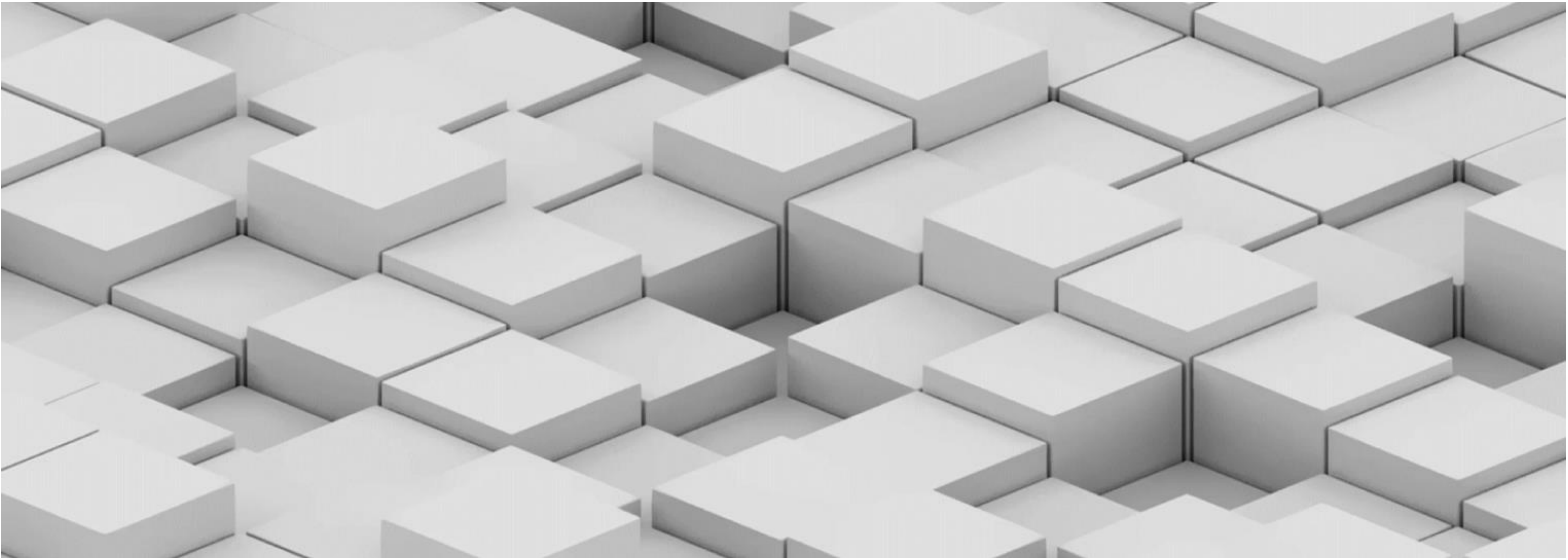
Traceability and Granularity of Requirements in Automotive SPICE®

Typical project pitfalls from my experience as an Automotive SPICE Assessor, Coach and SQIL

