# Simulink for AUTOSAR:

# Best Practices

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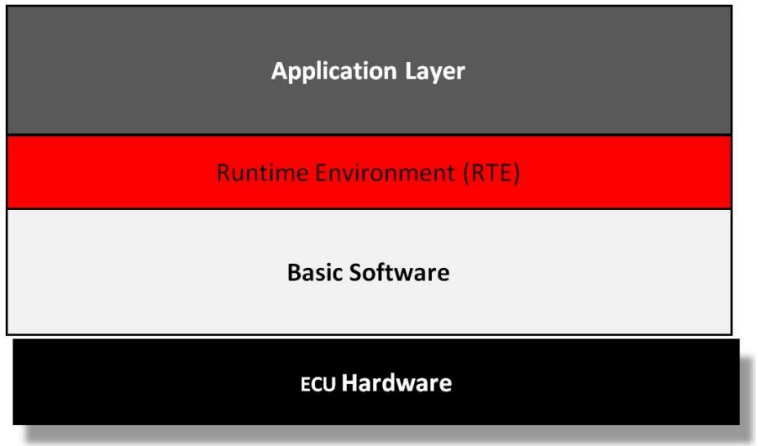
高级技术咨询顾问

# What is AUTOSAR?

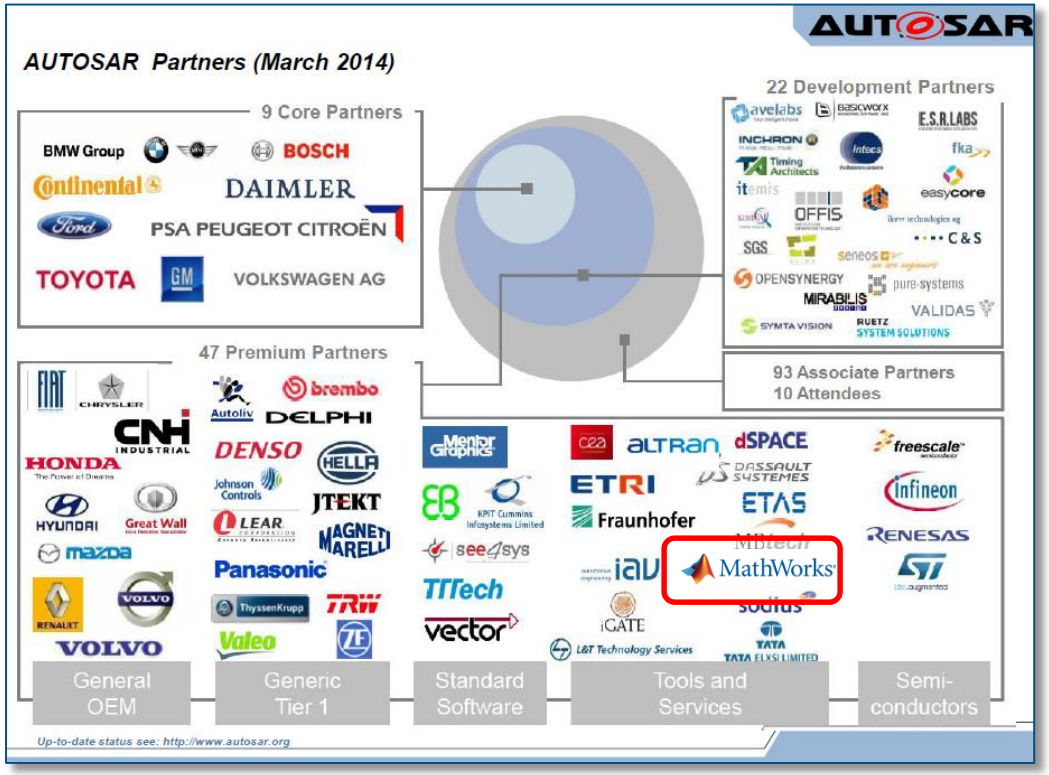
## *AUT*omotive *O*pen *S*ystem *AR*chitecture




- *Objective:*
  *Establish an open standard for automotive E/E architecture*

- *Partnership*
  *Consisting of more than 180 companies from the global automotive industry*

Latest update:
http://www.autosar.org/partners/current-partners/



# Agenda

## Simulink for AUTOSAR - Introduction

- Workflows
- Capabilities

## Simulink for AUTOSAR – User Stories

- Production Code Generation with Embedded Coder

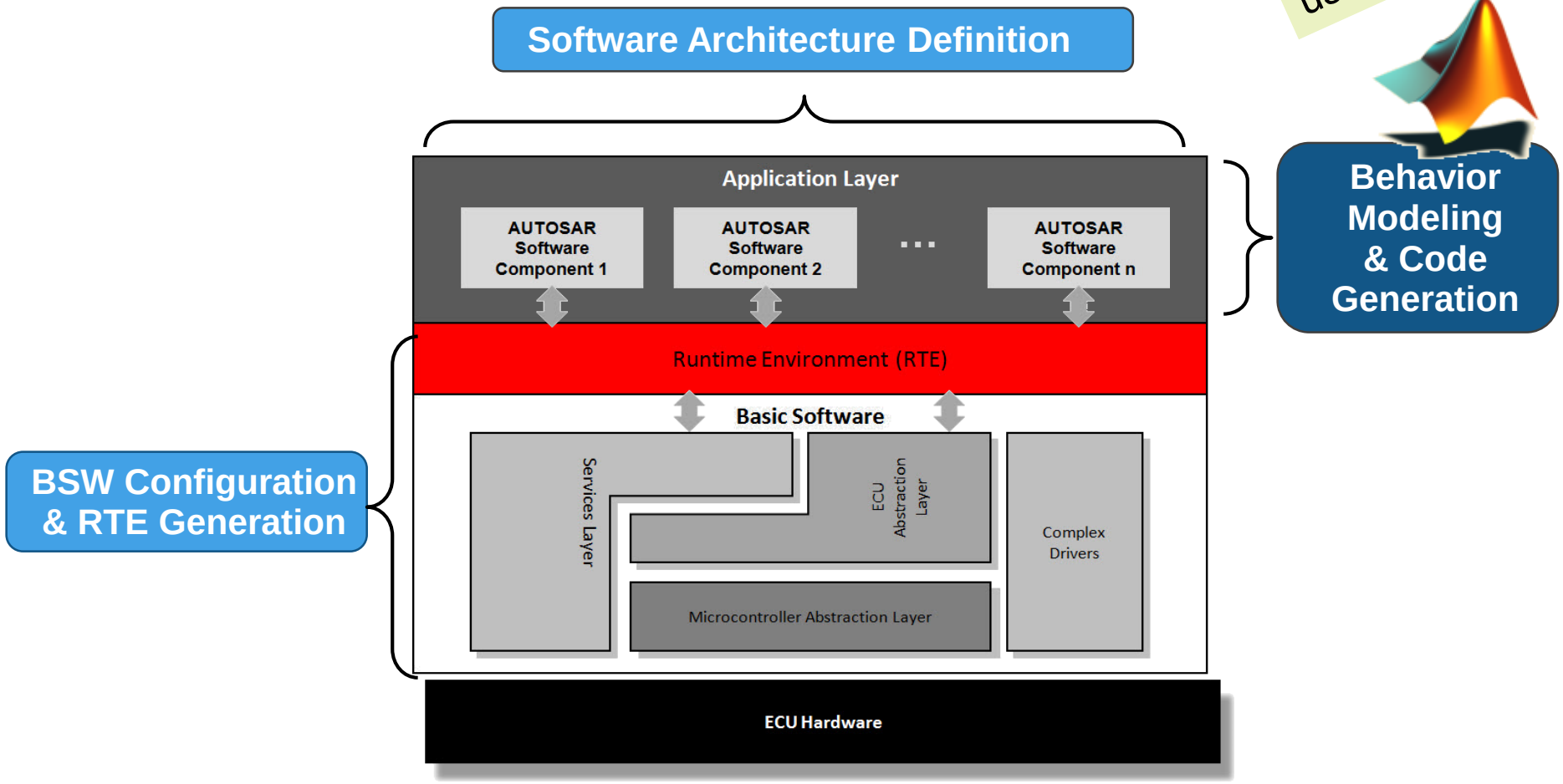
## Simulink for AUTOSAR – Best Practices

