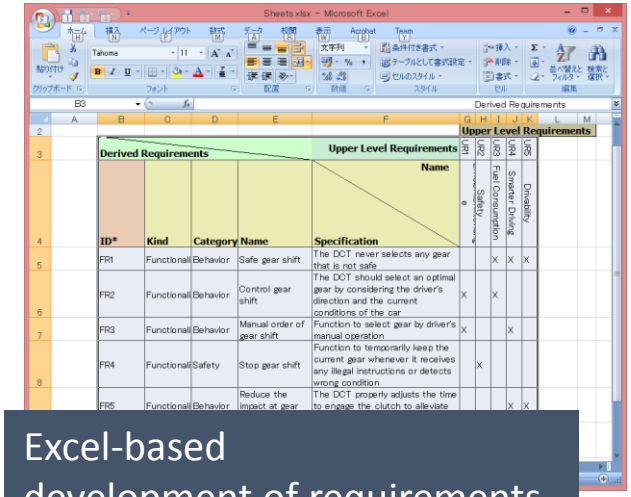

Excel-based development of requirements

- Intuitive, spreadsheet-based UI for entering detailed system design definitions
  - Structures
  - Behaviors
  - Requirements
  - Parametric constraints
- Integration with standard MBSE platforms (eg Rhapsody, MagicDraw) for rapid impact analysis of design changes, eg conflicting requirements
- Optimized views for specific tasks
  - Impact Analysis of Requirements
  - FMEA: Failure Mode & Effects Analysis
  - Trade-off studies
  - Structure analysis (Design Structure Matrix)

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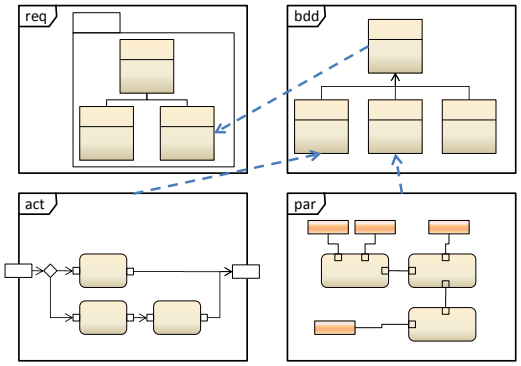
Andy Ko

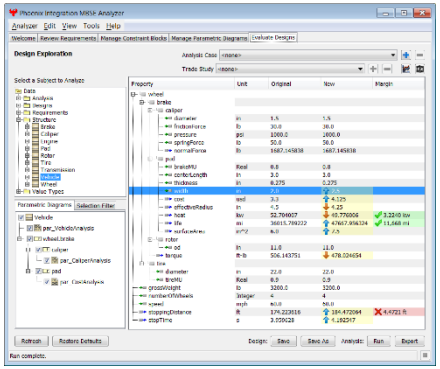
Design Verification with ModelCenter

PHX MBSE Pak

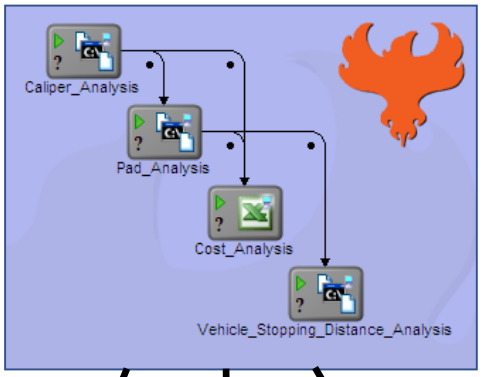
Systems Engineering: Architectural Model



MBSE Pak



Domain/Discipline Engineering: Executable Analysis Model



- Connect systems architecture models with engineering analyses to calculate system performance, check requirements, and perform design trade-offs
- Capabilities
  - Execute SysML parametric diagrams to evaluate designs
  - Perform requirements compliance analysis using modeling and simulation
  - Perform design trade-off studies
  - Update SysML models with analysis results
  - Import engineering analyses into a SysML model

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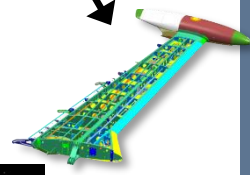
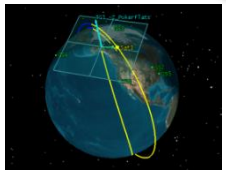