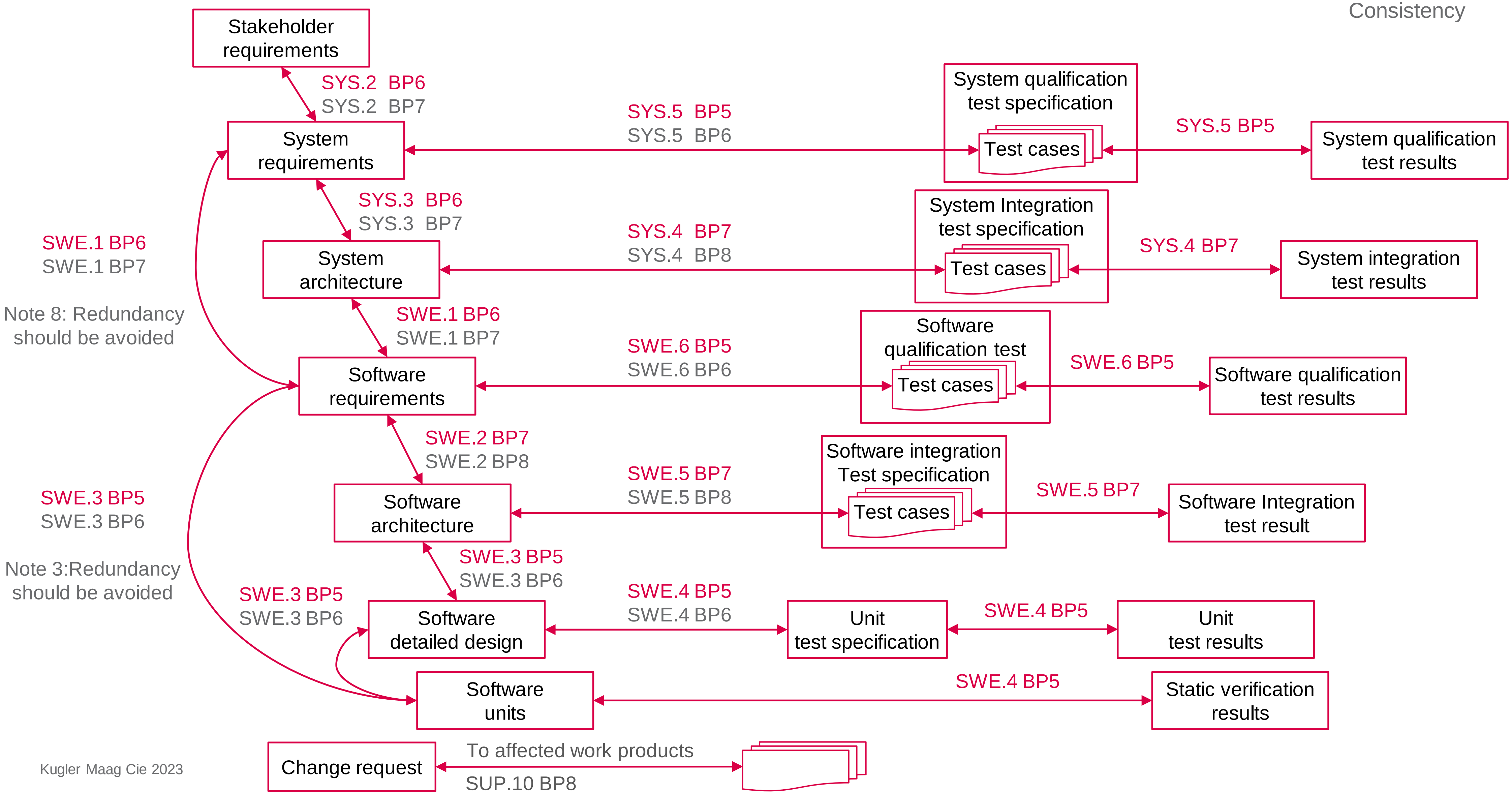


Dr. Giuseppe Pepe – Kugler Maag Cie – Automotive SPIN Italy – 30th May 2023

The Traceability According to Automotive SPICE®

The model

Bidirectional traceability
Consistency



Stakeholder requirements

SYS.2 BP6
SYS.2 BP7

System requirements

SYS.5 BP5
SYS.5 BP6

System qualification test specification

Test cases

SYS.5 BP5

System qualification test results

SYS.3 BP6
SYS.3 BP7

SWE.1 BP6
SWE.1 BP7

Note 8: Redundancy should be avoided

System architecture

SYS.4 BP7
SYS.4 BP8

System Integration test specification

Test cases

SYS.4 BP7

System integration test results

SWE.1 BP6
SWE.1 BP7

Software requirements

SWE.6 BP5
SWE.6 BP6

Software qualification test

Test cases

SWE.6 BP5

Software qualification test results

SWE.2 BP7
SWE.2 BP8

SWE.3 BP5
SWE.3 BP6

Note 3:Redundancy should be avoided

Software architecture

SWE.5 BP7
SWE.5 BP8

Software integration Test specification

Test cases

SWE.5 BP7

Software Integration test result

SWE.3 BP5
SWE.3 BP6

SWE.3 BP5
SWE.3 BP6

Software detailed design

SWE.4 BP5
SWE.4 BP6

Unit test specification

SWE.4 BP5

Unit test results

Software units

SWE.4 BP5

Static verification results

Change request

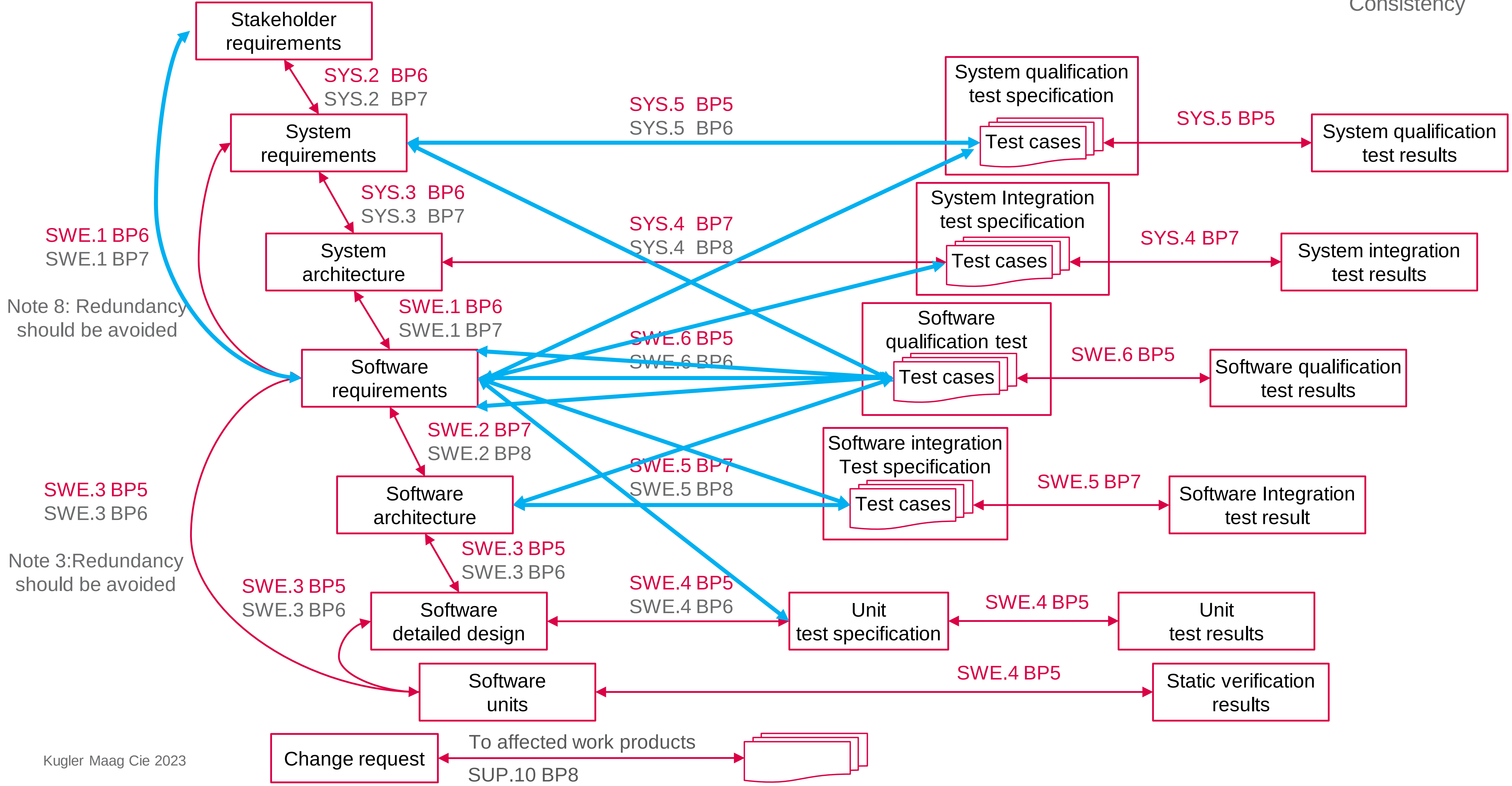
To affected work products

SUP.10 BP8

The Traceability According to Automotive SPICE®

