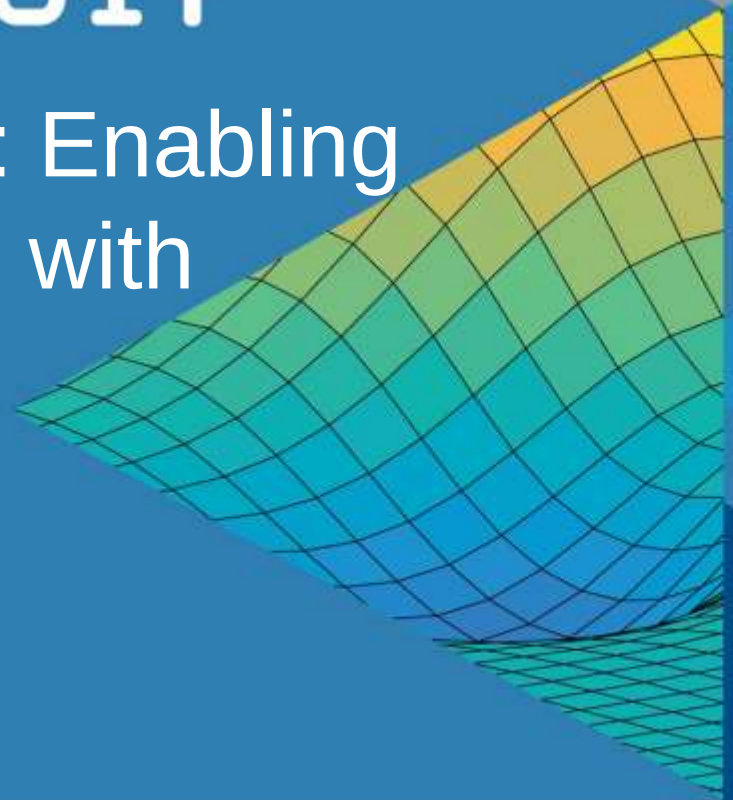
MATLAB EXPO 2017

From Simulink to AUTOSAR: Enabling AUTOSAR Code Generation with Model-Based Design

Durvesh Kulkarni



Agenda

- **Introduction to AUTOSAR**
  - Simulink approach to AUTOSAR
  - Overview of Modeling SWCs & Modeling Styles
- **AUTOSAR Design Workflows**
  - Bottom Up, Top Down & Round Trip
- **Advanced Topics – Top 5**
  - Startup, Reset, and Shutdown Modeling
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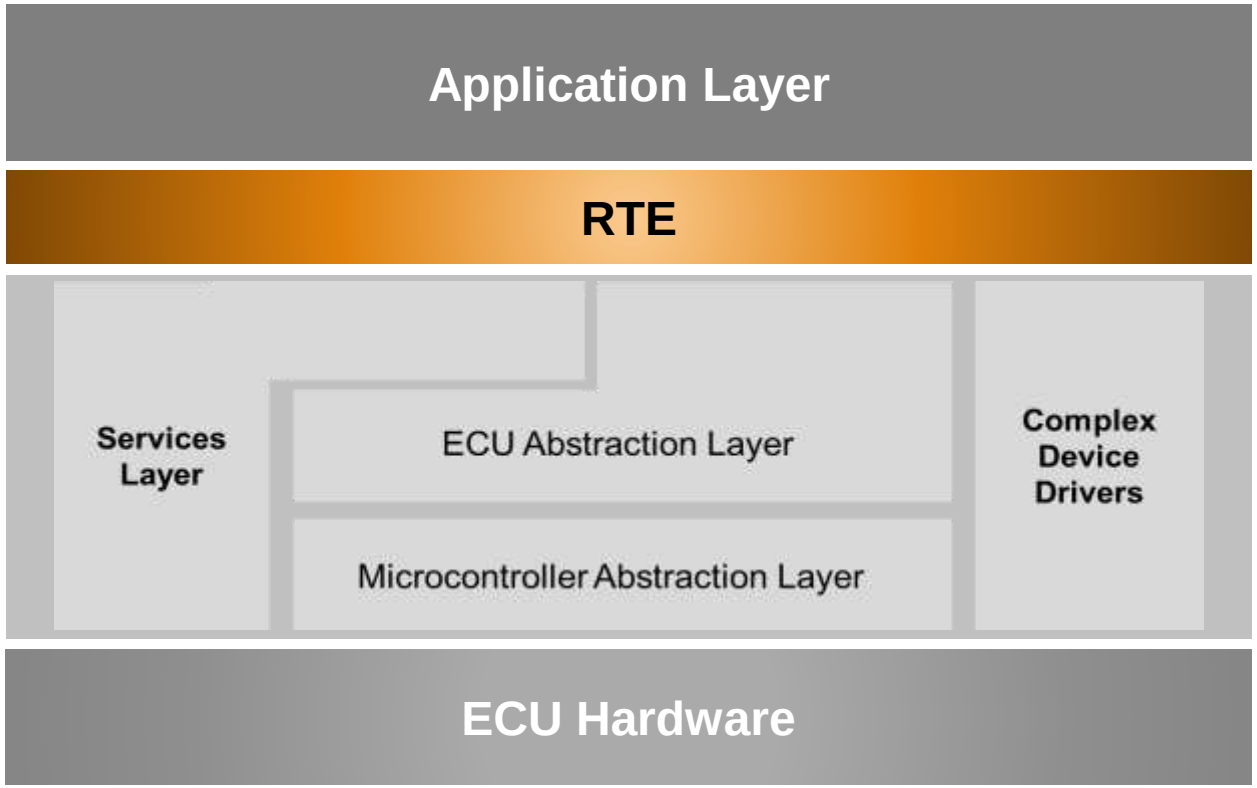
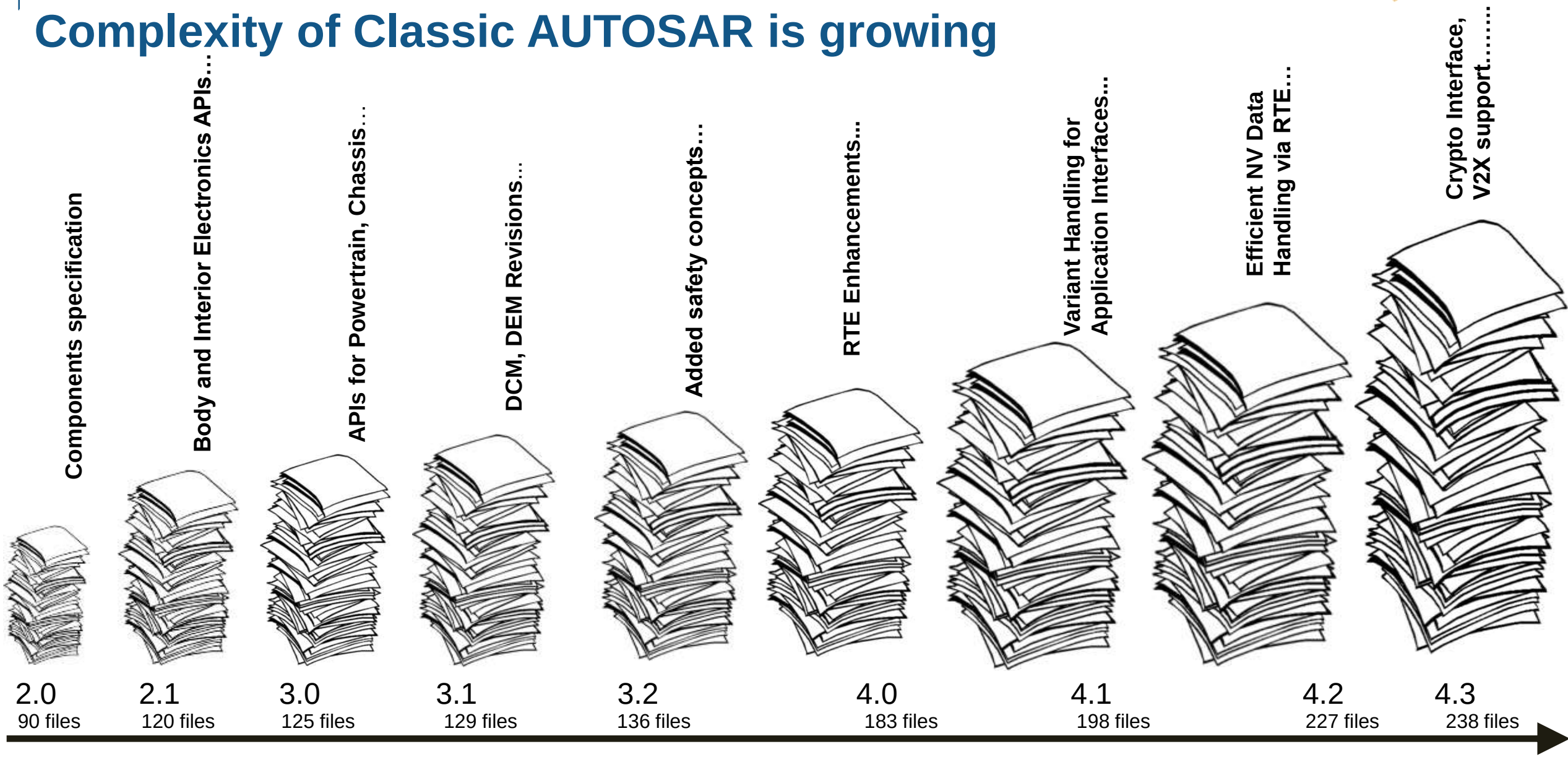
  - J-MAAB Type B Architecture
  - Mode Management (ModeSenderPorts, ModeSwitchPoints, …)
  - Variability inside a Software Component
- **Getting Started Resources**

What is AUTOSAR?

AUTOSAR® (**AUT**omotive **O**pen **S**ystem **AR**chitecture) is an open and standardized automotive software architecture

