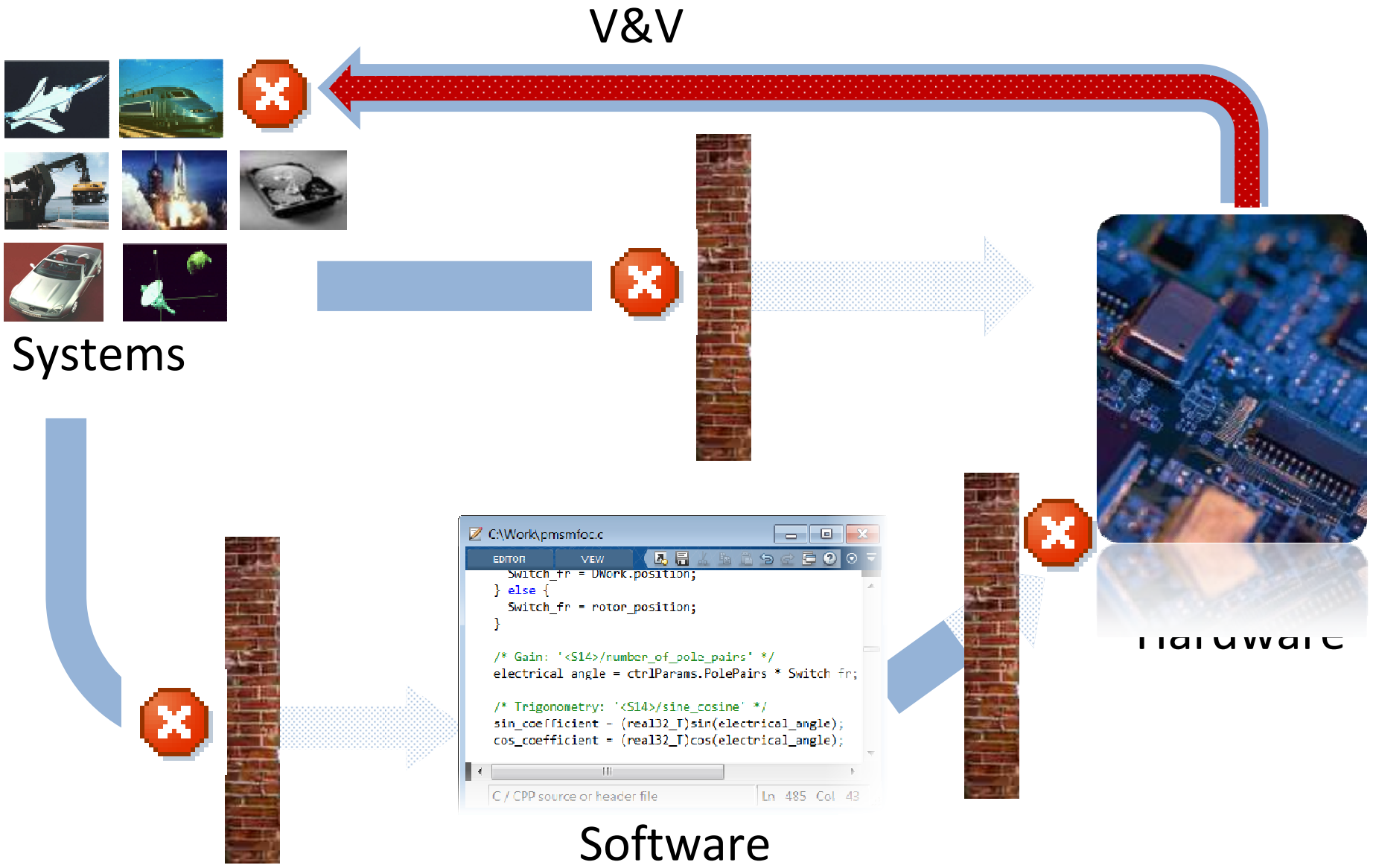
Model-Based Design of complex embedded systems using industry standards

Tom Erkkinen, Coder and Certification Product Manager, MathWorks

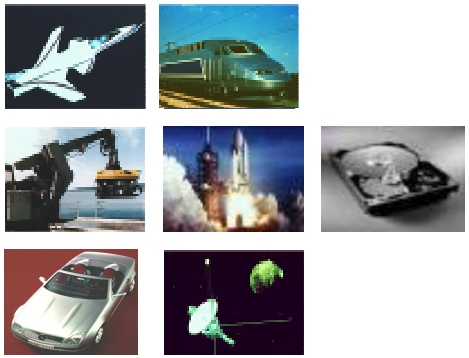
Agenda

- Model-Based Design Introduction
  - Key components
  - Users
  - Standards
- Model-Based Design Technologies
  - Systems
  - Software and Hardware
  - Verification and Validation (V&V)
- Q&A