- Best Practices for using Simulink for AUTOSAR

## Summary & Conclusions

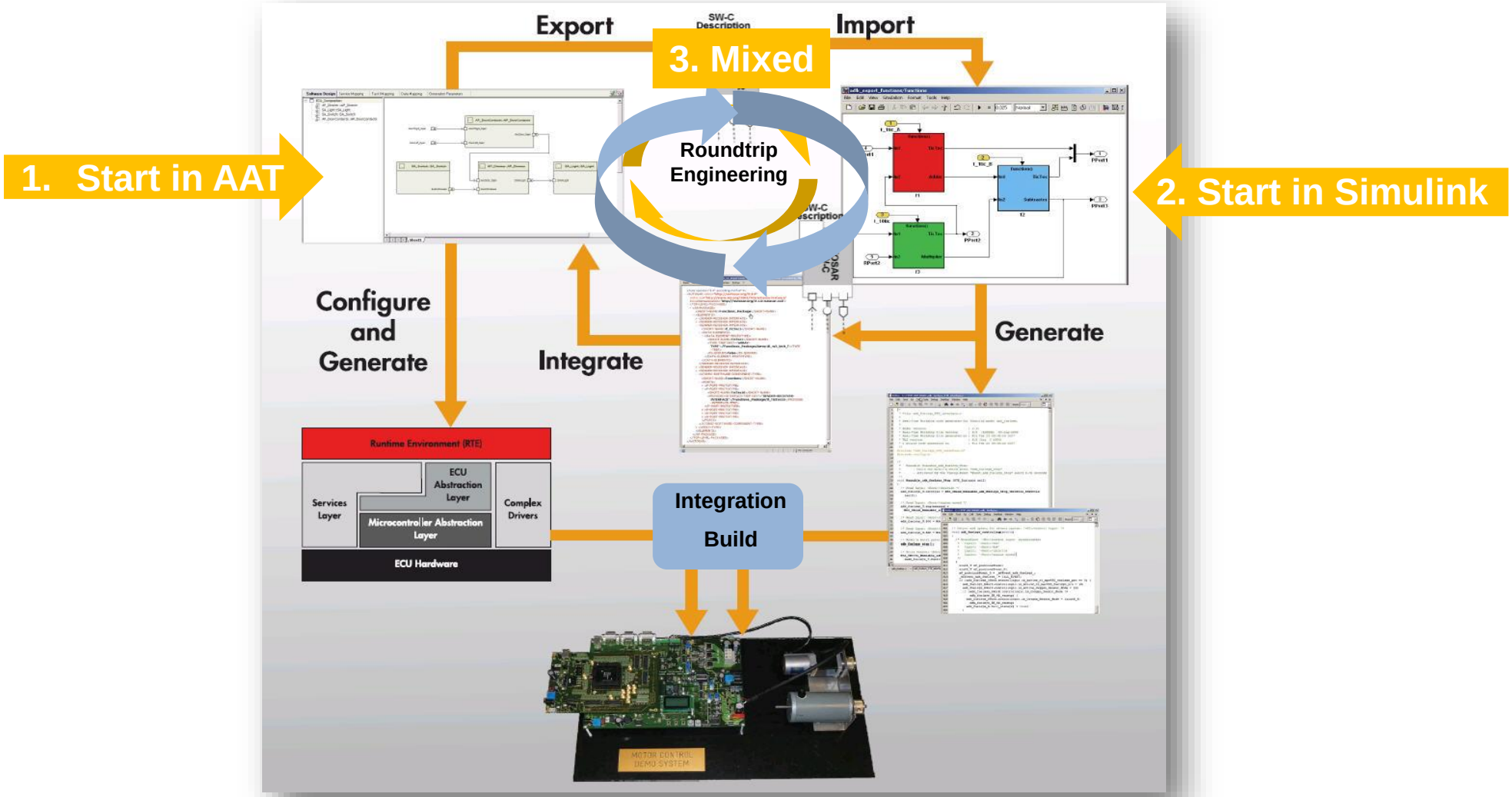
# Simulink & Stateflow for Behavior Modeling, Embedded Coder for Production Code

"All toolboxes for MBD are still usable."

