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Software Detailed Design for Model-Based Development – Obligatory or Superfluous?

Outline

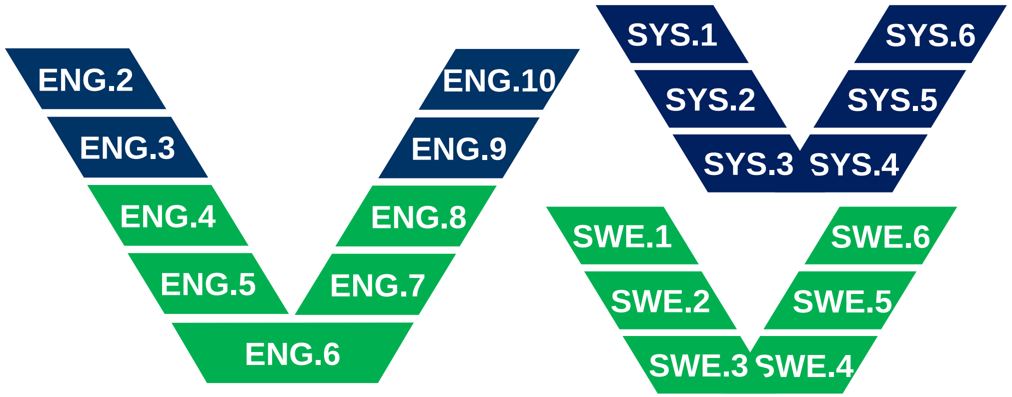
- Introduction
- Necessity of Software Detailed Design
- Requirements on Detailed Design
- Challenges Model Based Development and Detailed Design

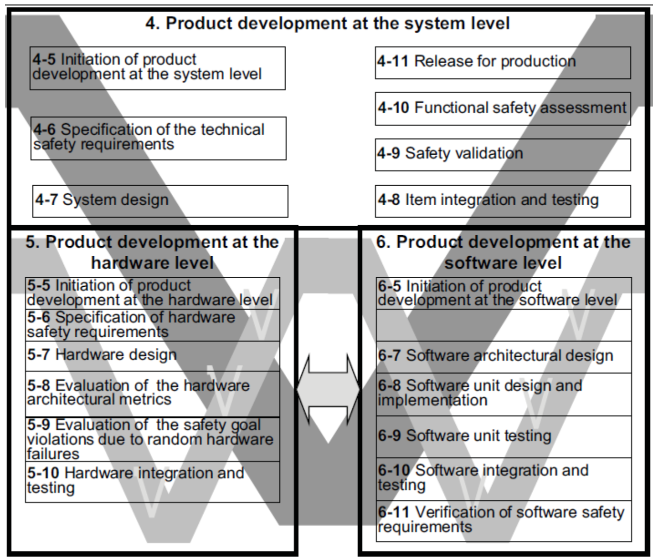
Introduction VW Software Quality Assurance

- VW Group Supplier Quality Assurance Electric/Electronics
- Responsible for quality assurance of VW group suppliers
  - Potential analysis before nomination
  - Full ASPICE assessments for focus projects
  - Technical revisions and supplier improvement program support
- 10 ASPICE assessors (+ colleagues at AUDI, MAN, Porsche, CARMEQ)
- Approx. 100 Software assessments/audits per year
- Focus on critical Software/ECU-projects for series with tier 1 suppliers
- Specification of VW Group Basic Software Requirements

ASPICE and ISO 26262

- requirements for development processes and quality criteria for automotive system and software development
- in general not specific to any programming language, but defined with the mindset of classic c-code implementation.





ASPICE **ISO 26262**

Model based development for series projects

- used mostly for functional application software, e.g. engine control, steering, suspension, climate control for series ECU development
- fast growing in new projects
- job split - functional modelling at OEM and industrialization / code generation at supplier

use of model based development in series projects*

*internal survey, projects of VW group suppliers 2013-2016

Software Design Understanding

Architectural Design

High-Level Design

Low-Level Design

Detailed Design

Unit requirements specification

Design

Software Design Description (IEEE 1016)

software unit design specifications (ISO 26262)

Why Software Design?

Automotive SPICE® v3.0 and implementation model

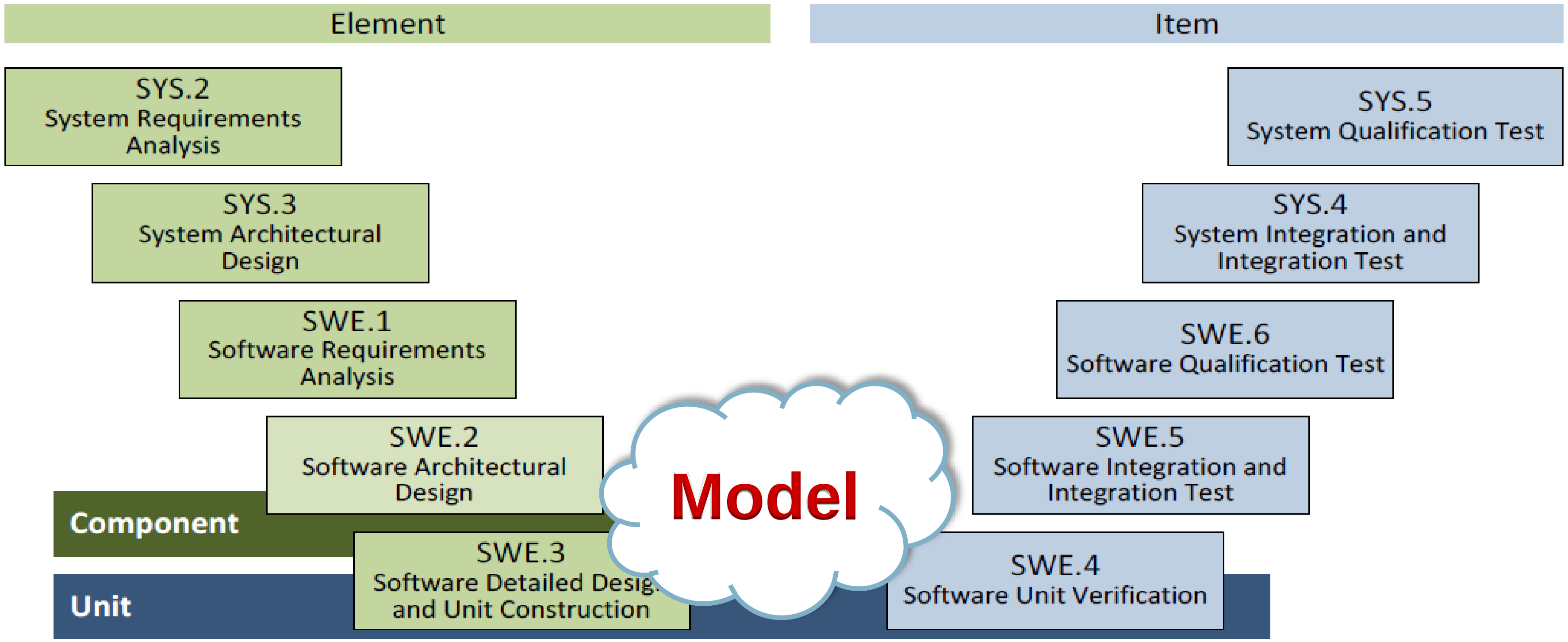


Figure D.3 — Element, Component, Unit, and Item

Requirements from Automotive SPICE® v3.0 (extract)

As a result of successful implementation of process SWE.3 "Software Detailed Design and Unit Construction":

- A detailed design is developed that describes software units.
- Interfaces of each software unit are defined.
- The dynamic behavior of the software units is defined.
- Consistency and bidirectional traceability are established between:
  - Software requirements and software units.
  - Software architectural design and software detailed design.
  - Software detailed design and software units.
- Software units defined by the software detailed design are produced.