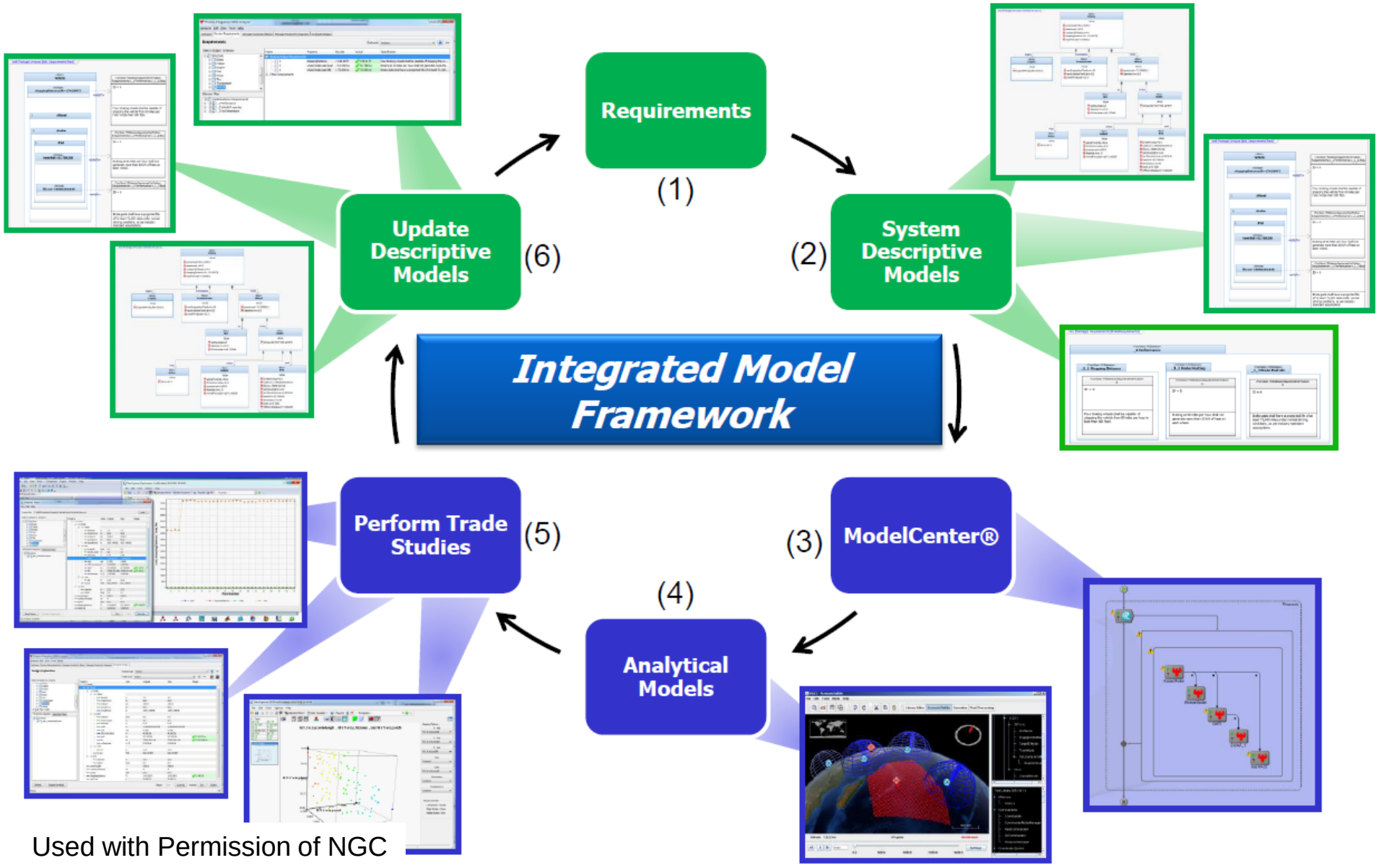


Engineering Analysis

Integrated Model Framework Example

Descriptive to Analytical and Back

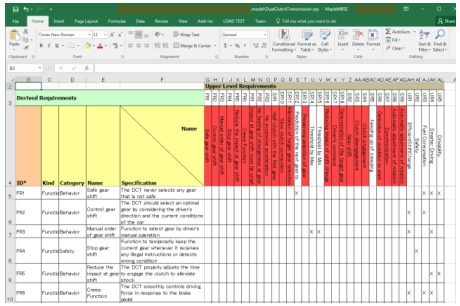
NORTHROP GRUMMAN

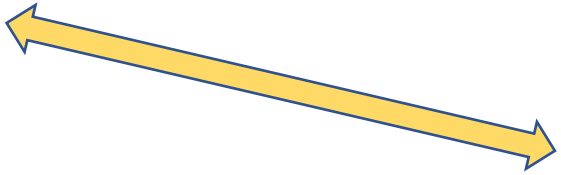


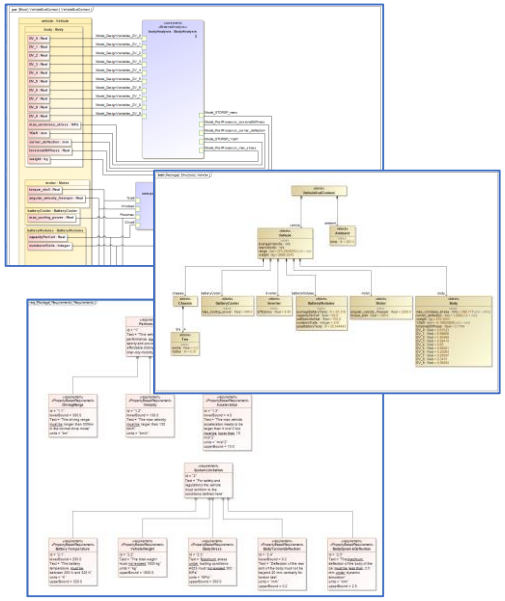
Used with Permission of NGC

Example Scenario

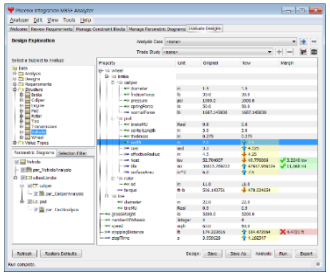
Maple MBSE

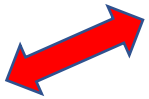




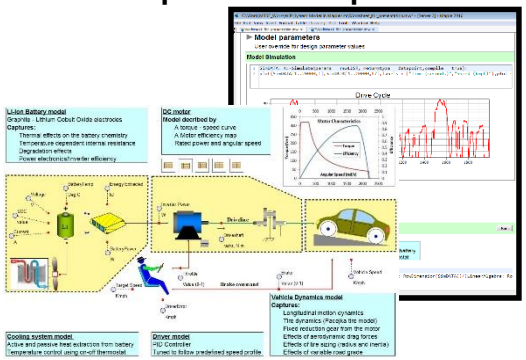


MBSE Pak





Maple & MapleSim

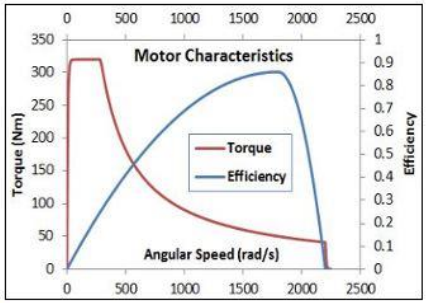


