

30 June 2020

AUTOSAR Architecture

Modeling of Multi-core

Electric Powertrain Controller

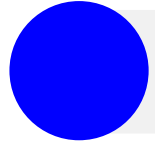
Dr Sakthivel Manikandan Sundharam /
Software Architect

Delphi
Technologies

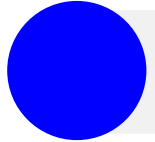


Bio : Sakthivel Manikandan Sundharam

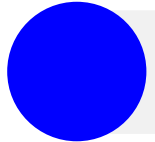
True! Bit longer name - Shortly "Sakthi"



Software Architect – Powertrain Electrification & Electronics



15+ Years of Automotive Embedded System Experience



Ph.D. in Timing Aware Model-Based Design to Automotive Embedded Systems, University of Luxembourg, Luxembourg




Masters in Embedded Systems, College of Engineering Chennai, India



Work revolves around software architectural topics incorporating timing, memory, and safety constraints of automotive software.

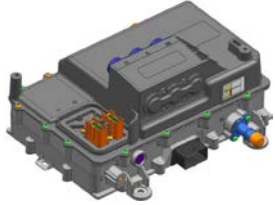


Outline / Agenda

- 
- 1 Delphi Technologies - Powertrain Electrification Product Portfolio
 - 2 HV Inverter System Context
 - 3 Pitfalls in Legacy Approach of SW Architecture Modeling
 - 4 Evaluation of Journey
 - Requirements to Architecture
 - Architecture authoring
 - Interfaces / Data dictionary
 - 5 Lessons learnt and Best practices

Delphi Technologies - Powertrain Electrification Product Portfolio

Low cost, high density, rugged with various levels of integration available



Single Inverter



Inverter w/ DC/DC (CIDD)



48V Inverter for BSG



48V DC/DC Converter



High Voltage Box



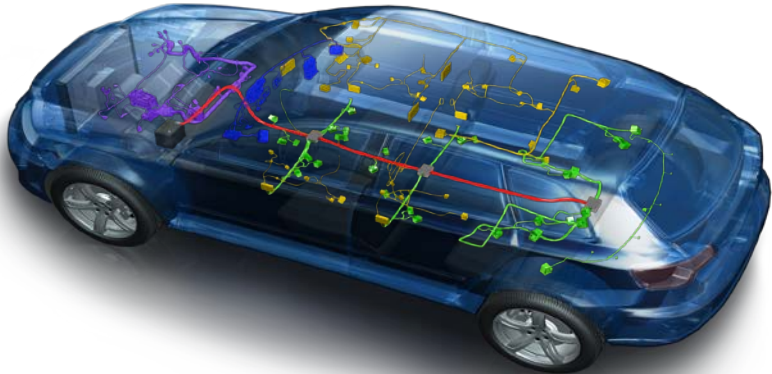
3-in-1 Inverter



DC/DC Converters



Dual Inverter



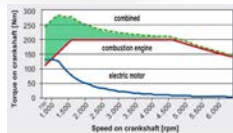
Battery Pack Controller



Dual Inverter/ Converter/ Hybrid Controller



Supervisory Controller (Hybrid Control Unit)



Hybrid Control Software



On-board Battery Chargers

Delphi Technologies Inverter – The Next Generation

Inverter with conventional Power Module



Conventional
Many, many wire-bonds

Gravimetric power density
(kVA/Kg)

16.1 → 20.6
25% higher

Volume (L)

10.7 → 7.6
30% smaller

Mass (Kg)

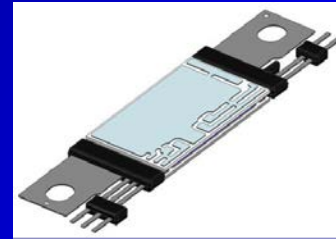
14.5 → 8.4
40% lighter

Efficiency Improvement (MPG)