Thesis:
„My model is my detailed design!“

Why a model may not be a Detailed Design?

Why a model may not be a Detailed Design (typical challenges):

- Missing design decisions - no answer why something is implemented that way (ISO 25010: functional suitability, maintainability, portability, etc.) (SWE3.BP4)
- No distinction between architectural and detailed design (sometimes)
- No distinction between specification and implementation model (ISO 26262)
- No specification of non-functional requirements (e.g. RAM, ROM usage)

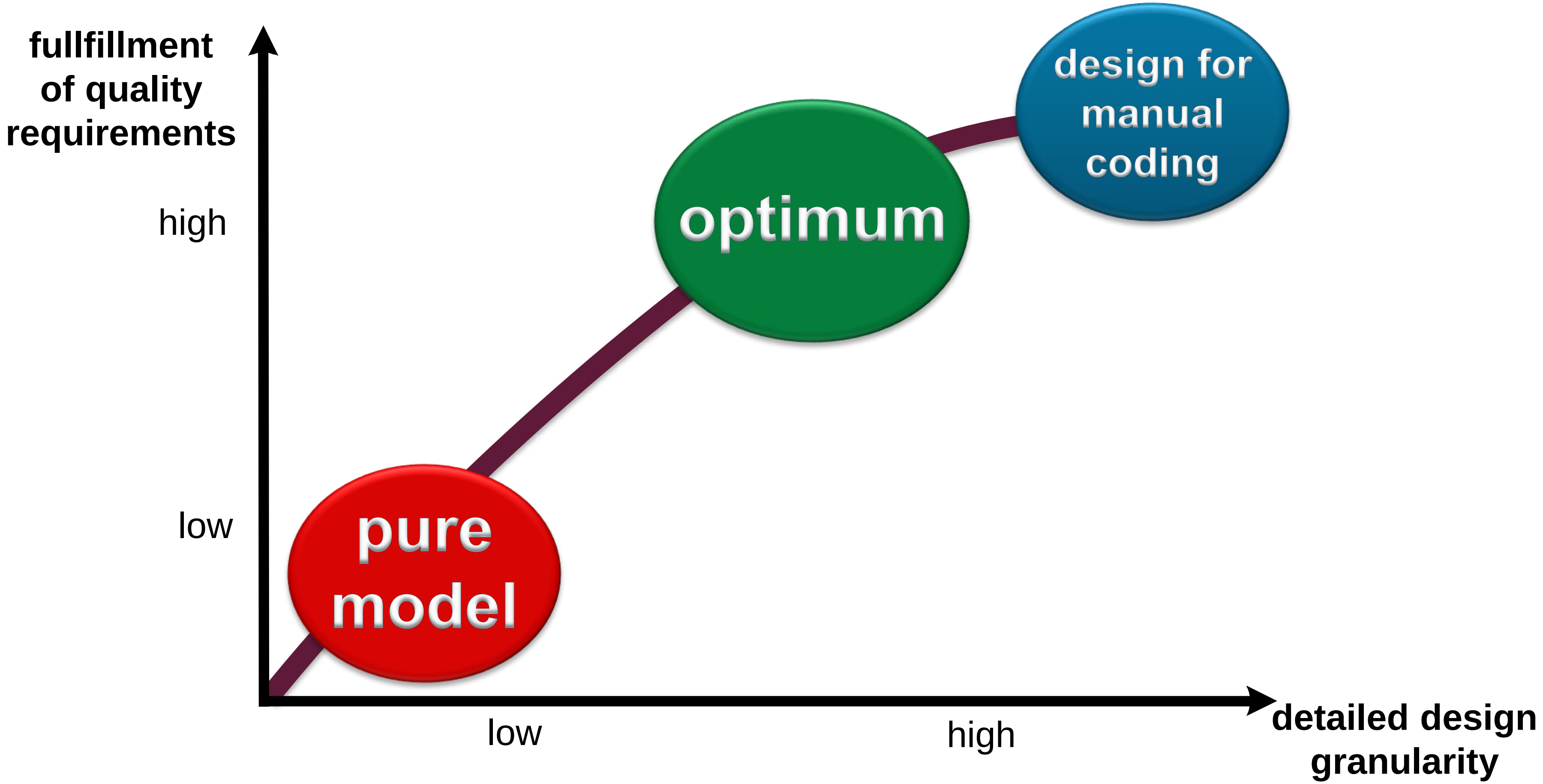
Why a model may be a Detailed Design?

Why a model <u>may be</u> a detailed design (typical issues):

- ✓ Describes structural break down and allows definition of smallest unit (e.g. submodel), which can be run dedicated.
- ✓ Consistency of interfaces is ensured inside of the model by use of data dictionary (SWE3.BP2, SWE3.BP6).
- ✓ Visualization of dataflow supported by graphical representation directly in the model (SWE3.BP1).
- ✓ Description of dynamic behavior (SWE3.BP3) by using synchronization elements, internal scheduler and sample timing definition.

Challenge – find the optimum!

- suitable extent of detailed design, no unnecessary overlap with model



So, how do YOU find the “optimum”?

And still achieve Automotive SPICE Compliance?