The reality

Bidirectional traceability
Consistency



Main Topics

1. Bypass of system requirements
   - How to trace customer’s requirements that are defined for the SW level

2. Granularity of requirements
   - How to decompose requirements

3. Oblique traceability
   - How to implement the traceability to test cases

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Ph.D. in Electronics Engineering
Bergische Universität Wuppertal
2004 - Germany

Laurea in Electronics Engineering
University of Ancona – *cum laude*
2000 - Italy

Languages

Italian, German, English

Experiences

- Lead Assessor for Automotive SPICE® assessments for both tier 1 and OEMs
- Lead Assessor for supplier evaluation based on OEM'S specific scheme
- SQIL at large Tier 1s in SAFe development
- Lead Assessor for HW SPICE Assessments
- Trainer for Automotive SPICE® and HW SPICE
- Process consultant and coach for several improvement processes at different Tier 1s

Qualifications and expertise

- Automotive SPICE® Principal Assessor incl. CS Extension
- VW Certified SW Quality Improvement Leader (SQIL)
- Co-Author of Hardware SPICE PRM/PAM
- TÜV-Certified Functional Safety Engineer (ISO 26262)
- TÜV-Certified Cybersecurity Engineer (ISO 21434)
- ISTQB Certified Tester incl. Agile
- CPRE Certified Professional for Requirements Engineering

