# HOW BMW DEVELOPS COMPLEX, SAFETY-CRITICAL SYSTEMS USING MODEL-BASED ENGINEERING.

## PTC FORUM EUROPE 2018, STUTTGART.


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BMW GROUP THE NEXT 100 YEARS ptc

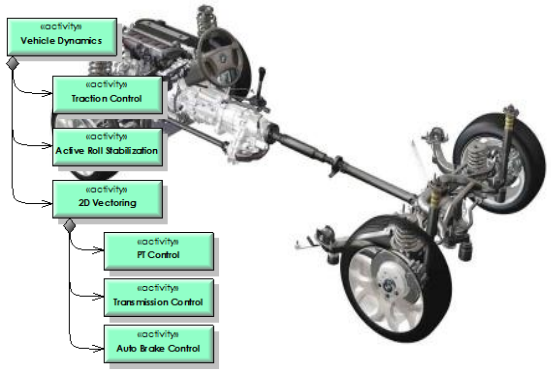
Rolls-Royce Motor Cars Limited

# AGENDA

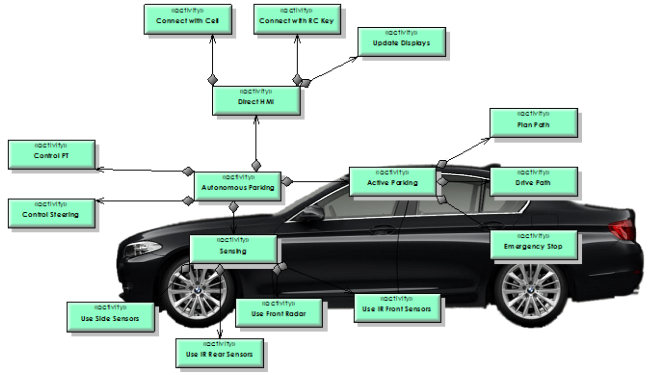
1. Motivation and goals.
2. SMArDT methodology – basic ideas.
3. SMArDT – a model-based Systems Engineering approach.
4. Integration with existing development tools.