0 → 2



Delphi Technologies Inverter with viper

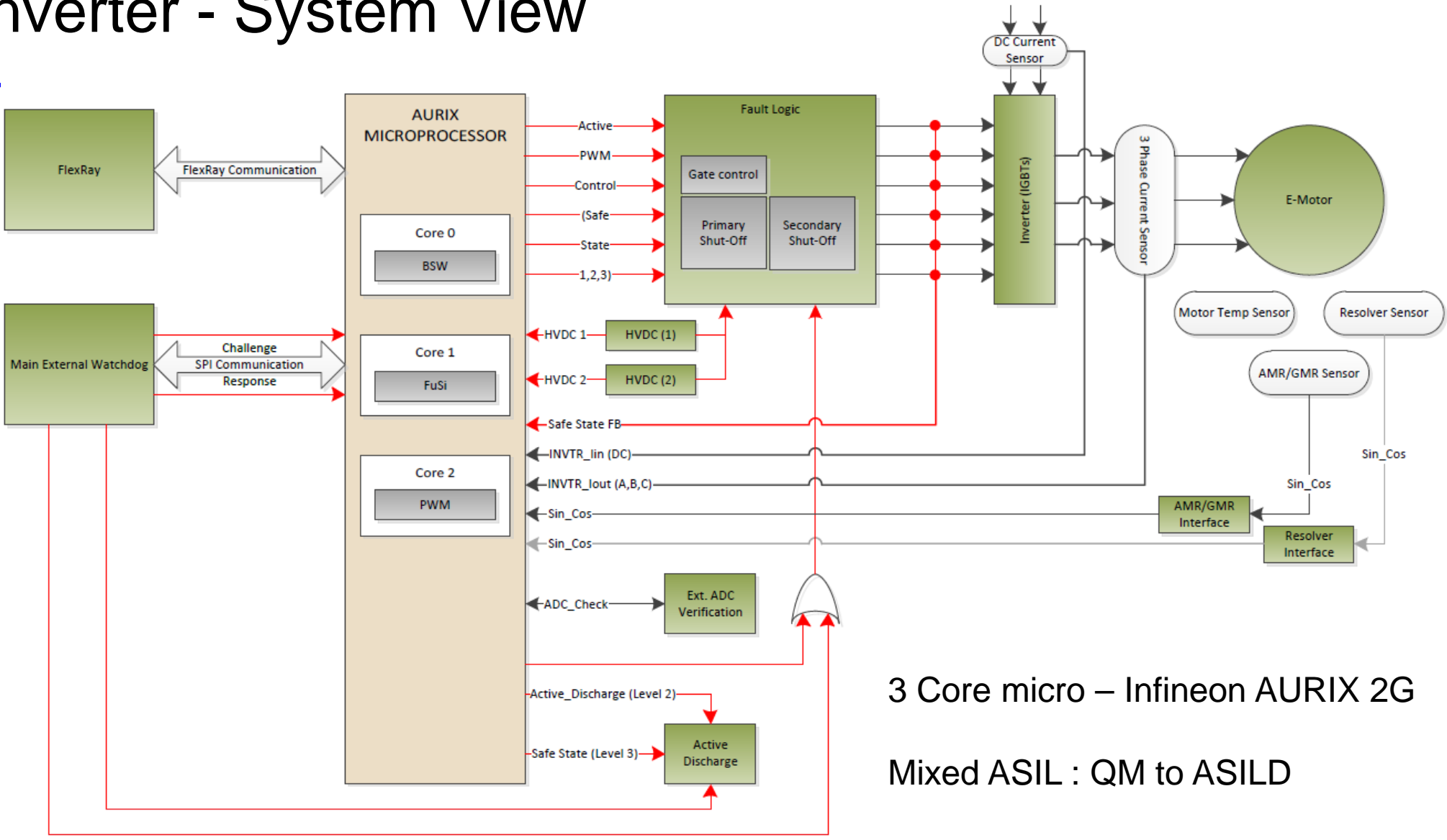


Delphi Inverter next generation

- Next gen Viper enables extra high voltage **800V** bus inverters
- Flexibility to move from **Si** to **SiC** power switch to enable higher efficiency & lower cost
- **Advanced capacitor** enables up to 70% reduction in component volume & weight