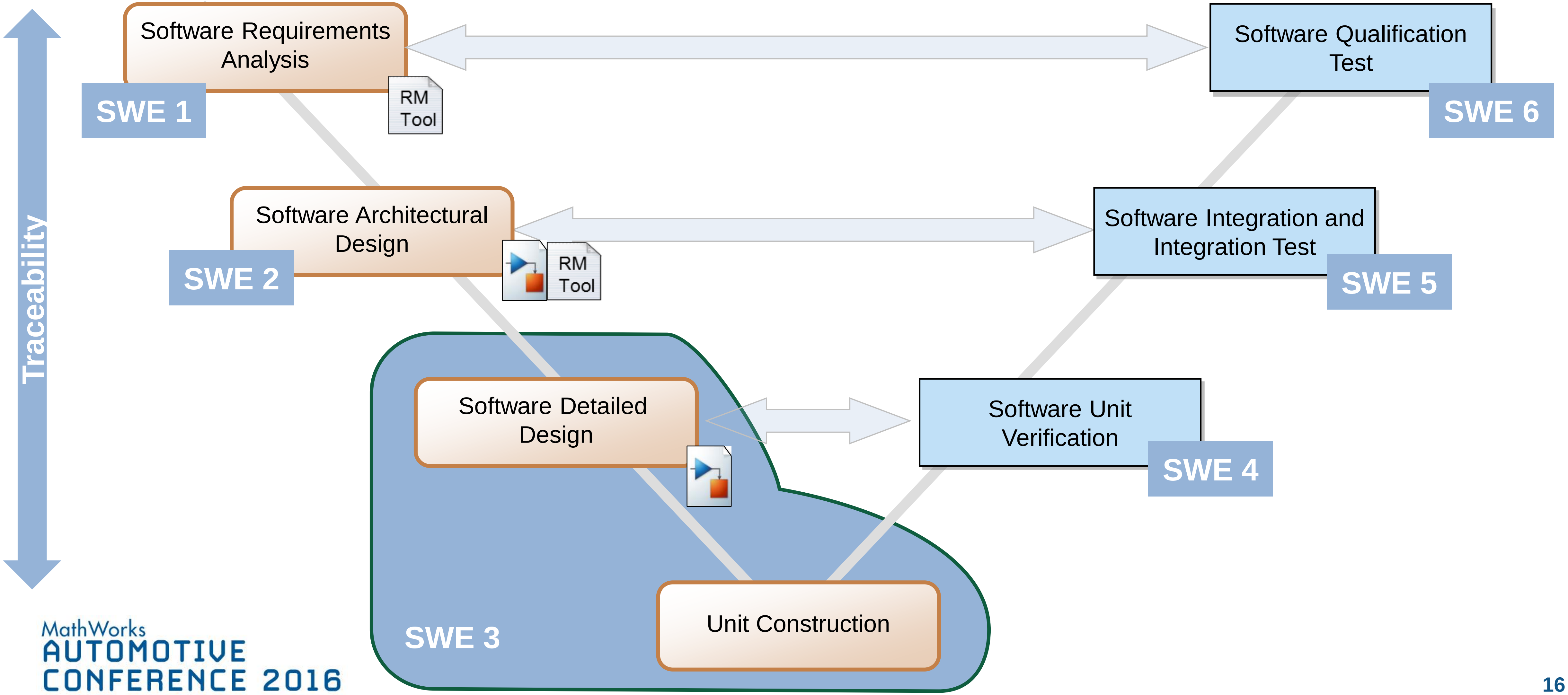
Automotive SPICE

SWE.3 Software Detailed Design - Typical Challenges

- All development activities must add value to the model.
- Activities’ effort has to be sustainable (and realistic) along the whole project lifecycle.
- Find the optimum and avoid duplicate work!
- Since end of 2014 we have been working on this topic together with Volkswagen to define a solution.

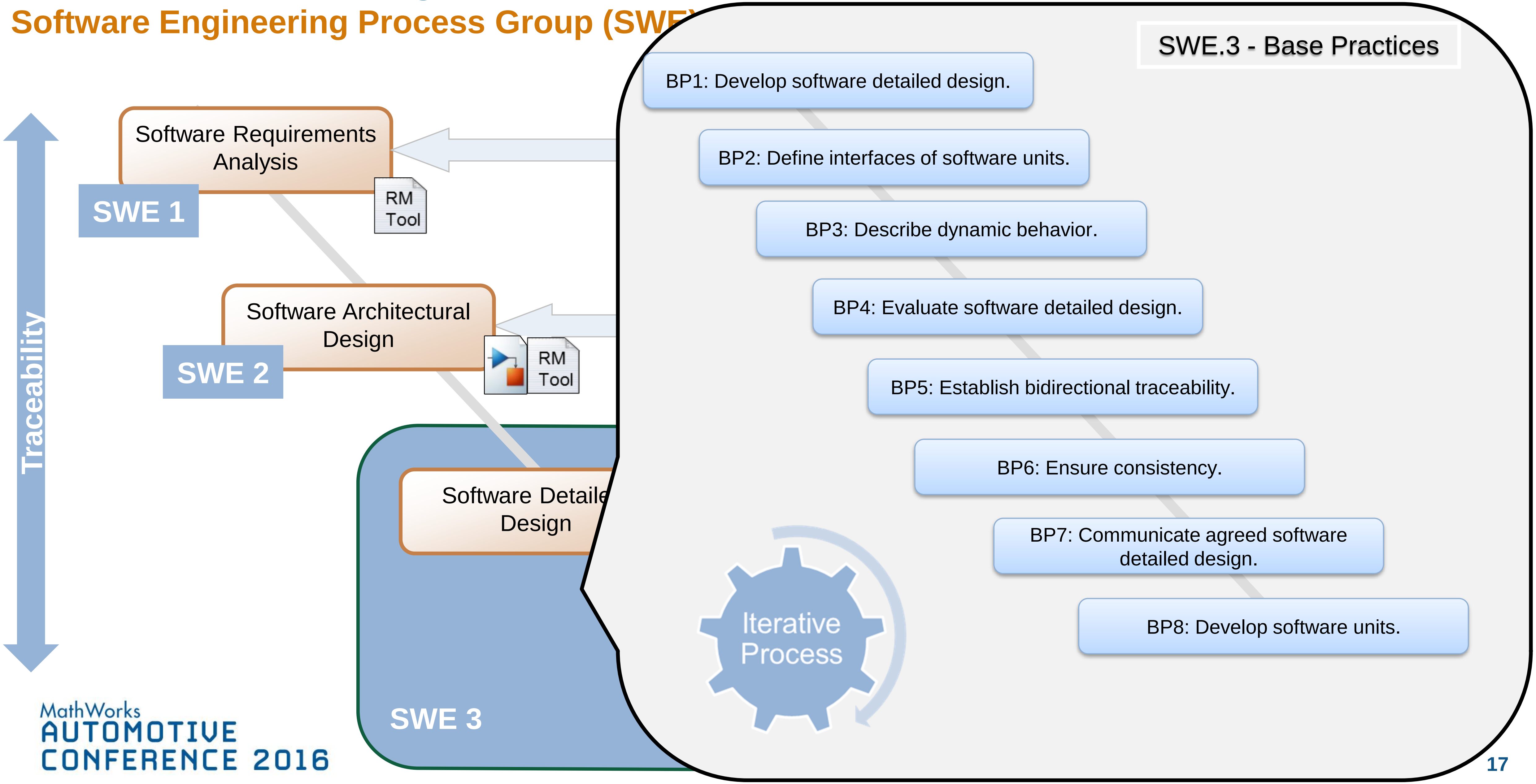
Model-Based Design & Automotive SPICE

Software Engineering Process Group (SWE)



Model-Based Design & Automotive SPICE

Software Engineering Process Group (SWE)