# MOTIVATION AND GOALS.
# MASTERING COMPLEX, DISTRIBUTED FUNCTIONS.


Component




Sub-System




Vehicle

Continuous increasing number of functions

Functions get distributed → increasing complexity

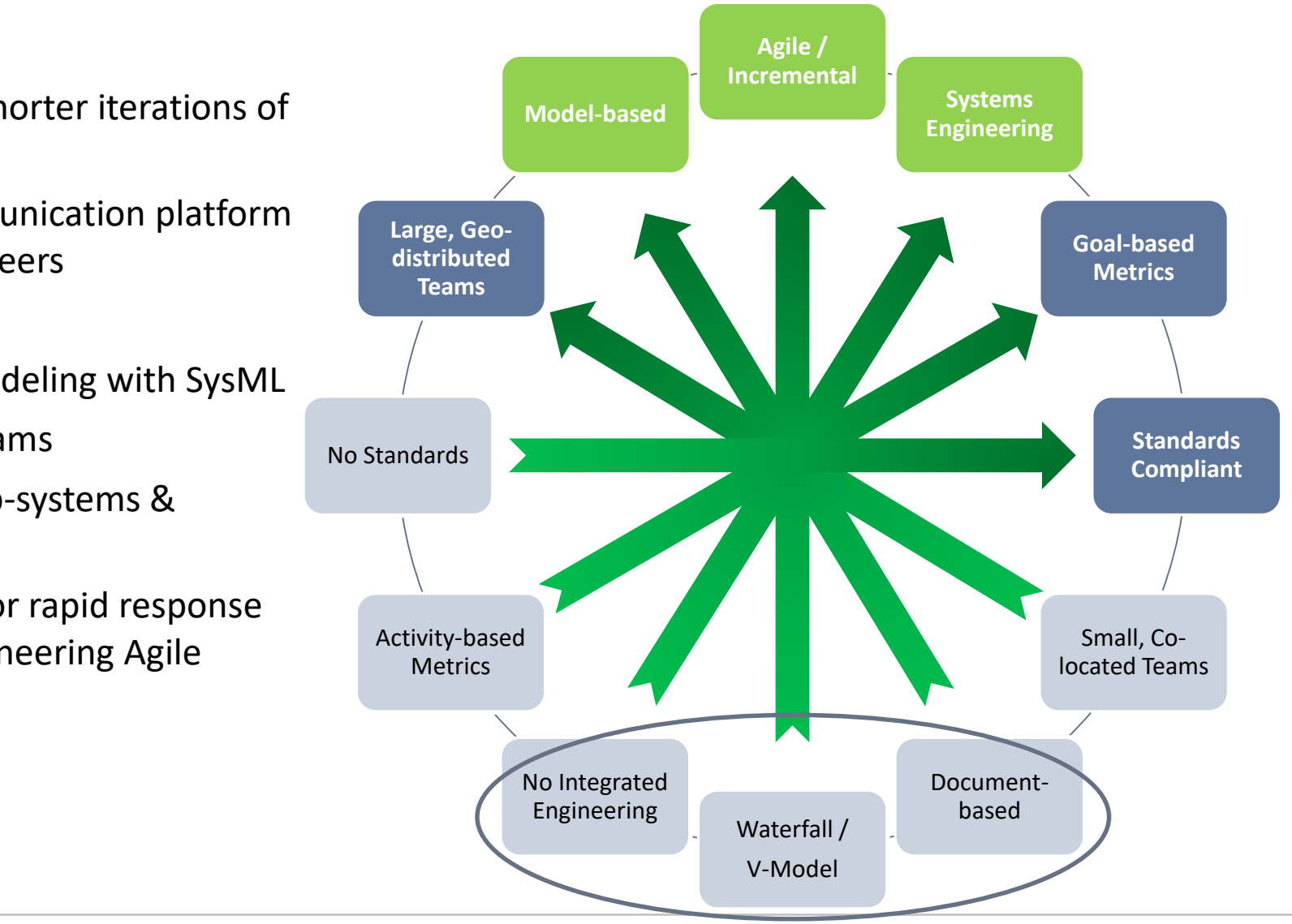
Autonomous driving

Functional Safety Compliance

# COMMON TRENDS IN SYSTEMS ENGINEERING. AND BMW'S FOCUS.

- Rapidly changing requirements & shorter iterations of delivery
- Models as the core and agile communication platform between all stakeholders and engineers
- Incremental functional analysis
- Executable Requirement / Story modeling with SysML
- Architecture – to enable parallel teams
- Asset-based modular design for sub-systems & interfaces
- System variability & product lines for rapid response to market & customer needs – Engineering Agile Systems

True Agile Engineering through MBSE



# REQUIREMENTS OF FUNCTIONAL SAFETY ACCORDING TO ISO 26262.

- Development of requirements and architecture on **several levels of abstraction**.
- **Traceability of requirements** over all levels of abstraction.
- **Allocation** between requirements and architecture elements of the same level of abstraction.
- **Traceability** of test-specification and requirements.
- Use ***semi-formal notation****) for requirements specification (req. for ASIL C-D).
- Use ***semi-formal notation****) for SW-architectural design (req. for ASIL B-D).

*) **Semi-formal notation (ISO26262):**
Description technique that has its syntax completely defined, but its semantics definition may be incomplete
EXAMPLE : Graphical modelling approaches such as UML use case diagrams, UML class diagrams, block diagrams and state charts.