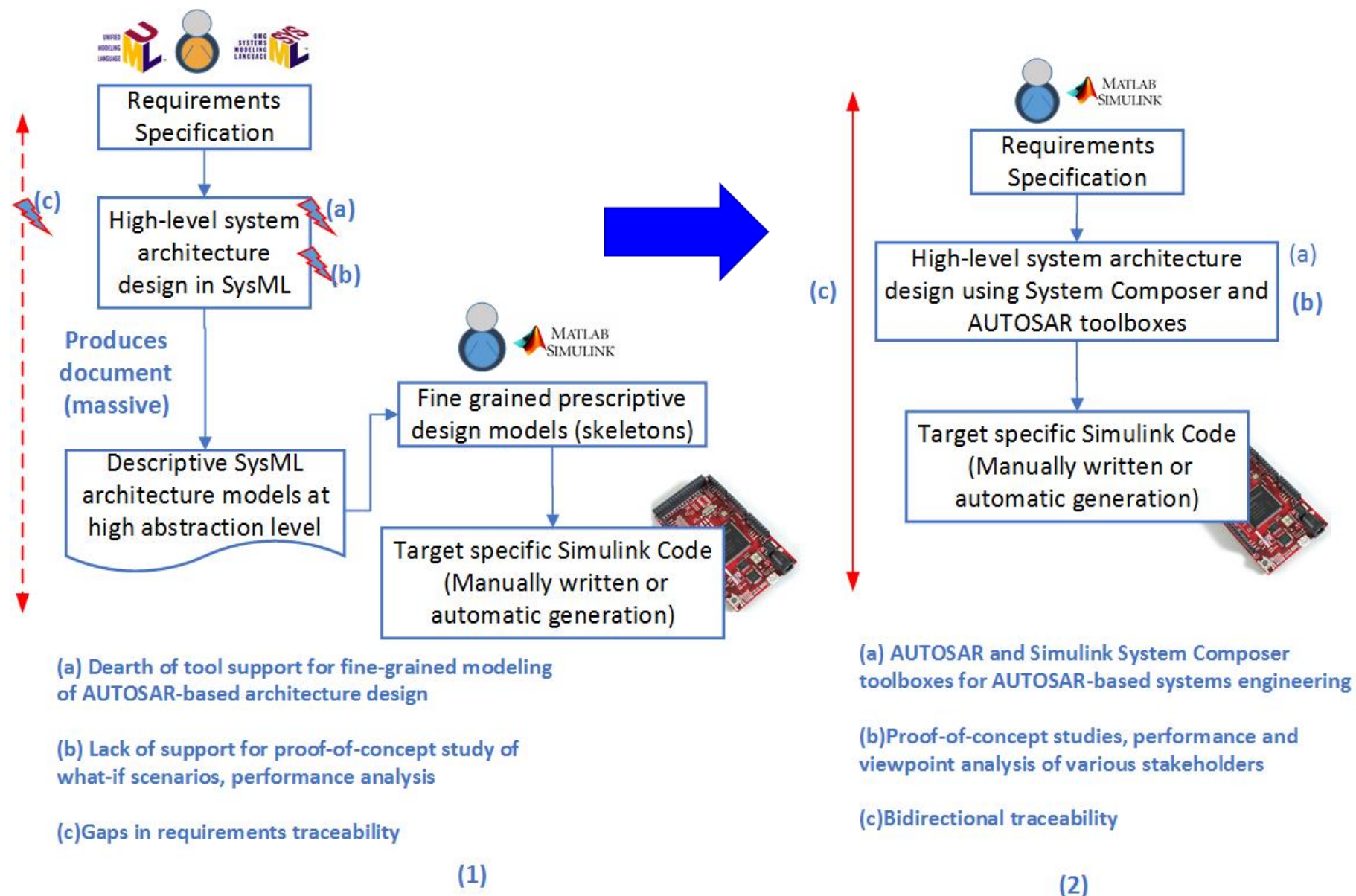
HV Inverter - System View



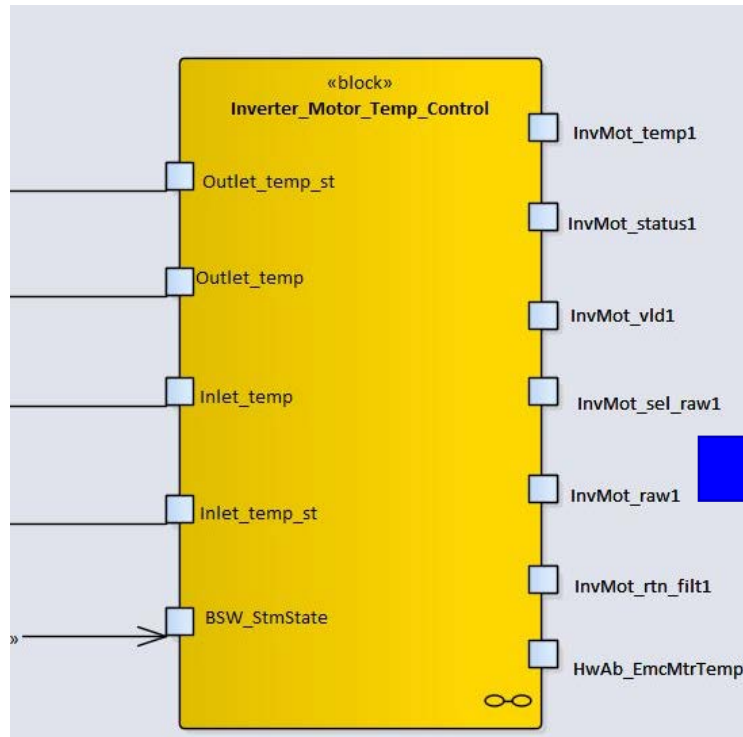
3 Core micro – Infineon AURIX 2G
 Mixed ASIL : QM to ASILD