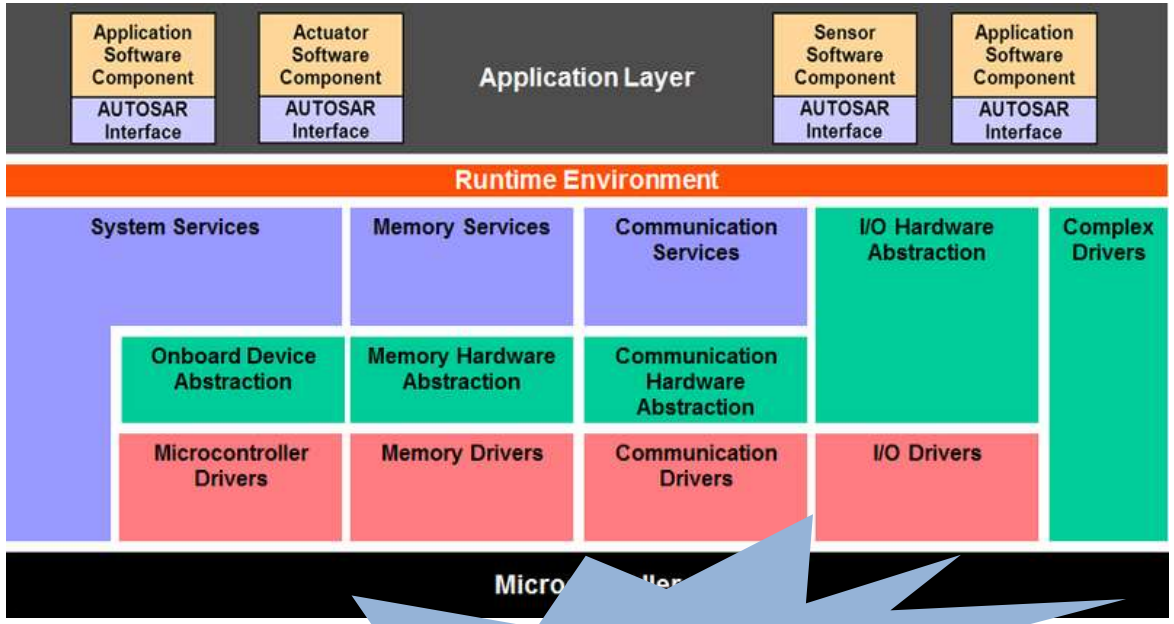


Complexity of Classic AUTOSAR is growing



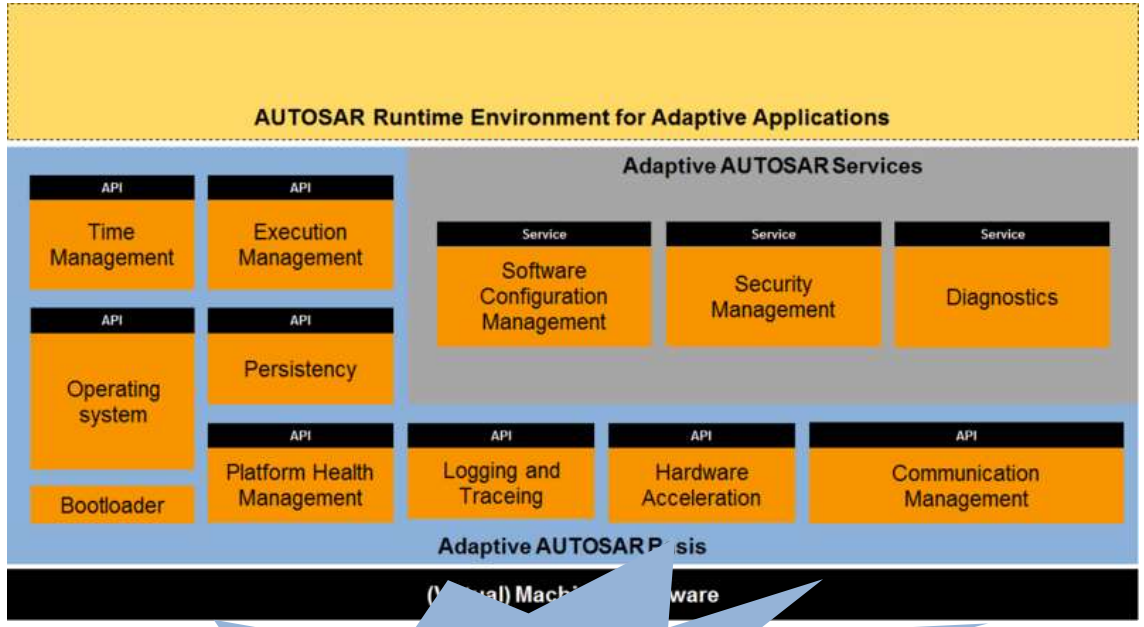
AUTOSAR Standards

Classic Platform



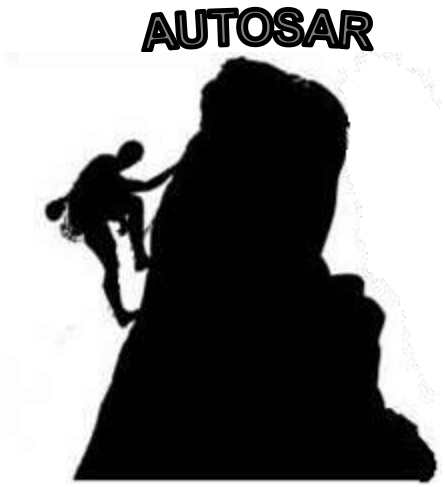
4.3 was released in Nov 2016

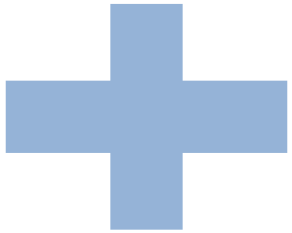
Adaptive Platform

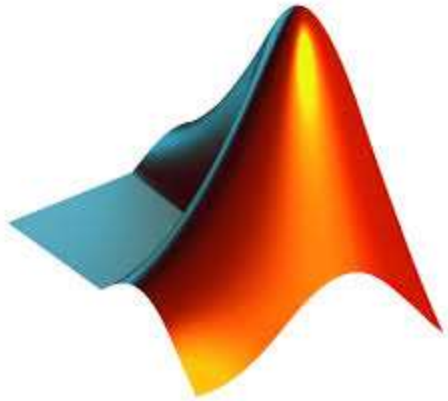


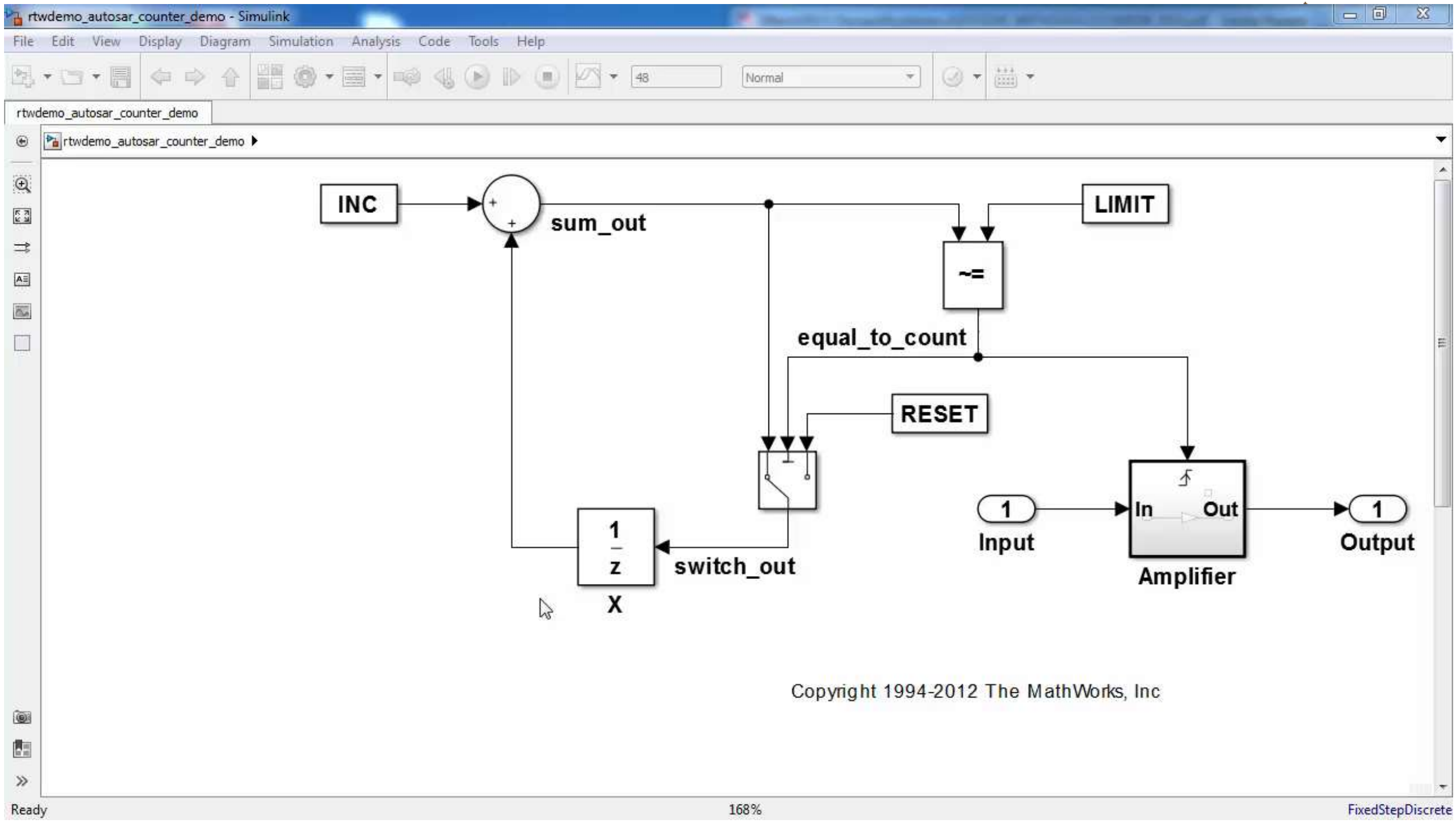
V1 was released in March 2017

AUTOSAR Adoption

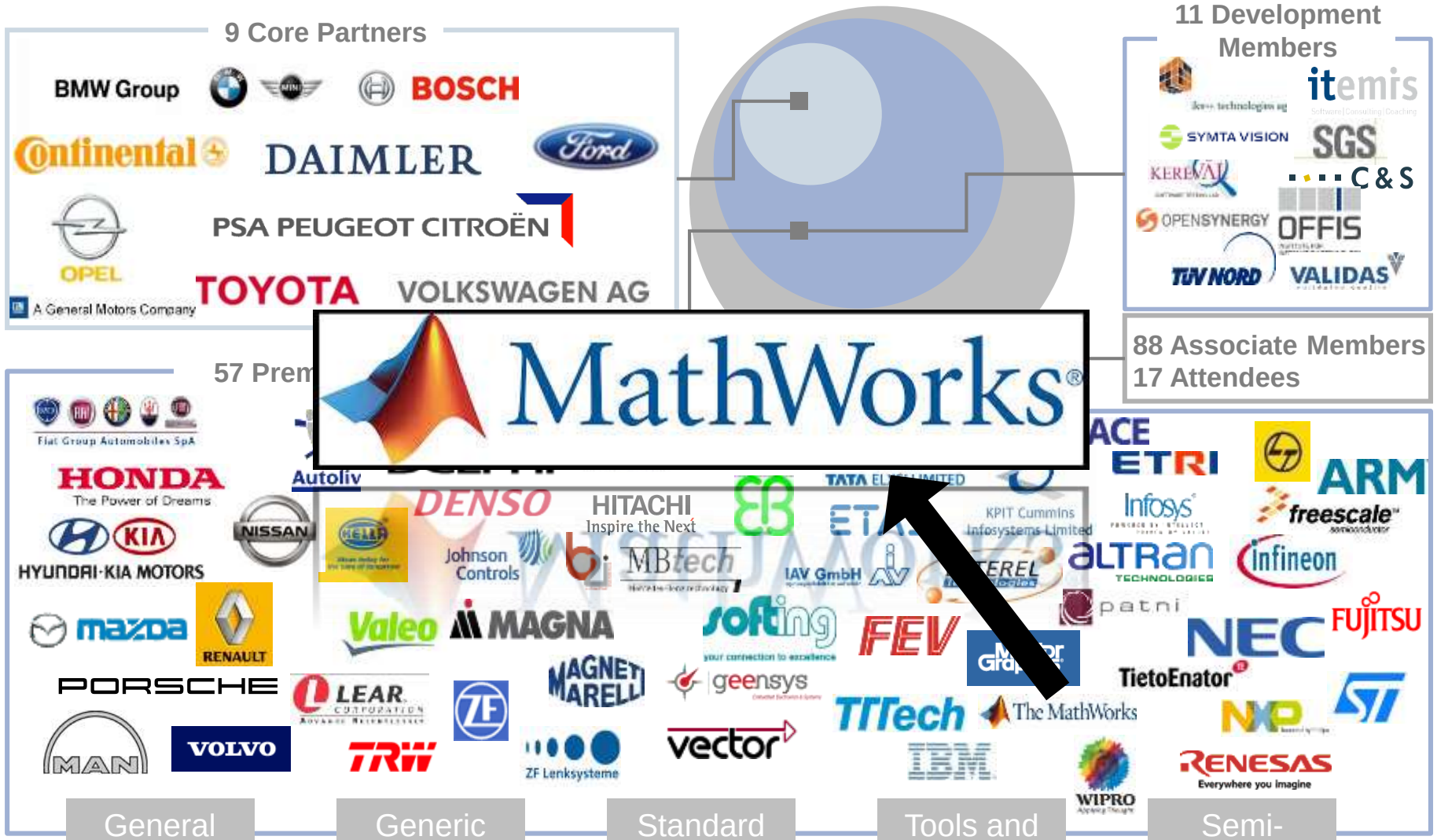




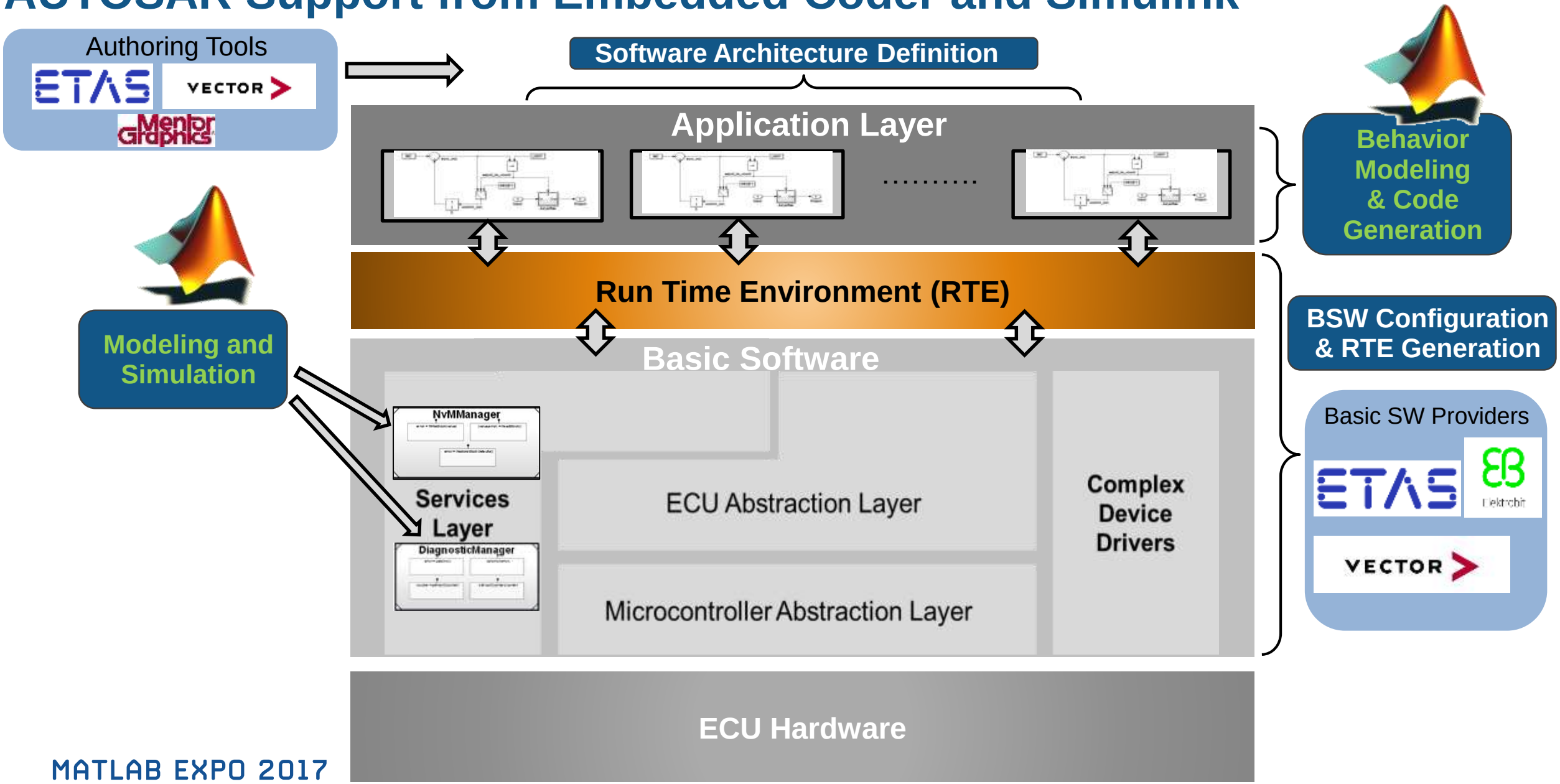



rtwdemo_autosar_counter_demo - Simulink
File Edit View Display Diagram Simulation Analysis Code Tools Help
48
Normal
rtwdemo_autosar_counter_demo
rtwdemo_autosar_counter_demo
INC
sum_out
LIMIT
~=
equal_to_count
RESET
1
z
X
switch_out
1
Input
In
Out
Amplifier
1
Output
Copyright 1994-2012 The MathWorks, Inc
Ready
168%
FixedStepDiscrete

AUTOSAR Members



AUTOSAR Support from Embedded Coder and Simulink



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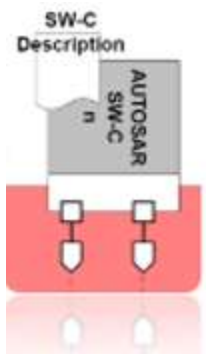
Simulink Approach to AUTOSAR