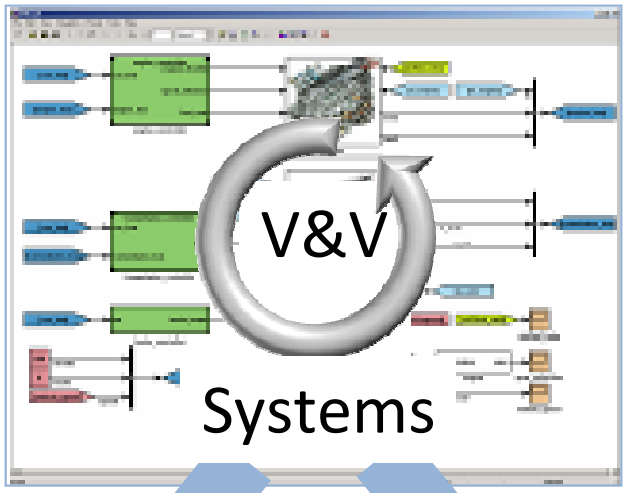
Problematic Development Process

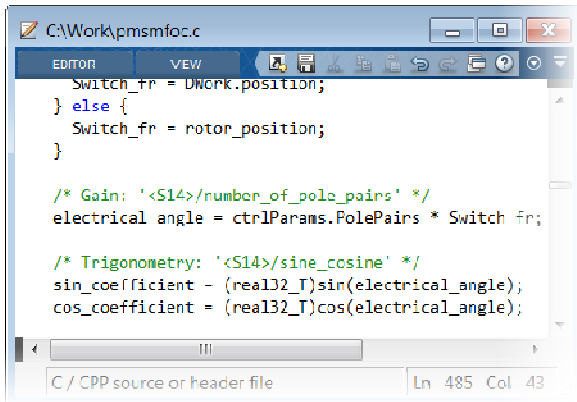


Model-Based Design

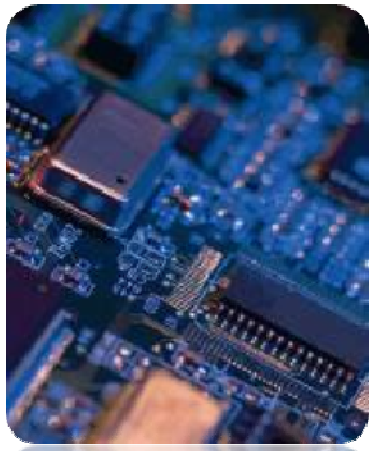


Systems





Software



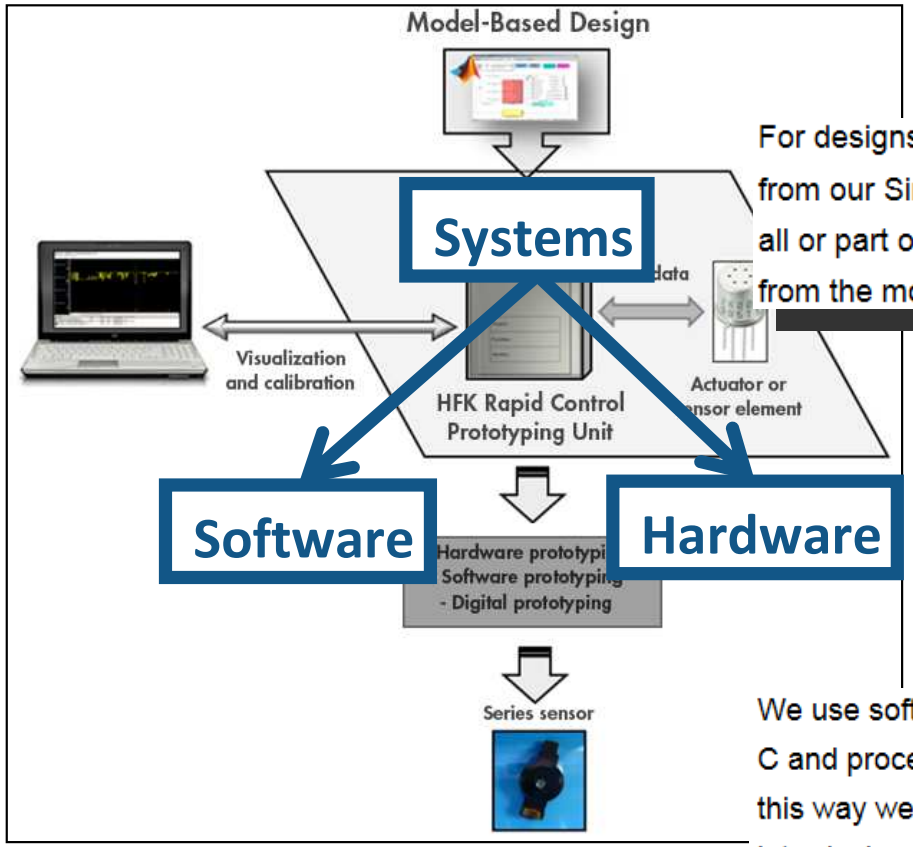
Hardware

Automotive Example of Model-Based Design

Newsletters

Accelerating Sensor Development with Rapid Prototyping and Model-Based Design

By Martin Hein, Hella Fahrzeugkomponenten GmbH



C & HDL Code Generation

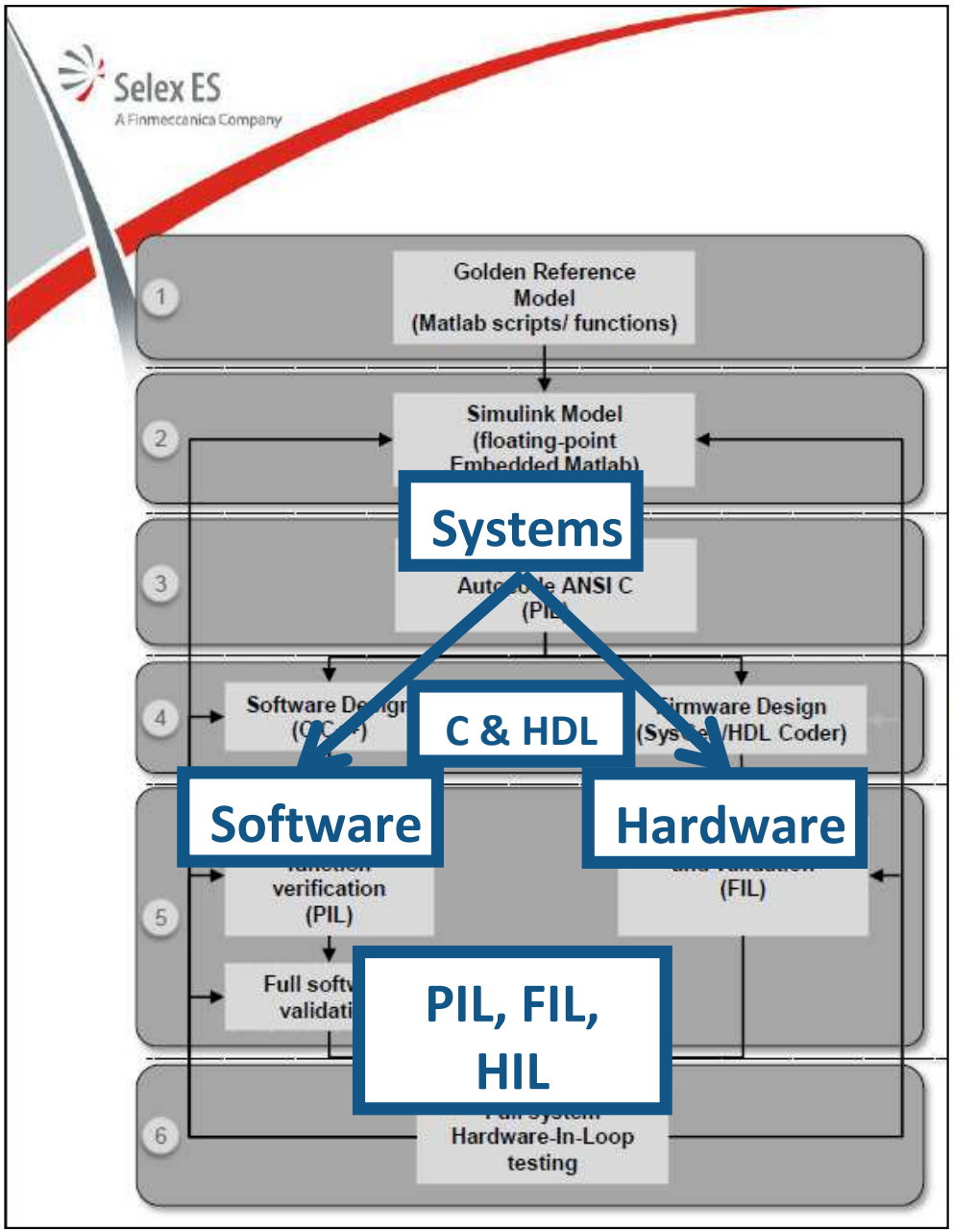
For designs that target a microprocessor, we use Embedded Coder™ to generate code from our Simulink model and deploy it to the TI C2000 processor on the HFK RCP unit. If all or part of the design requires an FPGA, we use HDL Coder™ to generate VHDL code from the model for deployment on the Xilinx FPGA.

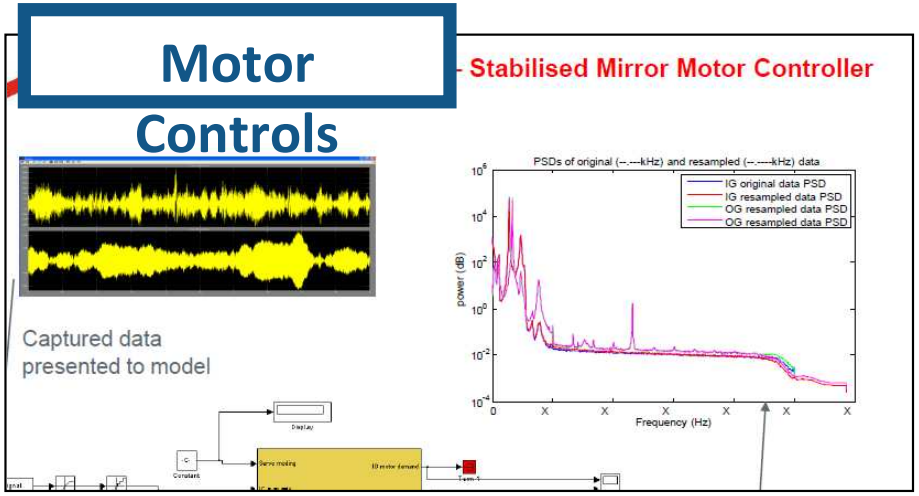
Early V&V (SIL, PIL)

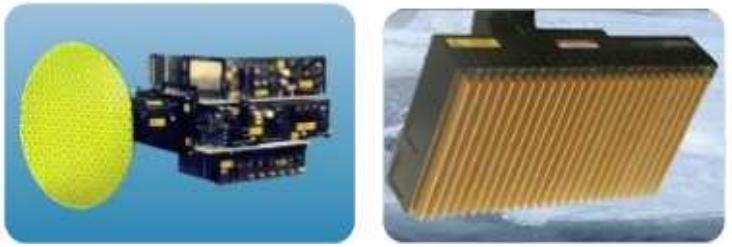
We use software-in-the-loop (SIL) testing to verify the implementation of our algorithms in C and processor-in-the-loop (PIL) testing to verify the algorithm on real-time hardware. In this way we ensure that the model, which we have already verified, is implemented without introducing errors.