Multicore Electric Powertrain Controller

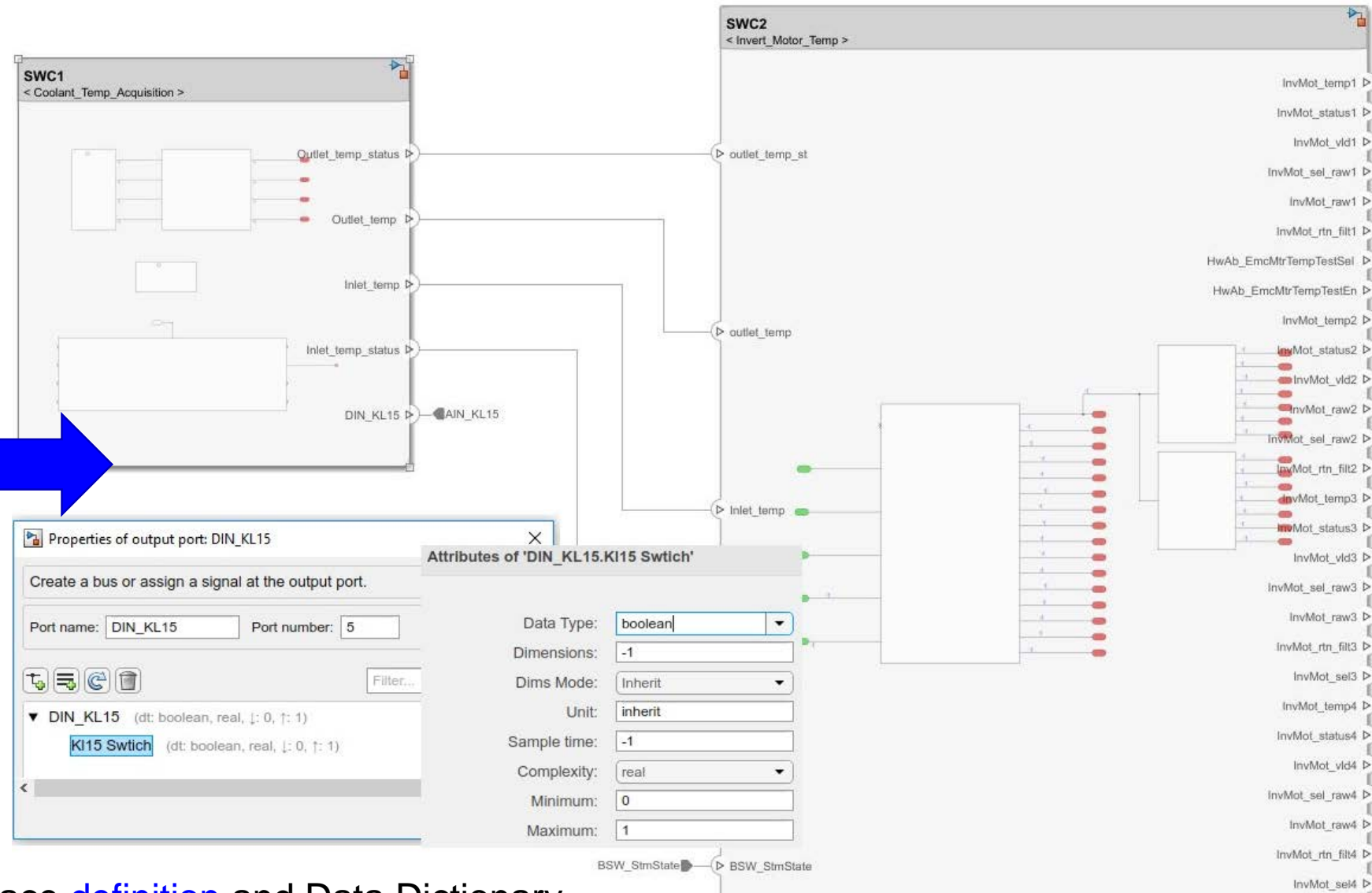
Pitfalls in Legacy Approach and Best Practices Evaluated



Static Software Architecture Tooling Twins MLSL's AUTOSAR Blockset + System Composer

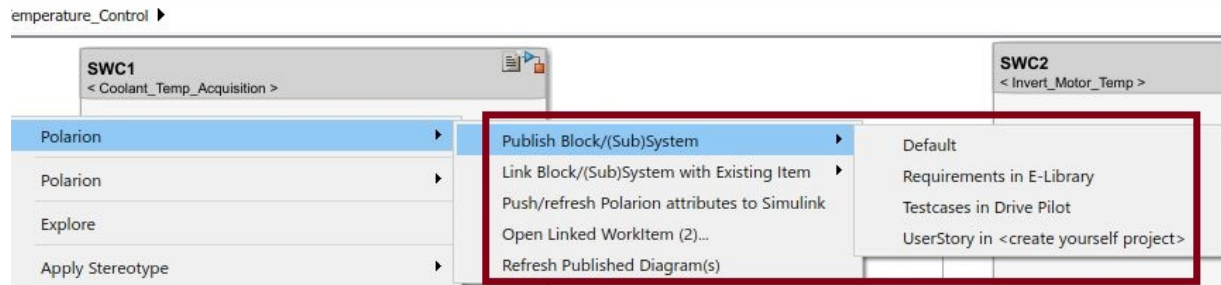
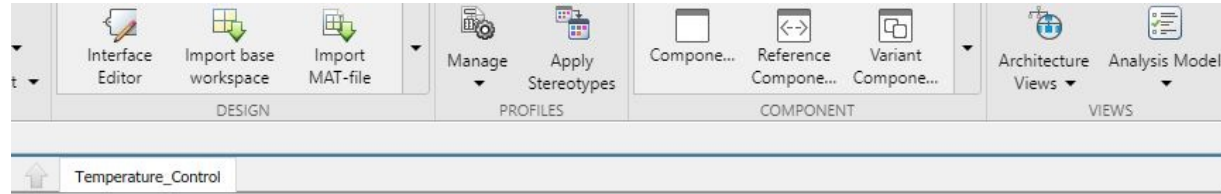