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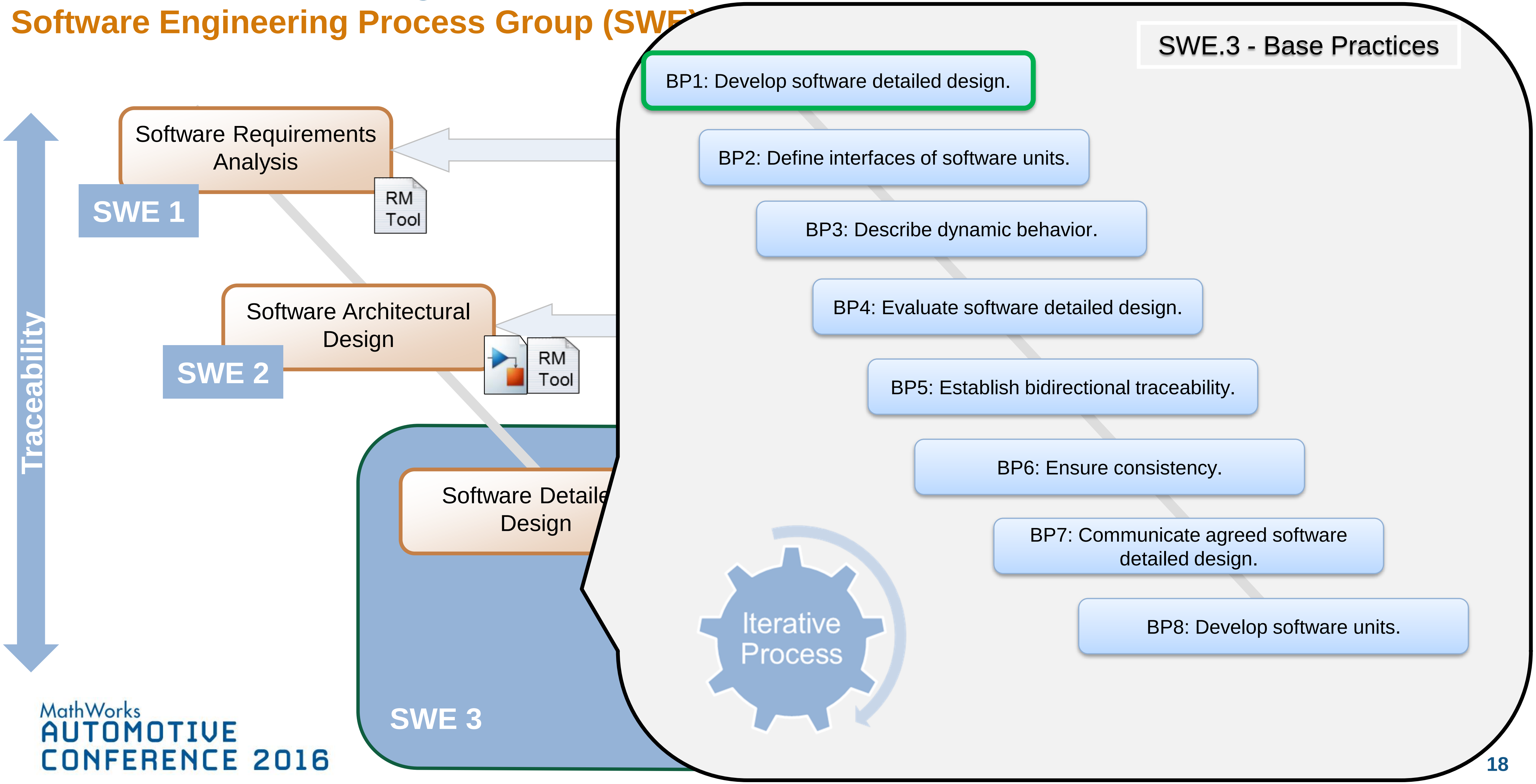
Software Engineering Process Group (SWE)



Automotive SPICE

SWE.3 BP1: Develop software detailed design.

- Develop a detailed design for each software component
  - Use Simulink, Stateflow and toolboxes.
  - Involve functional and non-functional requirements.
- Develop Specification Model
  - Assess the impact of requirements and design changes through simulation.
- Derive an Implementation Model
  - Fulfills all automotive relevant Model-Advisor checks (e.g. MISRA C, ISO 26262, MAAB, …).
  - Is ready for production code generation (e.g. uses Fixed-Point Data types, ...).
- Manage and document design decisions
  - Directly in the model or (if applicable) in the RM Tool.
  - Establish bidirectional linking between relevant blocks and satisfied requirements.

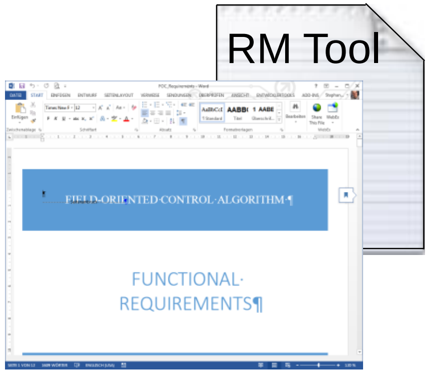
Traceability is key!

Model-Based Design & Automotive SPICE

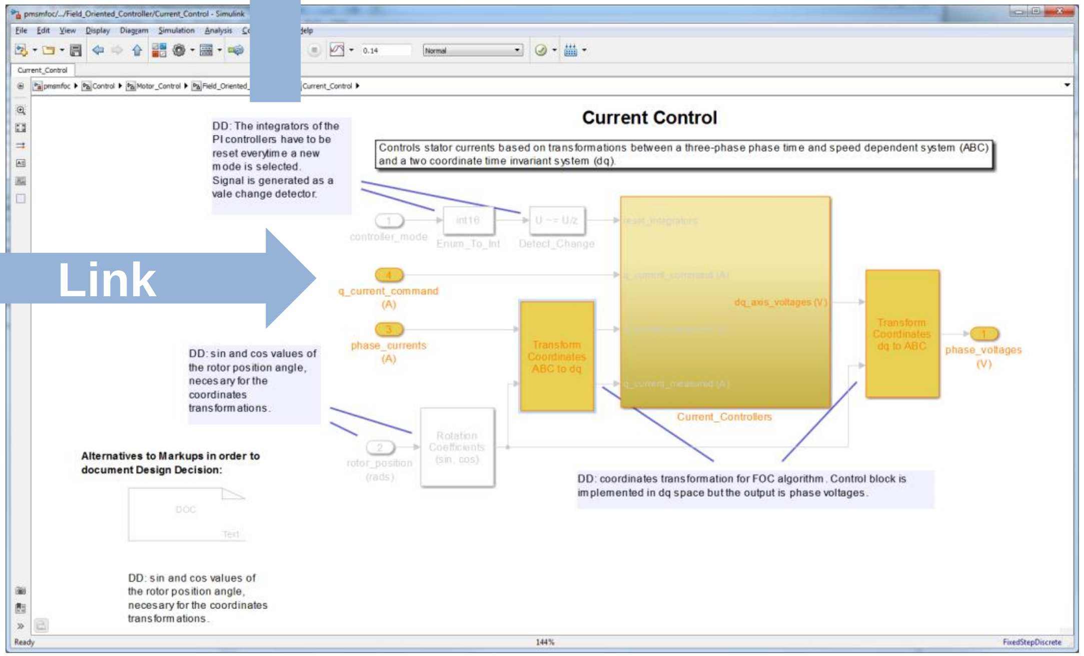
SWE.3 BP1: Develop software detailed design (2)

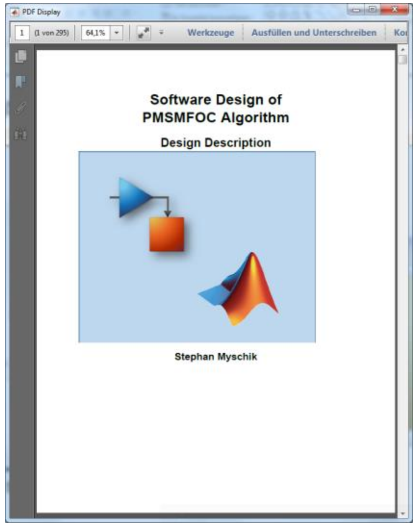
DD: The integrators of the PI controllers have to be reset everytime a new mode is selected. Signal is generated as a vale change detector.