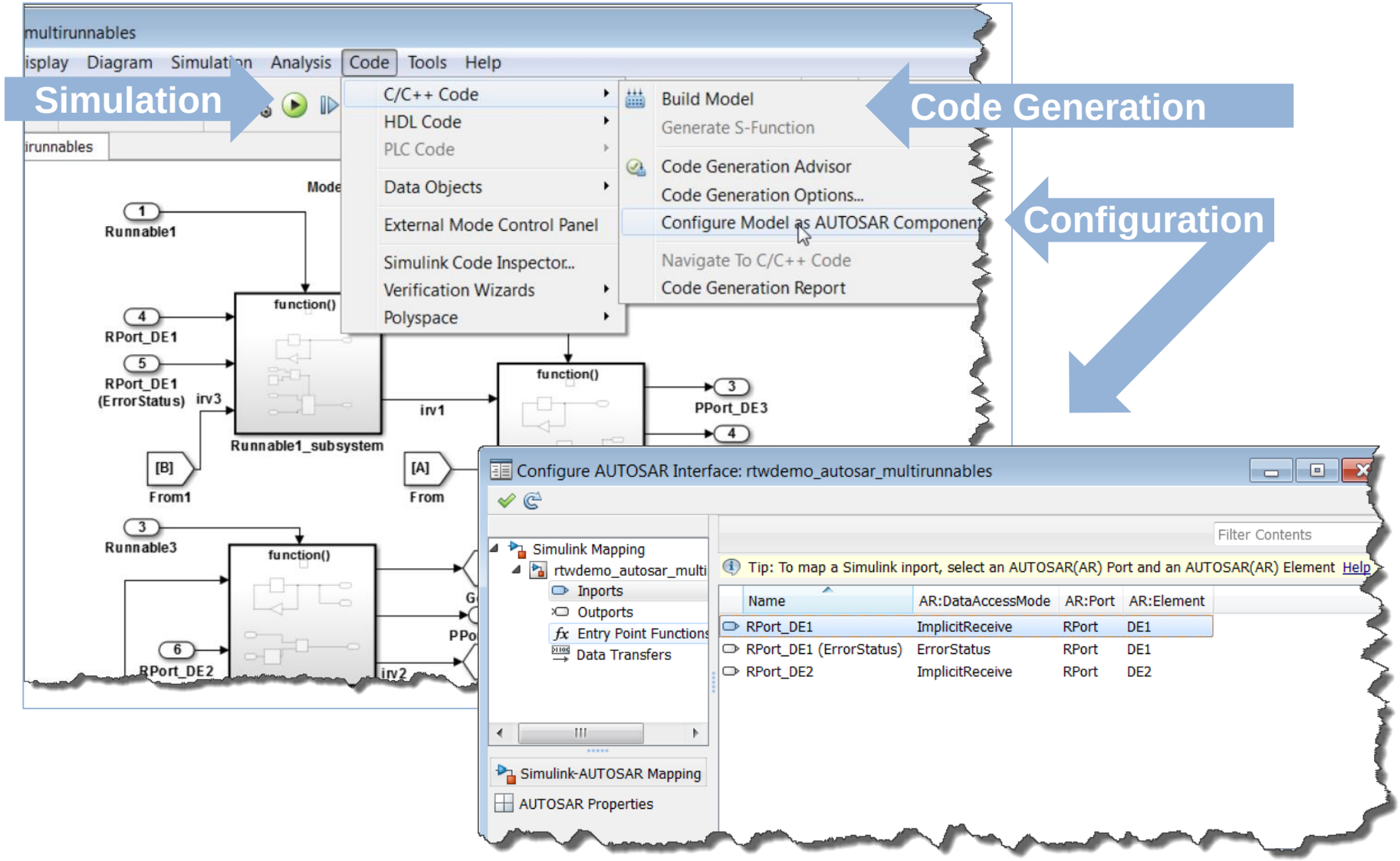


# Workflows

## 1. Top-Down, 2. Bottom-Up, 3. Mixed



# Capabilities



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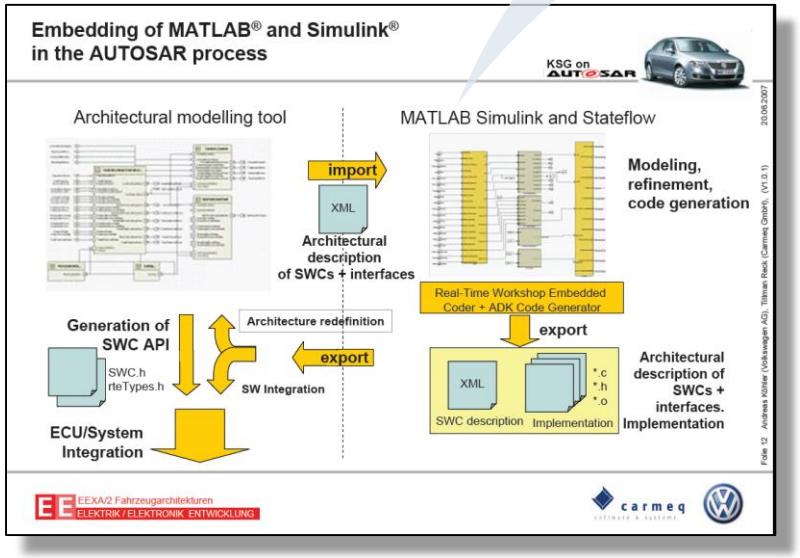
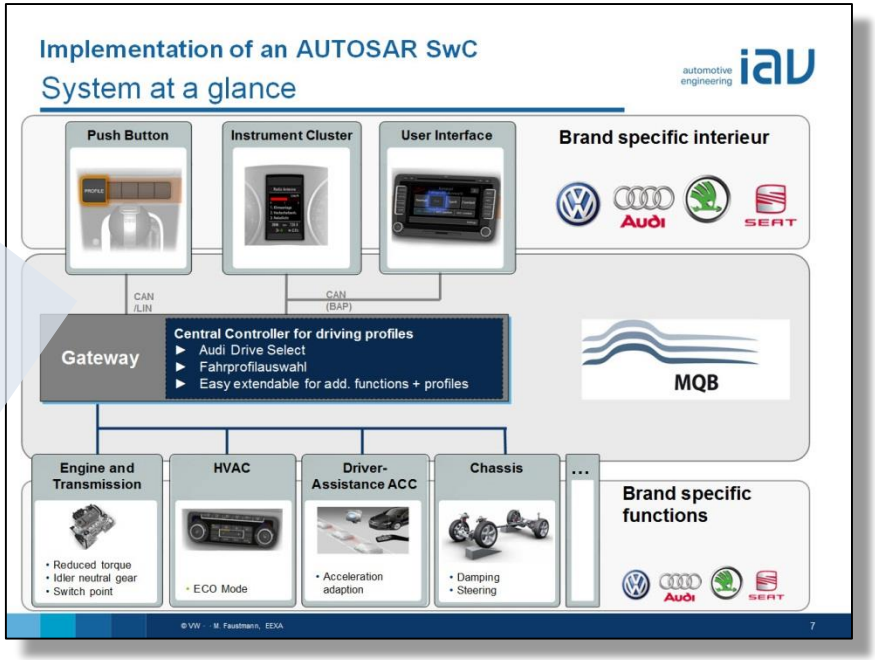
# Long-term Successful Collaboration with Volkswagen…