Legacy SysML



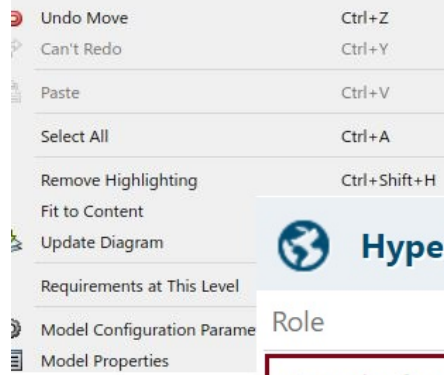
Interface definition and Data Dictionary

Publishing Architecture Modeling onto Requirements Database



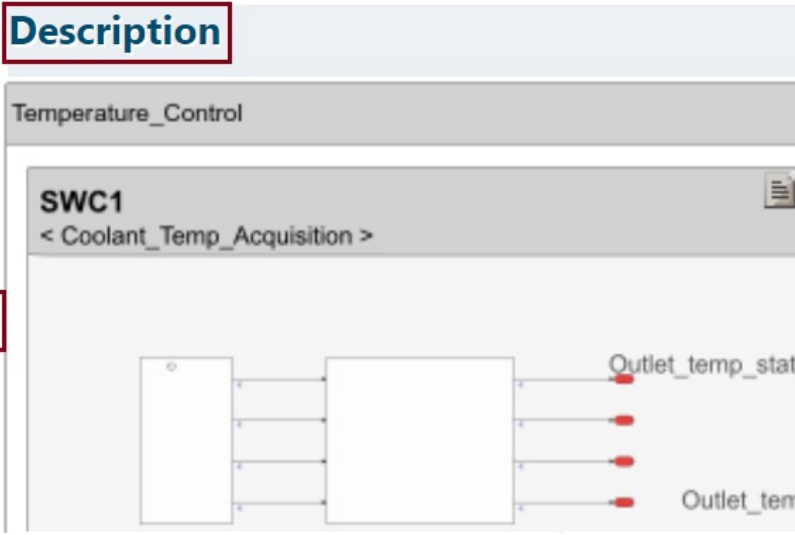
approach provides a **lean** way to **publish** the design to requirements database.

Also for existing requirements, it provides an option to **link** them



Hyperlinks	
Role	URL
external reference	http://localhost:31415/matlab/feval/r...

Attachments	
Title	File Name
Matlab Model	matlabssystem.png [direct link]



Requirements to Architecture Linking

The screenshot displays a software interface for system architecture. The main area shows a diagram of a system with components like SWC1 and SWC2, and various ports and signals. A red box highlights a list of URLs in the top right corner, which are: <https://reqdemo.polarion.com/polarion/>, <https://reqdemo.polarion.com/polarion/>, and <https://reqdemo.polarion.com/polarion/>. Below the diagram, a table titled 'Requirement links - Temperature_Control' is visible, showing a list of requirements and their links to the architecture.