Previous Positions

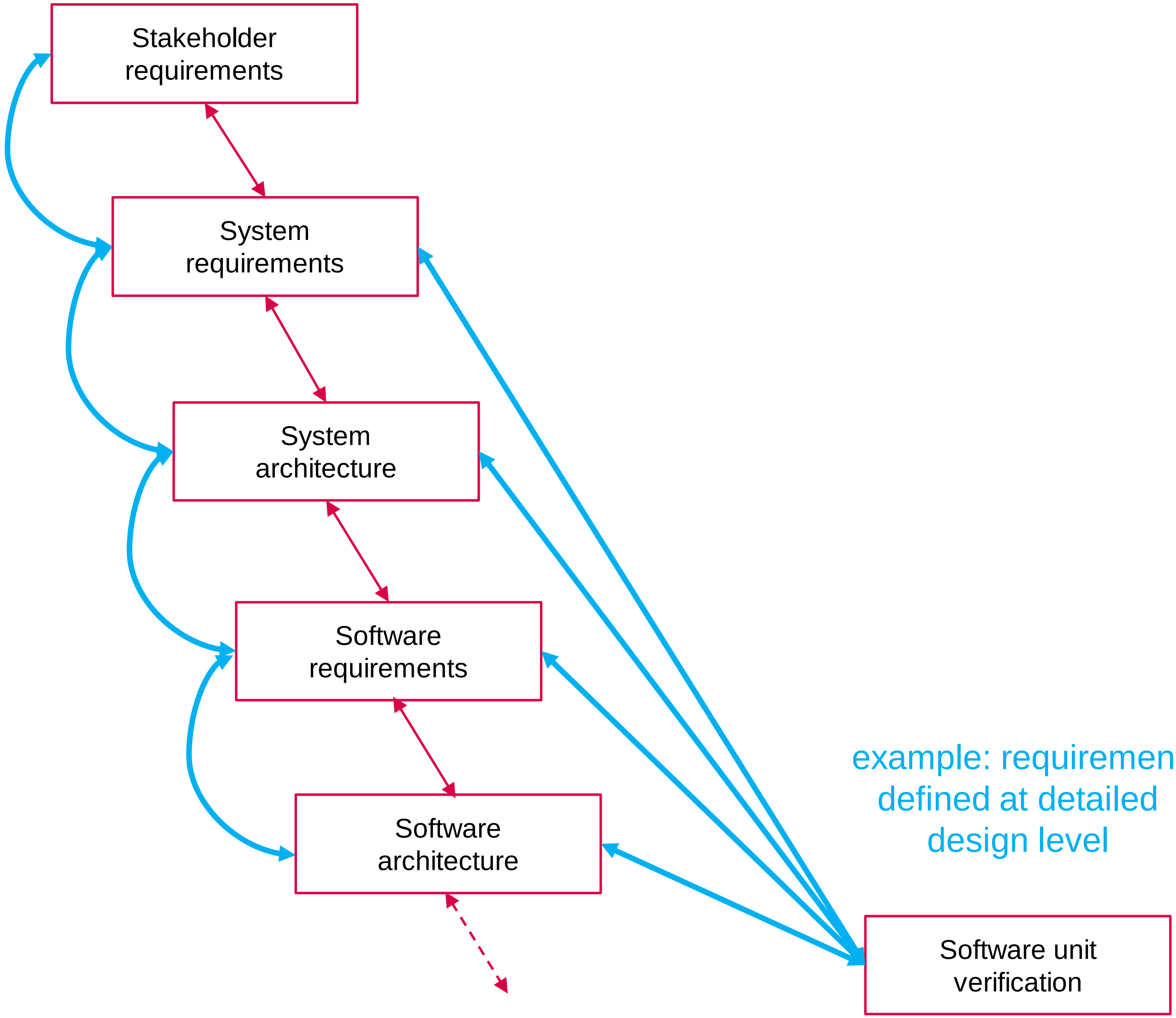
- Since 2018: Kugler Maag Cie GmbH
- 2013 – 2018: Start-Up Founder IT Company
- 2009 – 2013: Systems Engineering – Robert Bosch GmbH
- 2004 – 2009: Hardware Engineering – Robert Bosch GmbH
- 2001 – 2004: Ph.D. Candidate – Bosch SatCom GmbH

1. Bypass of system requirements

Copy / Paste of Customer Requirements that are Defined at Software Level

The death march

- Often, the customer's requirement is copy/pasted into the different levels.
- This is a bad requirement's engineering practice, as
  - It doesn't consider the different levels of abstractions of the requirements (e.g., system requirements are "black box").
  - It makes test coverage reports difficult to generate and interpret.
  - It generates effort in the management / linking of the requirements.
  - It makes impact analyses and testing over complicated.



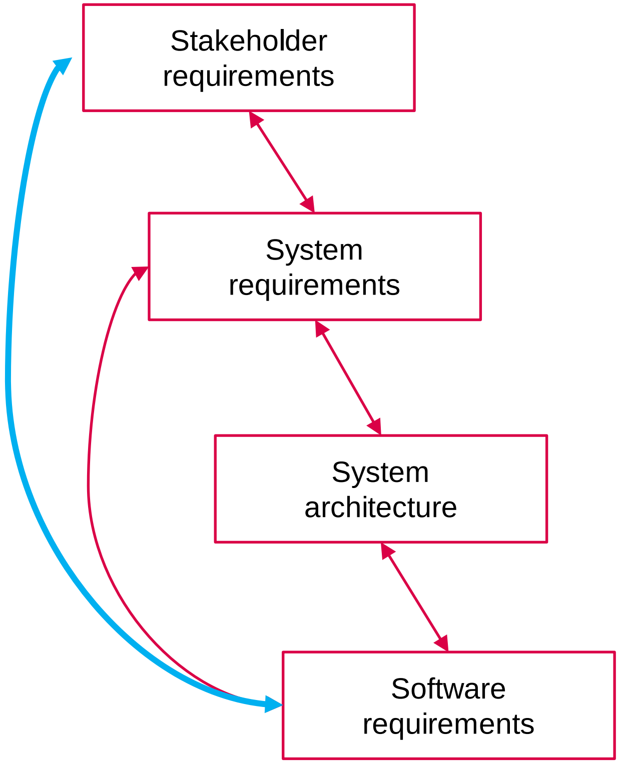
Bypass of System Requirements

Definition and risks

- Software requirements are linked directly to the stakeholder requirements, hence, bypassing the system level.