Document Design Decisions textually in Model (or in RM tool)



Link





Bidirectional traceability with Software Requirements

Generate Software Design Document

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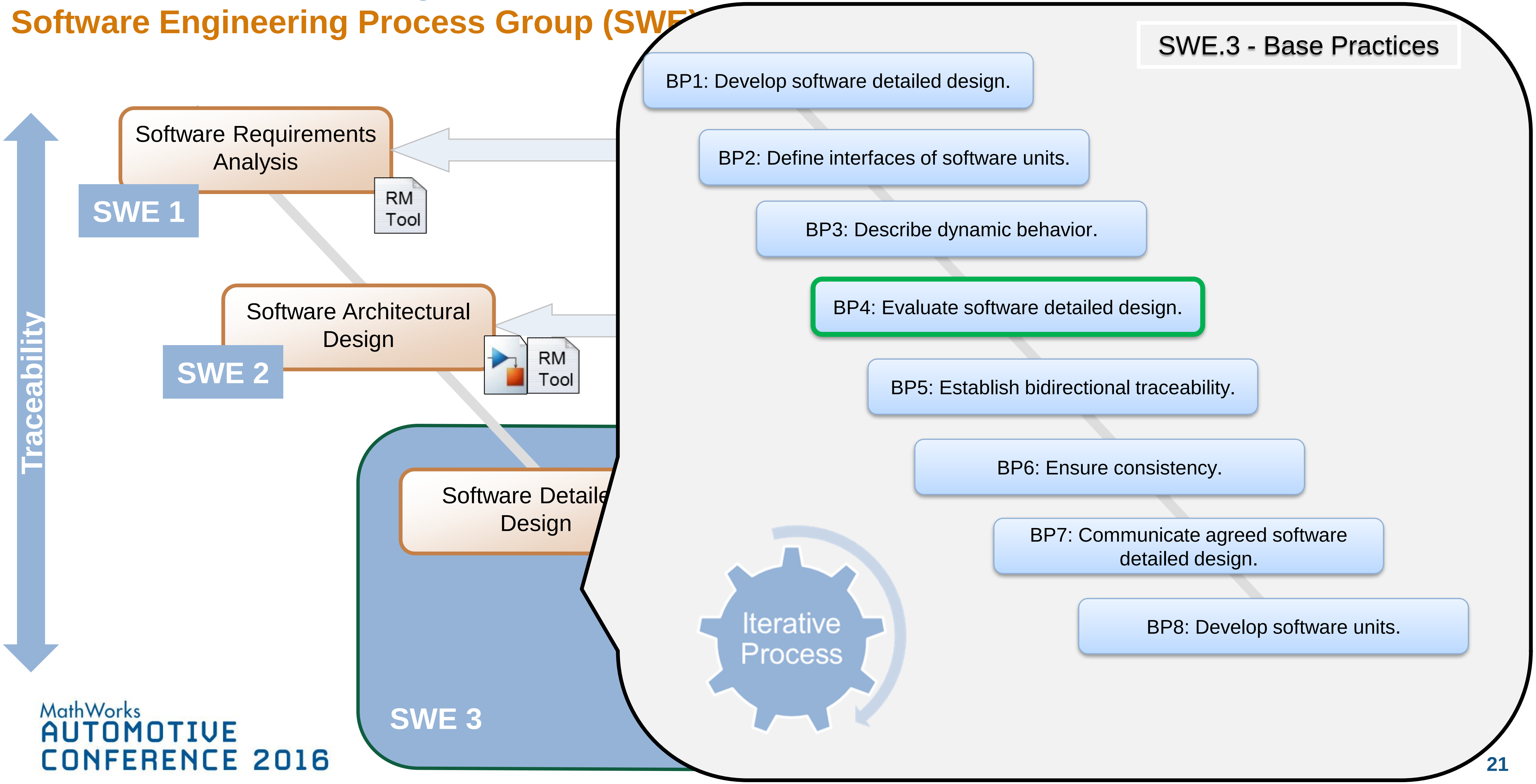
Software Engineering Process Group (SWE)



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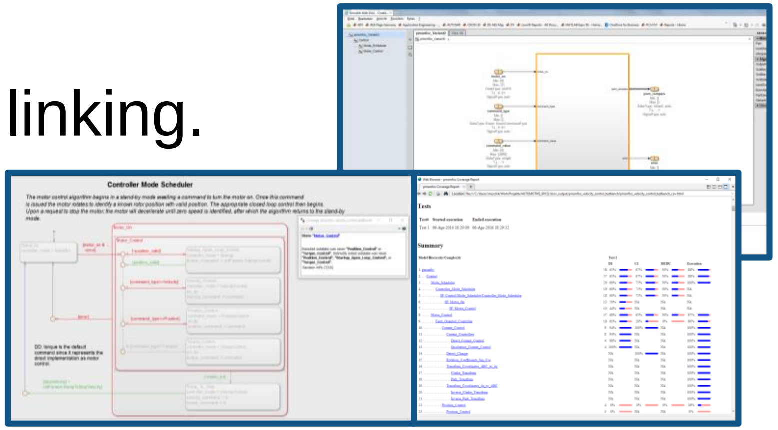
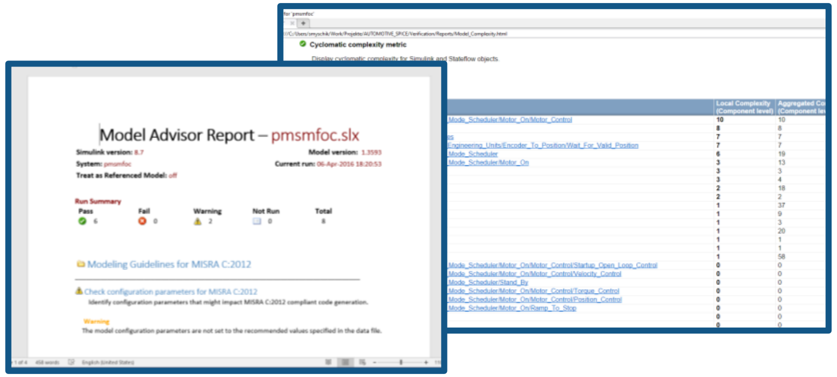
BP4: Evaluate software detailed design.



- Review models, design decisions and requirements linking.
- Execute test cases and model coverage analysis.
- Assess size and complexity of software units with model-metrics.
- Assess conformance to standards at model level (ISO 26262, MISRA, etc.).
  - Justify non-conformities through model annotations.