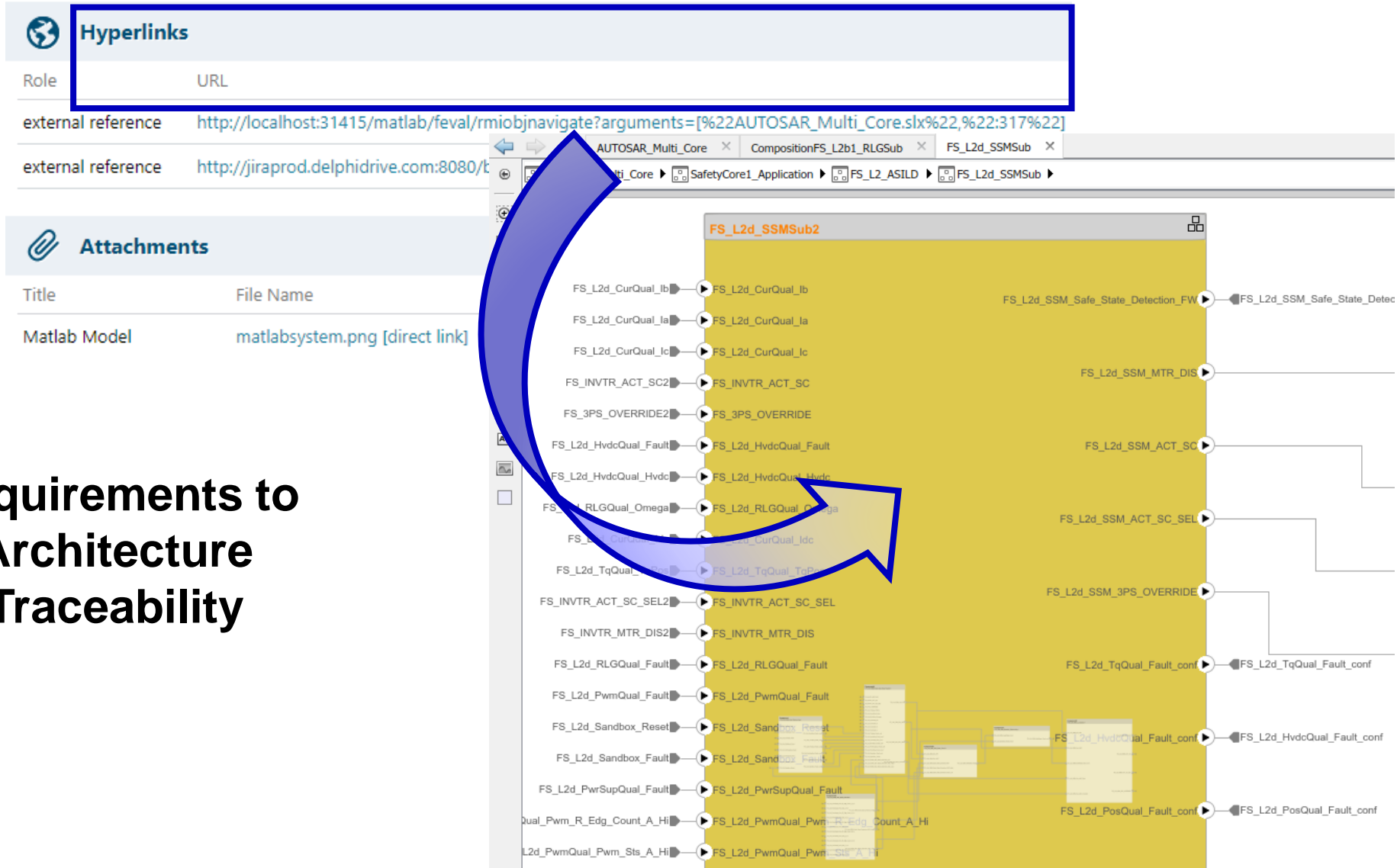
Label	Source	Type	Destination
Temperature_Control.slmx	Changed source: 0/9		Changed destination: 0/9
Polarion: IC-509	Temperature_Control	Implements	https://reqdemo.polarion.com/polarion/
Polarion: IC-510	SWC1	Implements	https://reqdemo.polarion.com/polarion/
Polarion: IC-512	Temperature_Control	Implements	https://reqdemo.polarion.com/polarion/
Polarion: IC-513	Out Bus Element1	Implements	https://reqdemo.polarion.com/polarion/
Polarion: IC-514	SWC3	Implements	https://reqdemo.polarion.com/polarion/
Polarion: IC-515	SWC1	Implements	https://reqdemo.polarion.com/polarion/
Polarion: IC-516	SWC2	Implements	https://reqdemo.polarion.com/polarion/
Polarion: IC-517	SWC1	Implements	https://reqdemo.polarion.com/polarion/

Tracking of requirements back and forth between modeling and requirements database to verify fulfillment of requirements

Bi-directional Traceability - Forward

is allocated to

 AINV-47779 - Reqs - SW Architecture




Hyperlinks

Role	URL
external reference	http://localhost:31415/matlab/feval/rmiobjnavigate?arguments=[%22AUTOSAR_Multi_Core.slx%22,%22:317%22]
external reference	http://jiraproduct.delphidrive.com:8080/t

Attachments

Title	File Name
Matlab Model	matlabssystem.png [direct link]

FS_L2d_SSMSub2



**Requirements to
Architecture
Traceability**

Bi-directional Traceability - Backward

The screenshot illustrates the process of backward traceability in a software development environment. It features a main workspace on the left with a hierarchical tree of components, a central context menu, a 'Linked Work Items' window, and a detailed view of a specific work item.