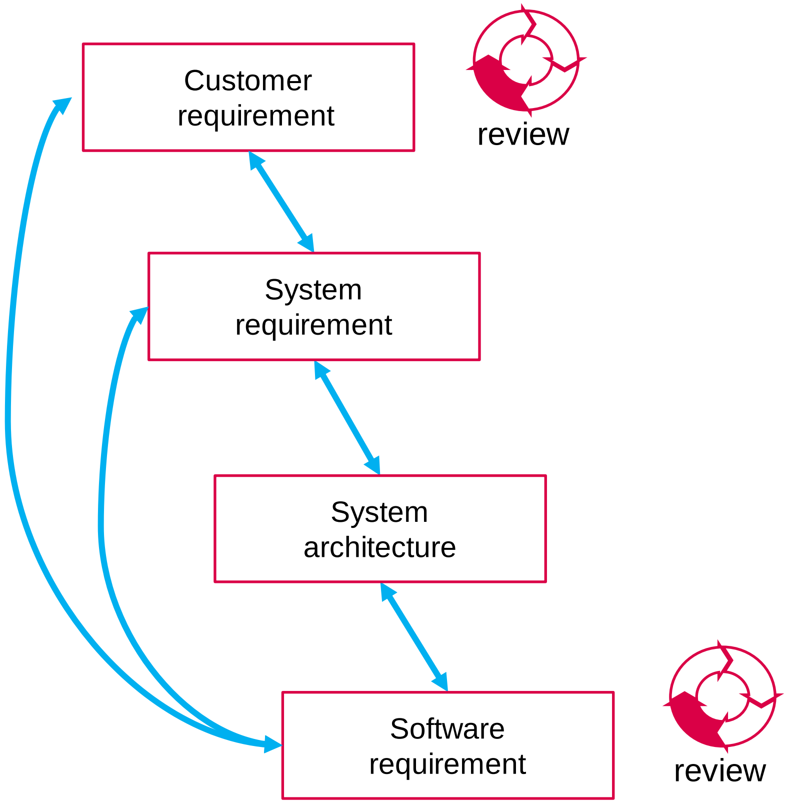
- This traceability includes a product risk, and it is not foreseen by the PAM.

- If not managed properly, the bypass leads to CL0 ratings.



Bypass of System Requirements

A possible approach

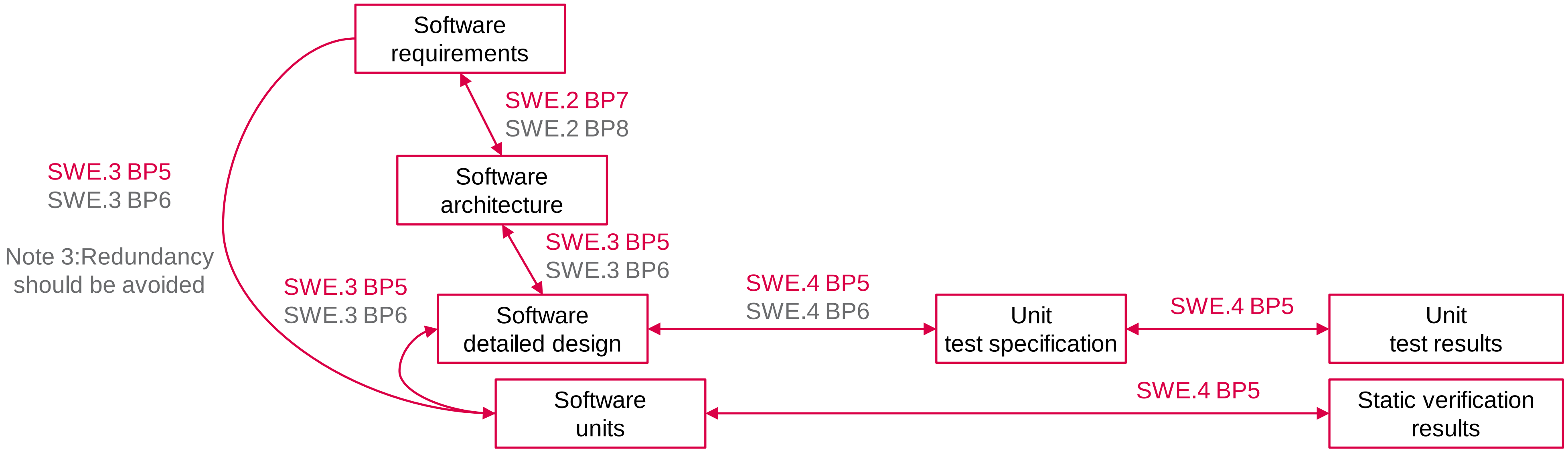


1. The customers requirement must be reviewed by system and software experts.
2. The derived software requirements are linked to the customer requirements.
3. A system requirement (e.g., placeholder) is created and the software requirements are linked to it.
4. Vertical traceability between customer requirements, system requirements, system architecture and software requirements is established.
5. The software requirements are reviewed.
6. This approach supports a proper impact analysis.

2. Granularity of requirements

What is a SW Unit and why does its Size Matter?