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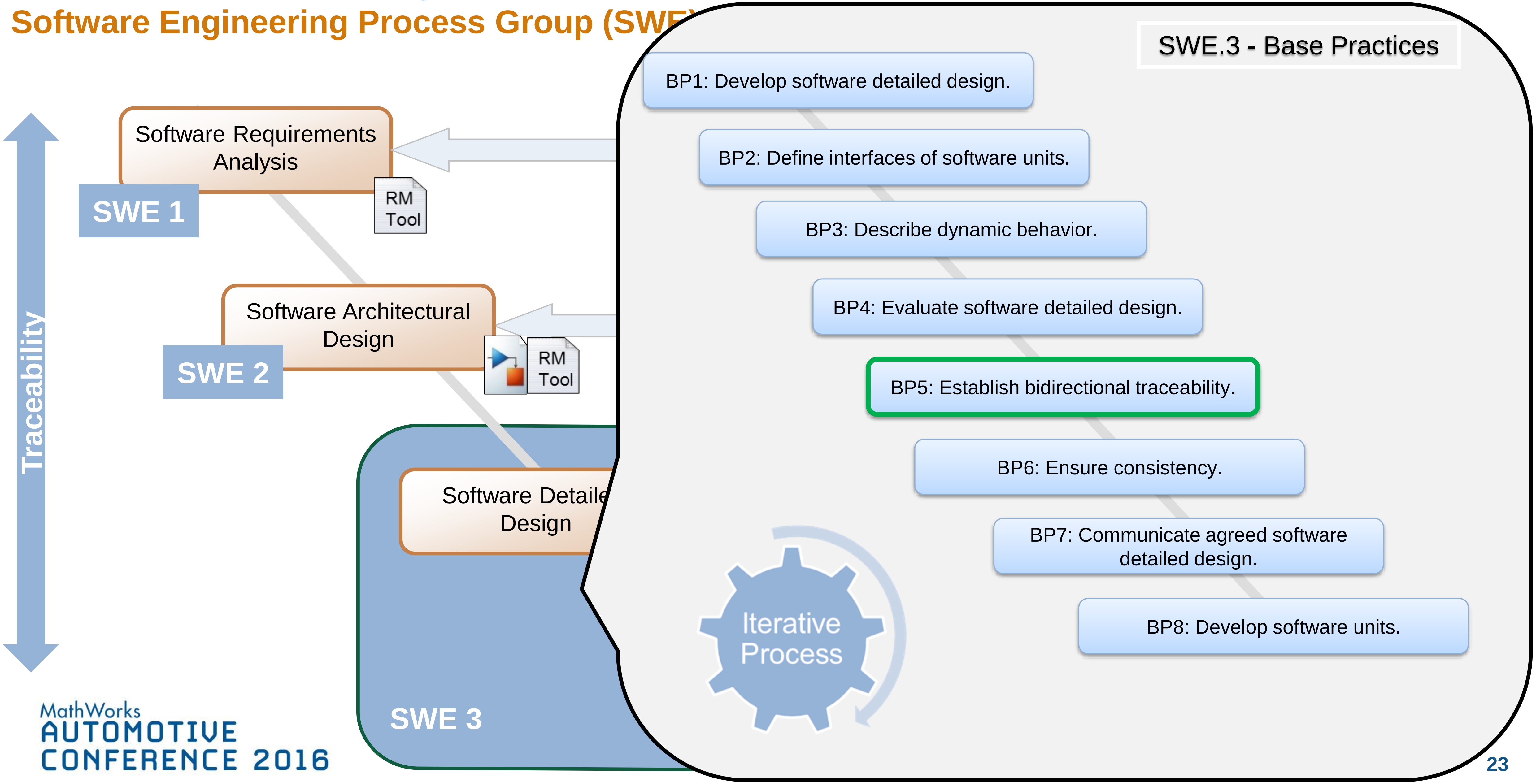
Software Engineering Process Group (SWE)



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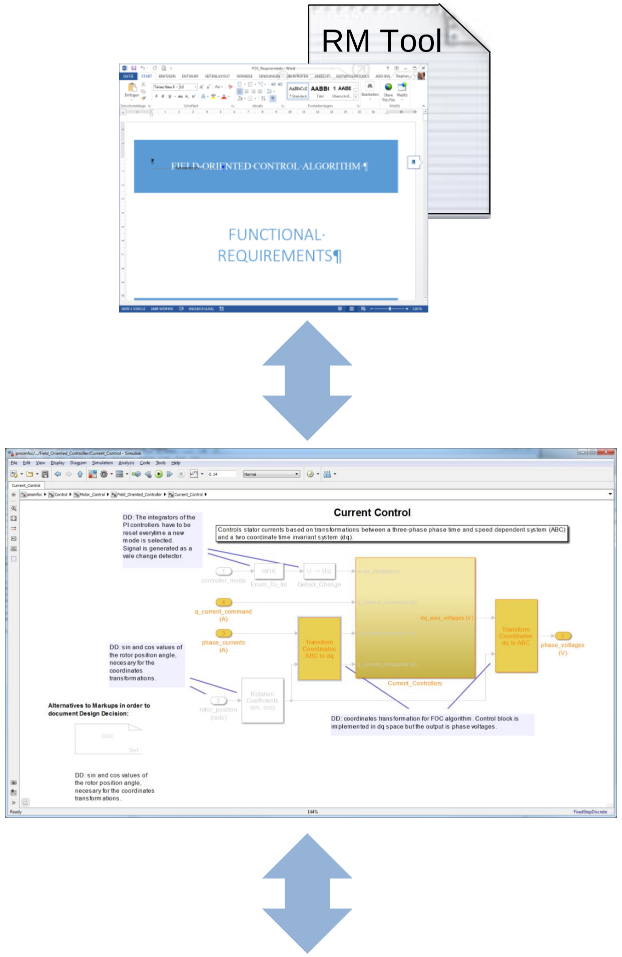
BP5: Establish bidirectional traceability.

- Establish bidirectional traceability between software requirements and the software detailed design.
- Bidirectional traceability
  - Requirements
  - Design decisions
  - Model
- These can include:
  - Parametrization and interface requirements on a high-level of abstraction
  - Specific requirements, e.g. for a start-up task
- Ensure traceability through traceability report or traceability matrix