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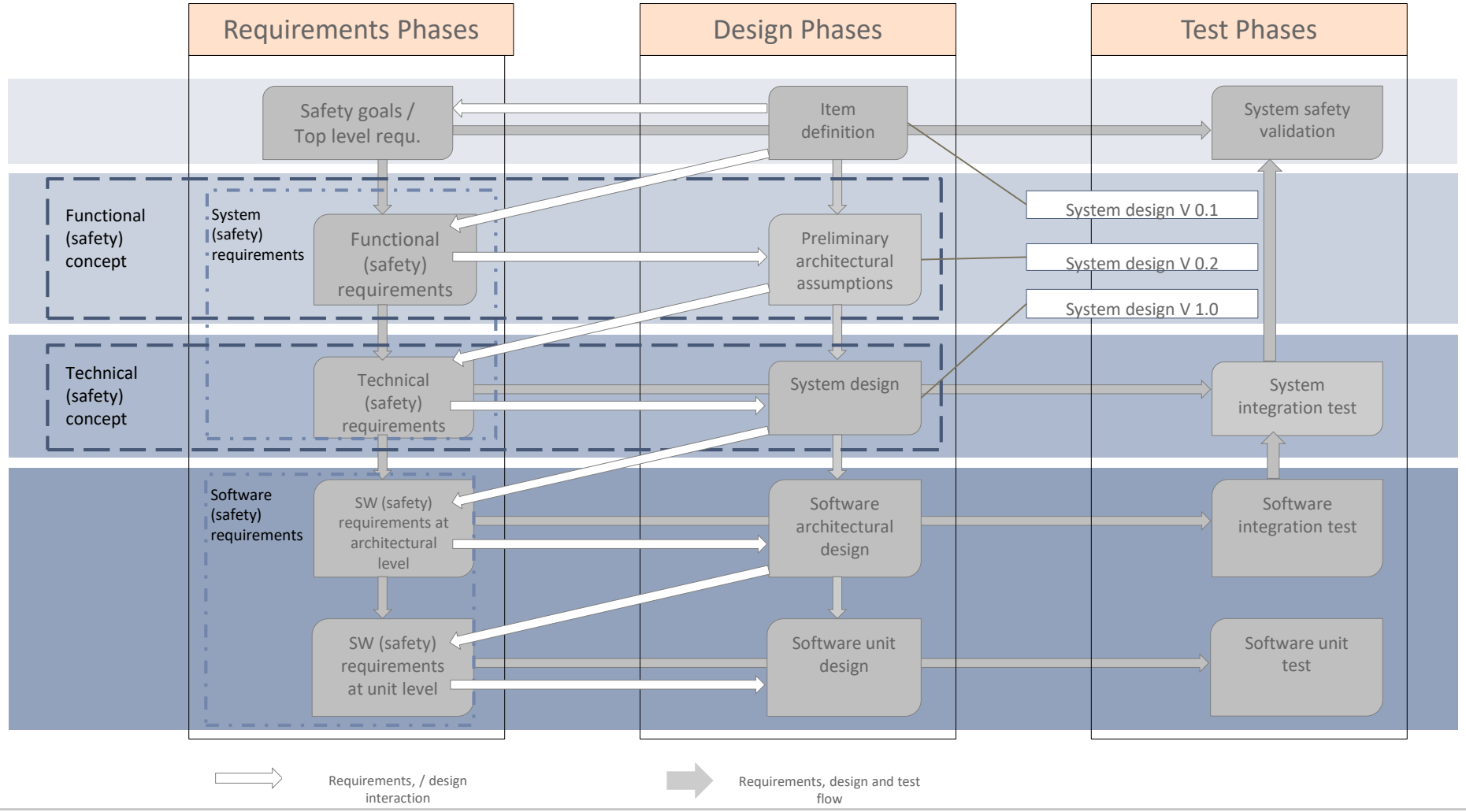
# BASIC IDEA OF SMARDT METHODOLOGY - OVERVIEW.