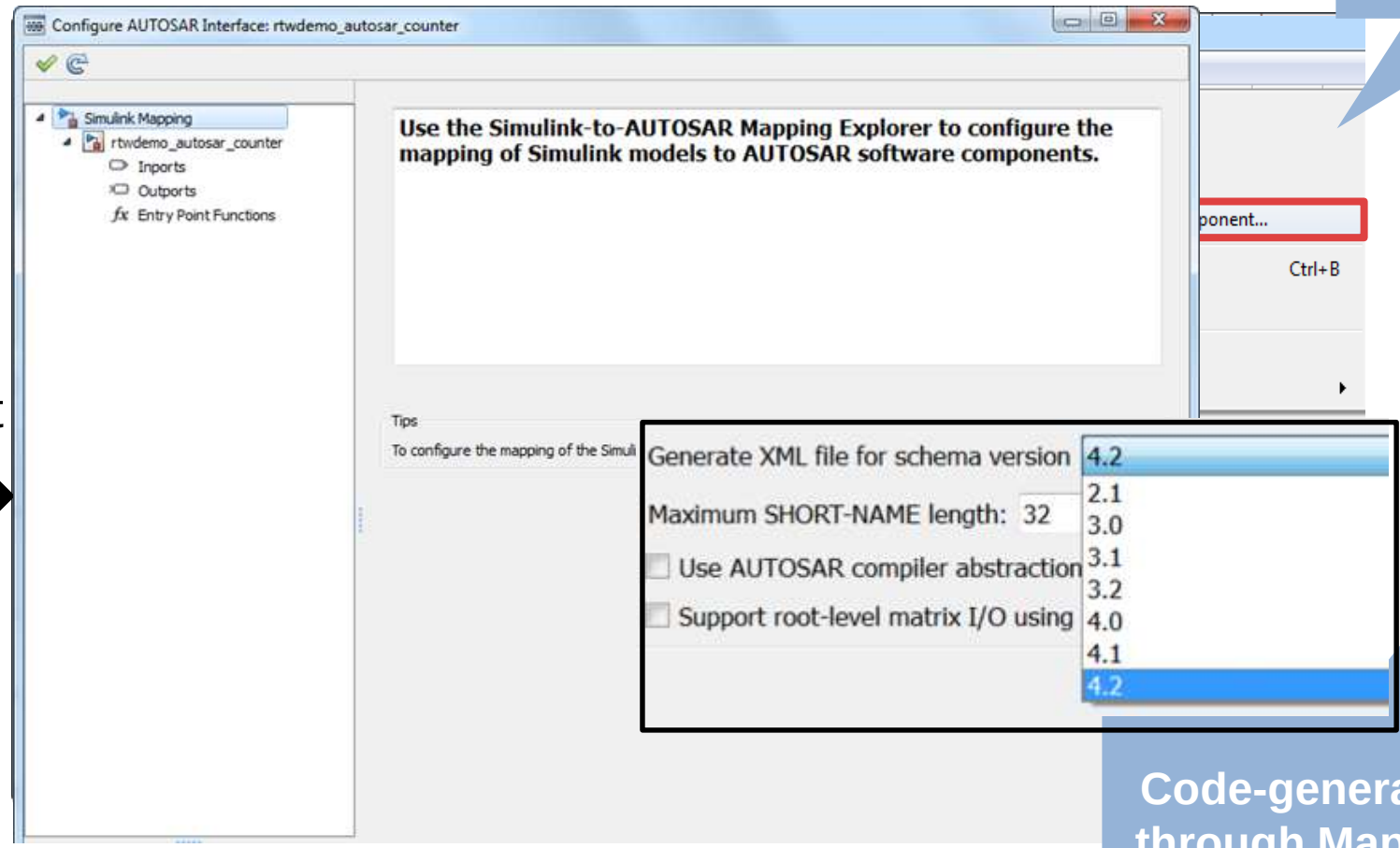
Available via web download

Simulink and Embedded Coder
+ **AUTOSAR Support package for Embedded Coder**

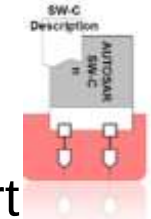
No separate AUTOSAR Blockset needed



Import



Export

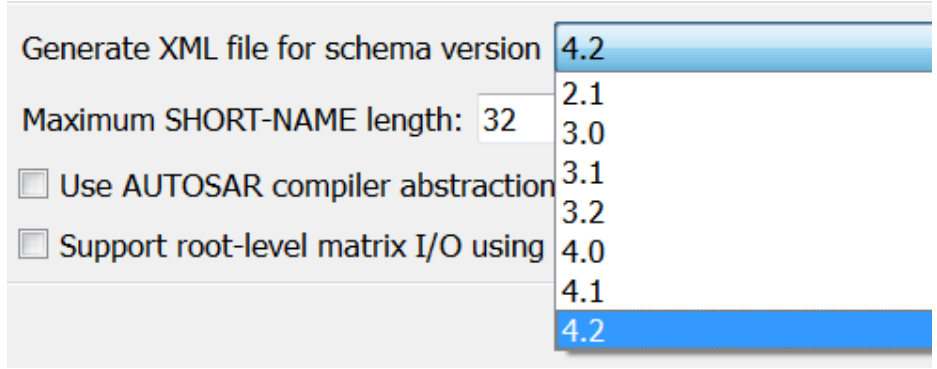


C Code and ARXML

Code-generation through Mapping

AUTOSAR Schema Versions

Seamless support for AUTOSAR Releases



- Import detects AUTOSAR 2.x – 4.x release from ARXML file
- User selects AUTOSAR release from configuration set options for code generation and ARXML export

MATLAB Release	AUTOSAR Release
R2015b, R2016a/b, R2017a	2.1, 3.0, 3.1, **3.2** (Rev 3.2.2), 4.0, 4.1, **4.2** (Rev 4.2.1, 4.2.2)
R2014b, R2015a	2.1, 3.0, 3.1, 3.2, 4.0, **4.1** (Rev 4.1.1)
R2012a/b, R2013a/b, R2014a	2.1, 3.0, 3.1, 3.2, **4.0** (Rev 4.0.2)
R2011b	2.0, 2.1, 3.0, 3.1, 3.2
R2010a/b, R2011a	2.0, 2.1, 3.0, 3.1
R2009a/b	2.0, 2.1, 3.0
R2008a/b	2.0, 2.1

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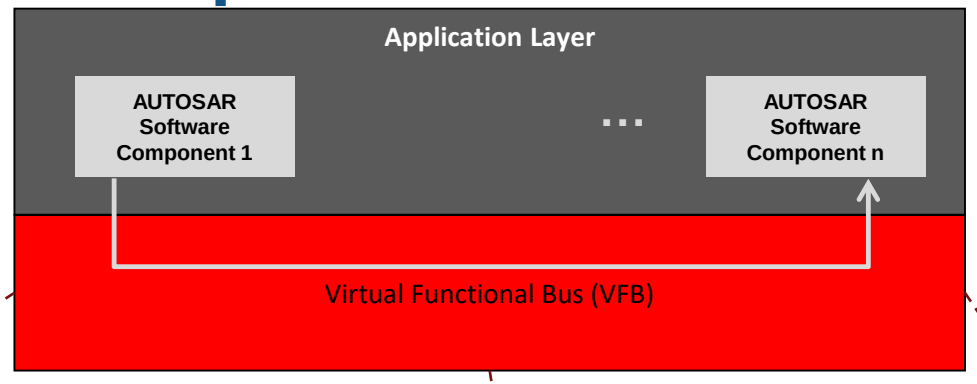
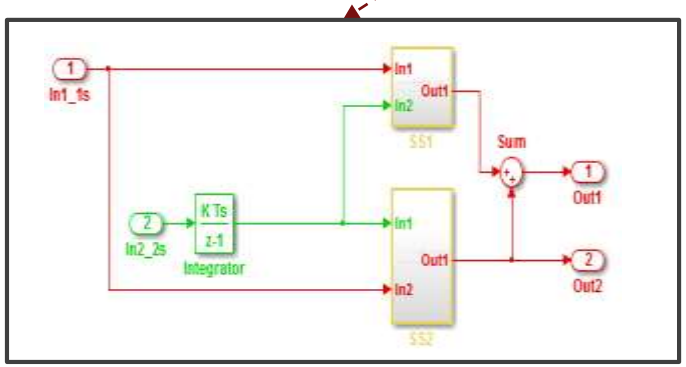
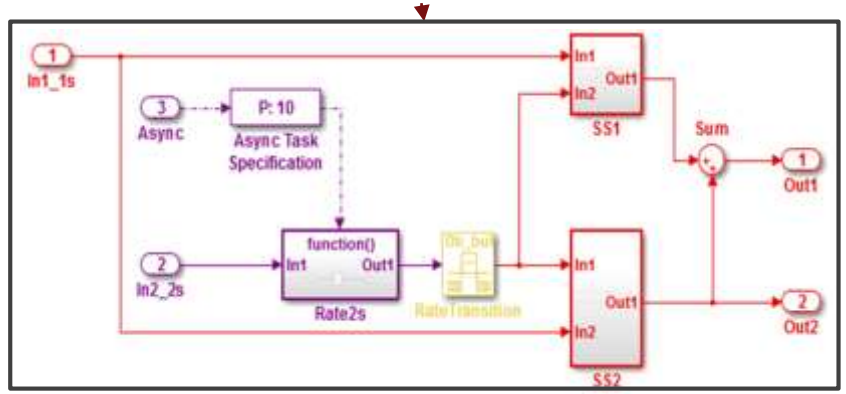
Model AUTOSAR Components