2007

2012



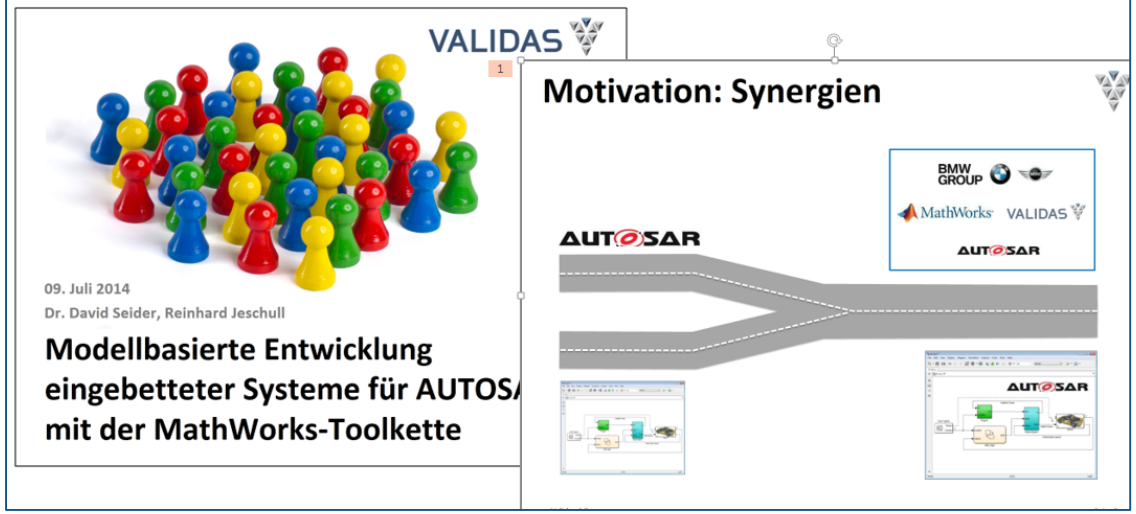

**…from a “Proof of Concept” project**

**…to series production across brands**

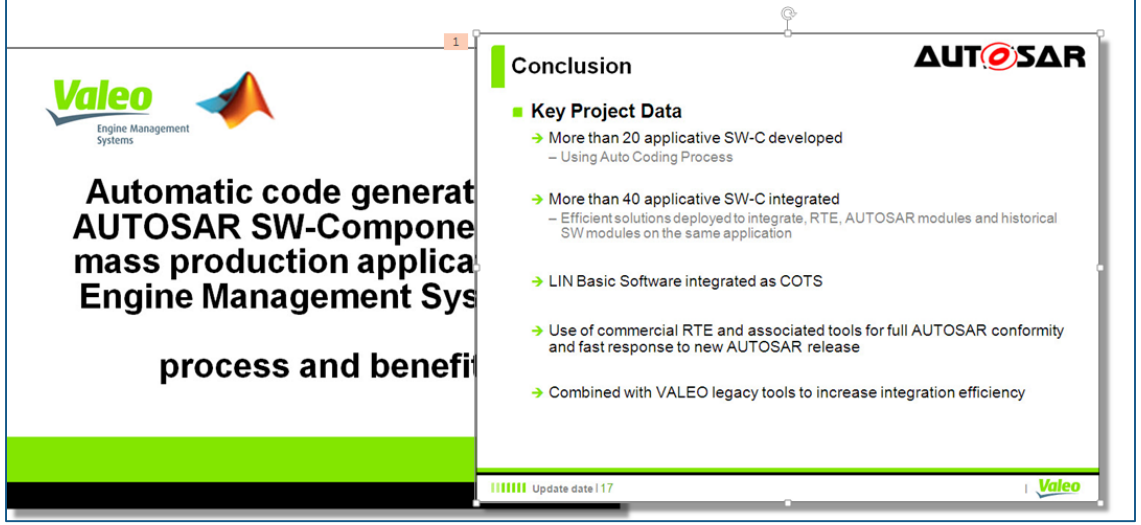
# More User Stories…

## Market Situation and Rollout Strategies: Volvo Cars


## Market situation and rollout strategies at our most important customers: Validas for BMW




## Market Situation and Rollout Strategies at Our Most Important Customers: Valeo



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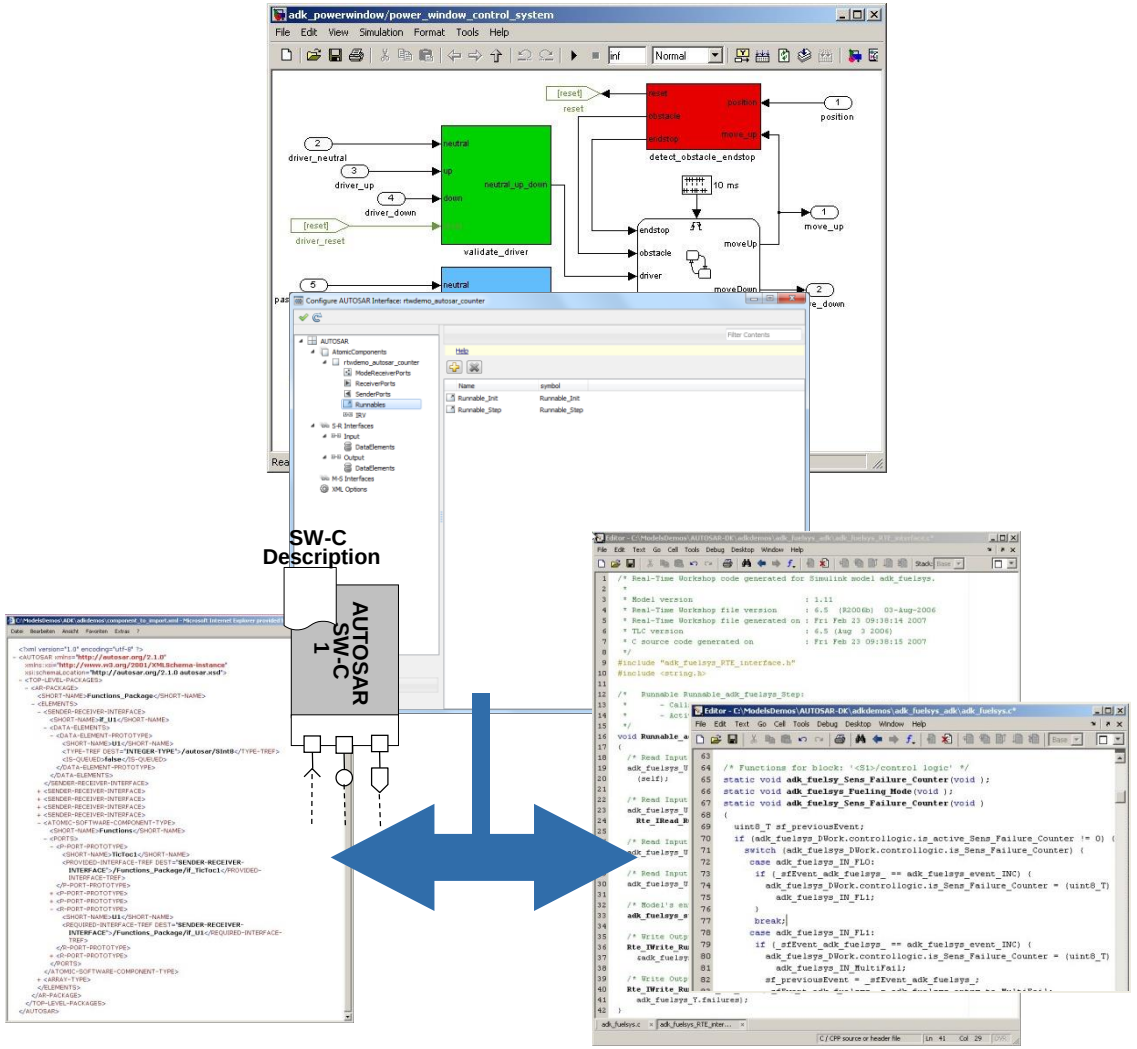
## Summary & Conclusions