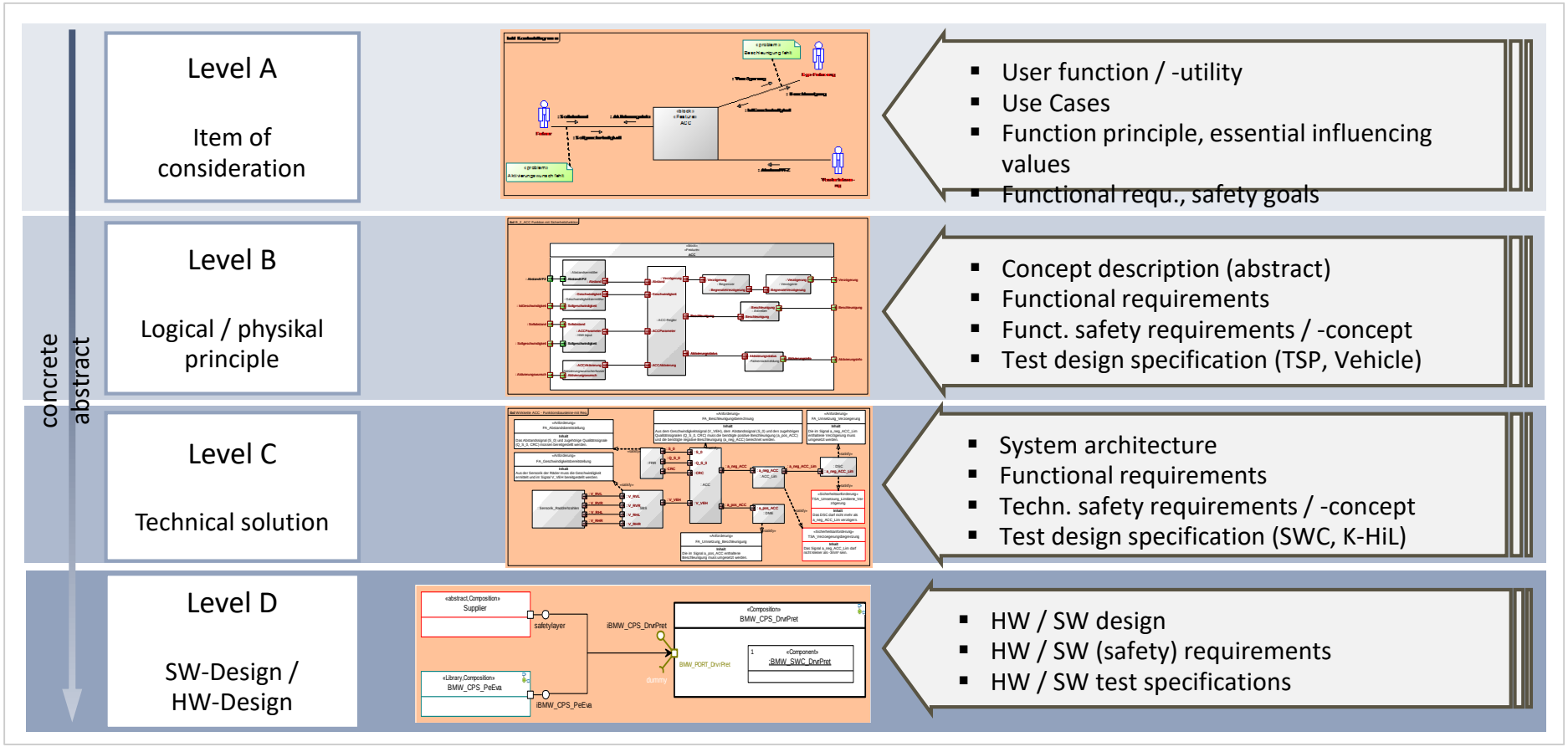



Multi-level development of requirements and architecture

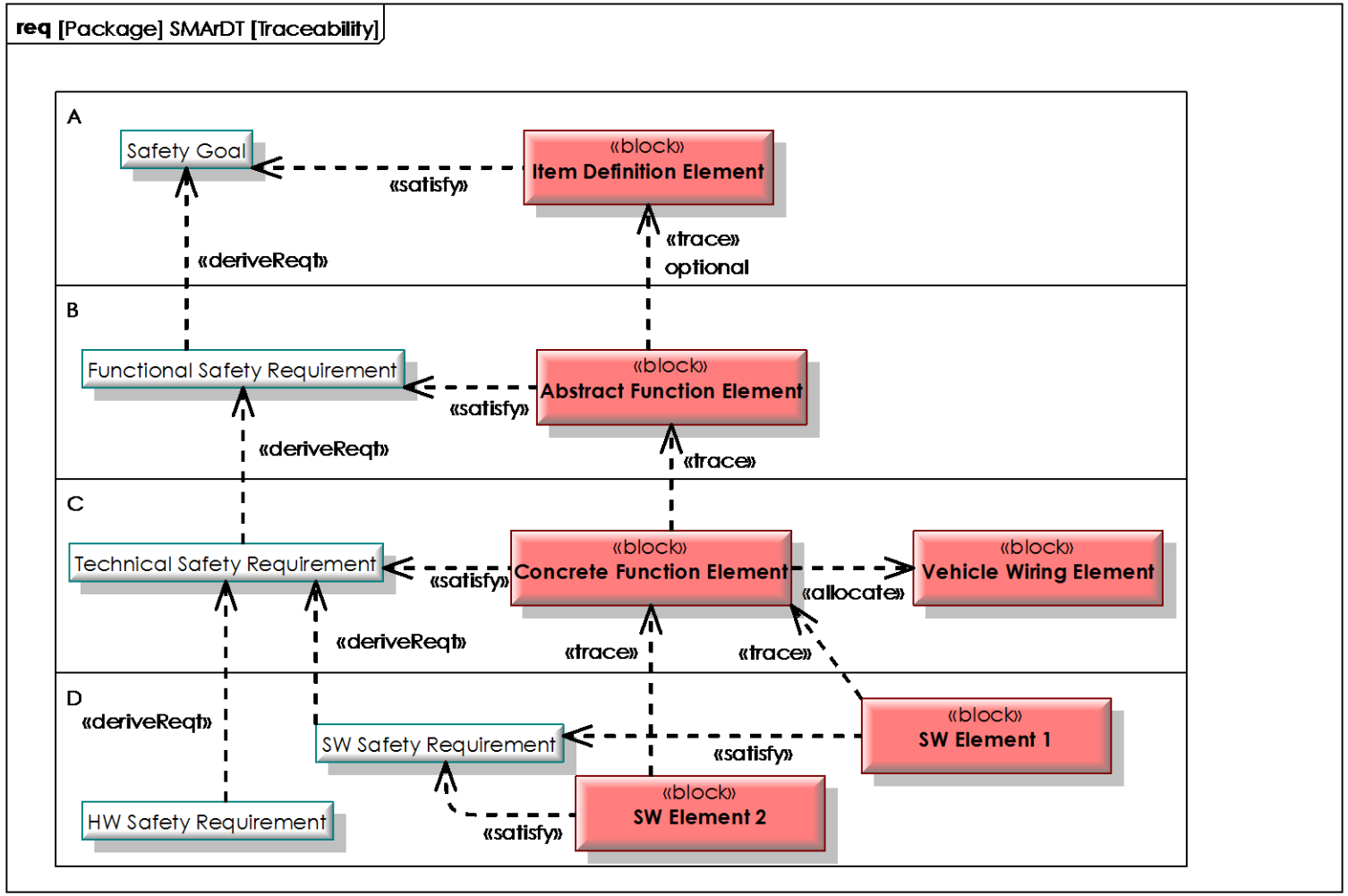
Traceability of requirements <-> architecture <-> test

Common development environment and methodology

# BMW SMARDT METHODOLOGY: MODELLING GUIDELINES.



# BMW SMARDT METHODOLOGY: A MODEL-BASED SYSTEM ENG. APPROACH.




4 SMArDT Levels
according, but simplifying ISO26262

Semi-formal notation / modeling of requirements and architecture

Using SysML and UML
plus an SysML-based SMArDT Profile

PTC Integrity Modeler chosen due to

- Adaptability
- Multi-User Support
- Interfaces

integrity™
integrity™ modeler

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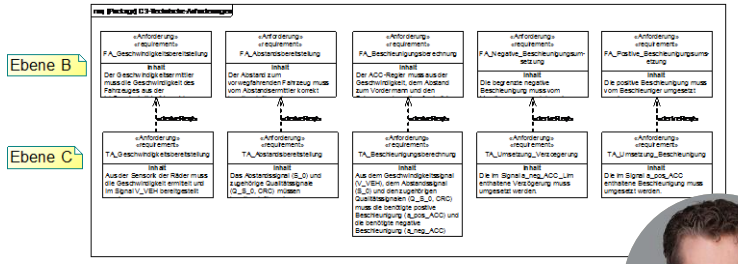
# BMW SMARDT METHODOLOGY: MODELLING OF COMPLEX SYSTEMS. COLLABORATION BY ABSTRACTION AND MULTI-VIEW CONCEPT.