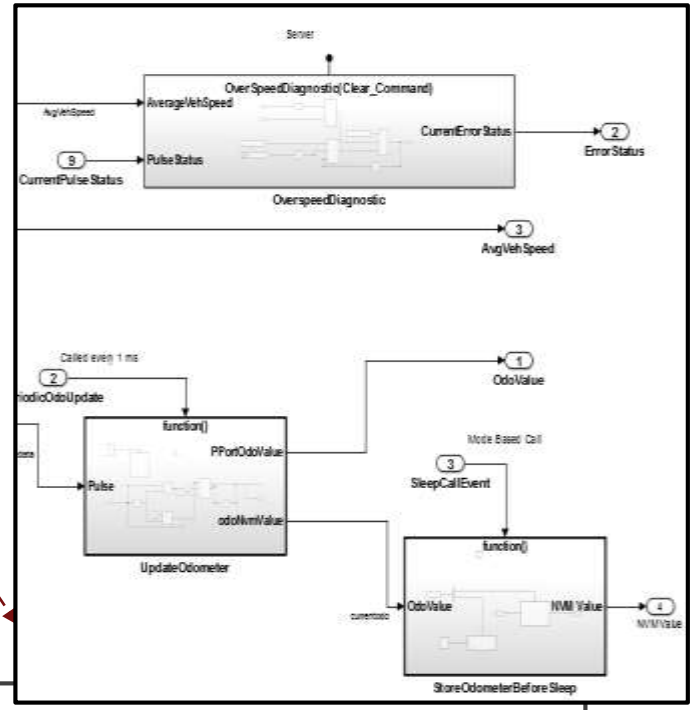


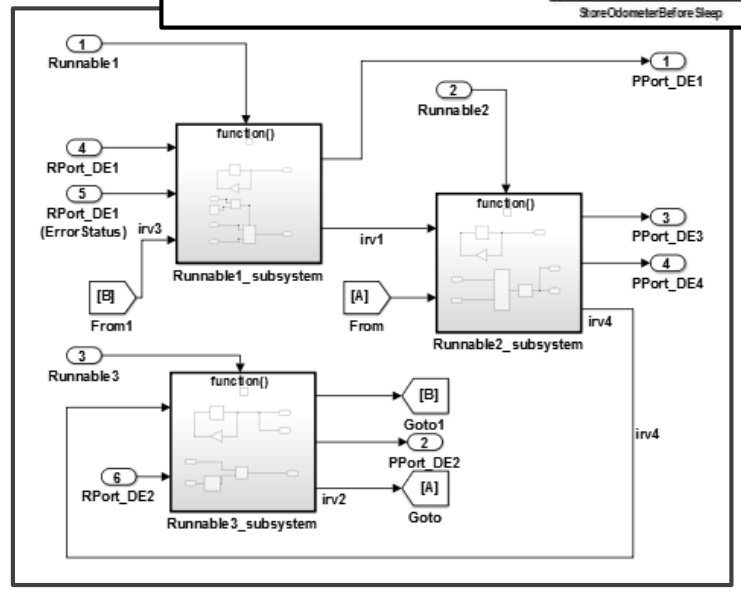


Periodic Rate-Based



Periodic & Asynchronous

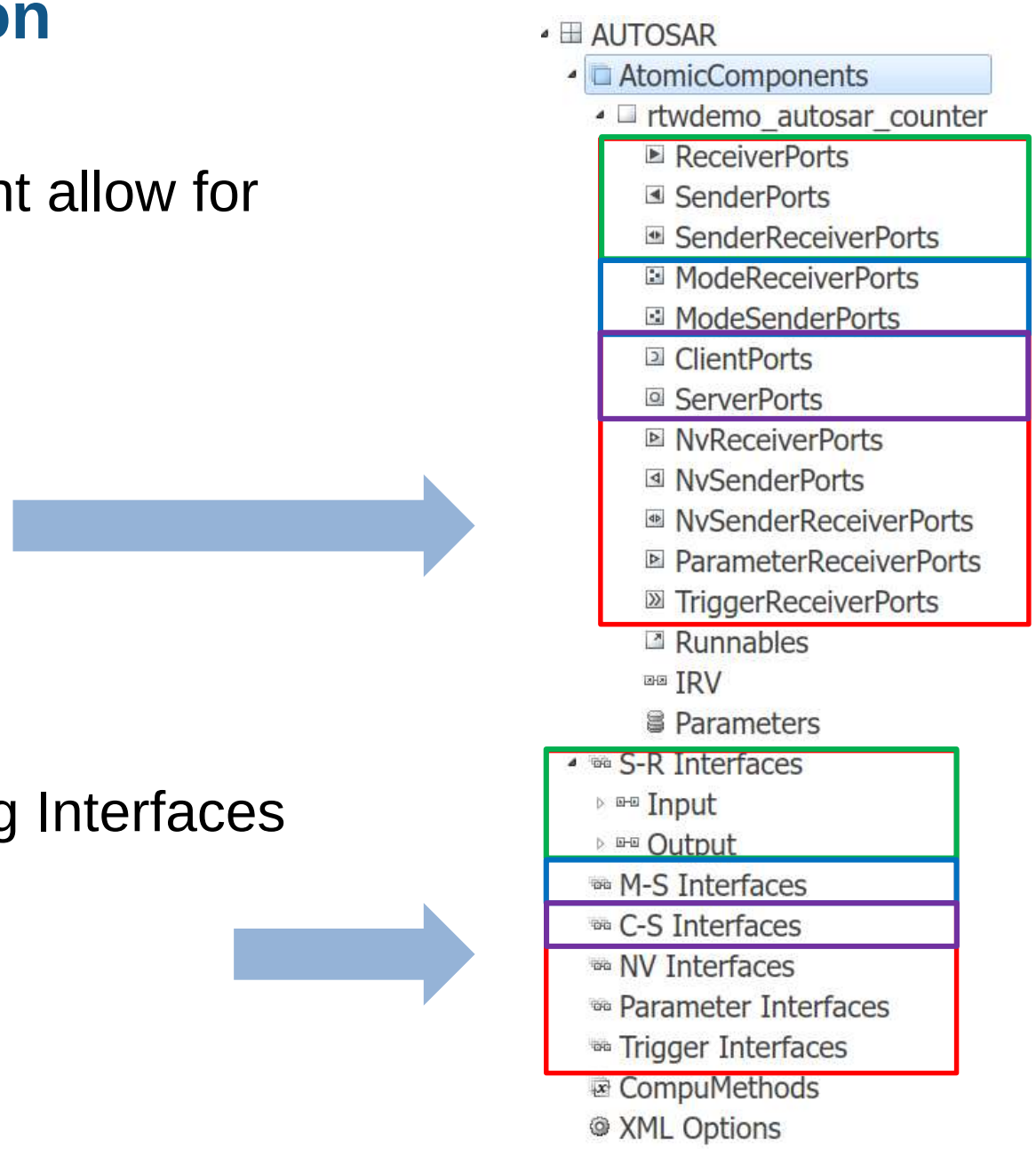




Multi-Rate & Asynchronous

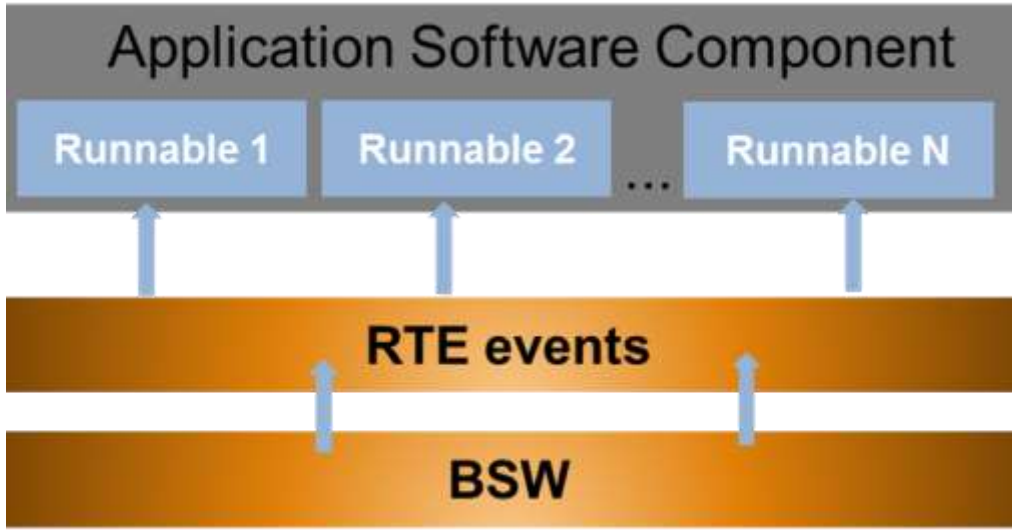
Modeling AUTOSAR Communication

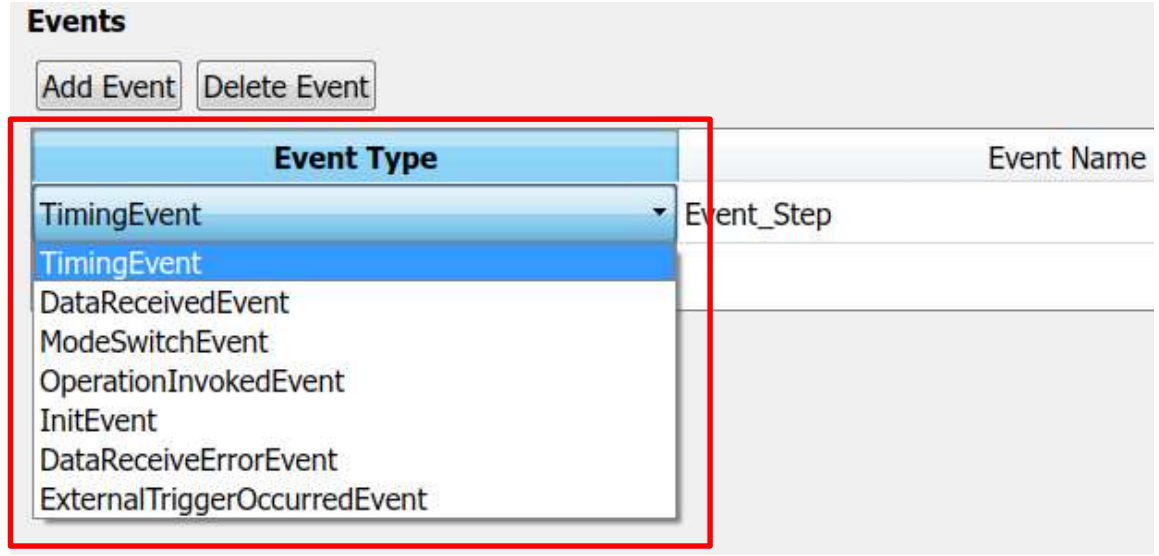
- Ports in a AUTOSAR software component allow for communication
- Categories of ports based on direction
  - Require port
  - Provide port
- Each port can have either of the following Interfaces



Supported Events for a Runnable

Each Runnable should have at least one event attached





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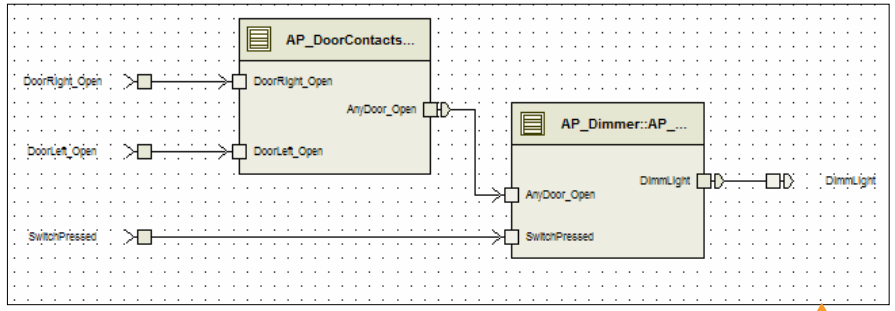
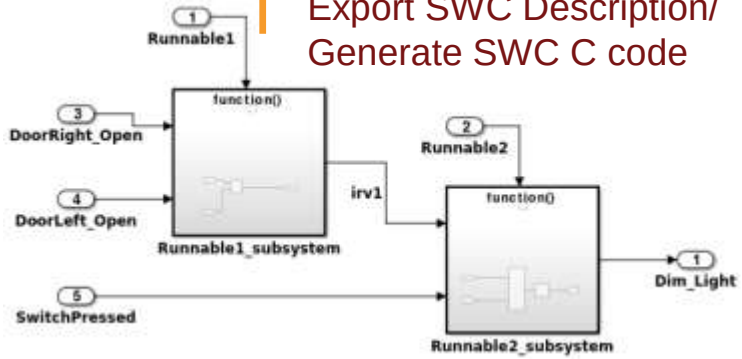
Bottom-Up Workflow (Starting from Simulink)

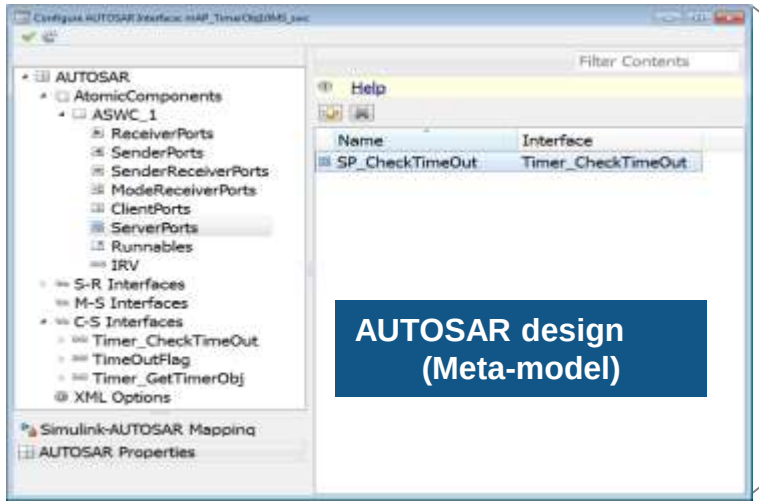
AUTOSAR Authoring Tool



Import
SWC Description

Export SWC Description/
Generate SWC C code





AUTOSAR design (Meta-model)

Using MATLAB for automating common tasks

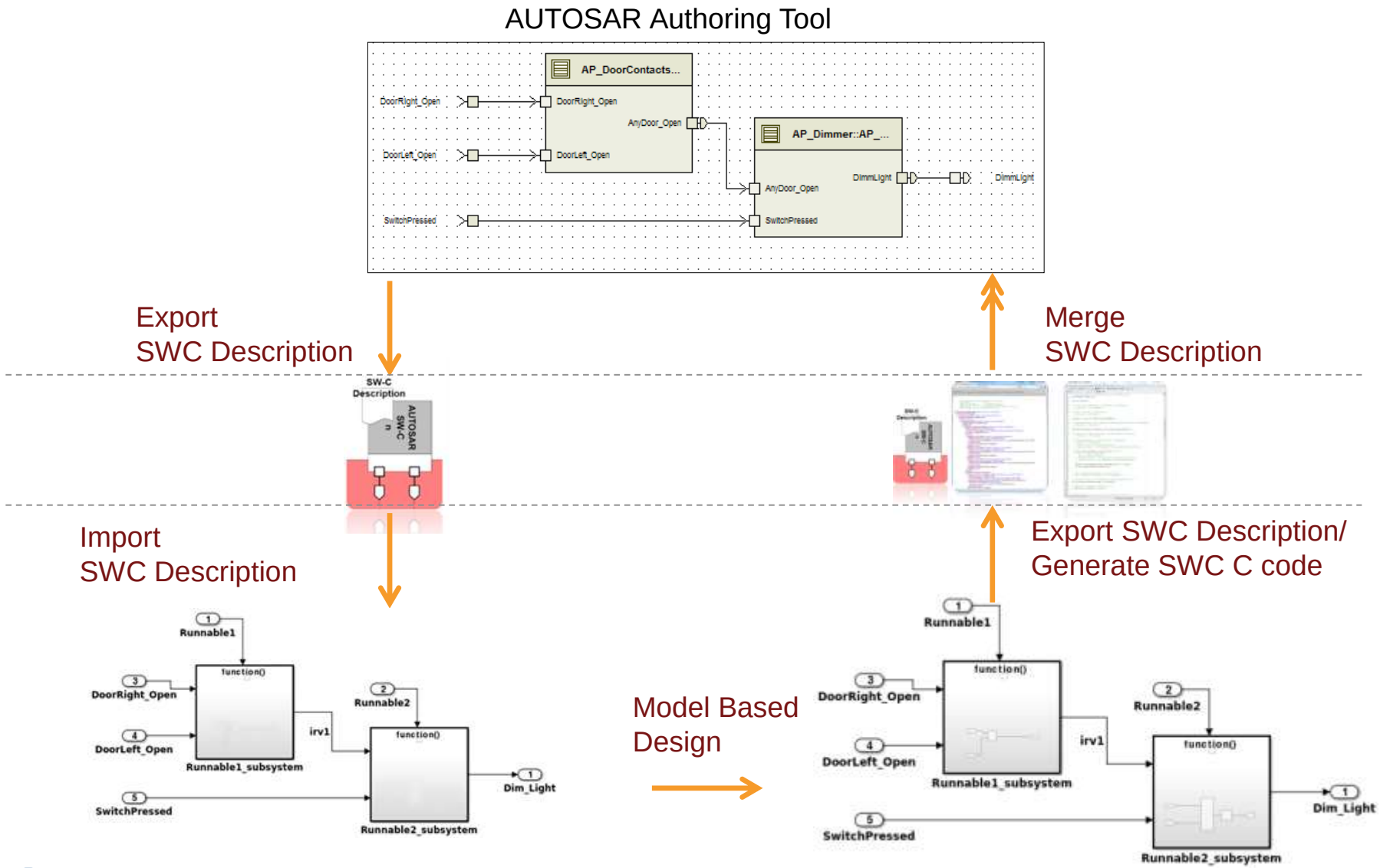
```
%% Setup AUTOSAR Configuration programmatically

model = 'Average_VehicleSpeed_Calculation';

% Modify AUTOSAR Properties
autosarProps = autosar.api.getAUTOSARProperties(model);
set(autosarProps, 'Input', 'IsService', true);
set(autosarProps, 'XmlOptions', 'ArxmlFilePackaging','SingleFile');

% Modify Simulink Mapping to AUTOSAR
slMap = autosar.api.getSimulinkMapping(model);
mapInport(slMap, 'Input' , 'Input', 'Input' , 'ExplicitReceive');
mapOutport(slMap, 'Output' , 'Output', 'Output' , 'ExplicitSend');
```