# #1 Decide strategy for migrating existing Simulink models to AUTOSAR

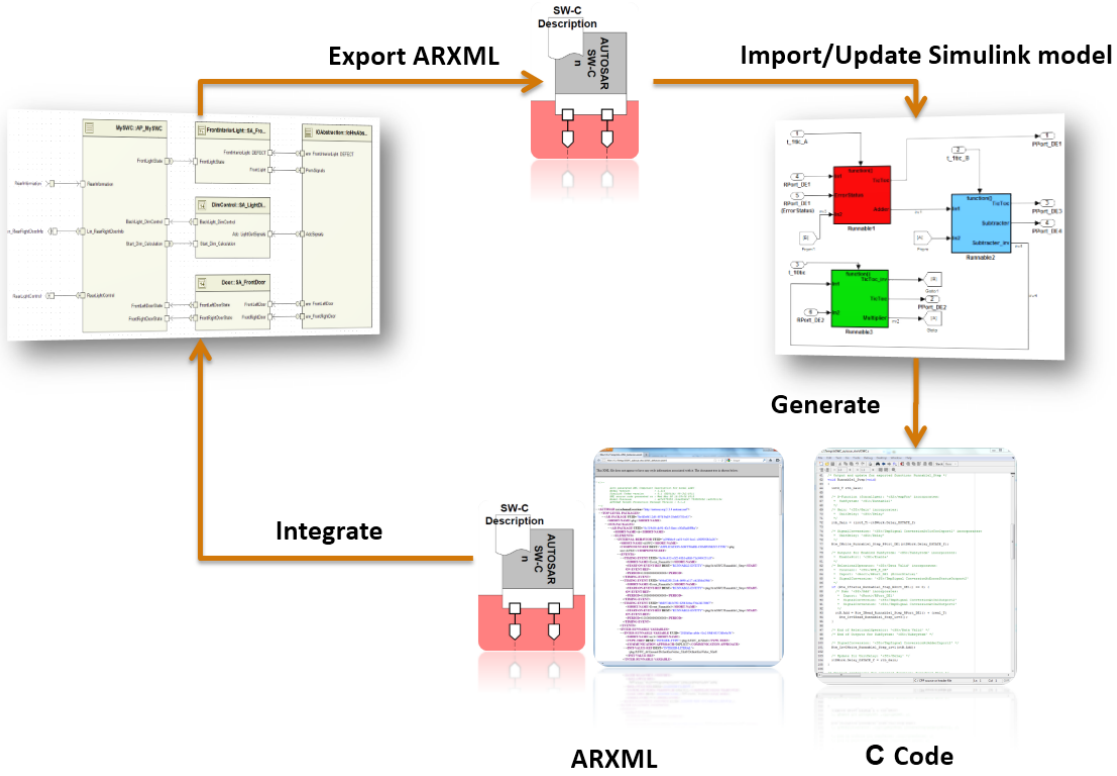
- Clean sheet start
- Start with existing Simulink models
- Maintain one model for AUTOSAR and non-AUTOSAR



# #2 Use one AUTOSAR workflow

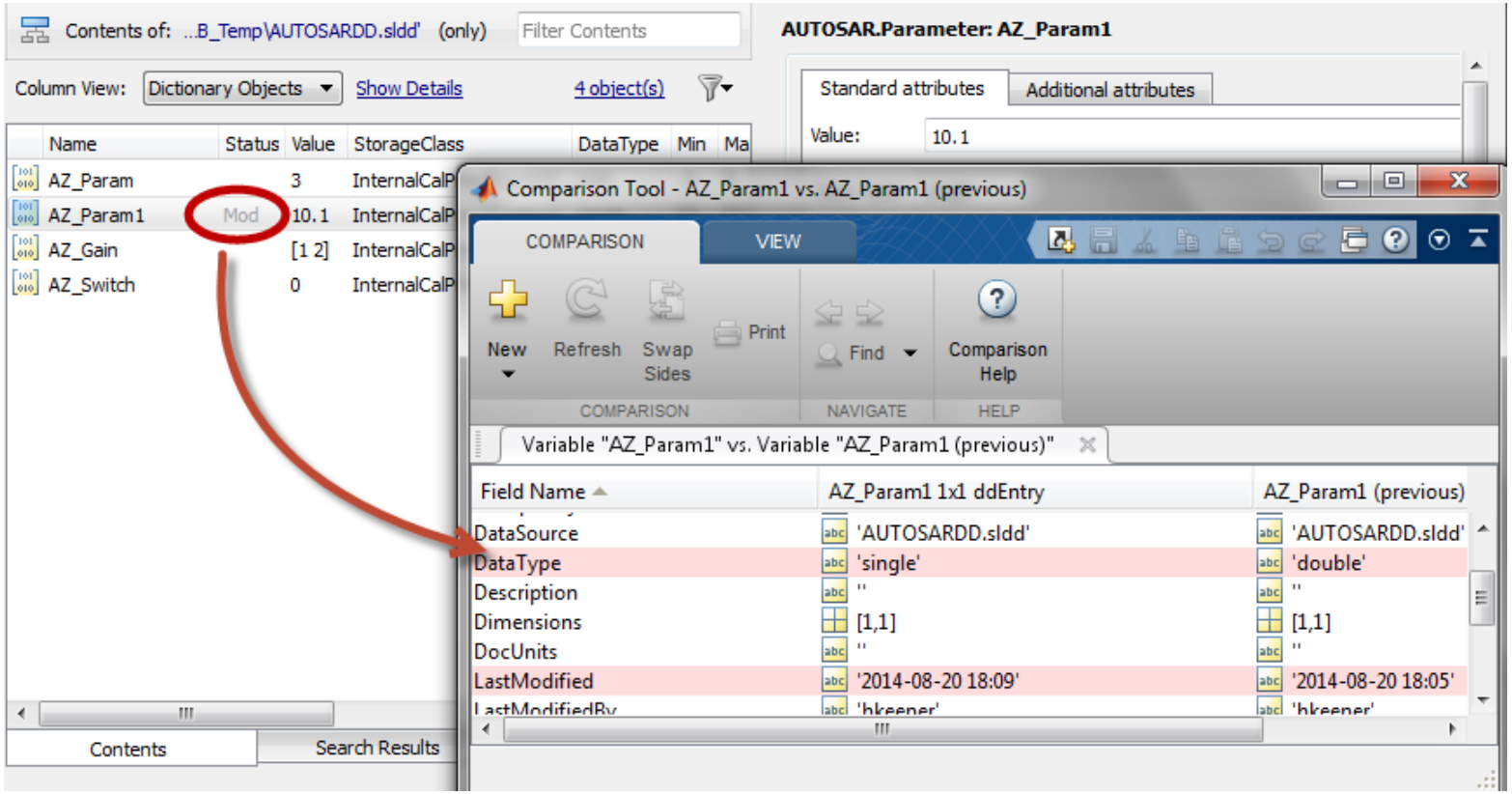
– Select top-down or bottom-up approach
– Round-trip works best with one clear owner of data

- Select tools that best support your workflow and AUTOSAR concepts
- Select simplest approach for applying AUTOSAR configuration to your Simulink model