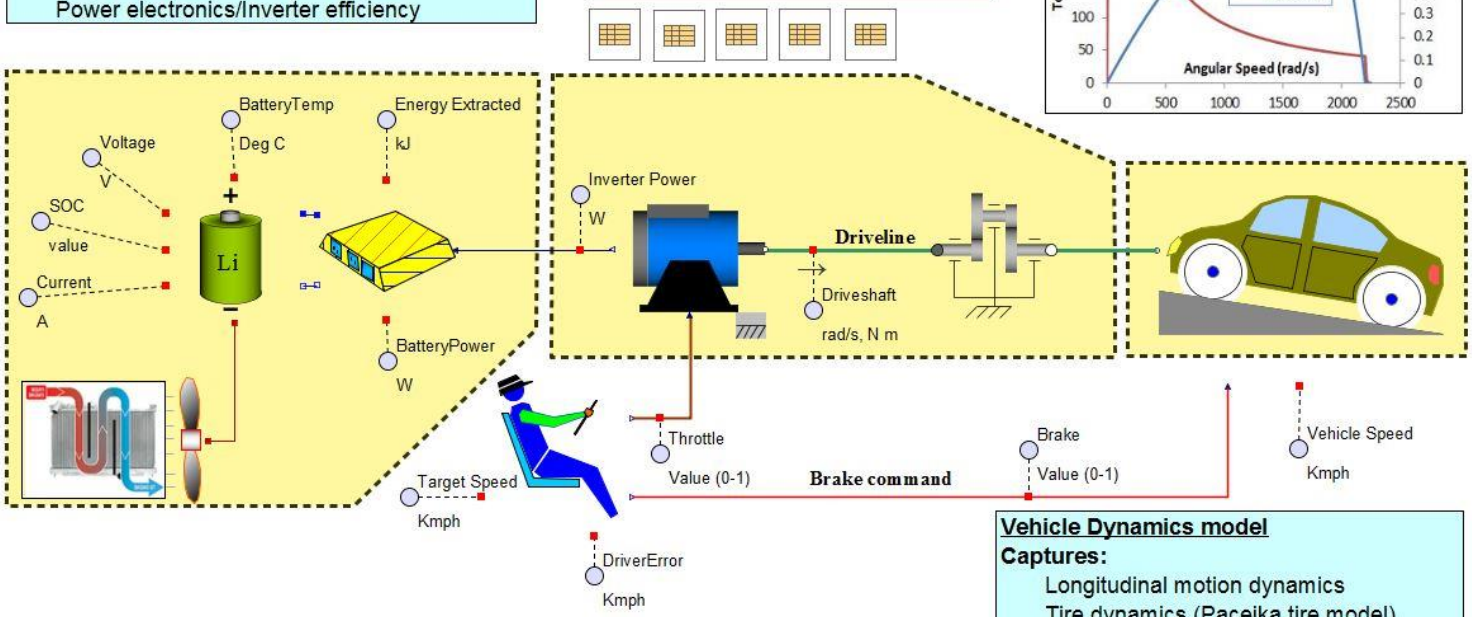
Systems Model

Analytical Model
Multi-domain System-level Dynamics

Li-ion Battery model
Graphite - Lithium Cobult Oxide electrodes
Captures:
- Thermal effects on the battery chemistry
- Temperature dependent internal resistance
- Degradation effects
- Power electronics/Inverter efficiency

DC motor
Model decribed by
- A torque - speed curve
- A Motor efficiency map
- Rated power and angular speed





Vehicle Dynamics model
Captures:
- Longitudinal motion dynamics
- Tire dynamics (Pacejka tire model)