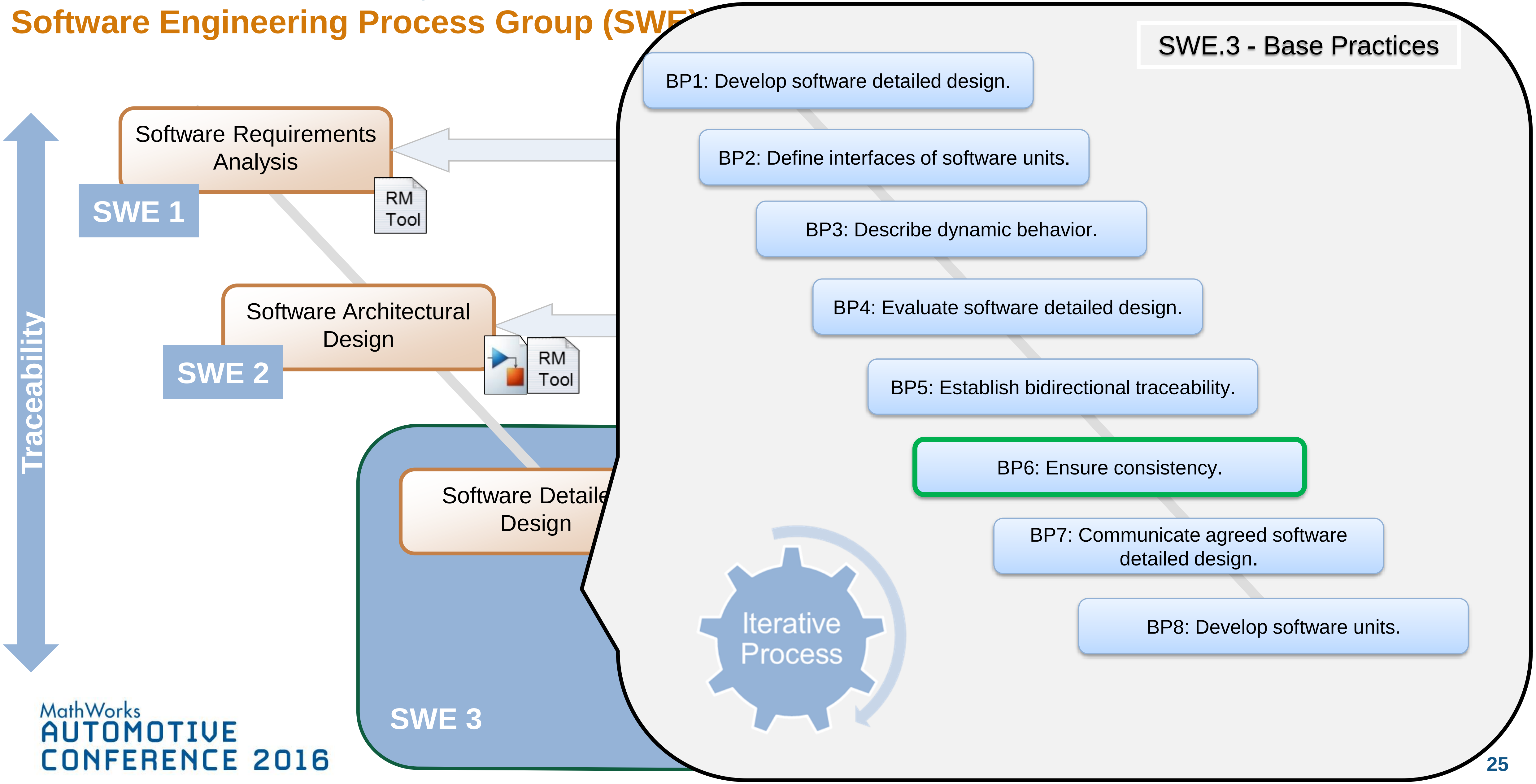


	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Model Object Type	Model Object Path	Model Object Subsystem	Model Object SID	Model Object Optimized	Model Optimization Rationale	Code File Name	Code Function	Code Line Number	Code File Location	Code Comment Checksum	Requirements Source	Requirements Location
2	Inport	model1	model1	model1:4			model1.c	Global	22	C:\work\model1_ert_rtw	CS_533947273	C:\work\req1.doc	@ID_0123: Input Interface
3	Inport	model1	model1	model1:4			model1.c	model1_step	38	C:\work\model1_ert_rtw	CS_116158590	C:\work\req1.doc	@ID_0123: Input Interface
4	Inport	model1	model1	model1:4			model1.c	model1_step	43	C:\work\model1_ert_rtw	CS_116158590	C:\work\req1.doc	@ID_0123: Input Interface
5	Inport	model1	model1	model1:4			model1.h	Global	49	C:\work\model1_ert_rtw	CS_533947273	C:\work\req1.doc	@ID_0123: Input Interface
6	Gain	model1	model1	model1:2			model1.c	Global	23	C:\work\model1_ert_rtw	CS_405027874	C:\work\req1.doc	@ID_0005: Functionality
7	Gain	model1	model1	model1:2			model1.c	Global	27	C:\work\model1_ert_rtw	CS_104796431	C:\work\req1.doc	@ID_0005: Functionality

Requires: 'IEC Certification Kit' for IEC 61508 and ISO 26262;
'Embedded Coder'

Model-Based Design & Automotive SPICE

Software Engineering Process Group (SWE)



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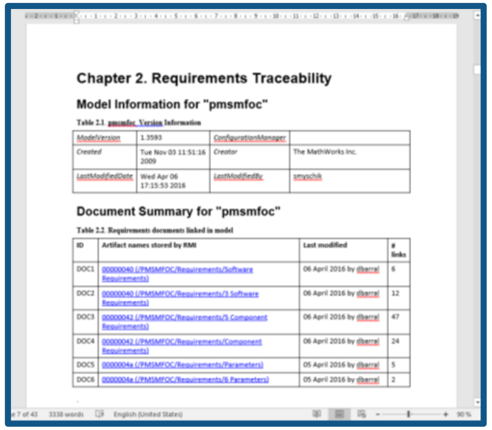
BP6: Ensure consistency.

- Ensure consistency between software requirements and software units.
- Ensure consistency between the software detailed design and software units.
- Consistency check
  - Missing documents
  - Invalid links
  - Modified requirements
  - Unidirectional links



Chapter 2. Requirements Traceability

Model Information for "pmsmfoc"

Table 2.1. pmsmfoc Version Information

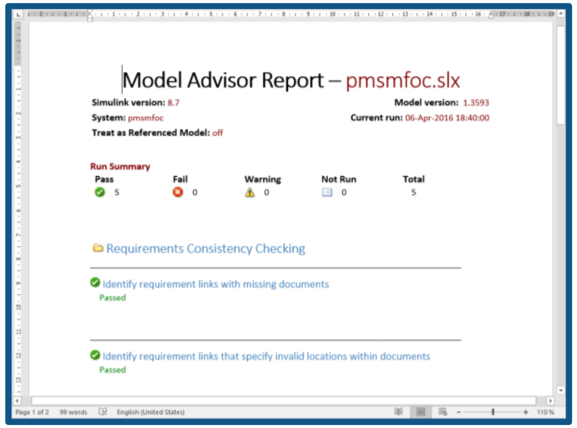
ModelVersion	1.3593	ConfigurationManager	
Created	Tue Nov 03 11:51:16 2009	Creator	The MathWorks Inc.
LastModifiedDate	Wed Apr 06 17:15:53 2016	LastModifiedBy	smyschik

Document Summary for "pmsmfoc"

Table 2.2. Requirements documents linked in model

ID	Artifact names stored by RMI	Last modified	# links
DOC1	00000040 (/PMSMFOC/Requirements/Software Requirements)	06 April 2016 by dbarral	6
DOC2	00000040 (/PMSMFOC/Requirements/3 Software Requirements)	06 April 2016 by dbarral	12
DOC3	00000042 (/PMSMFOC/Requirements/5 Component Requirements)	06 April 2016 by dbarral	47
DOC4	00000042 (/PMSMFOC/Requirements/Component Requirements)	06 April 2016 by dbarral	24
DOC5	0000004a (/PMSMFOC/Requirements/Parameters)	05 April 2016 by dbarral	5
DOC6	0000004a (/PMSMFOC/Requirements/6 Parameters)	05 April 2016 by dbarral	2