# #3 Decide data management

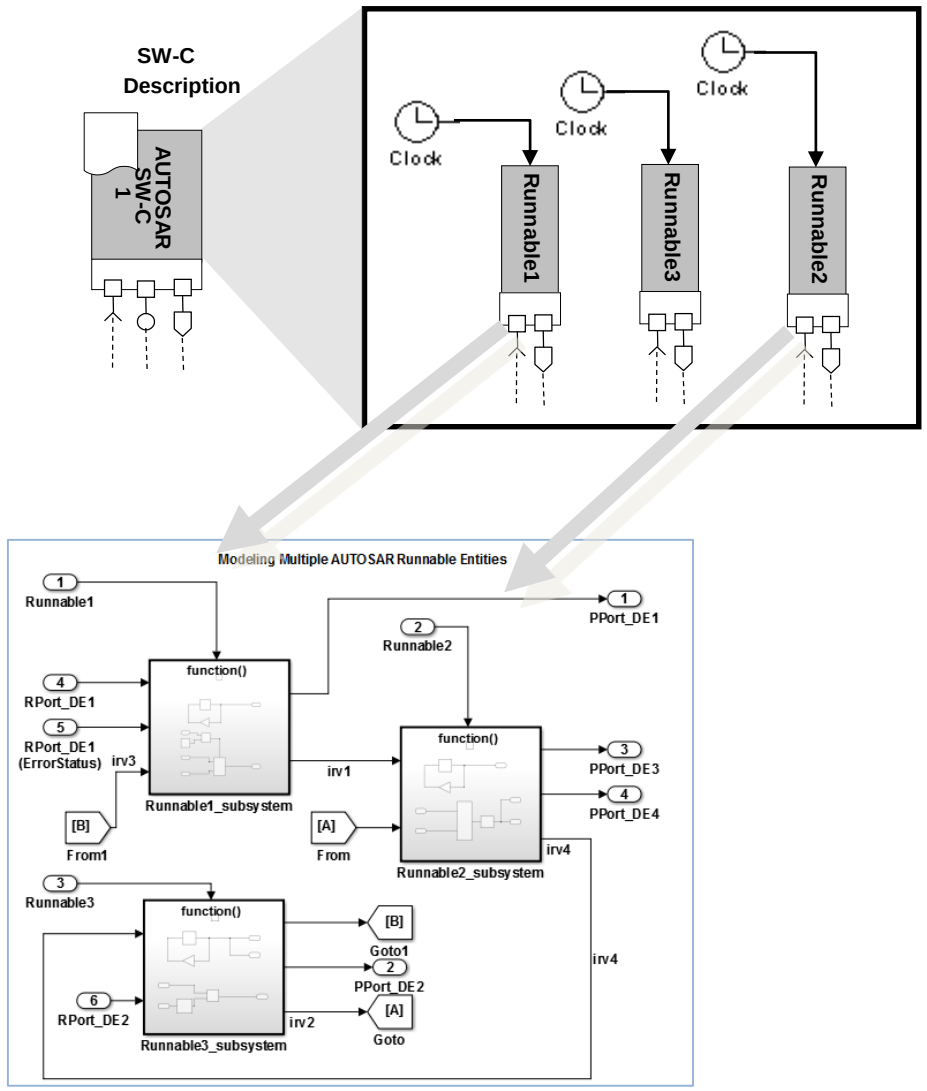
- Will Simulink or AUTOSAR tools manage data?
- Will projects or teams define and manage data?
- How will change management be handled?



# #4 Establish modeling standards

## – For Simulink and AUTOSAR

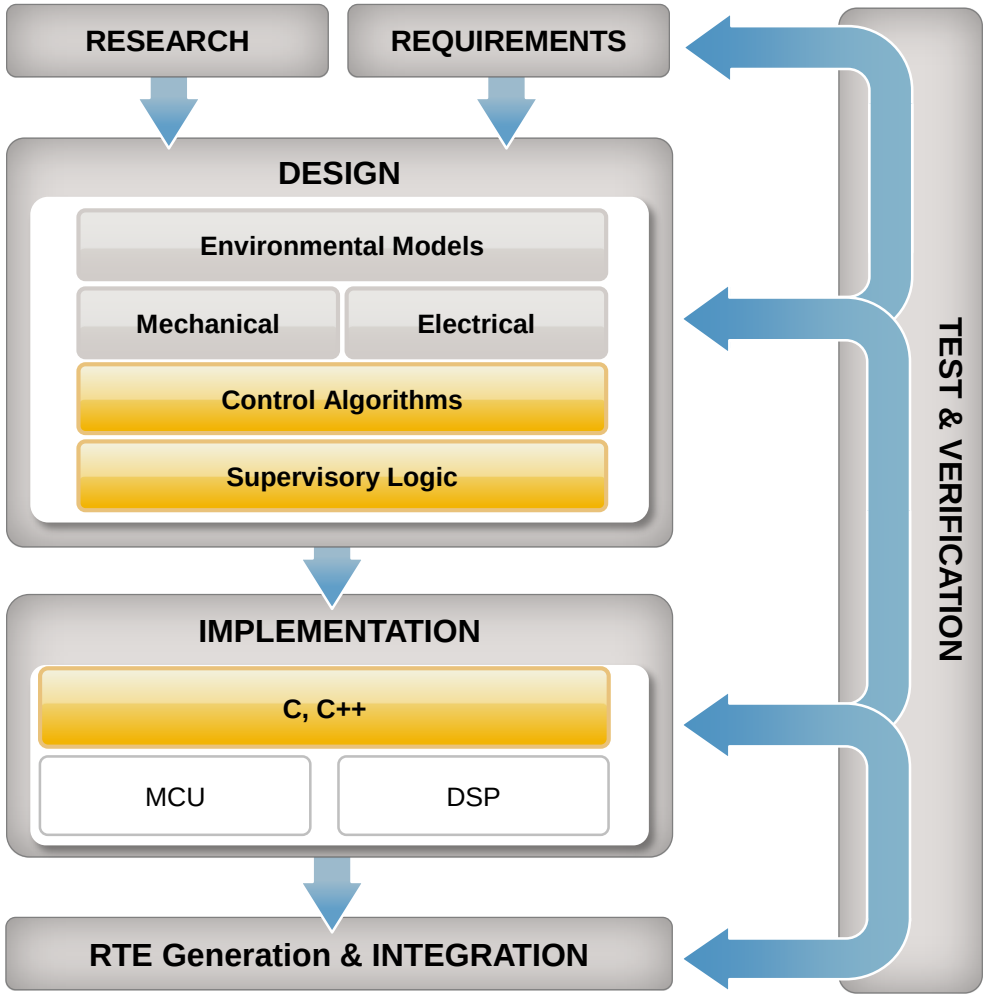
- Base it on your workflow and data management
- Use Simulink Model Advisor to enforce modeling style early in model development



# #5 Simulate before you generate code

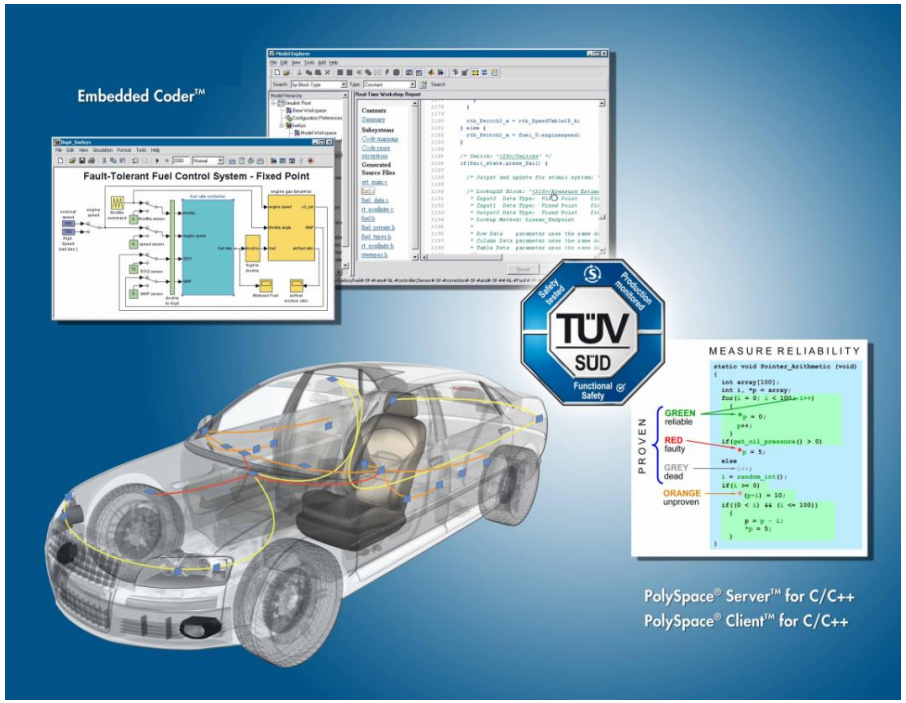
## – Take advantage of **early verification** through simulation