Linked Work Items Window:

ID	Title
AINV-55960	Planning - SW Architecture - Safe State Manager

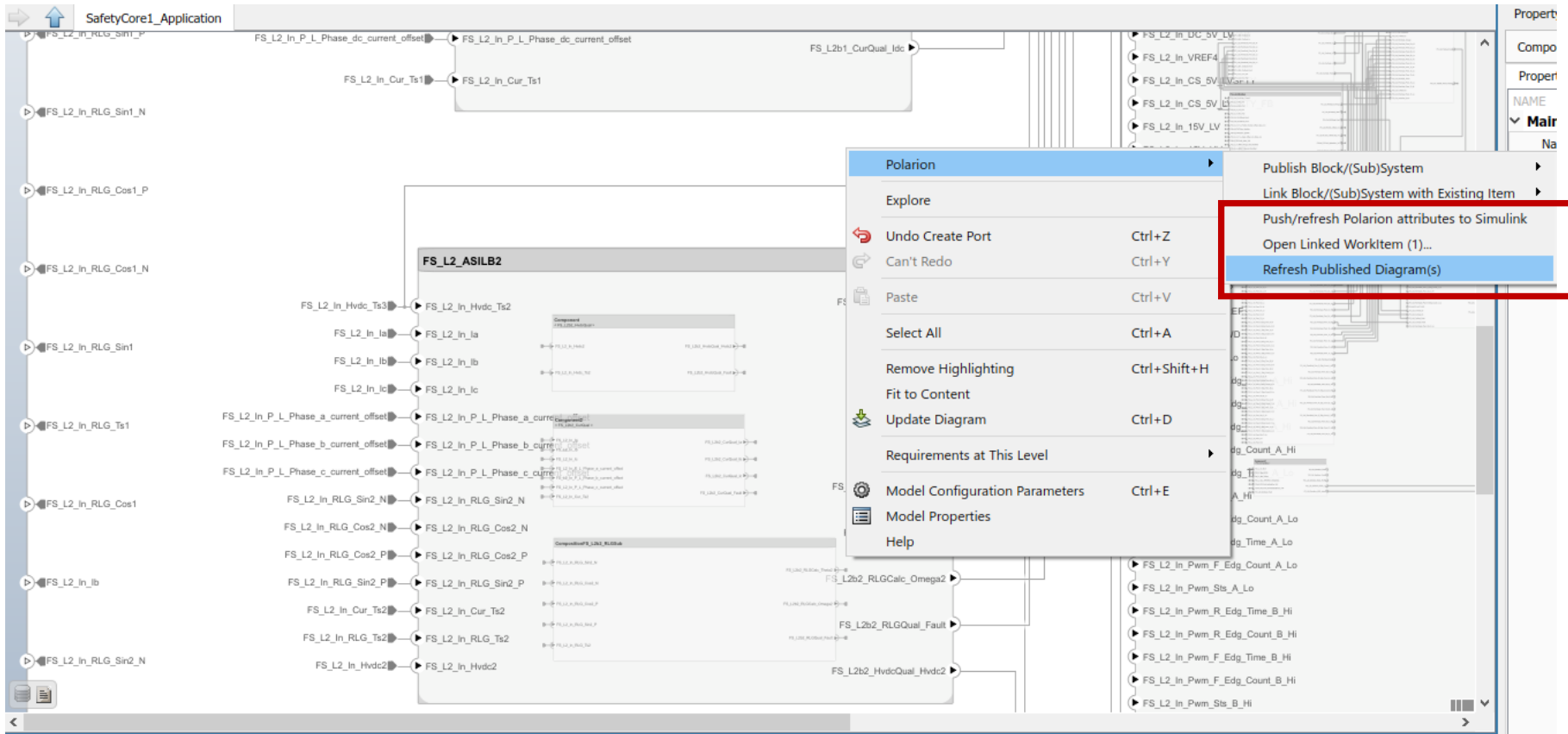
Work Item Details:

- Title: AINV-55960 - Planning - SW Architecture - Safe State Manager
- ID: AINV-47779
- Type: Work Package
- Planned In: B2OR3 (2020-01-14)
- Status: In Progress

A large blue curved arrow points from the 'Open Linked WorkItem (1)...' option in the context menu to the work item details, indicating the flow of information from the architecture back to the requirements.

Architecture to Requirements Traceability

Architecture to Requirements – Seamless Approach



- Whenever model updated due to maturity of the project, refresh option updates the same model onto requirements database
- Reversely, requirement attributes changed on the requirements database can easily be pushed back to SW architecture

Label	Source	Type	Destination
AUTOSAR_Multi_Core.slmx	Changed source: 0/3		Changed destination: 0/3
Polaron: AINV-58075	SafetyCore1_Application	Implements	http://polarionprod1.delphidrive.com/polarion/
Polaron: AINV-58341	BSWCore0_Application	Implements	http://polarionprod1.delphidrive.com/polarion/
Polaron: AINV-59475	AUTOSAR_Multi_Core	Implements	http://polarionprod1.delphidrive.com/polarion/

arxml Import from BSW Tools (f.e Vector BSW-stack Tools)

The image illustrates the process of exporting a component from Vector DaVinci Developer to ARXML and then importing it into the AUTOSAR Importer App.