- Fixed reduction gear from the motor
- Effects of aerodynamic drag forces
- Effects of tire sizing (radius and inertia)
- Effects of variable road grade

Cooling system model
Active and passive heat extraction from battery
Temperature control using on-off thermostat

Driver model
PID Controller
Tuned to follow predefined speed profile

Requirements Compliance Testing

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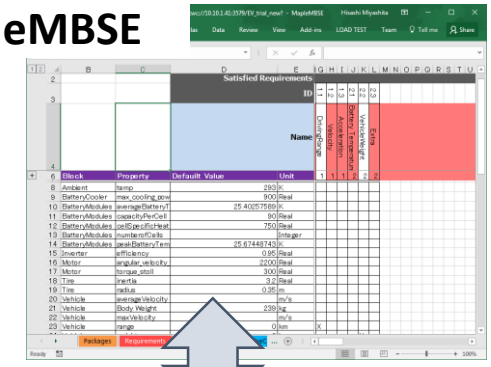
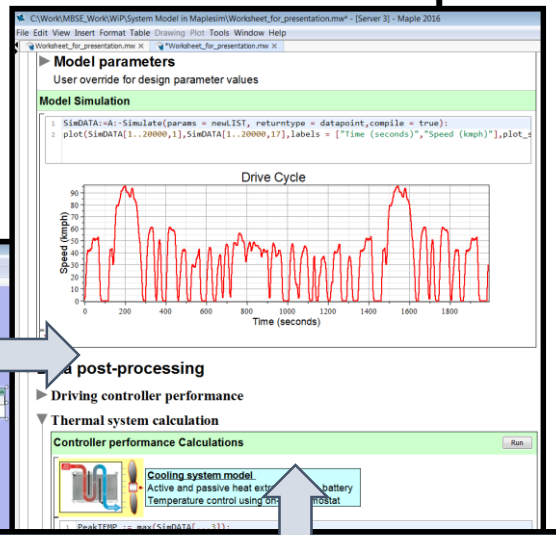
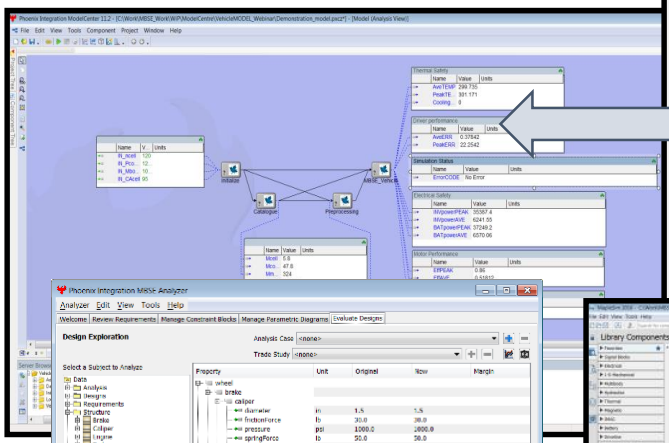