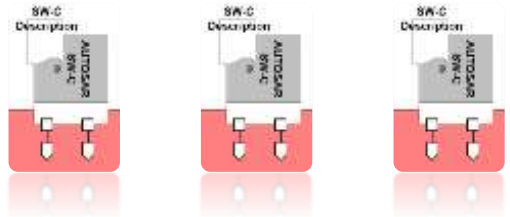
Top-Down Workflow (Starting from SWC Description)



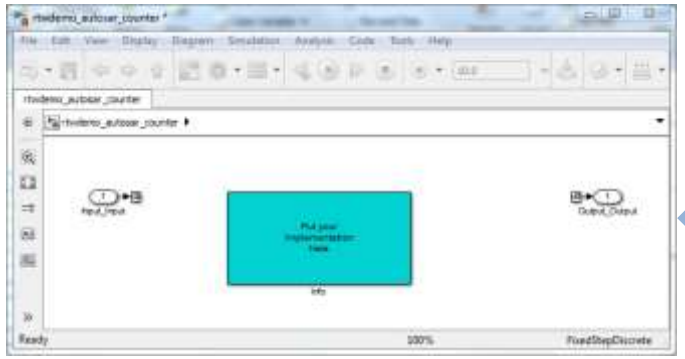
Top Down Workflow

AUTOSAR Authoring Tool

ARXML FIles

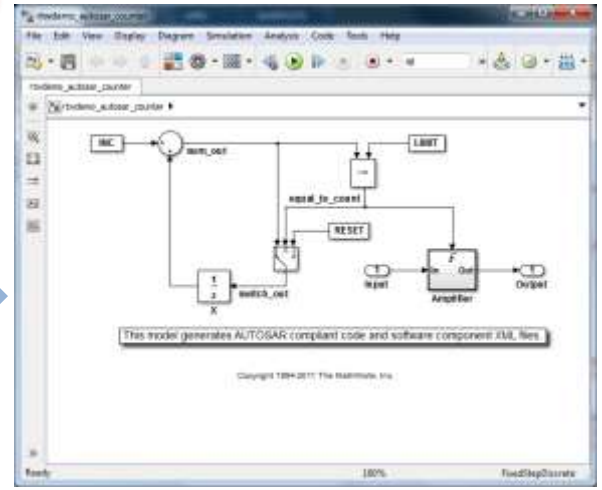


Import as new Simulink model



OR

Update existing Simulink model



Top Down Workflow

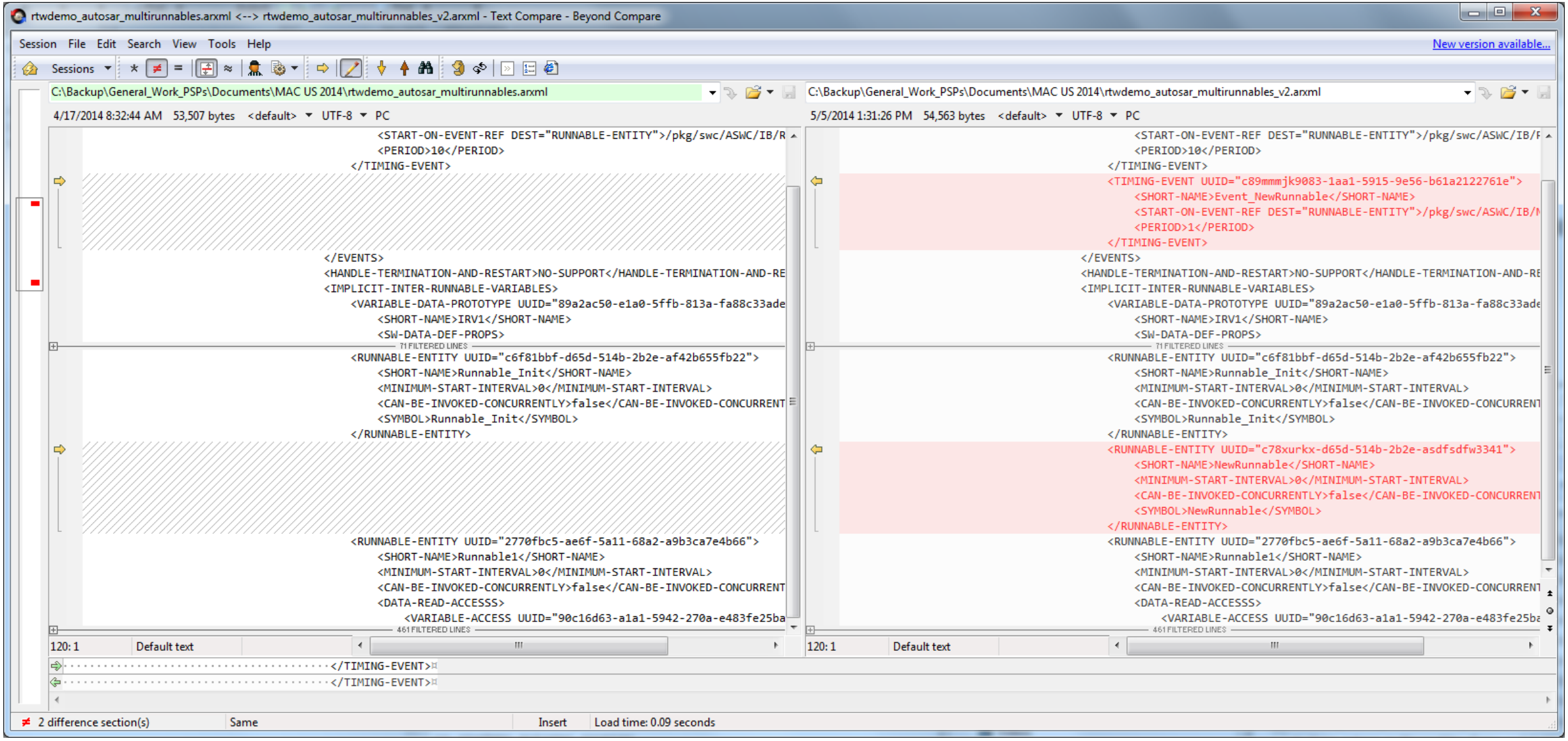
Starts with Authoring Tool, then user exports ARXML files from Authoring tool.

User can then either import the ARXML files into a new Simulink Skeleton model or Update an existing Simulink Model.

Updating Existing Models from ARXML

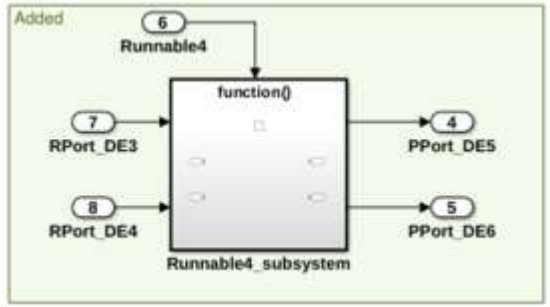
V1.arxml

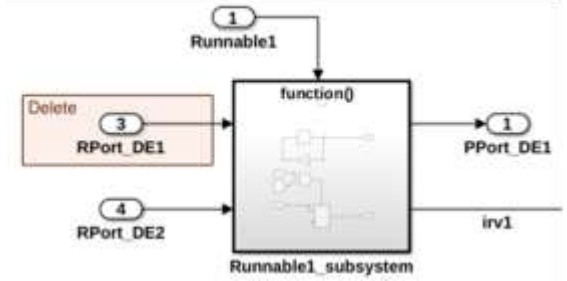
Updated to V2.arxml



Update Existing Models from ARXML

```
1    %cleanup
2 -  bdclose('all');
3 -  clear;
4
5 -  open_system('ASWC'); % Model needs to be open in order to perform update Model Command
6
7    %Import ARXML Files
8 -  importerObj = arxml.importer('rtwdemo_autosar_multirunnables_v2.arxml')
9
10   %Update existing model
11 -  importerObj.updateModel('ASWC')
```





AUTOSAR Update Report for ASWC

Software component /pkg/swc/ASWC
Original model saved as: ASWC_backup

This report details the updates applied to Simulink model ASWC based on differences between the imported arxml and the existing AUTOSAR configuration contained in the model. A backup of the original model has been saved to ASWC_backup (compare models). The report also recommends manual model changes.

Simulink

Automatic Model Changes

Automatic Workspace Changes

Required Manual Model Changes

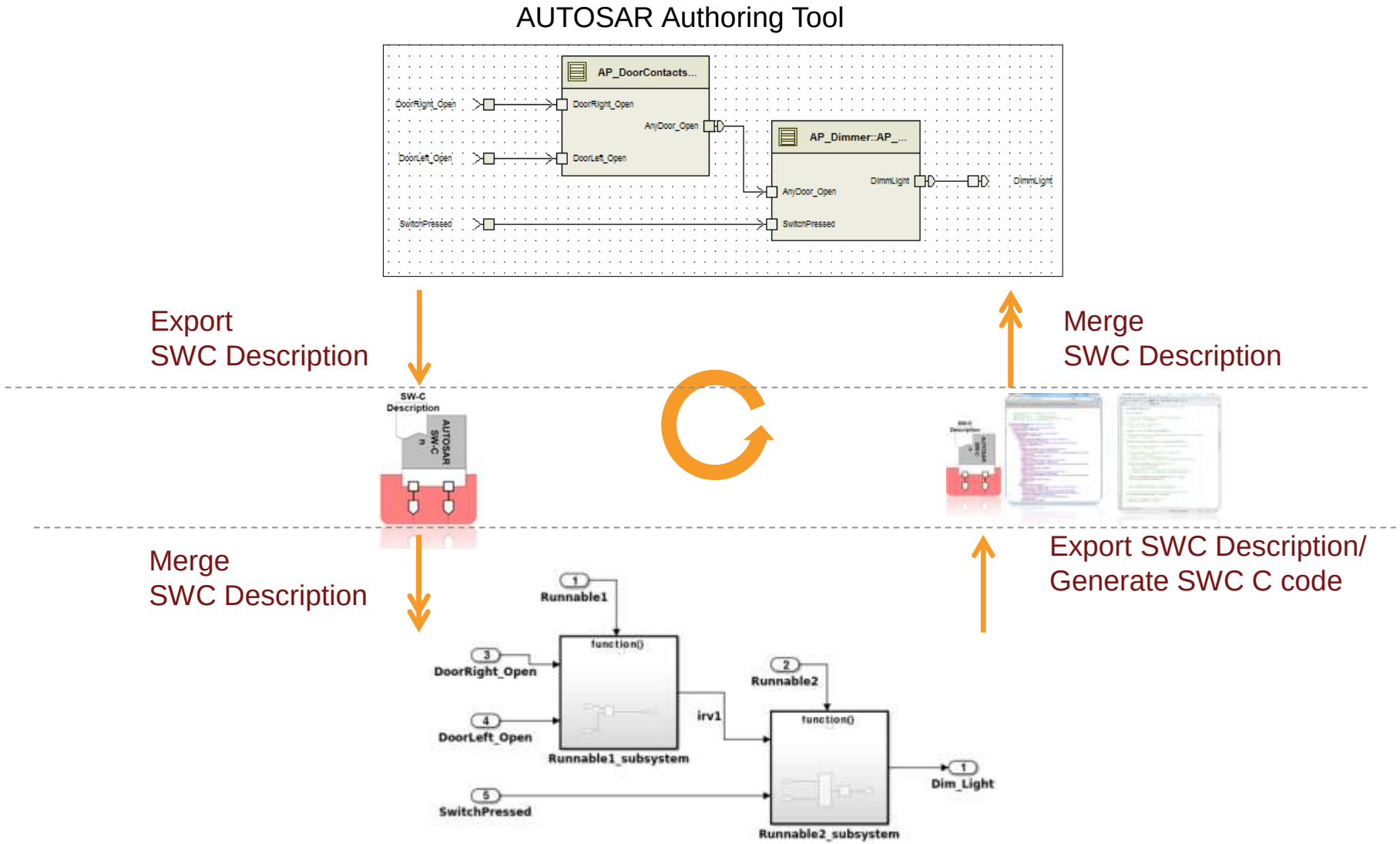
Optional Manual Workspace Changes

AUTOSAR

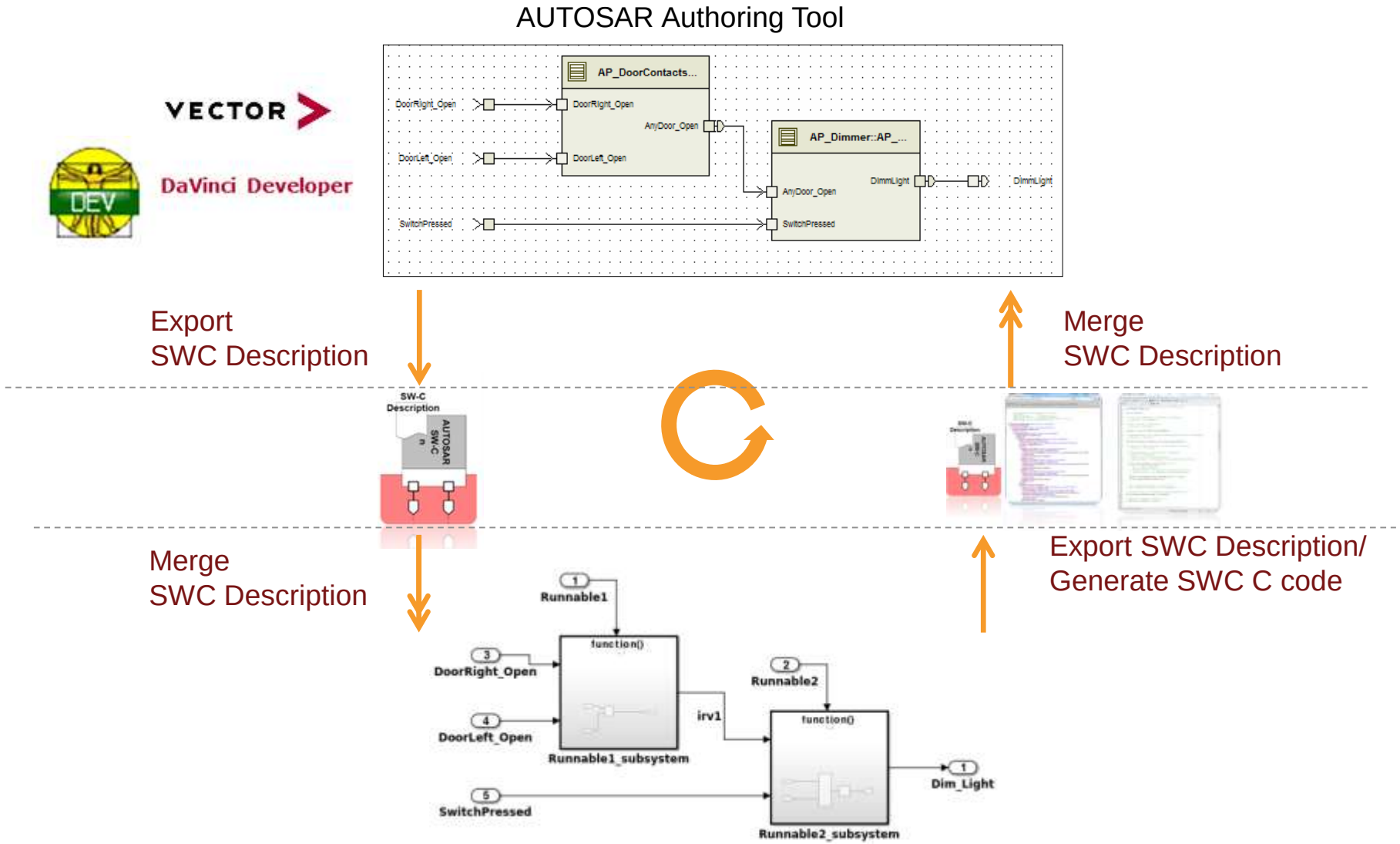
Automatic AUTOSAR Element Changes

Added ConstantSpecification /pkg/dt/Ground/DefaultInitValue_Single
Added FloatingPoint /pkg/dt/Single
Updated Type reference of InData /pkg/swc/ASWC/IB/IRV4 from /pkg/dt/Double to /pkg/dt/Single