- Make sure SWC implementation is correct early
- Simulate multiple SWC's together in Simulink before code integration
- Use SIL and PIL to verify the generated code at the unit level before RTE generation



# #6 Plan ahead for ISO 26262 – Determine how AUTOSAR process will address safety-standards

- Products supported for ISO 26262 tool qualification include:
  - Embedded Coder
  - Simulink V&V
  - Simulink Design Verifier
  - PolySpace
- Artifacts certified by TÜV SÜD
  - Requires use of V&V workflow
- ISO 26262 Advisory Service available





CERTIFICATE
No. Z10 11 06 67052 010
Holder of Certificate: The MathWorks, Inc.
3 Apple Hill Drive
Natick MA 01760-2098
USA
Factory(ies): 67052
Certification Mark:
Product: Software Tool for Safety Related Development
Model(s): Embedded Coder™
Real-Time Workshop® Embedded Coder™
Parameters:


CERTIFICATE
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Holder of Certificate: The MathWorks, Inc.
3 Apple Hill Drive
Natick MA 01760-2098
USA
Factory(ies): 67779
Certification Mark:
Product: Software Tool for Safety Related Development
Model(s): Polyspace® Code Prover™ and
Polyspace® Bug Finder™
Polyspace® Client™ and
Polyspace® Server™ for C/C++
Parameters:


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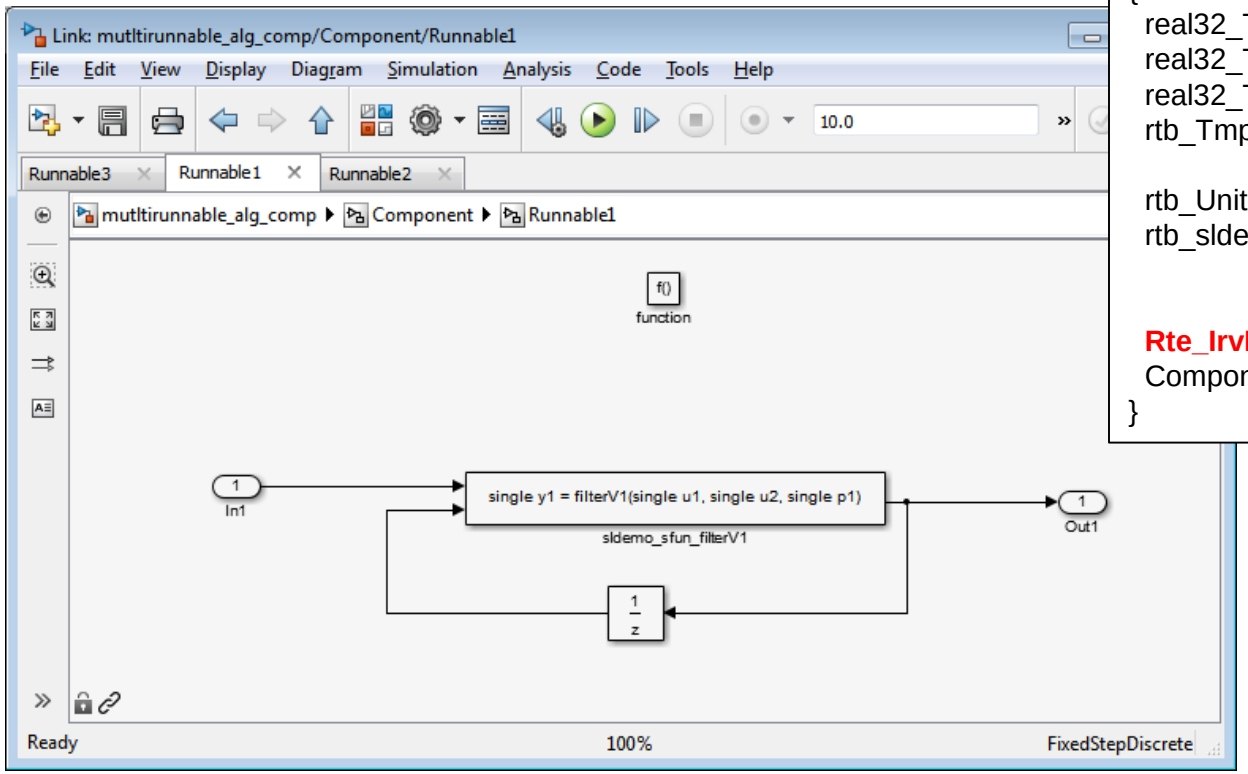
3 Apple Hill Drive
Natick MA 01760-2098
USA
Factory(ies): 67052
Certification Mark:
Product: Software Tool for Safety Related Development
Model(s): Simulink® Verification and Validation™
Simulink® Design Verifier™
Parameters:

# #7 Use Simulink to migrate legacy code to AUTOSAR

Reuse of Legacy Code

- Integration for simulation, production code generation
- Can generate AUTOSAR RTE API access points




```
void Runnable_Runnable1(void)
{
  real32_T rtb_TmpSignalConversionAtIn1Out;
  real32_T rtb_UnitDelay;
  real32_T rtb_sldemo_sfun_filterV1;
  rtb_TmpSignalConversionAtIn1Out =
                    Rte_IRead_Runnable_Runnable1_Fast_in_Fast_in();
  rtb_UnitDelay = Component_DWork.UnitDelay_DSTATE;
  rtb_sldemo_sfun_filterV1 = filterV1( (real32_T)rtb_TmpSignalConversionAtIn1Out,
                    (real32_T)rtb_UnitDelay,
                    (real32_T)Component_P.sldemo_sfun_filterV1_p1);
  Rte_IrvIWrite_Runnable_Runnable1_a(rtb_sldemo_sfun_filterV1);
  Component_DWork.UnitDelay_DSTATE = rtb_sldemo_sfun_filterV1;
}
```

# #8 Automate, automate, automate

## – Use API's for workflow automation!

- **Manual process is difficult due to:**
  - The complexity of the standard, naming conventions
  - Iterative work cycles with AUTOSAR
  - Complex code APIs and XML file definitions

- Use documented MATLAB APIs to configure SWCs in Simulink

```
%% Setup AUTOSAR Configuration
programmatically

model = 'rtwdemo_autosar_counter';

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

# #9 Use production code generation

## – Hand coding AUTOSAR is painful (Code and description)