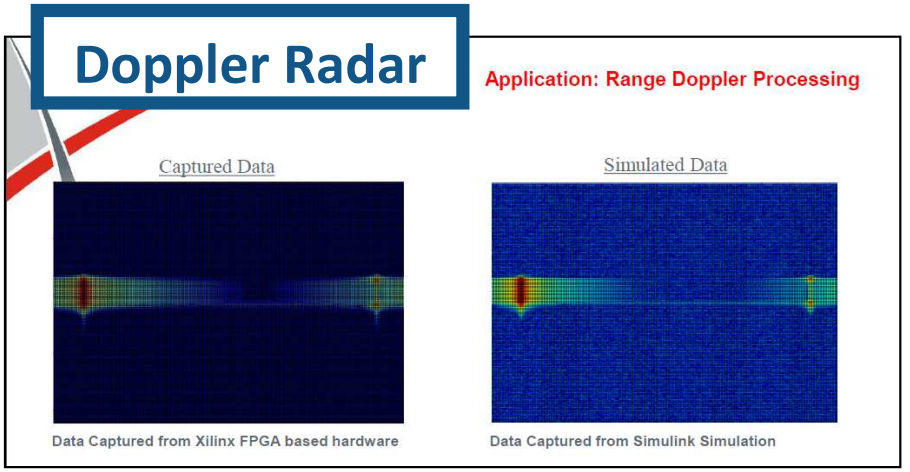
www.mathworks.com/company/newsletters/articles/accelerating-sensor-development-with-rapid-prototyping-and-model-based-design.html

Aerospace Example of Model-Based Design









http://www.mathworks.com/tagteam/75977_Concepts_to_Chips_SELEX_ES.pdf

Model-Based Design – Certification Examples

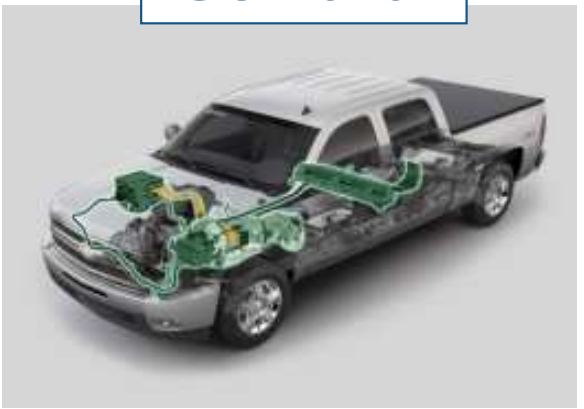
DO-178 (Level A)

Honeywell Aerospace USA
Flight Control Systems

EN 50128

Alstom France
Propulsion Control Systems

ISO 26262



GM Global
Hybrid Powertrain

IEC 62304

Weinmann Medical Germany
Transport ventilator

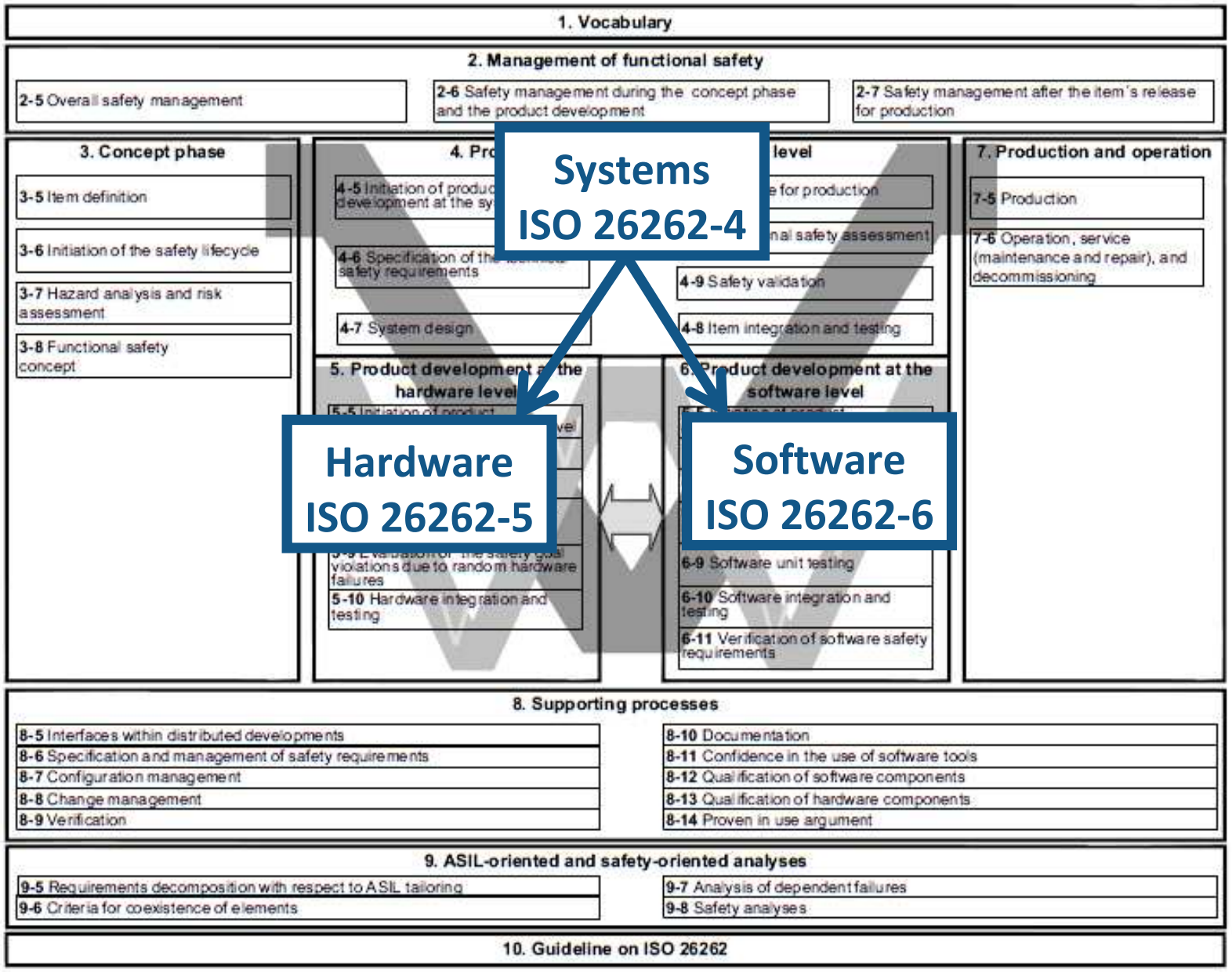
IEC 61508

Alstom Grid UK
HDVC Power Systems

???????

Academia and Schools
Project Based Learning

Automotive Standard (ISO 26262)



Model-Based Design is deeply rooted in ISO 26262

1.74 model-based development

development that uses models to describe the functional behavior of the elements which are to be developed

NOTE Depending on the level of abstraction used for such a model it can be used for simulation or code generation or both.

Annex B
(informative)

Model-based development

B.1 Objectives

This Annex describes the concept of model-based development of in-vehicle software and outlines its implications on the product development at the software level.

The seamless utilisation of models facilitates a highly consistent and efficient development.

Aerospace Standard (ARP4754A)