Export to XML (Vector DaVinci Developer):

- File: []
- AUTOSAR version: AUTOSAR V4.3.0
- Export user-defined attributes
- Create data types/constants for signals if required
- Don't export Communication data
- Don't export Data Mapping
- Don't export End-to-End Protection
- Create UUID on export
- Export AUTOSAR package (platform types,...)

AUTOSAR Importer App:

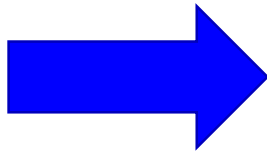
- Select ARXML
- Create Component
- Select AUTOSAR software description to import
- Arxml Files: "CrashManager.arxml" "DataTypes.arxml" [Browse]
- What to consider: Import an AUTOSAR software description ARXML file to create a Simulink model.

Imported Component (AUTOSAR):

- Component < CrashManager_1 >
- Ports: PpCrashMgr_Trigger_SafeState, Com_HV_Stable, PpPL_Crash_AD_Active, DELOutlf_AB_Deaktivierung_HV, PpPL_Crash_React_st, IoHwAb_KL15_Switch, PpPL_Crash_st, MotCtrl_Control_Mode_R, P_L_Actvdcha_main_command_S

Generation of SW Architecture Documents

The image shows the MATLAB R2019b environment. The file explorer on the left displays a project directory structure including folders like 'arxmls', 'documentation', and 'FS_Arch', and files such as 'AUTOSAR_Multi_Core.pdf' and 'AUTOSAR_Multi_Core.slx'. The editor window shows MATLAB code for defining enumeration types using 'Simulink.defineIntEnumT'. A 'Command Window' at the bottom displays the execution of a script: `>> run('C:\Users\pj9zjw\MY21\09_Tools_Working\SystemComposer_ML\AUTOSAR_Multi_Core.slx')`, with the output 'Document creation started...'. An 'Autocode Helper' dialog box is open in the foreground, showing 'AUTOSAR_Multi_Core.slx' selected and buttons for 'Please wait...' and 'Perform Autocode'.



Automated Scripts

The image shows a PDF document titled 'AUTOSAR_Multi_Core.pdf' in Adobe Acrobat Reader DC. The document has a table of contents with chapters: Chapter 1. Model Version, Chapter 2. Root System (with sub-chapters 2.1. Scheduling and 2.2. Description), Chapter 3. Subsystems, Chapter 4. Dictionary (with sub-chapters 4.1. Inputs, 4.2. Outputs, 4.3. Locals, and 4.4. Default Values). A metadata table is present in the top right corner:

Delphi Technologies	AINV54431
	Issue 1.0

Below the metadata is the title 'Software Architecture Document'. At the bottom, another table provides document details:

Author	Sakthivel Manikandan SUNDHARAM
Date	29-Jan-2020
Model	AUTOSAR_Multi_Core

At the very bottom, there is a confidentiality notice: 'Delphi Technologies confidential. All rights reserved. No part of this publication may be reproduced in any material form (including photocopying or storing in any medium by electronic means and whether or not transiently or incidentally for some other use of this publication) without the written permission of Delphi Technologies.'

Lessons Learnt and Best Practices

MLSL

AUTOSAR SW Architecture Authoring

- Modeling of AUTOSAR-based system architecture using AUTOSAR blockset together with System composer toolbox in recent releases of Matlab/Simulink.
- Creating fine-grained AUTOSAR architecture models using Simulink System Composer data dictionary support.



Requirements to SW architecture mapping

- Employing seamless approach to establish bidirectional traceability between modeling environment and the requirements database. Tracking of requirements back and forth between both the environments to verify fulfillment of requirements.
- To publish requirements and design on to requirements database. Also, the approach updates both requirements and design whenever adapted for changes due to technical discussions in a more efficient way.



Architectural simulation and SAD

- Import and export of ARXMLs between architectural modeling environment to Basic software (BSW) configuration and development tool-chain to reduce ambiguity on architectural considerations and development time.
- Early model-based performance and trade-off analysis of non-functional requirements using custom-defined profiles (e.g. employing Matlab/Simulink and System Composer toolboxes).

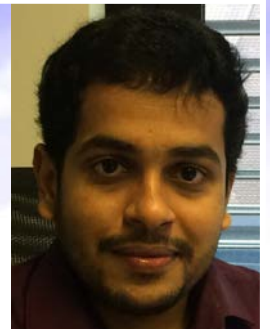


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AUTOSAR Architecture
Modeling of Multi-core
Electric Powertrain Controller

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Software Architect

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Q & A