The problem of large units



- Automotive SPICE: a Unit is “*Part of a software component which is not further subdivided*”.
- KGAS: “*A unit is the smallest separately executable and testable entity of a component*”.
- Units must be traceable to SW requirements and the SDD must be traceable to the unit test specification.
- If the units are too large:
  - The traceability to SW requirements is meaningless, because SW developers don’t understand what is required and have to make “assumptions” and take design decisions to write the code.
  - Testers need to focus on something much smaller than the unit and the horizontal traceability gets lost completely.

Design Guidelines for SW Units

Cyclomatic complexity, no assumptions at coding / full completeness of SDD

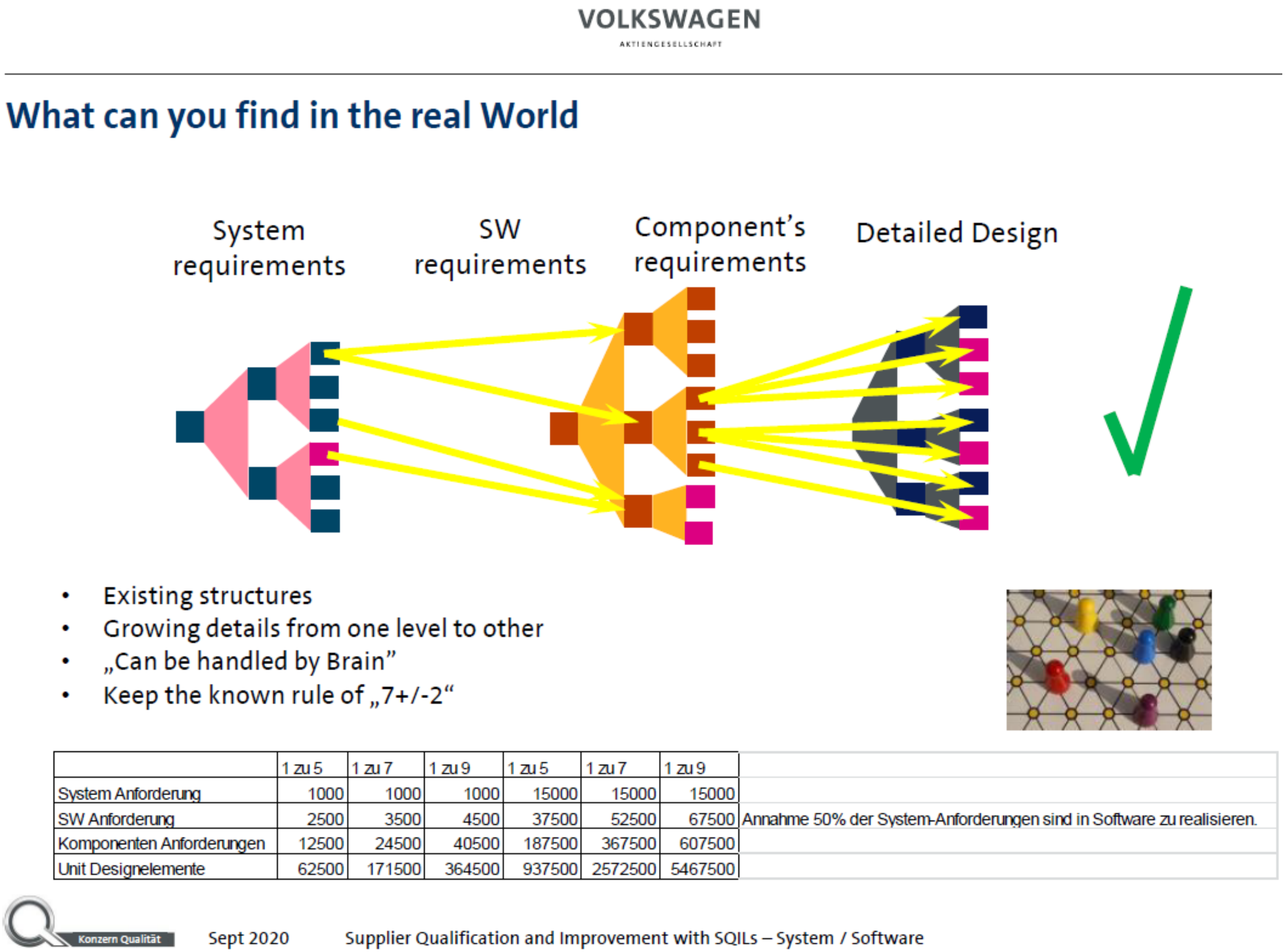
- ☞ Keep units small (KGAS: cyclomatic complexity ≤ 10).

- ☞ For higher complexity, reduce the granularity of the requirements (in order to ensure the traceability to “unit elements” like calculations, interfaces, macros) and split the unit.

- ☞ Remember that the implementation of the units must be possible without assumptions. The SDD must be complete.