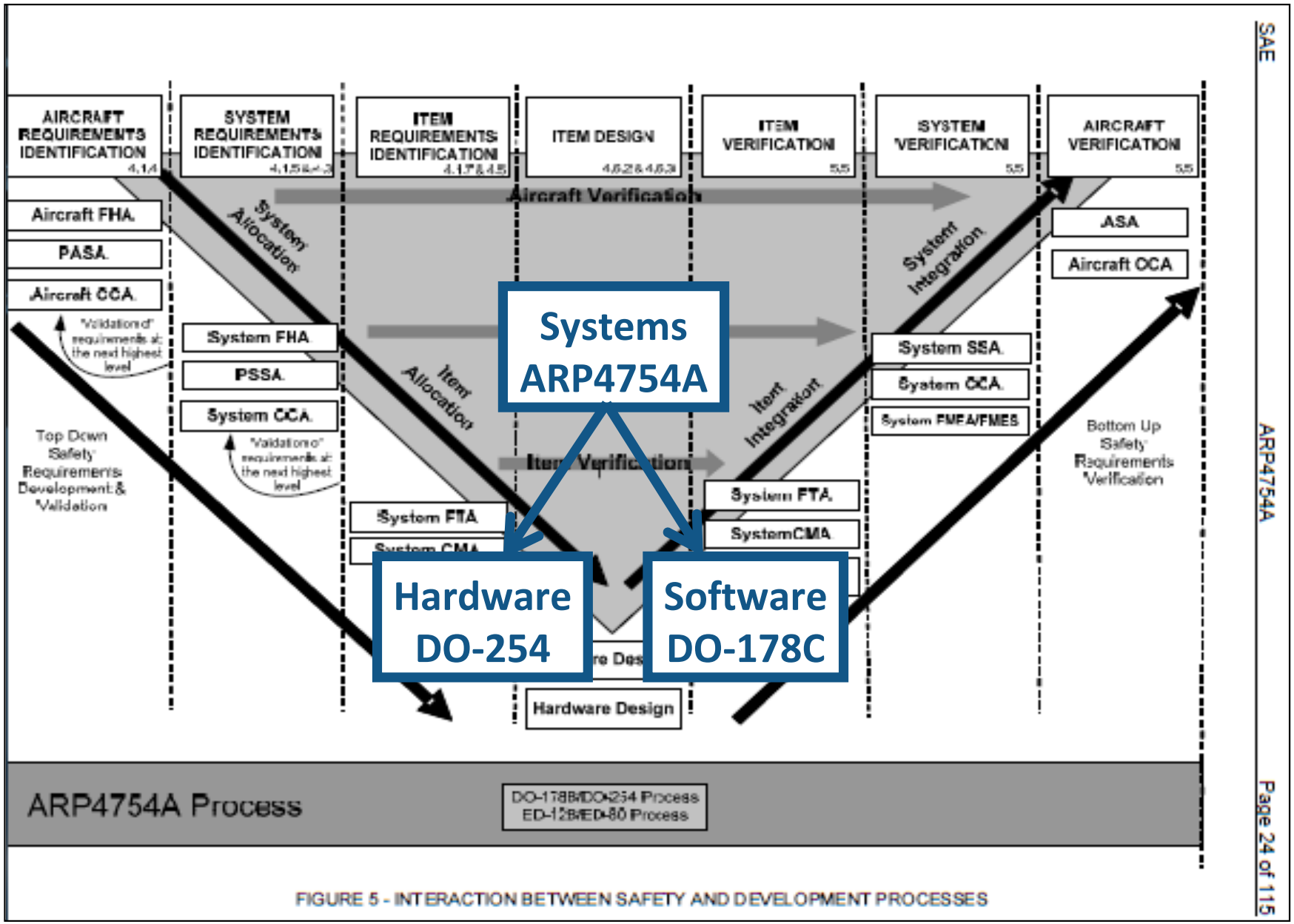


FIGURE 5 - INTERACTION BETWEEN SAFETY AND DEVELOPMENT PROCESSES

Model-Based Design is highly recommended in ARP4754

Help uncover missing requirements

Prototypes are models of the desired system that may be hardware and/or software based, and may or may not be development versions of the system. Prototypes permit users of a system to interact with a proposed model of the system to uncover missing requirements, behaviors of the system that should be prohibited, and potential problems with user interaction.

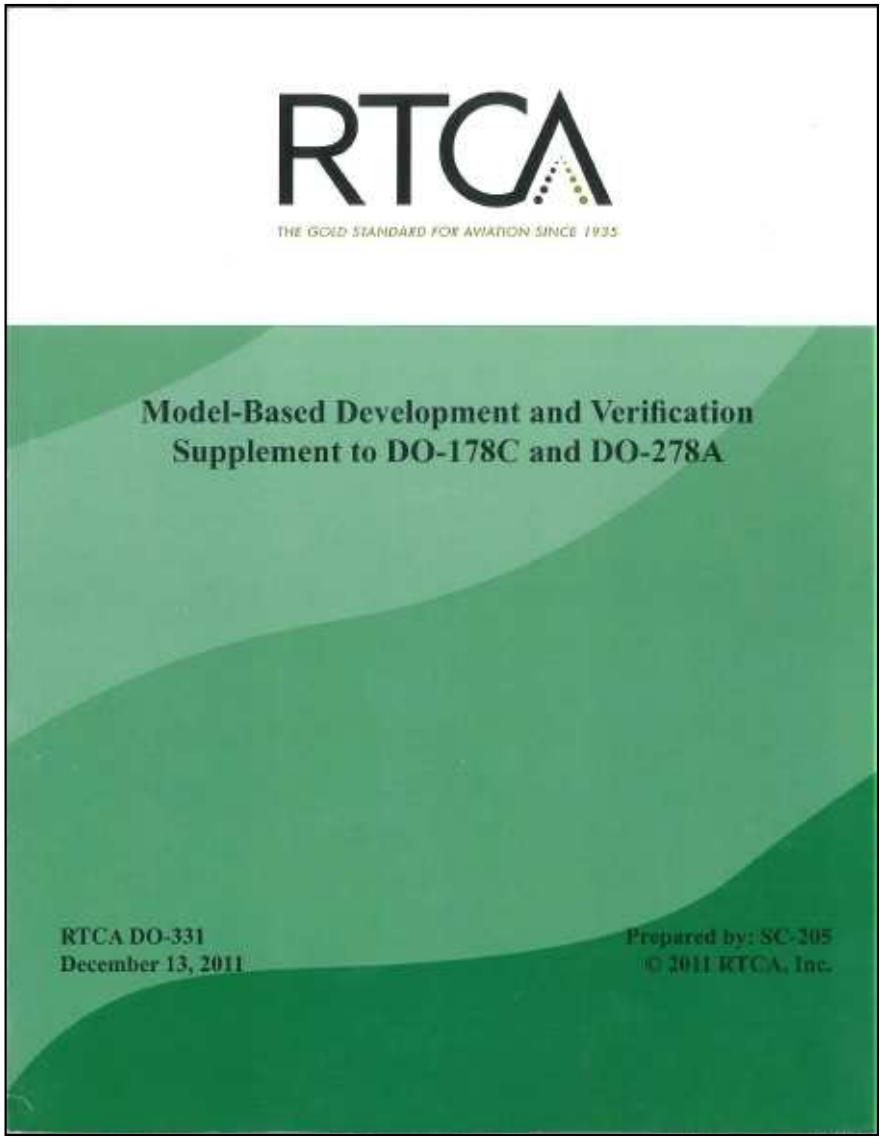
How well the prototype represents the actual system may drive the likelihood of identifying missing requirements. The tools used to create prototypes should minimize development time.

The model should be developed in a structured manner. For example, subsets of model elements which may be used more than once may be handled and represented either as a unit or as the full contents.

Model use for requirements validation typically uses a model of the environment of a system being developed, which is interfaced to a prototype of a design solution for those requirements. An environment model that is representative of the environment of the system being developed, provides a high degree of functional coverage in exercising either a simulated or real system.

provide a high degree of function coverage

Model-Based Design has a dedicated supplement* in DO-178C



*DO-331: Model-Based Supplement to DO-178C and DO-278A

First Task: Figure out what model represents

RTCA

Table MB.1-1 Model Usage Examples

Process that generates the life-cycle data	MB Example 1	MB Example 2	MB Example 3	MB Example 4 (See Note 1)	MB Example 5 (See Note 1)
System Requirement and System Design Processes	Requirements allocated to software	Requirements from which the Model is developed	Requirements from which the Model is developed	Requirements from which the Model is developed	Requirements from which the Model is developed
					Design Model
Software Requirement and Software Design Processes	Requirements from which the Model is developed	Specification Model (See Note 2)	Specification Model	Design Model	
	Design Model	Design Model	Textual description (See Note 3)		
Software Coding Process	Source Code	Source Code	Source Code	Source Code	Source Code