Round-Trip Workflow

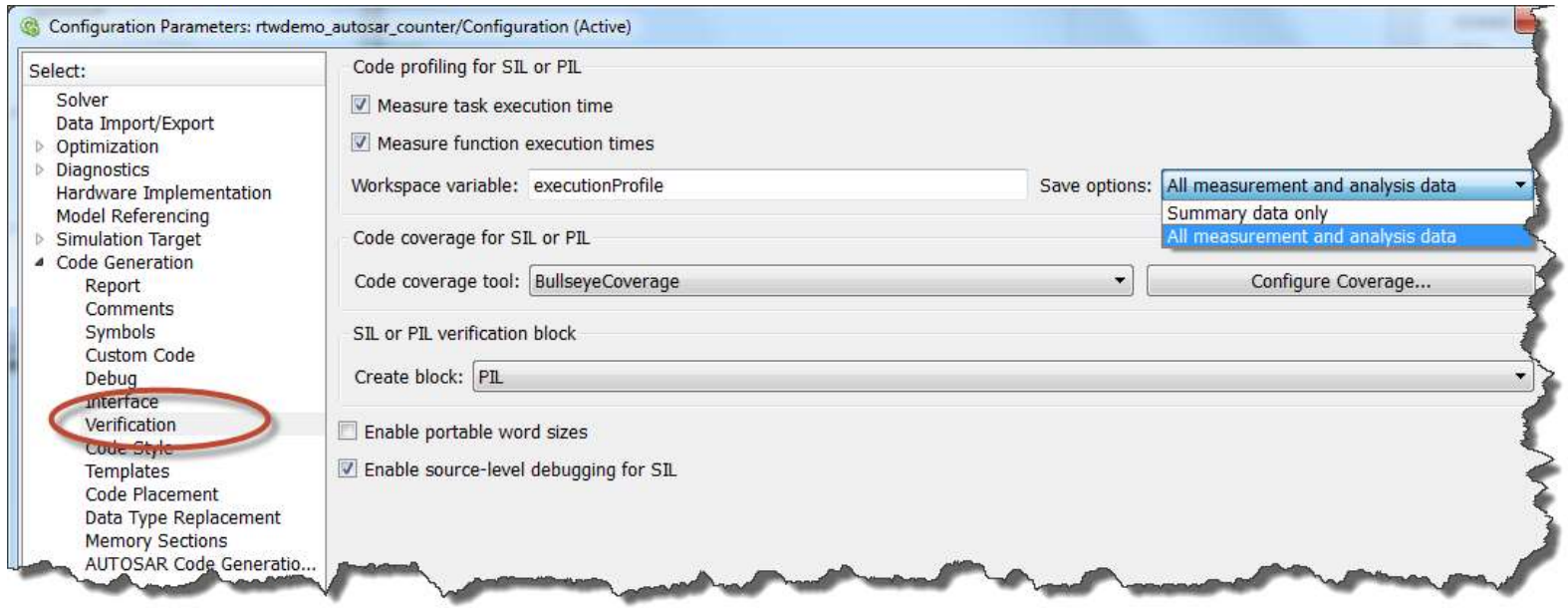


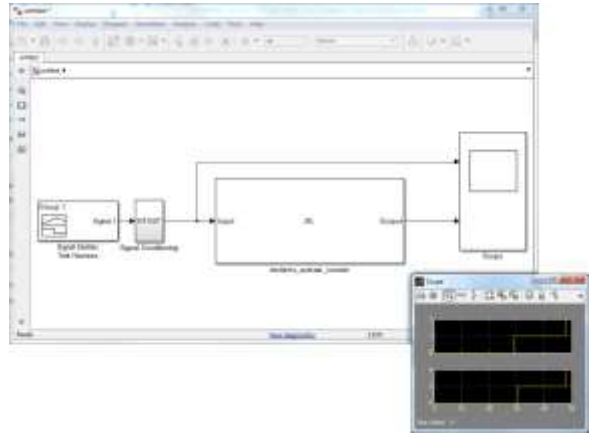
ARXML Import using Vector DaVinci



Verification with Software- and Processor-In-The-Loop (PIL)

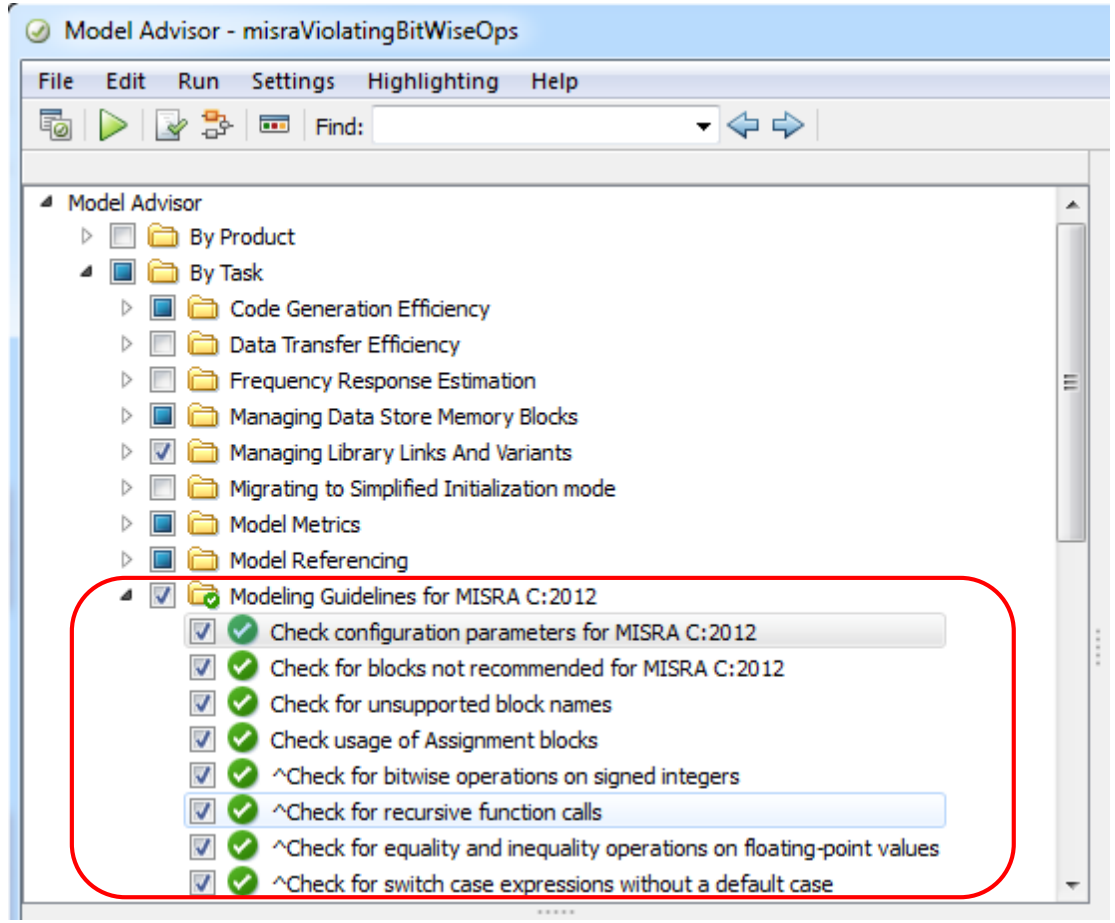
- Support for SIL/PIL with AUTOSAR target
- Profile code and measure execution time on target
- Develop a custom PIL target for AUTOSAR using the toolchain build approach





MISRA C:2012 for AUTOSAR target

100% Compliance with MISRA C:2012 Mandatory and Required rules



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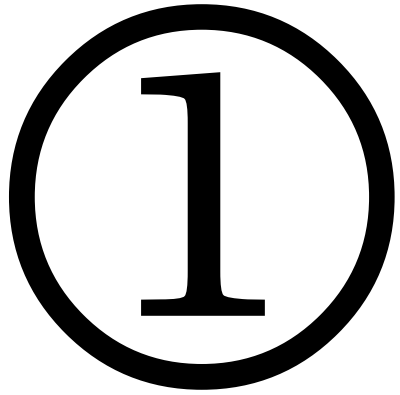


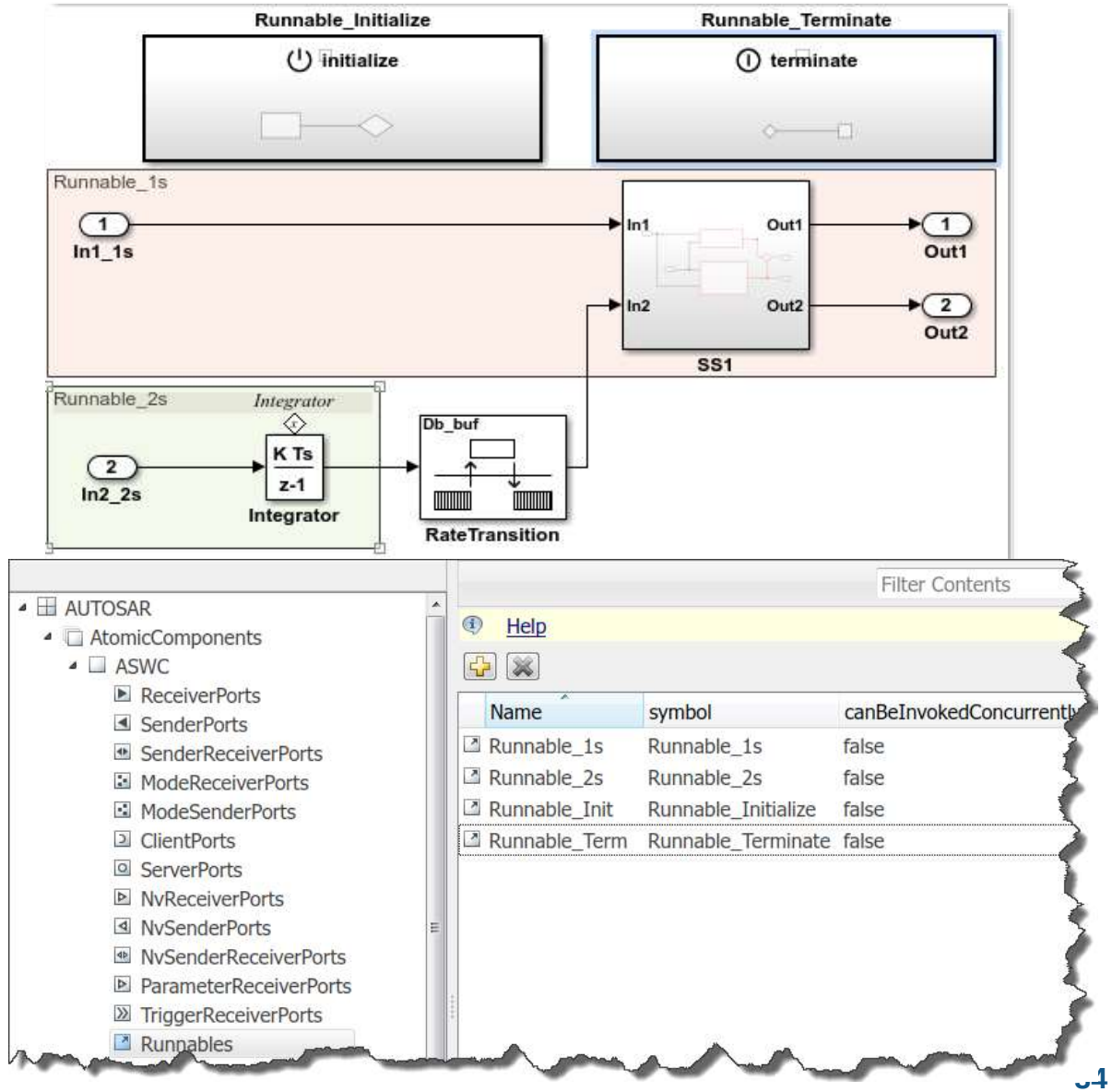
Startup, Reset, and Shutdown Modeling

AUTOSAR Startup, Reset, and Shutdown Modeling

New Simulink blocks for Initialize Function and Terminate Function

- You can map each Simulink initialize, reset, or terminate entry-point function to an AUTOSAR runnable
- All modeling styles are supported
  - Flexibility to use either Rate-Based or Export function modeling style
- Less wiring is required
- Can perform SIL

```
» rtwdemo_autosar_swc
```