Traceability Report



Model Advisor Report – pmsmfoc.slx

Simulink version: 8.7 Model version: 1.3593

System: pmsmfoc Current run: 06-Apr-2016 18:40:00

Treat as Referenced Model: off

Run Summary

Pass	Fail	Warning	Not Run	Total
5	0	0	0	5

Requirements Consistency Checking

Identify requirement links with missing documents

Passed

Identify requirement links that specify invalid locations within documents

Passed

Requirements Consistency Check

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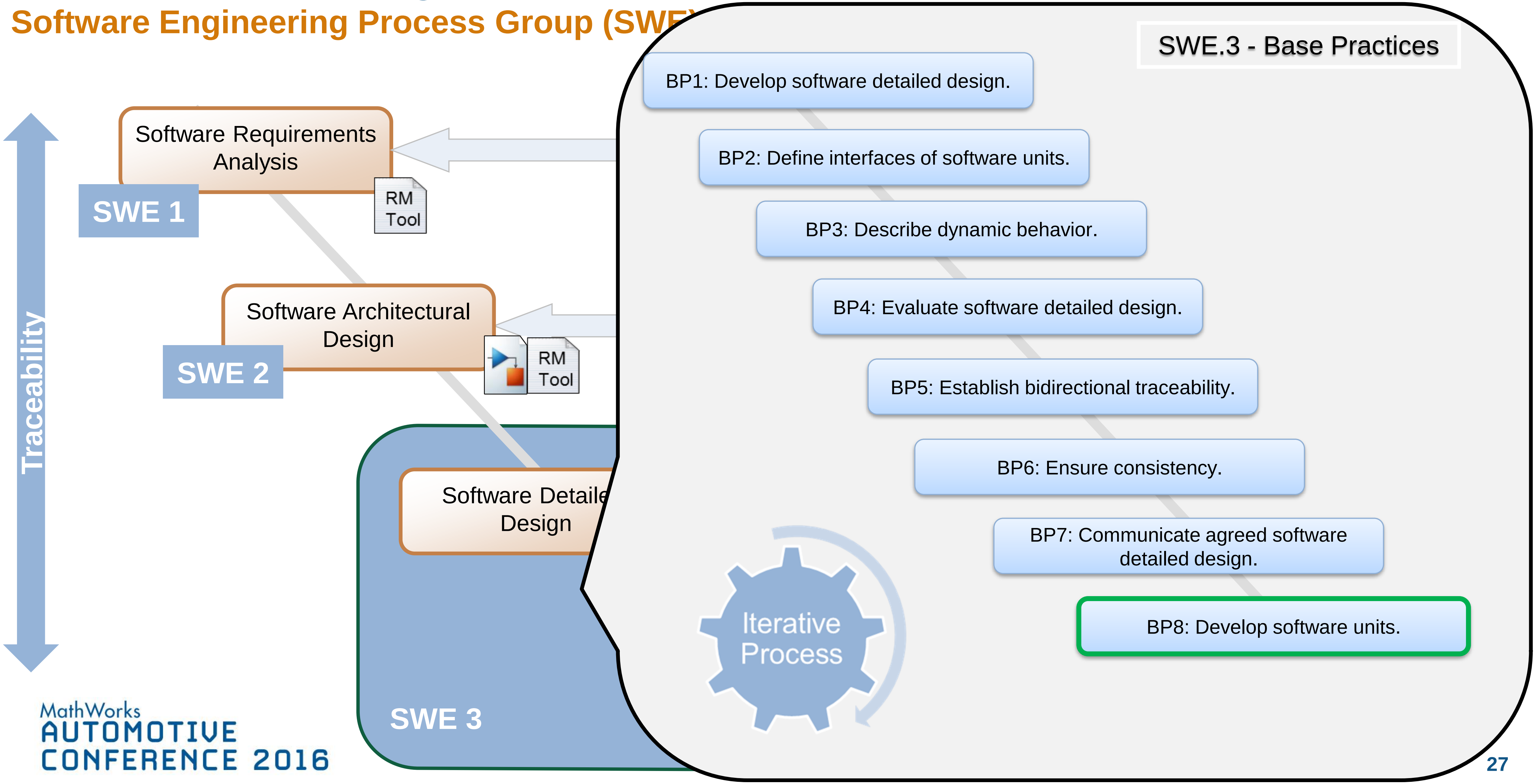
Software Engineering Process Group (SWE)



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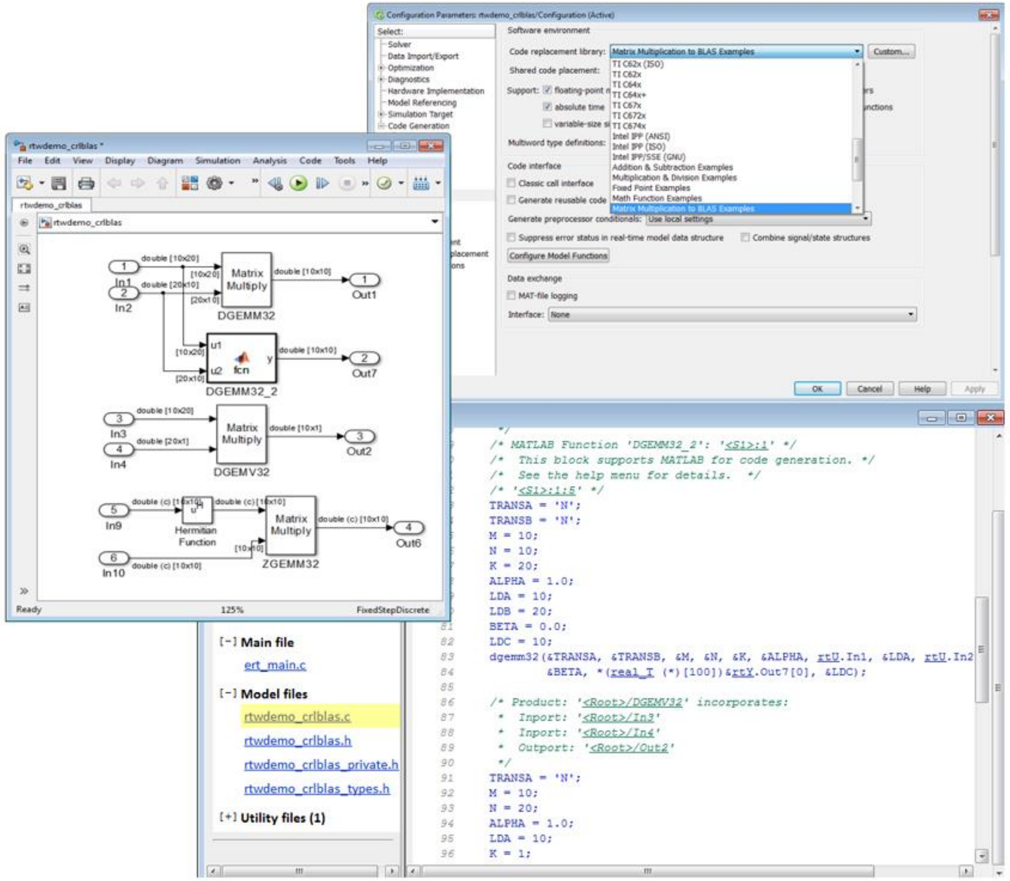
BP8: Develop software units.

- Code generation for MBD
  - Implementation model (consideration of all production code parameters as fixed-point arithmetic, etc.)
  - Coder Configuration
    - Target hardware
    - Resources optimization
    - Function prototypes and variables allocation



- Automatic report with bidirectional traceability
  - Requirements
  - Design Decisions
  - Model
  - Code

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Model & Detailed Design

- Thesis: „My model is my detailed design!“

- Model = Detailed Design, if fulfills:
  - Design Decisions documentation
  - Interfaces definition
  - Dynamic behavior description
  - Design review
  - Bidirectional requirements traceability
  - Consistency check

- Software Units
  - Implementation model
  - Code generation
  - Model has much more value than a static drawing

Base Practice	Measure	Recommended Tool or Functionality	Artif
BP1: Develop software detailed design.	+ Use Model Reference Blocks, Atomic Subsystems, Function-Call Subsystems or Simulink Functions to achieve functional decomposition into testable units + Use Interface view to assess signal flow and decomposition + Adhere to MAAB Modeling Standards, e.g. avoid mixing basic blocks and subsystems	Simulink® Stateflow® Simulink Verification and Validation® - Model Advisor MAAB Checks	N/A *Part and Desc*
BP2: Define interfaces of software units.	+ Use unambiguous names for Signals and Ports + Definition of complex interfaces with multiple signals through non-virtual busses (Bus Objects) + Link Interface Requirements to Data Dictionary Elements	Simulink® Simulink® - Data Dictionary Simulink Verification and Validation® - Requirements	N/A *Part and Desc*

MBD ASPICE Compliance Guideline

- **Result of collaboration:**
  - **Guideline for efficient ASPICE-conform Model-Based Design development.**
  - **MathWorks Expertise for customer support.**

Conclusion and Outlook

- VW Quality Goal: Improvement of “VW Group Basic Software Requirements” to consider a Model-Based Design development workflow
- VW and MathWorks successfully collaborated to craft a Model-Based Design process that is targeted towards reaching compliance with important industry quality standards
- MATLAB & Simulink provides a documented and traceable workflow aligned with the requirements of Automotive SPICE and ISO 26262-6
- Auditor community needs to adopt a common approach for assessments with Model-Based Design
- Definition of industry-wide standards for model quality criteria, e.g. complexity indicators and limits (like HIS-MISRA for C).