```
void Runnable_simple_alg_Step(void)
{
  real_T rtb_Gain;
  real_T rtb_Delay;
  real_T rtb_Delay1;
  real_T rtb_TmpSignalConversionAtFast_i;
  if (simple_alg_M->Timing.TaskCounters.TID[1] == 0) {
    Rte_Receive_Fast_in_Fast_in(&rtb_TmpSignalConversionAtFast_i);
    rtb_Delay = simple_alg_DWork.Delay_DSTATE;
    rtb_Delay1 = simple_alg_DWork.Delay1_DSTATE;
    rtb_Gain = simple_alg_DWork.Delay2_DSTATE;
    rtb_Gain = (((rtb_TmpSignalConversionAtFast_i + simple_alg_DWork.Delay_DSTATE) +  simple_alg_DWork.Delay1_DSTATE) +
                rtb_Gain) * simple_alg_P.Gain_Gain;
    if (simple_alg_M->Timing.TaskCounters.TID[2] == 0) {
      simple_alg_B.RateTransition = rtb_Gain;
    }
     simple_alg_DWork.Delay_DSTATE = rtb_TmpSignalConversionAtFast_i;
    simple_alg_DWork.Delay1_DSTATE = rtb_Delay;
    simple_alg_DWork.Delay2_DSTATE = rtb_Delay1;
  }
   if (simple_alg_M->Timing.TaskCounters.TID[2] == 0) {
    Rte_IWrite_Runnable_simple_alg_Step_Out1_Out1(simple_alg_B.RateTransition
                + Rte_IRead_Runnable_simple_alg_Step_Slow_in_Slow_in());
  }
   rate_scheduler();
}
```

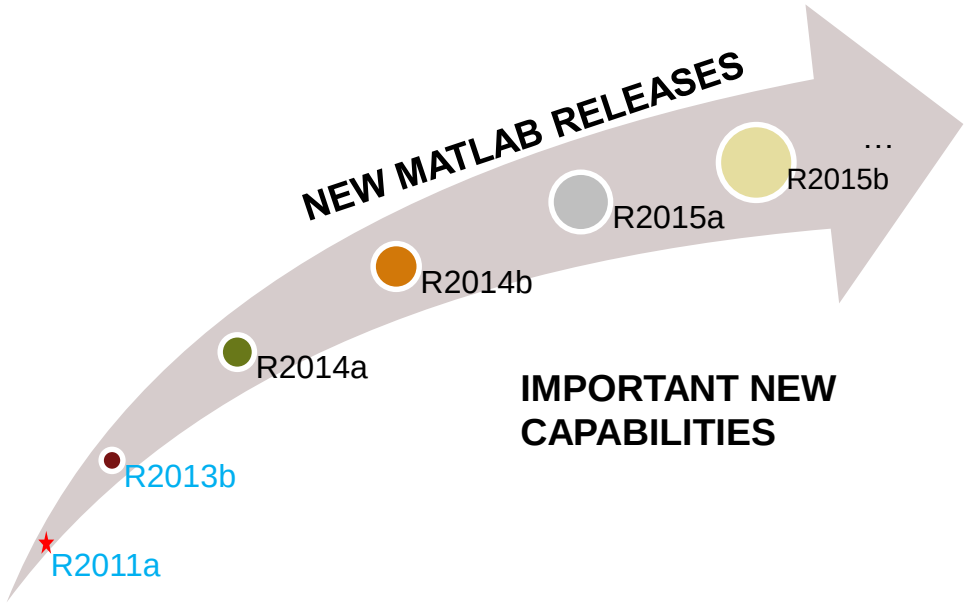
```
…
<RUNNABLE-ENTITY UUID="aef16585-a355-494f-accd-1a548ca22e27">
  <SHORT-NAME>Runnable_simple_alg_Step</SHORT-NAME>
    <MINIMUM-START-INTERVAL>0</MINIMUM-START-INTERVAL>
      <CAN-BE-INVOKED-CONCURRENTLY>false</CAN-BE-INVOKED-CONCURRENTLY>
      <DATA-READ-ACCESSS>
        <VARIABLE-ACCESS>
          <SHORT-NAME>IN_Slow_in_Slow_in</SHORT-NAME>
            …
</RUNNABLE-ENTITY>
…
```

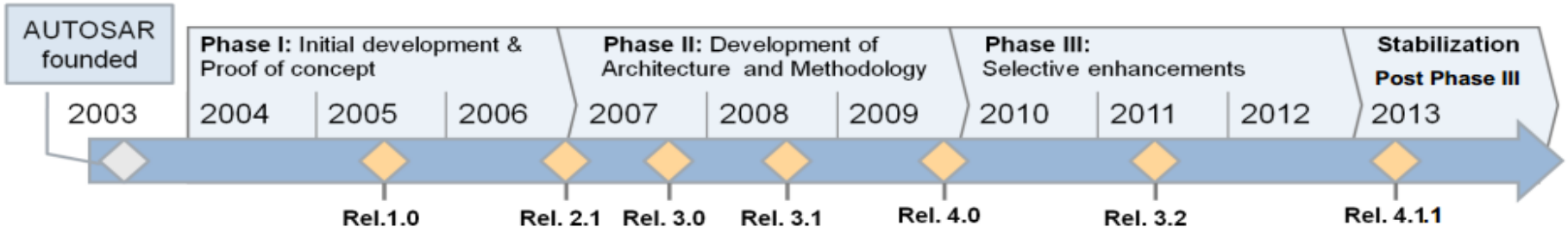
```
…
<SENDER-RECEIVER-INTERFACE>
  <SHORT-NAME>Out1</SHORT-NAME>
    <IS-SERVICE>false</IS-SERVICE>
    <DATA-ELEMENTS>
      <VARIABLE-DATA-PROTOTYPE>
        <SHORT-NAME>Out1</SHORT-NAME>
          …
       </VARIABLE-DATA-PROTOTYPE>
  </DATA-ELEMENTS>
</SENDER-RECEIVER-INTERFACE>
…
```

# #10 Actively plan for migration

## – Tools and standards are changing rapidly

- Account for:
  - New versions of AUTOSAR
  - New versions of Simulink
- Consider:
  - How often to upgrade
  - What will drive upgrade




Source: AUTOSAR, 6th Open Conference 11.13.2013

***R4.2.1 has been released in 2014**
**MATLAB 2015b supports this revision**

# Best practices for using Simulink with AUTOSAR

- Decide strategy for migrating existing Simulink models to AUTOSAR
- Use one AUTOSAR workflow
- Decide data management
- Establish modeling standard
- Simulate before code generation
- Plan ahead for ISO 26262
- Use Simulink to migrate legacy code to AUTOSAR
- Automate, automate, automate
- Use production code generation
- Actively plan for migration

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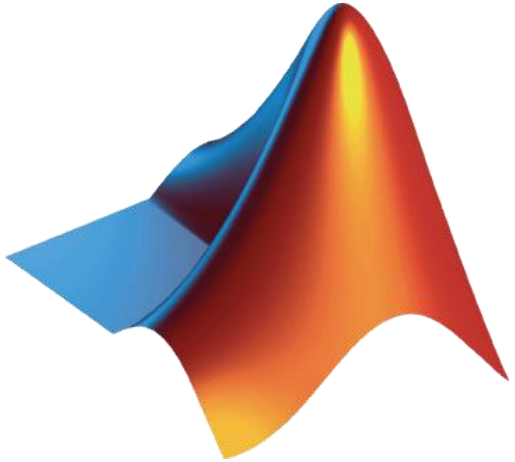
# Summary

- Simulink and Embedded Coder provide extensive AUTOSAR capabilities out-of-the-box, along with API's for workflow automation
- Leading automotive companies are successfully deploying AUTOSAR for production by leveraging MathWorks tools and industry experience
- Take advantage of best practices for deploying AUTOSAR with Production Code Generation to accelerate your projects while reducing risk and improving quality

# Thank you for your attention!



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