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

Durvesh Kulkarni
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
What is AUTOSAR?

AUTOSAR® (AUTomotive Open System ARchitecture) is an open and standardized automotive software architecture
Complexity of Classic AUTOSAR is growing

- Components specification
- Body and Interior Electronics APIs...
- APIs for Powertrain, Chassis...
- DCM, DEM Revisions...
- Added safety concepts...
- RTE Enhancements...
- Variant Handling for Application Interfaces...
- Efficient NV Data Handling via RTE...
- Crypto Interface, V2X support...

**AUTOSAR Releases**

- 2.0: 90 files
- 2.1: 120 files
- 3.0: 125 files
- 3.1: 129 files
- 3.2: 136 files
- 4.0: 183 files
- 4.1: 198 files
- 4.2: 227 files
- 4.3: 238 files

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www.autosar.org
AUTOSAR Standards

Classic Platform

Adaptive Platform

4.3 was released in Nov 2016

V1 was released in March 2017

www.autosar.org
AUTOSAR Adoption
AUTOSAR Members

9 Core Partners

BMW Group, BOSCH, DAIMLER, PSA PEUGEOT CITROËN, OPEL, TOYOTA, VOLKSWAGEN AG

57 Premium Members

HONDA, DENSO, HITACHI, MAN, TITT, etc.

11 Development Members

itemis, SGS, C & S, etc.

88 Associate Members

88 Attendees

General, OEM, Generic Tier 1, Standard Software, Tools and Services, Semi-conductors

www.autosar.org
AUTOSAR Support from Embedded Coder and Simulink

![AUTOSAR Diagram](image)

- **Software Architecture Definition**
  - Application Layer
  - Run Time Environment (RTE)
  - Basic Software
    - ECU Abstraction Layer
    - Services Layer
      - Diagnostics
    - Microcontroller Abstraction Layer
    - Complex Device Drivers
- **Modeling and Simulation**
- **Behavior Modeling & Code Generation**
- **BSW Configuration & RTE Generation**
- **Basic SW Providers**

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Getting Started Resources
Simulink Approach to AUTOSAR

Simulink and Embedded Coder
+ AUTOSAR Support package for Embedded Coder

Available via web download

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

<table>
<thead>
<tr>
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<th>AUTOSAR Release</th>
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<tr>
<td>R2015b, R2016a/b, R2017a</td>
<td>2.1, 3.0, 3.1, <strong>3.2</strong> (Rev 3.2.2), 4.0, 4.1, <strong>4.2</strong> (Rev 4.2.1, 4.2.2)</td>
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<td>R2014b, R2015a</td>
<td>2.1, 3.0, 3.1, 3.2, 4.0, <strong>4.1</strong> (Rev 4.1.1)</td>
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<td>R2012a/b, R2013a/b, R2014a</td>
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<td>2.0, 2.1, 3.0</td>
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<tr>
<td>R2008a/b</td>
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Agenda

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- Getting Started Resources
Model AUTOSAR Components

Application Layer

AUTOSAR Software Component 1

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AUTOSAR Software Component n

Virtual Functional Bus (VFB)

Periodic Rate-Based

Periodic & Asynchronous

Multi-Rate & Asynchronous

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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

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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)
%% 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)

AUTOSAR Authoring Tool

Import SWC Description

Export SWC Description

Merge SWC Description

Model Based Design

Export SWC Description/Generate SWC C code
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

% cleanup
bdclose('all');
clear;

open_system('ASWC'); % Model needs to be open in order to perform update Model Command

% Import ARXML Files
importerObj = axml.importer('rtwdemo_autosar_multirunnables_v2.arxml')

% Update existing model
importerObj.updateModel('ASWC')
Round-Trip Workflow

AUTOSAR Authoring Tool

Export SWC Description

Merge SWC Description

Export SWC Description/
Generate SWC C code
ARXML Import using Vector DaVinci

AUTOSAR Authoring Tool

Export SWC Description

Merge SWC Description

Export SWC Description/
Generate SWC C code

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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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Getting Started Resources
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

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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 ($\beta$) — Places function layers above scheduling layers.

```plaintext
rtwdemo_autosar_swc_fcncalls
```

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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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Getting Started Resources
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.

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.

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

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

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AUTOSAR Training Module

MATLAB and Simulink Training

Course Schedule

Prerequisites

Simulink® for System and Algorithm Modeling (or Simulink for Automotive System Design or Simulink for Aerospace System Design) and Embedded Coder® for Production Code Generation. Knowledge of C programming language and the AUTOSAR standard.

See detailed course outline.

Code Generation for AUTOSAR Software Components

This one-day course discusses AUTOSAR-compliant modeling and code generation using the Embedded Coder Support Package for AUTOSAR Standard. Workflows for top-down and bottom-up software development approaches are discussed in the context of Model-Based Design. This course is intended for automotive industry software developers and systems engineers who use Embedded Coder for automatic C/C++ code generation. Topics include:

- Generating Simulink models from existing ARXML system descriptions
- Configuring Simulink models for AUTOSAR compliant code generation
- Configuring AUTOSAR communication elements in a Simulink model
- Modeling AUTOSAR events in Simulink
- Creating calibration parameters
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Meet Our Team
Kirsty van Ryneveld is a consultant engineer who focuses on data analysis, software development, and application deployment.

"MathWorks Consultants" were well-qualified, professional, and fast. They understood not only the technical issues but also the business goals, which is essential when working on a core business system. We got more than we expected from MathWorks.

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

Source: https://youtu.be/zkaIf0odHs8 German Coast Guard Commercial 'We are Sinking' [HD]
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