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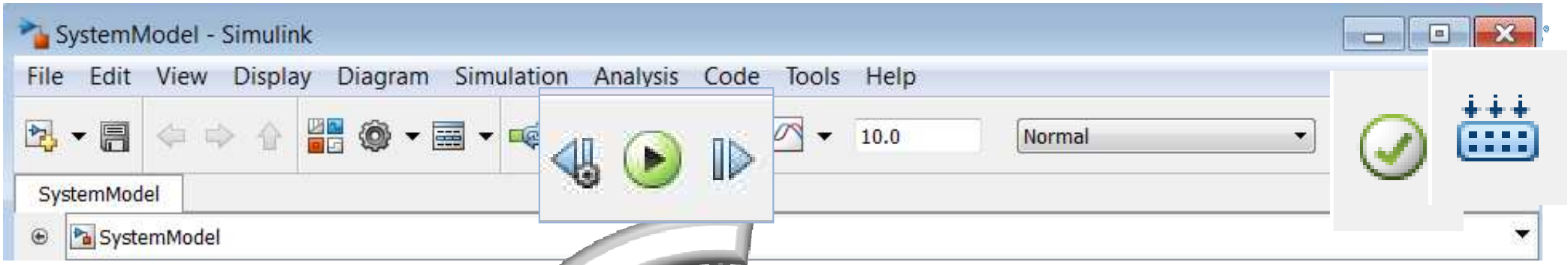
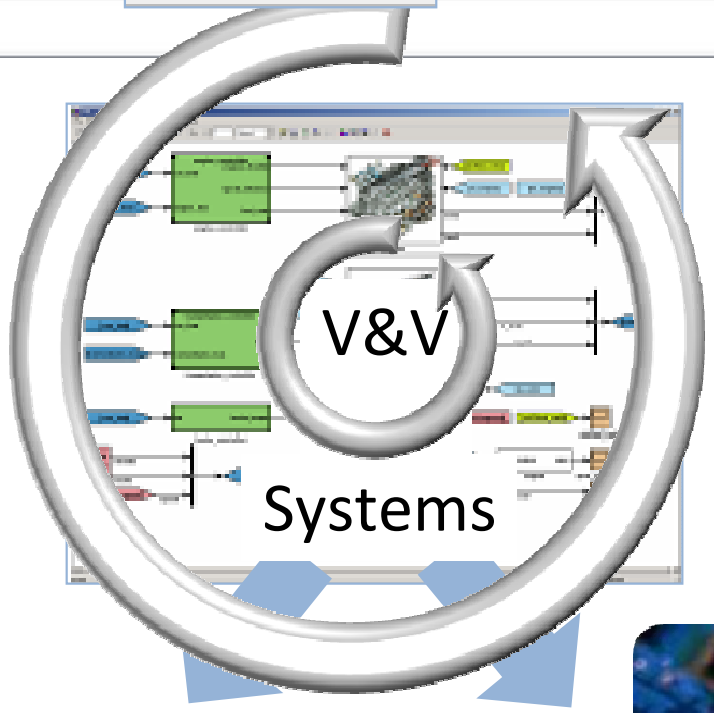
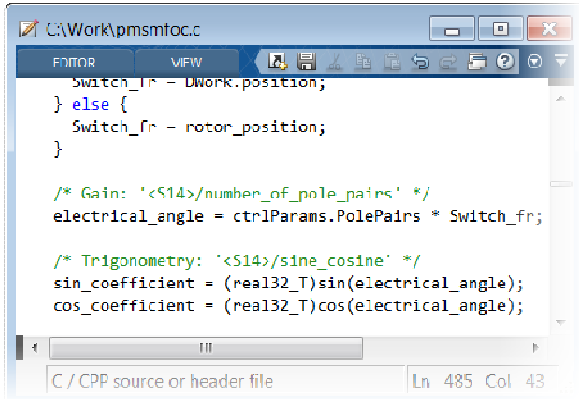
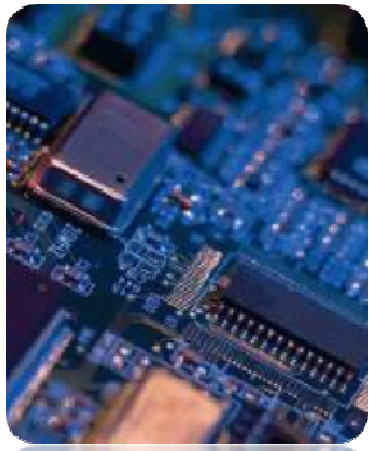