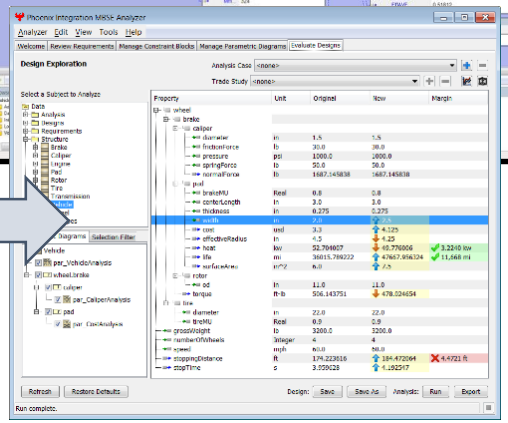
No Magic
Teamwork Cloud

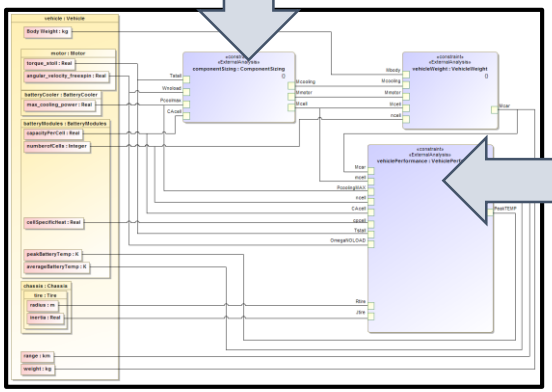
Maple



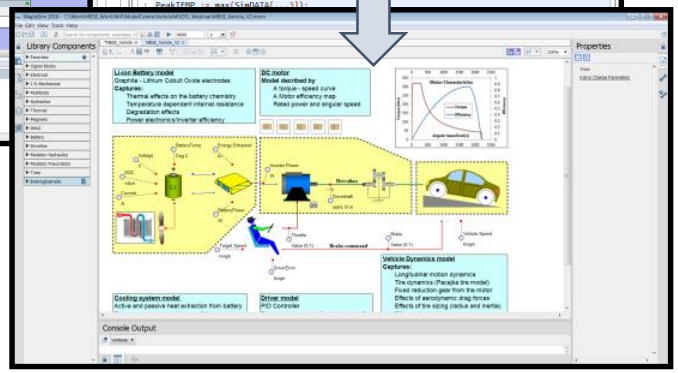
Phoenix ModelCenter with MBSEPak







Cameo Systems Modeler