Granularity of Requirement

The rule 7 ± 2



VOLKSWAGEN
AKTIENGESELLSCHAFT

What can you find in the real World

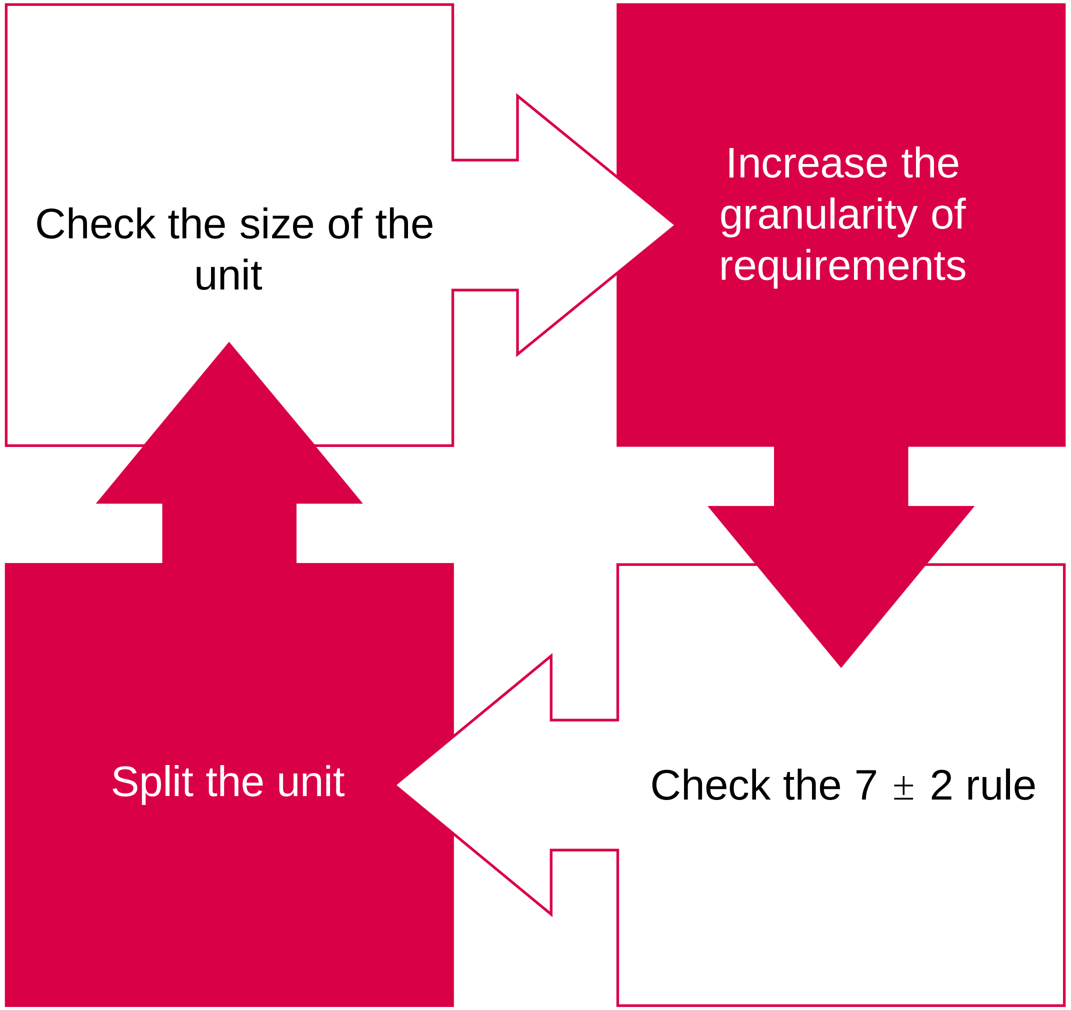
- Existing structures
- Growing details from one level to other
- „Can be handled by Brain"
- Keep the known rule of „7+/-2"

	1 zu 5	1 zu 7	1 zu 9	1 zu 5	1 zu 7	1 zu 9	
System Anforderung	1000	1000	1000	15000	15000	15000	
SW Anforderung	2500	3500	4500	37500	52500	67500	Annahme 50% der System-Anforderungen sind in Software zu realisieren.
Komponenten Anforderungen	12500	24500	40500	187500	367500	607500	
Unit Designelemente	62500	171500	364500	937500	2572500	5467500	

Konzern Qualität Sept 2020 Supplier Qualification and Improvement with SQILs – System / Software