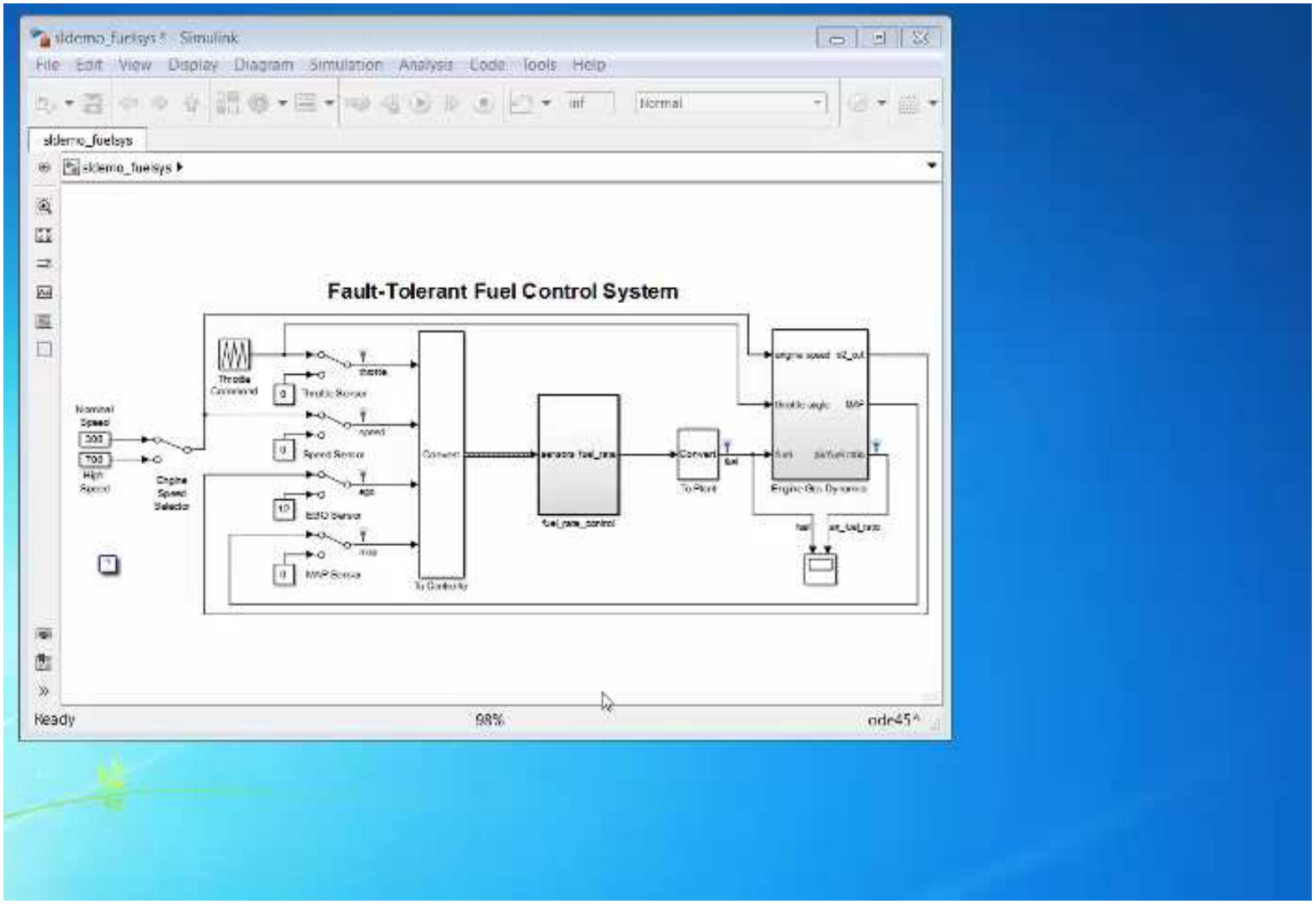


Software

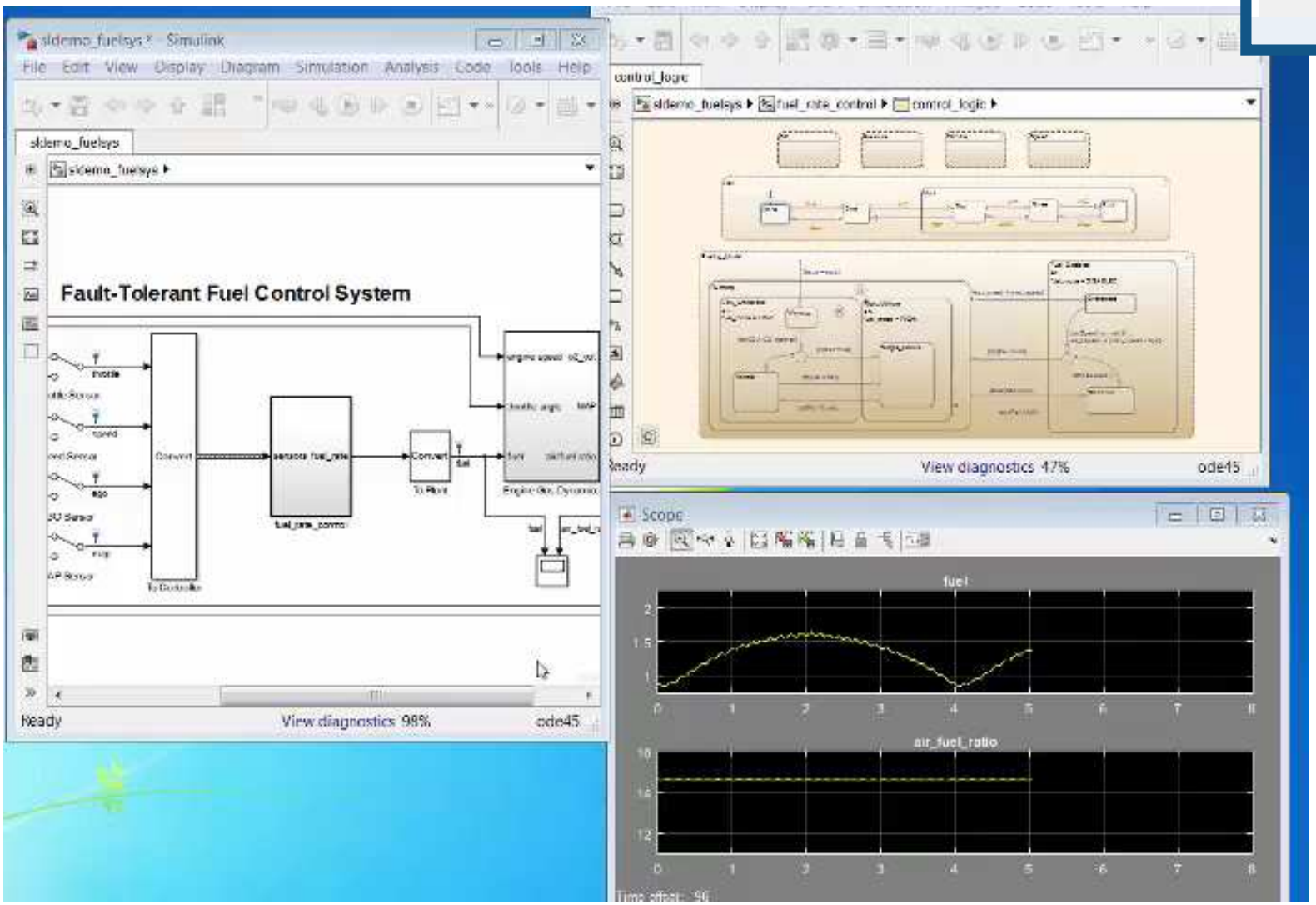


Hardware

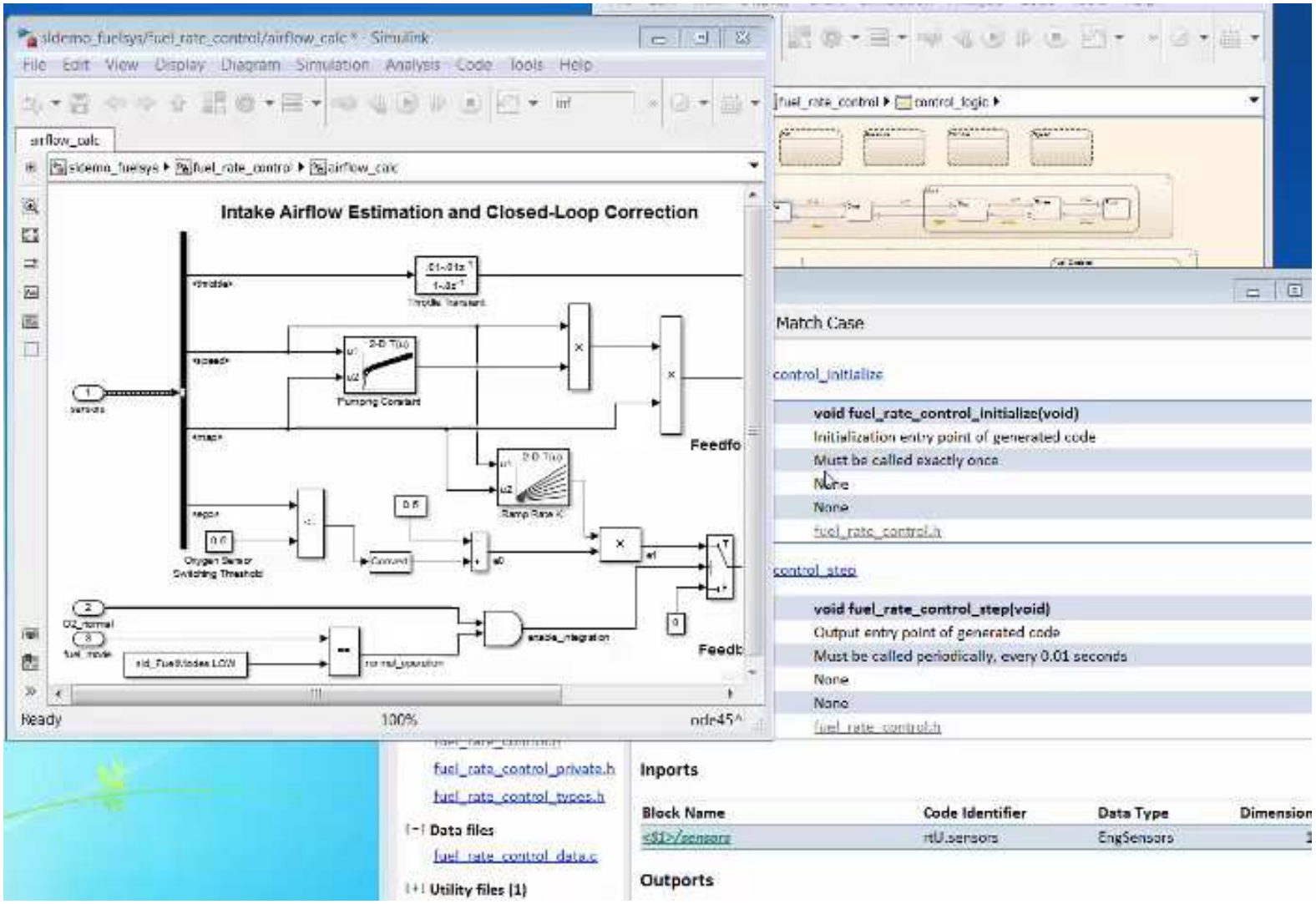
Systems simulation



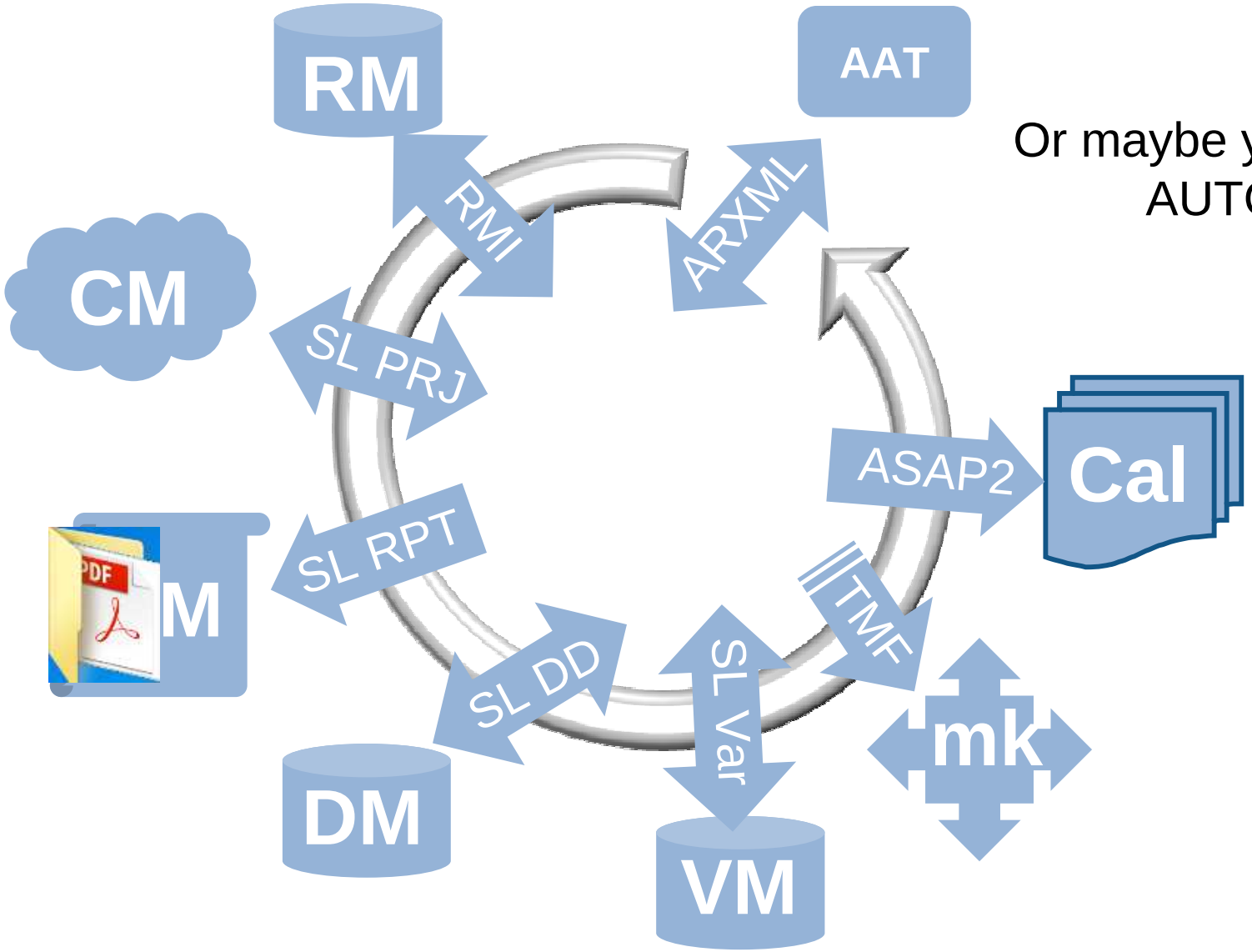
Software and hardware generation



Early verification and validation



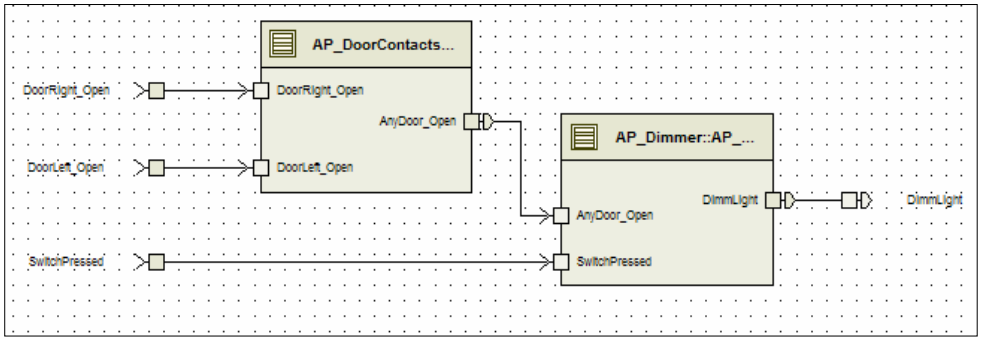
Integral and backbone process



Or maybe you have ….