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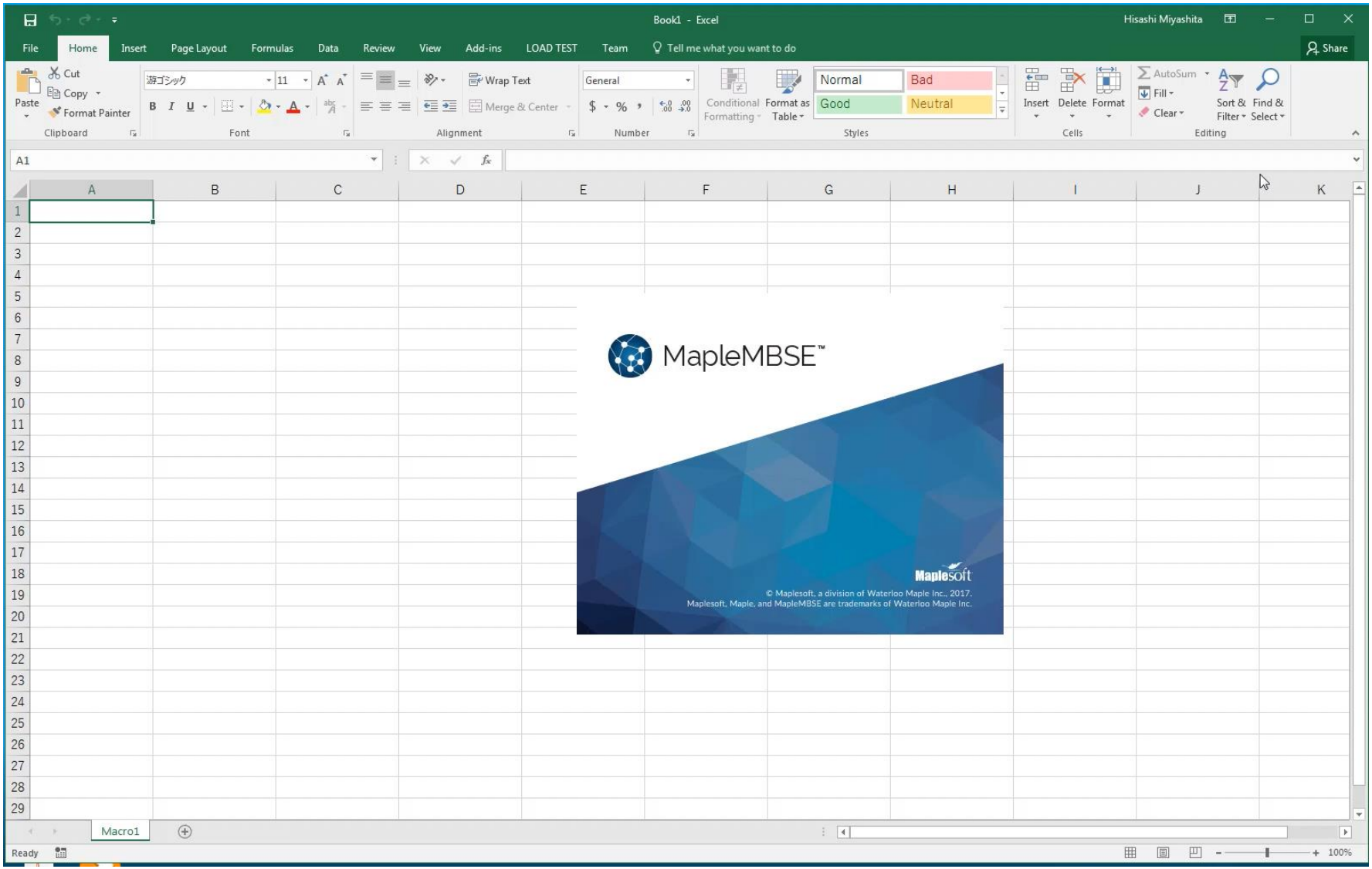

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Requirements Compliance Testing

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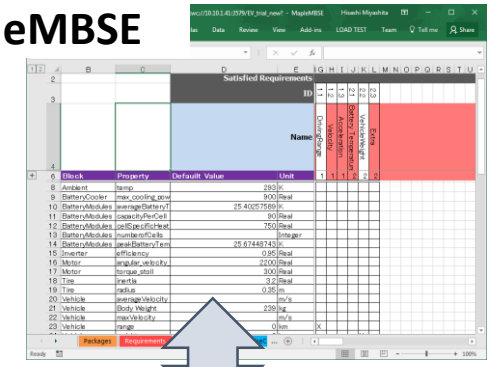