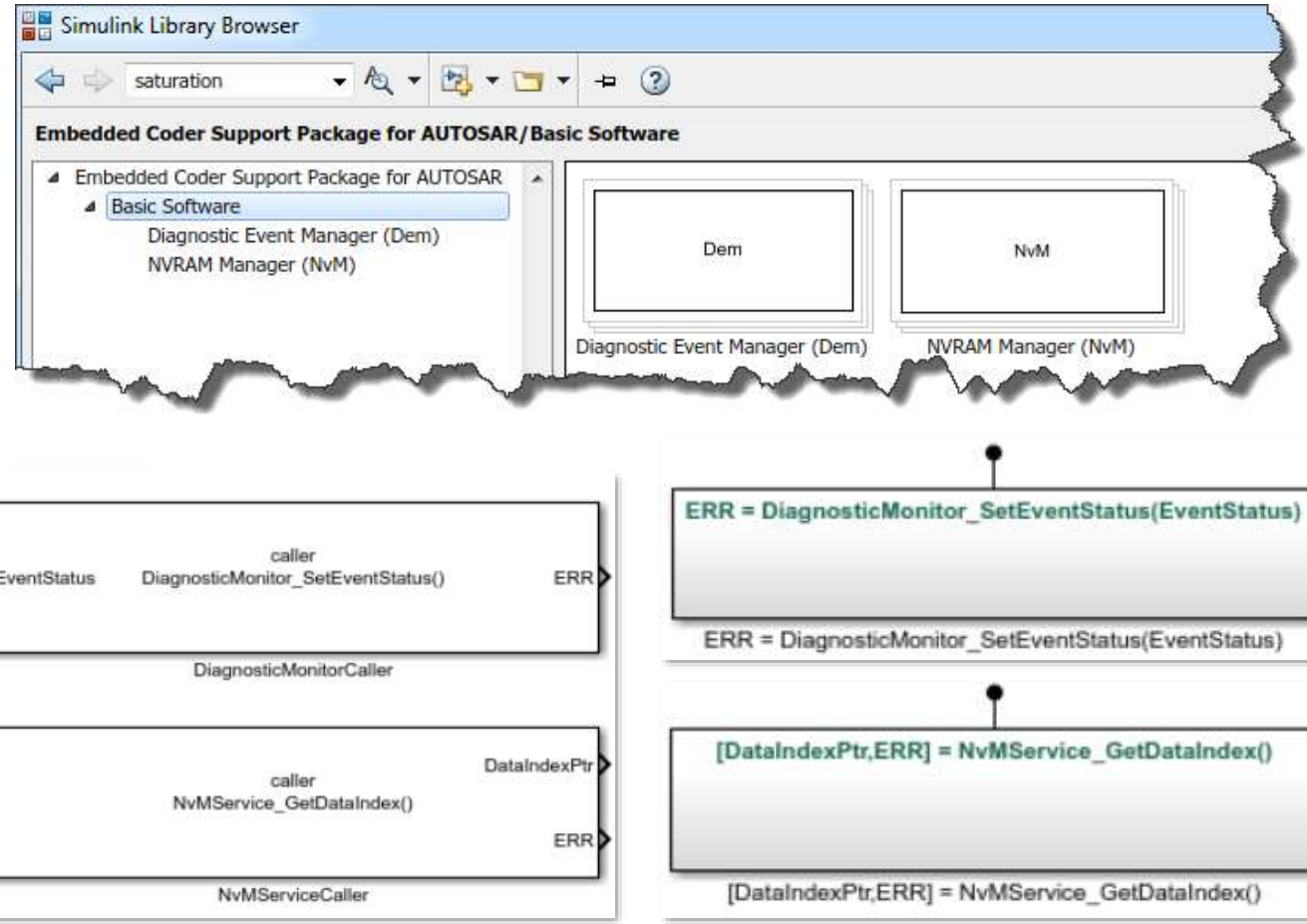


Basic Software (BSW) Access

AUTOSAR Basic Software (BSW) block library

Simulate BSW including Diagnostic Event Manager (DEM) and NVRAM Manager (NvM)

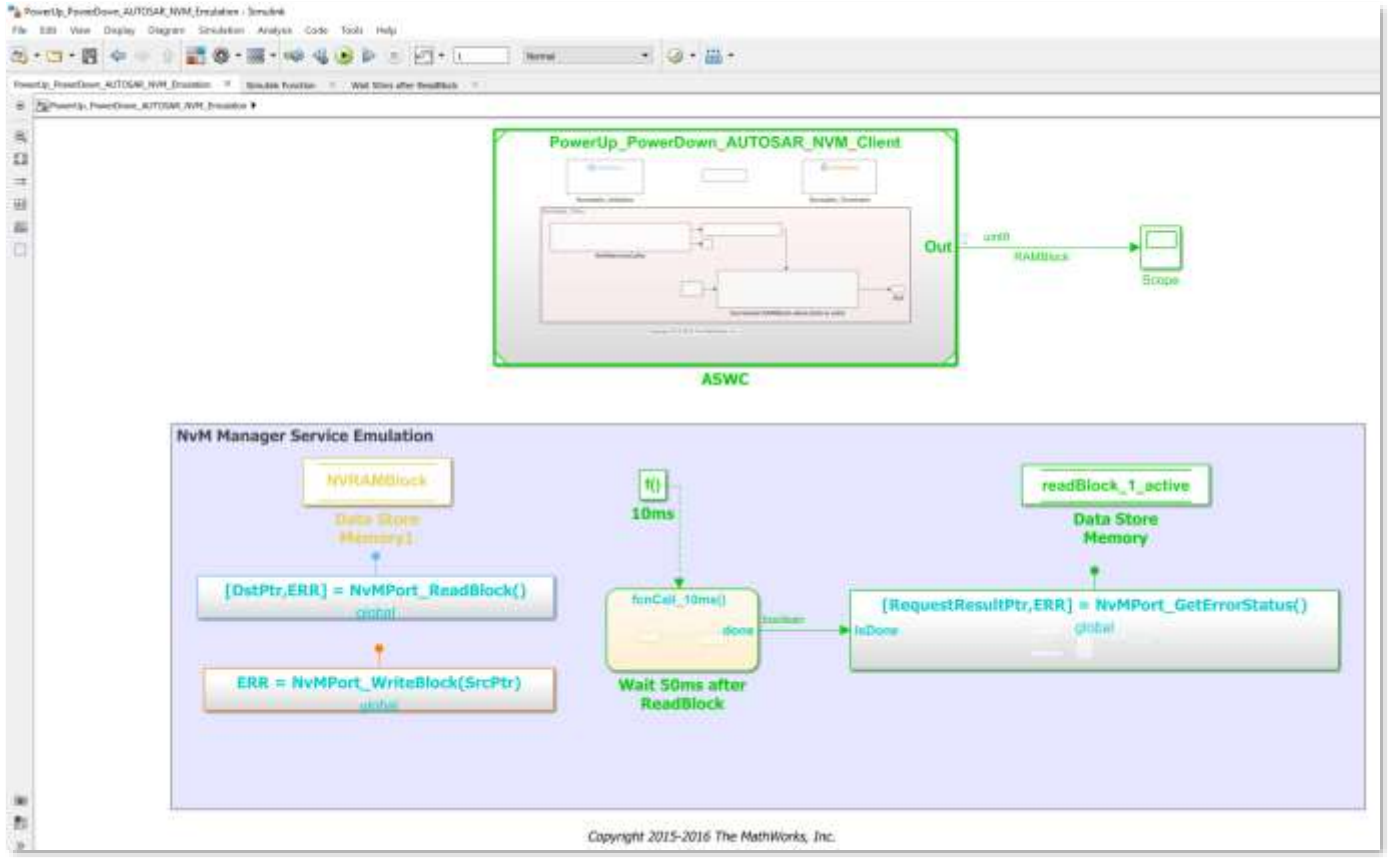
- Out of the box solution for calls to AUTOSAR BSW services
  - Drag and drop DEM/NvM blocks for Basic Software simulation
  - Everything is preconfigured




```
» rtwdemo_autosar_nvm_emulation
```

Power Up Power Down AUTOSAR NvM Emulation

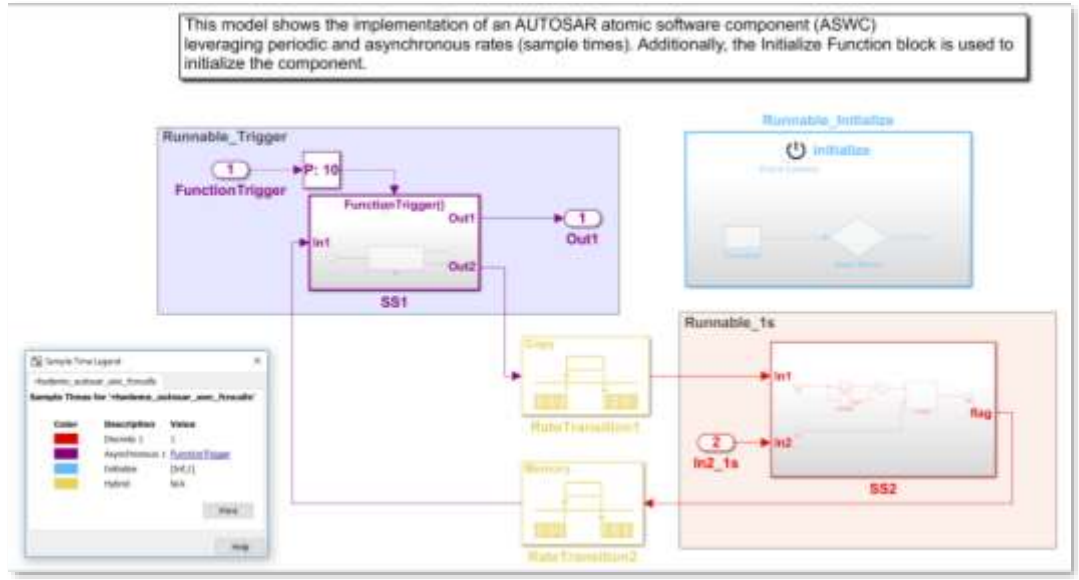
- Initialize, Reset & Terminate Blocks can be effectively used to model Start Up and Shut Down functionalities.
- System Level Modelling of AUTOSAR Components & Services Basic Software blocks can be used.



J-MAAB Type B Support

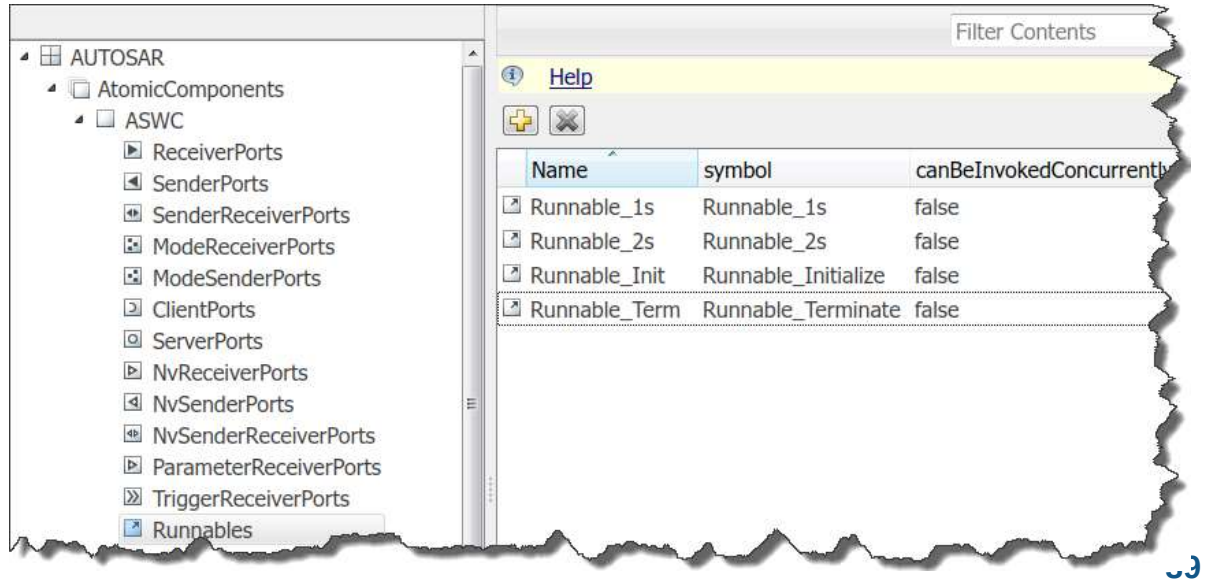
AUTOSAR J-MAAB Type B Modeling

R2016b adds support for JMAAB type beta modelling in AUTOSAR models



- This model shows the implementation leveraging periodic and asynchronous rates (sample times).
- Asynchronous function-call runnable at the top level of the model interacts with a periodic rate-based runnable.
- Model type B (β) — Places function layers above scheduling layers.

```
» rtwdemo_autosar_swc_fcncalls
```