Granularity of Requirements

All together



Check the size of the unit

Increase the granularity of requirements

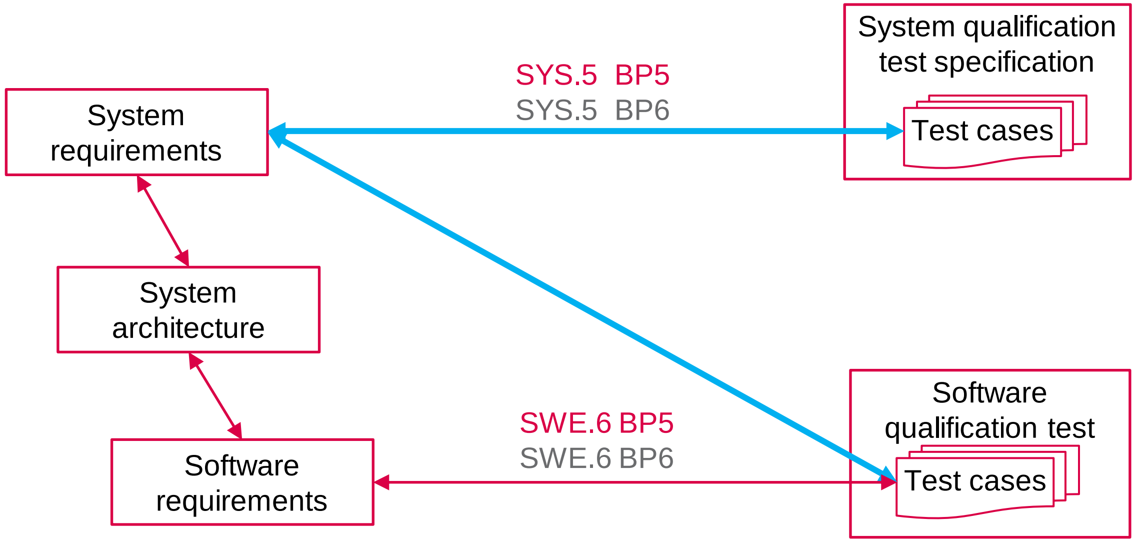
Check the 7 ± 2 rule

Split the unit

3. Oblique traceability

System Requirements Tested at Software Level

Oblique traceability and verification criteria

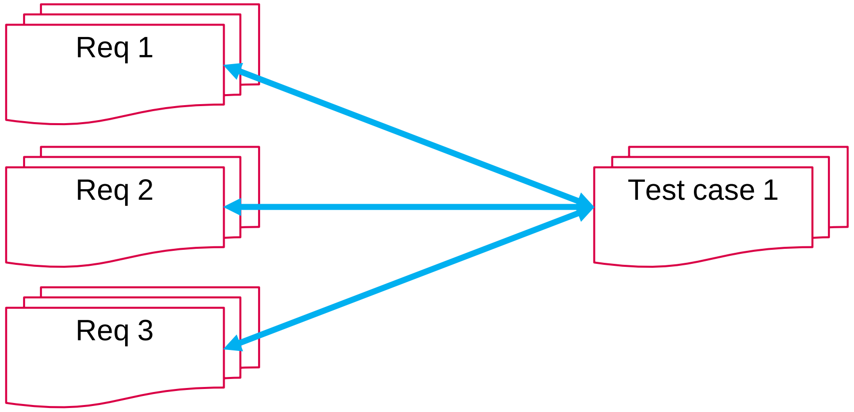


- A system requirement is linked to 1 test case at software level.
  - The consistency of the test case with the requirement is not given, or the system requirement is actually a software requirement.
  - If used, a justification must be documented (e.g., in the verification criterion).
  - Must be provided with at least one test case at system qualification level.

- A system requirement is linked to 1 test case at software level and 1 test case at system level.
  - The consistency of the test cases must be ensured.
  - The verification criterion must provide a clear description of the two test cases.

Multiple Requirements Tested with the Same Test Case(s)

The need of decision table testing

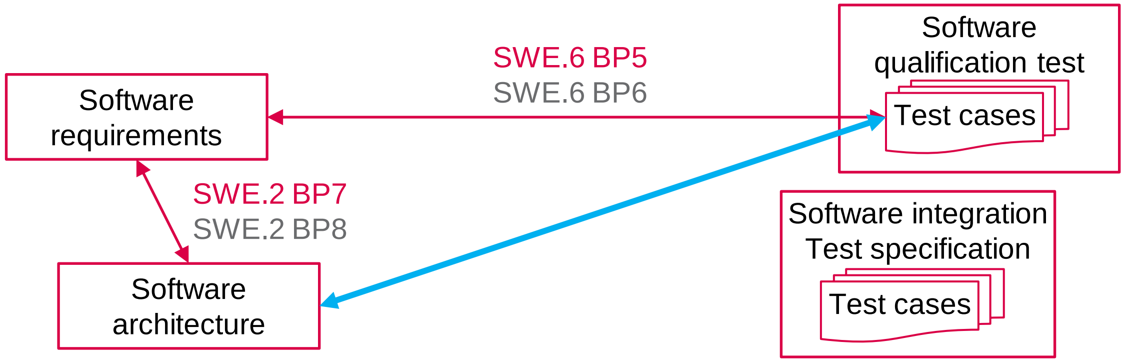


- This is not a model deviation, as long as:
  - The consistency of the test case with the requirements is ensured.
  - Decision tables covering different input combinations and their corresponding system behavior are used.

Software Integration Tests are “Indirectly” Executed at Qualification Test level

The direct way to CL0 rating at SWE.5

- *Interviewee: We know that the interfaces work, because the SW fulfills its requirements!*
- *Assessor: Great! Can you show me that in this way all interfaces are tested against the specification of the software architecture?*
- *Interviewee: No.*
- *Assessor: Thank you.*



☞ Remember the purpose of the software integration test!

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