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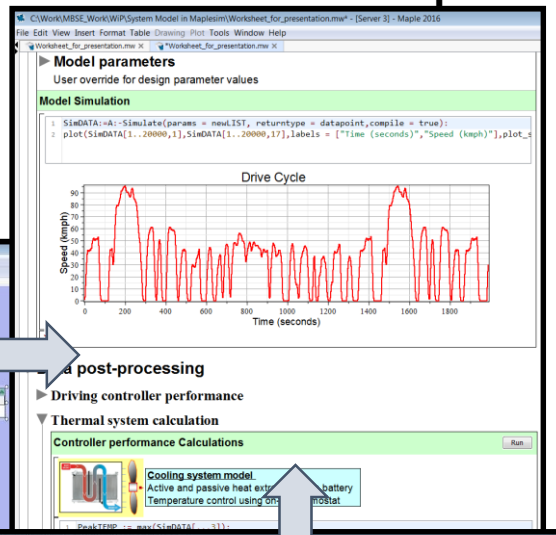
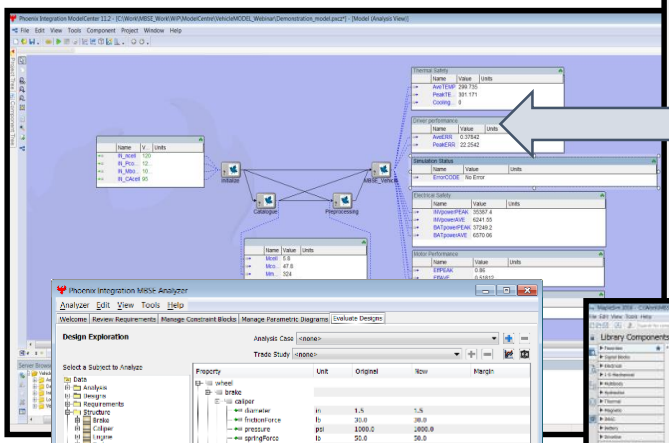


Phoenix ModelCenter with MBSEPak



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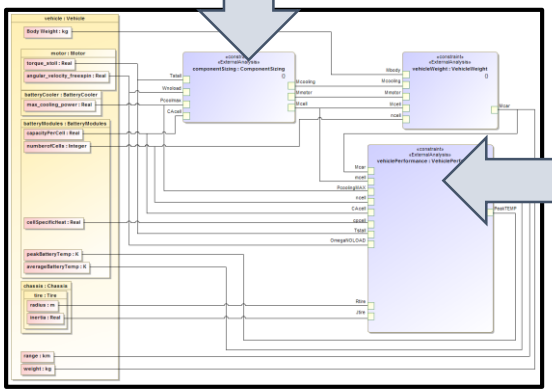

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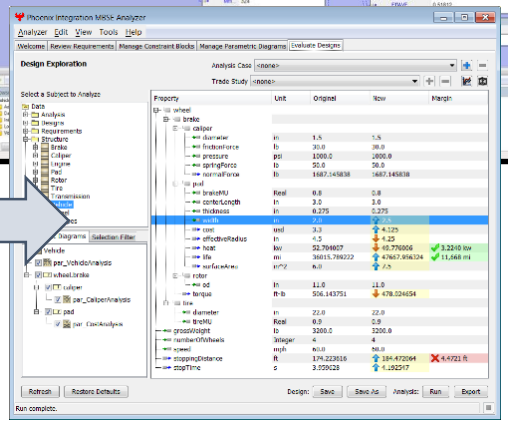

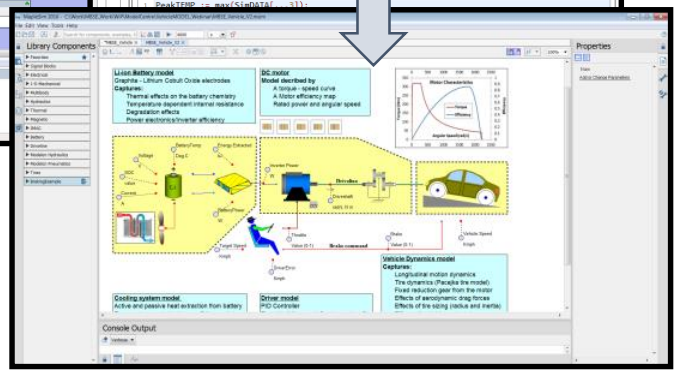

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Summary

- MBSE: Proven business methodology for managing design complexity, risk and costs
- MapleMBSE provides Excel-based UI for detailed product definition by a wide range of stakeholders, while maintaining integration with SysML architectural model
- MapleSim provide rapid functional mockups for verification of complex multidomain dynamic systems
- ModelCenter brings everything together for rapid requirements-compliance testing, trade-off studies, and impact analysis due to changes in design requirements
- **Convergence of tools helps realize the V process**

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Thank You

Questions?

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FREE Maple Plug-in for ModelCenter

- Easy implementation of Maple calculation worksheets in ModelCenter.
  - No need to convert to scripts
  - No “ModelCenter version” required
- Automatic detection of inputs and outputs from header information
- Dimensional units support
- Support for execution of MapleSim models
  - Pre-processing of model parameters
  - Model execution
  - Post-processing of results