AUTOSAR

AUTOSAR Target Workflow (Top-Down)

AUTOSAR Authoring Tool



Export
SWC Description

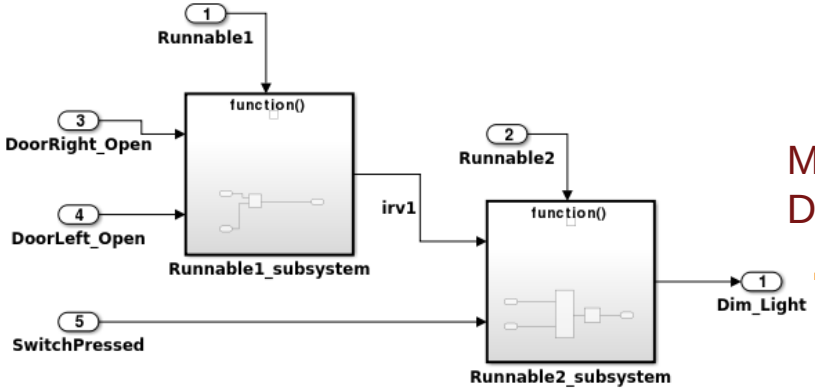
Merge
SWC Description

SW-C

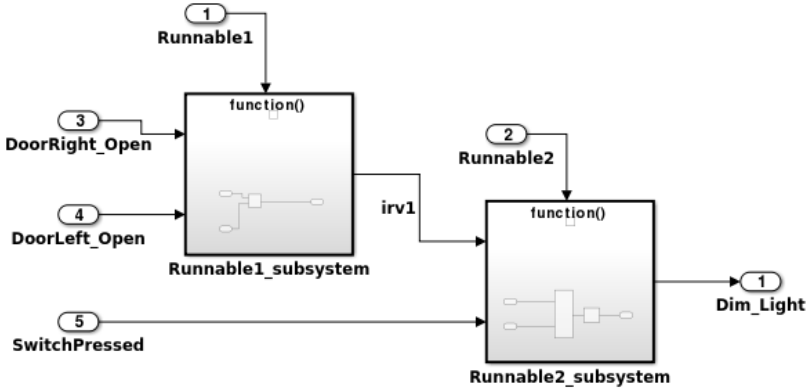
SW-C

Import
SWC Description

Export SWC Description/
Generate SWC C code

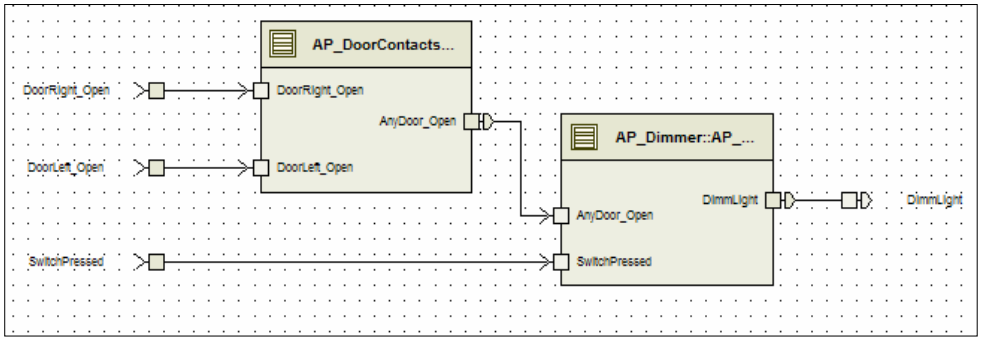


Model Based
Design



AUTOSAR Target Workflow (Bottom-Up)