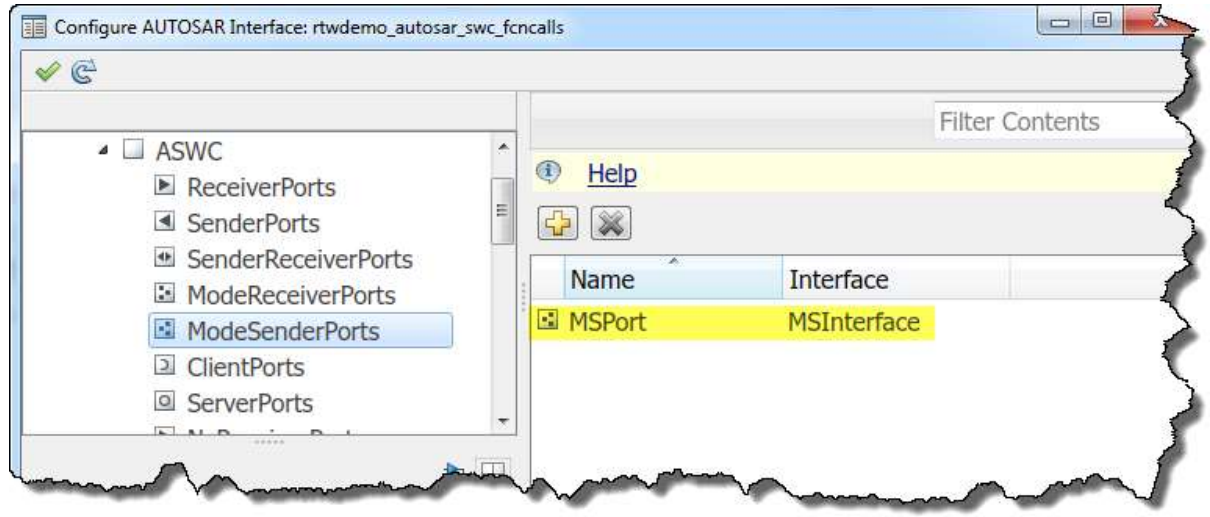


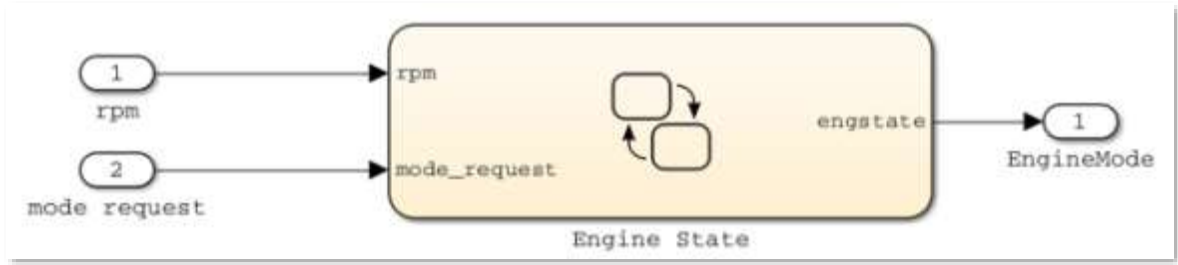
Mode Management (ModeSenderPorts, ModeSwitchPoints, …)

AUTOSAR ModeSenderPorts and ModeSwitchPoints

Modeling of AUTOSAR Mode-Switch (M-S) communication

- Ability to model application mode manager components, including AUTOSAR mode sender ports.
- Mode sender ports output a mode switch to connected mode user components.



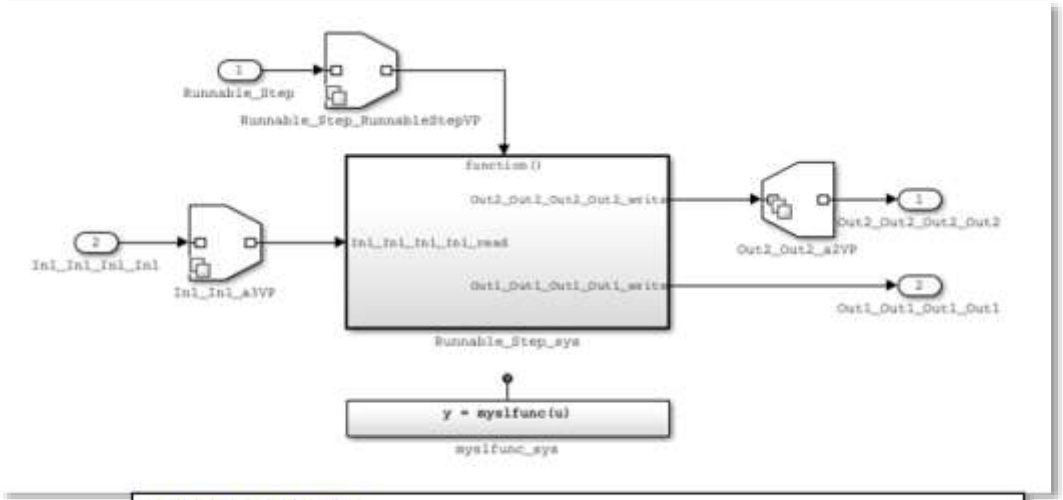


Variability inside a Software Component

Variants in AUTOSAR component modeling

Create variants for Ports and Runnables

- Import Variation Points on Ports and Runnables into Simulink
- Model using Variant Source and Variant Sink blocks
- Validate variant conditions on blocks match designed behavior from imported ARXML files




```
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  <SHORT-NAME>Runnable_Step</SHORT-NAME>
...
  <VARIATION-POINT>
    <SHORT-LABEL>RunnableStepVP</SHORT-LABEL>
    <SW-SYSCOND BINDING-TIME="PRE-COMPILE-TIME">
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        /mInlineVariant_pkg/mInlineVariant_dt/SystemConstants/A</SYSC-REF>==4
    </SW-SYSCOND>
  </VARIATION-POINT>
</RUNNABLE-ENTITY>
```

Agenda

- **Introduction to AUTOSAR**
  - Simulink approach to AUTOSAR
  - Overview of Modeling SWCs & Modeling Styles
- **AUTOSAR Design Workflows**
  - Bottom Up, Top Down & Round Trip
- **Advanced Topics – Top 5**
  - Startup, Reset, and Shutdown Modeling
  - Basic Software (BSW) Access
  - J-MAAB Type B Architecture
  - Mode Management (ModeSenderPorts, ModeSwitchPoints, …)
  - Variability inside a Software Component
- **Getting Started Resources**

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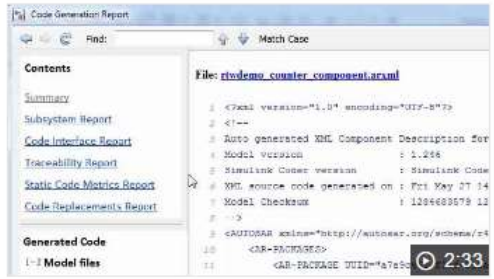
AUTOSAR Support from Embedded Coder

Author and develop AUTOSAR software components for automotive systems

AUTOSAR (AUTomotive Open System ARchitecture) is an open and standardized automotive software architecture jointly developed by automobile manufacturers, suppliers, and tool developers.

Embedded Coder® Support Package for AUTOSAR Standard lets engineers model and simulate AUTOSAR software components, generate AUTOSAR production code, and verify AUTOSAR generated code using software- and processor-in-the-loop simulations. The support package also enables import and export of AUTOSAR Software Component descriptions that support top-down, bottom-up, and round-trip workflows involving third-party AUTOSAR authoring tools such as DaVinci Developer.



AUTOSAR Support from Simulink and Embedded Coder

Platform and Release Support

See the hardware support package system requirements table for current and prior version, release, and platform availability.

View new features in the release notes.

Ready to install?

Before installing the support package, confirm you have the correct setup. View system requirements and installation options.

Get Support Package

Getting Started Resources

Expand all

Videos

- Model-Based Software Development: An OEM's Perspective (24:55)
- AUTOSAR Code Generation for Multiple Runnable Entities (2:46)
- Automatic Code Generation of AUTOSAR Software Components for Mass Production Application of Engine Management Systems: Process and Benefits (26:03)
- From Simulink to AUTOSAR Production Code (5:16)
- AUTOSAR Client-Server SIL Simulation (5:38)
- Simulation of AUTOSAR Software Components (6:01)
- Model AUTOSAR Variants in Simulink (4:53)
- Model AUTOSAR ECU Power-Up and Power-Down Behavior in Simulink (7:20)

http://www.mathworks.com/hardware-support/autosar.html

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Embedded Coder Support Package for AUTOSAR Standard

version 1.9 (15.1 KB) by MathWorks Embedded Coder Team

Develop AUTOSAR software components for automotive systems.

★★★★★ 1 Rating

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Overview

Embedded Coder® Support Package for AUTOSAR Standard provides additional support to Embedded Coder that includes modeling AUTOSAR elements and generating arxml and AUTOSAR-compatible C code from a Simulink® model. Verify AUTOSAR generated code using software- and processor-in-the-loop simulations.

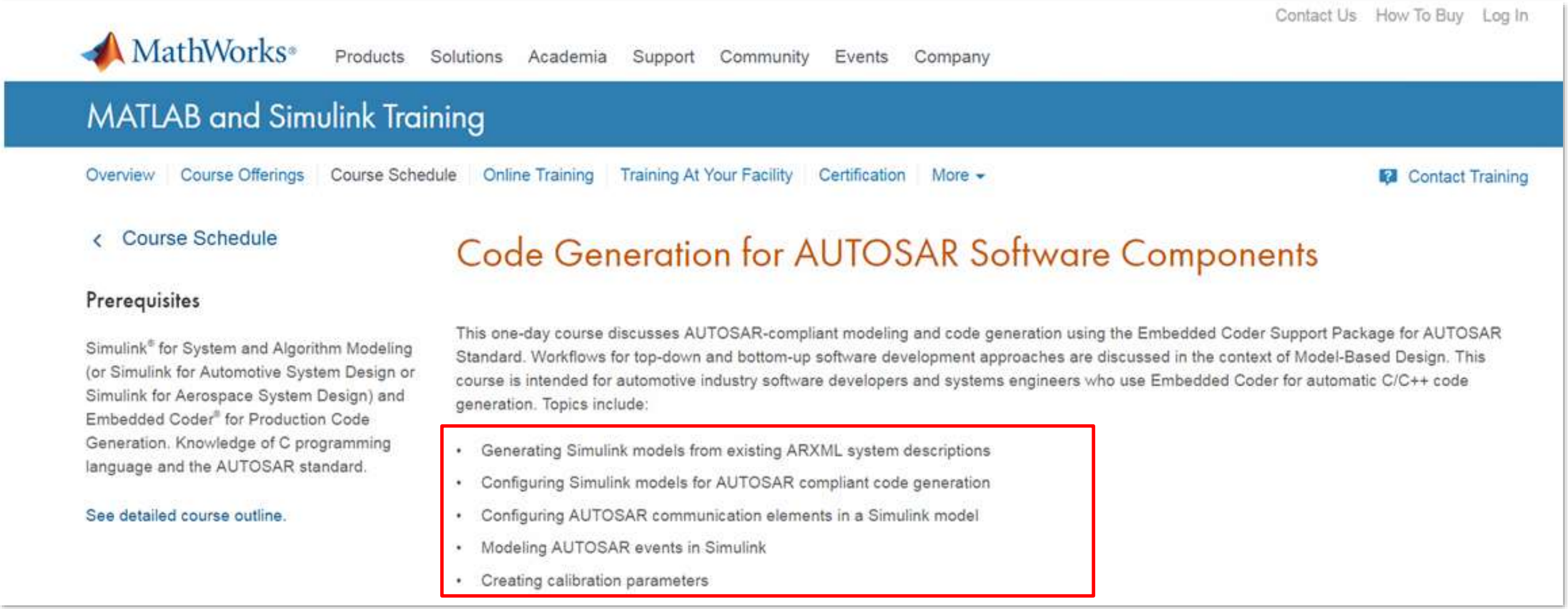
This support package is functional for R2014b and beyond.

Requires

Simulink Coder
Embedded Coder
Simulink
MATLAB Coder
MATLAB

http://www.mathworks.com/matlabcentral/fileexchange/47890-embedded-coder-support-package-for-autosar-standard

AUTOSAR Training Module



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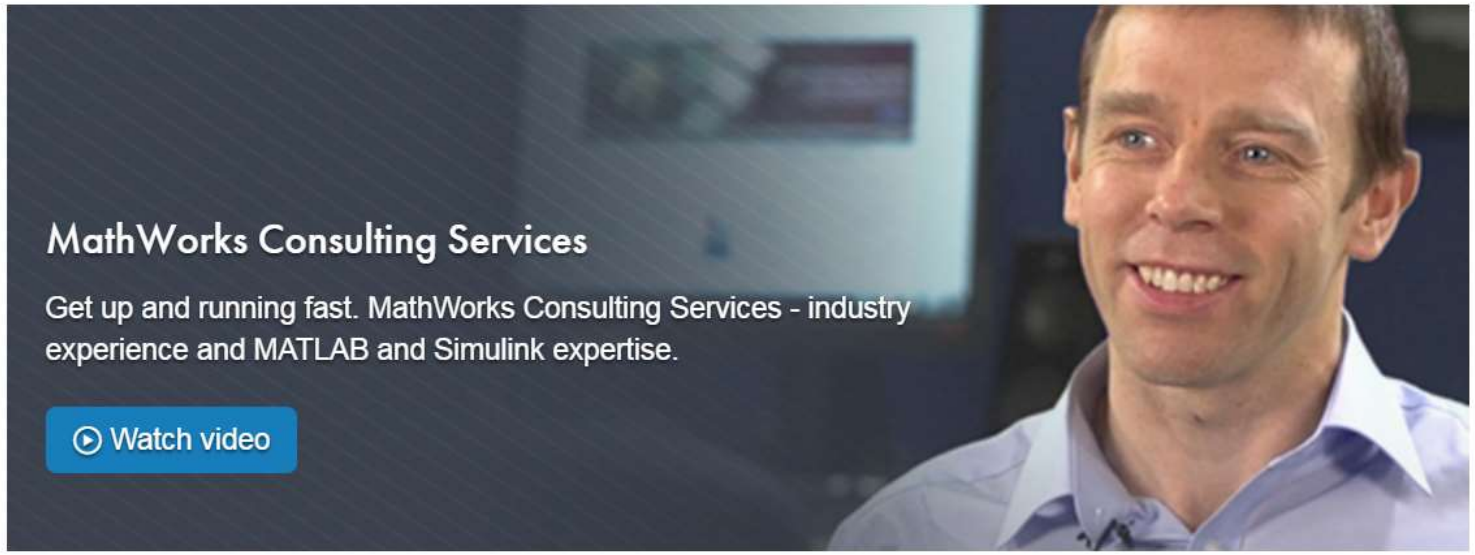

Questions?

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Meet Our Team

Kirsty van Ryneveld is a consultant engineer who focuses on data analysis, software development, and application deployment.

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And one last thing …
AUTOSAR – Antagonizing the „German Coast Guard“ Effect

Source: https://youtu.be/zkalf0odHs8 German Coast Guard Commercial 'We are Sinking' [HD]

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