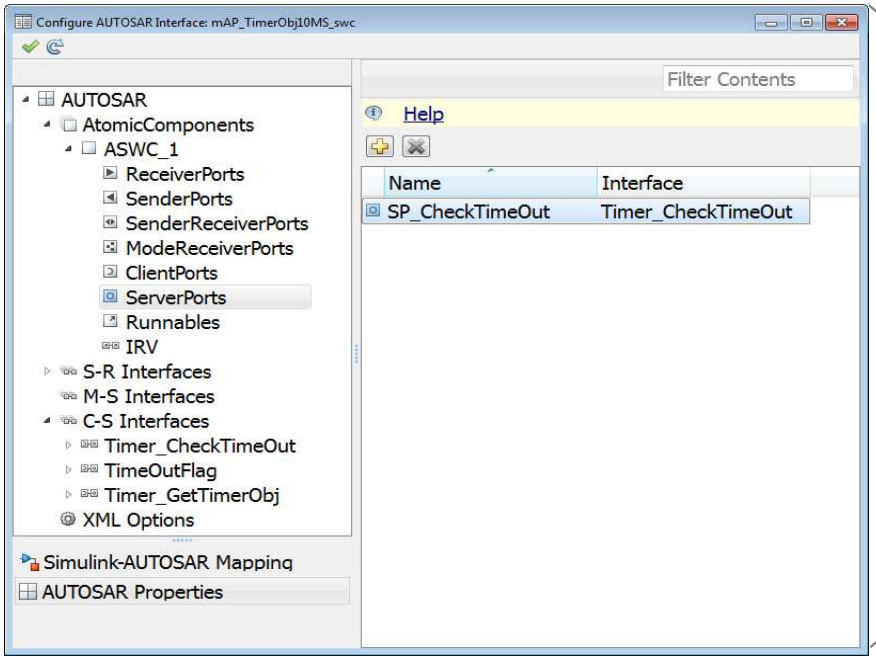
AUTOSAR Authoring Tool

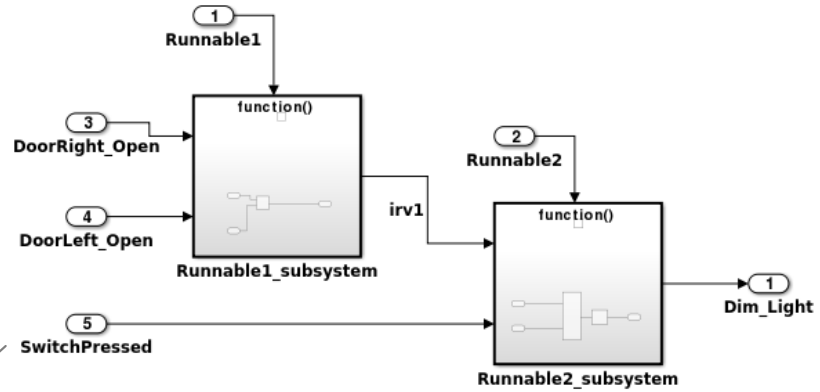


Import
SWC Description

SW-C

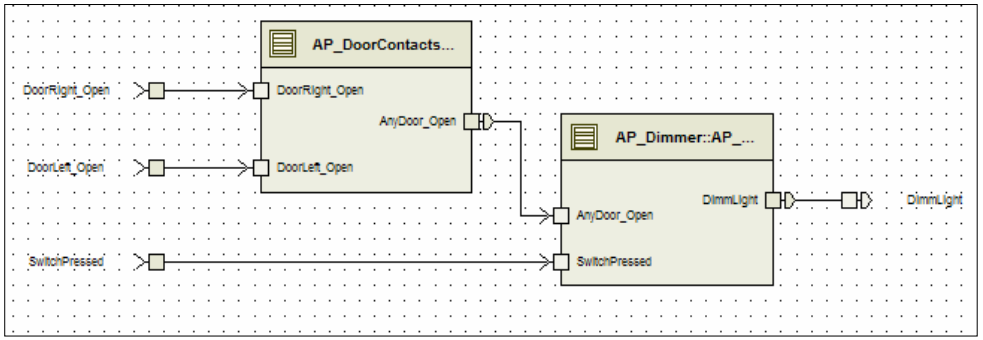
Export SWC Description/
Generate SWC C code





AUTOSAR Target Workflow (Round-Trip)

AUTOSAR Authoring Tool



Export
SWC Description

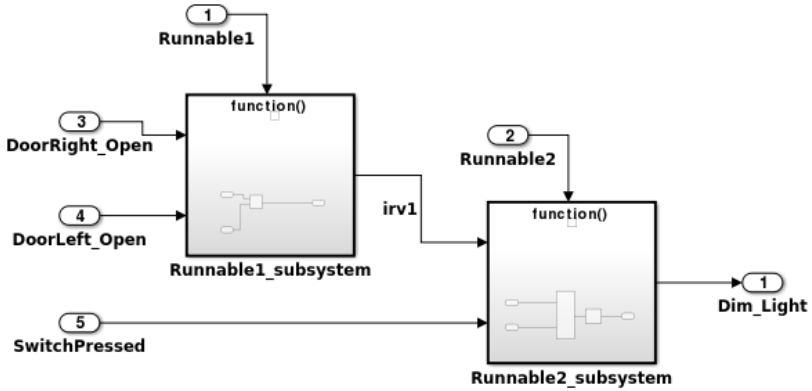
Merge
SWC Description

SW-C

SW-C

Merge
SWC Description

Export SWC Description/
Generate SWC C code

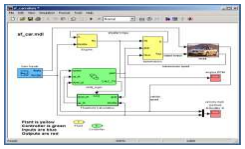


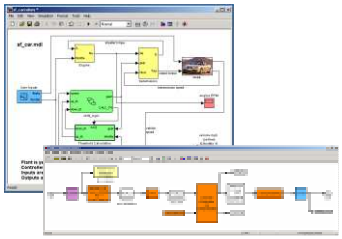
Thank You!

- Questions?

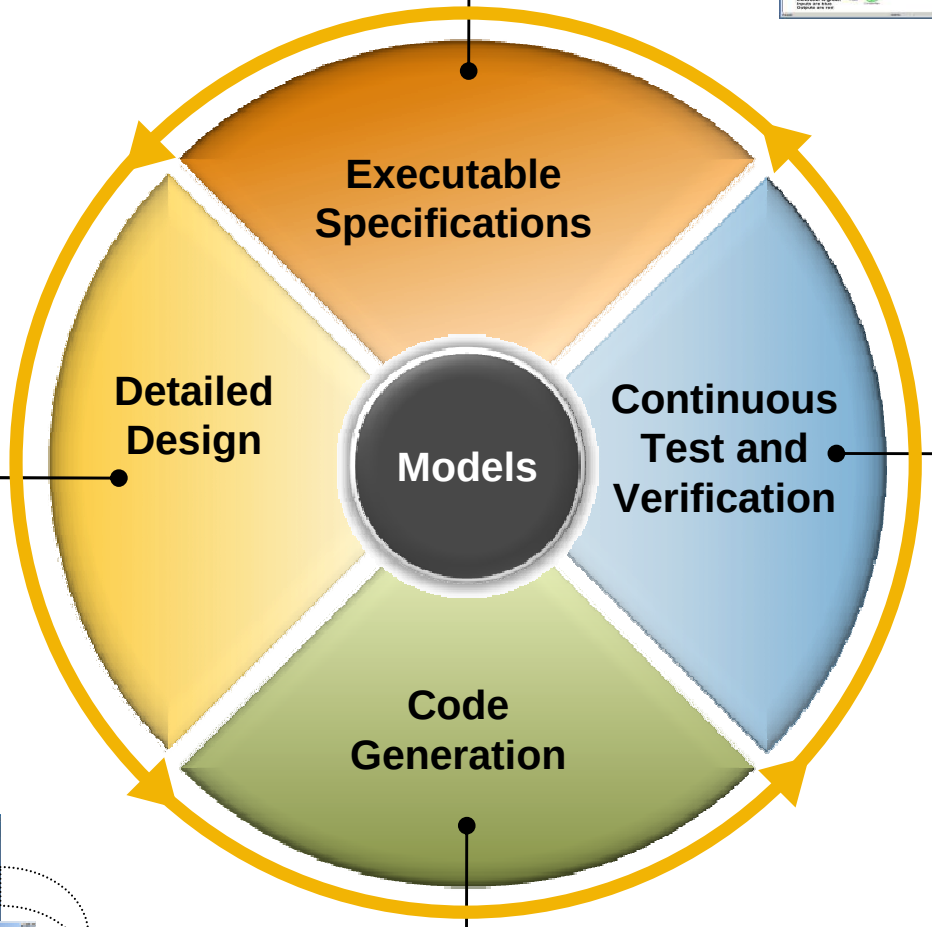
Model-Based Design

System Truth
- rapid iterations/prototypes

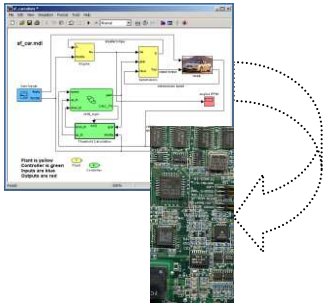


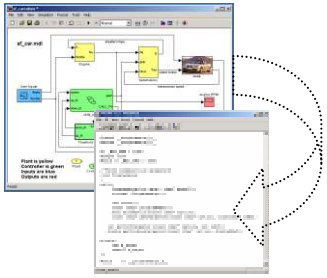


Hardware & Software
- convert float- to fixed point



Test Reuse
- detect errors earlier





Production code
-Eliminate hand code errors

Model-Based Design

Executable Specs, Automatic Code Generation, and Early V&V