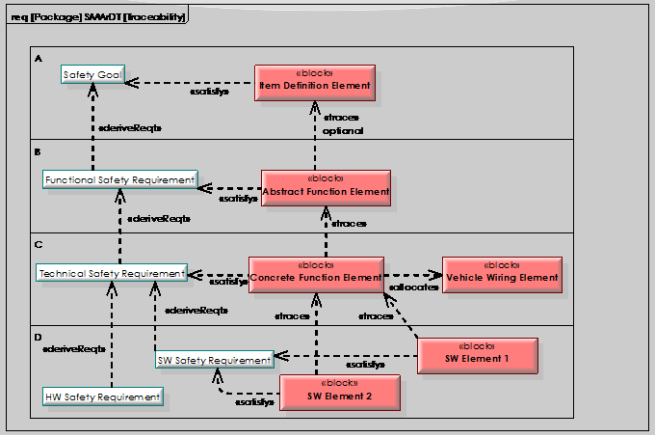

Test Requirements View

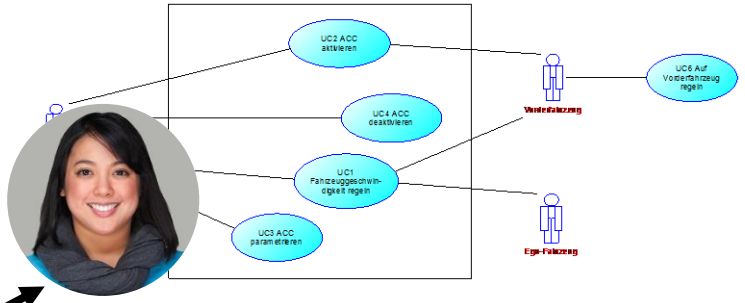
Test Engineer

integrity™

integrity™ modeler

SMArDT
System Model

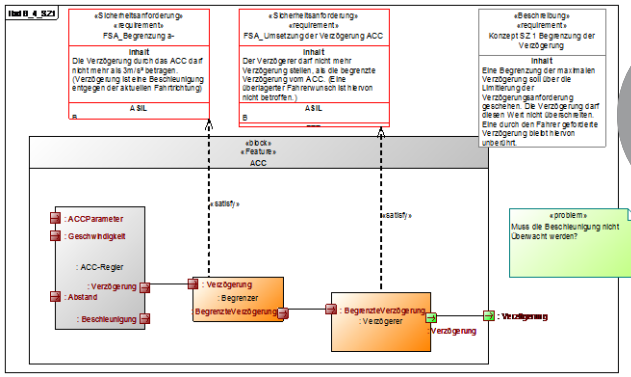


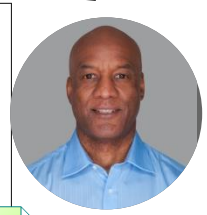






Systems Architect

System Use Cases View

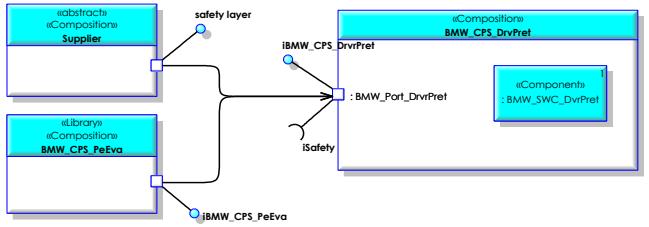


Safety Engineer

Safety Concept View

Software Developer




SW Design View

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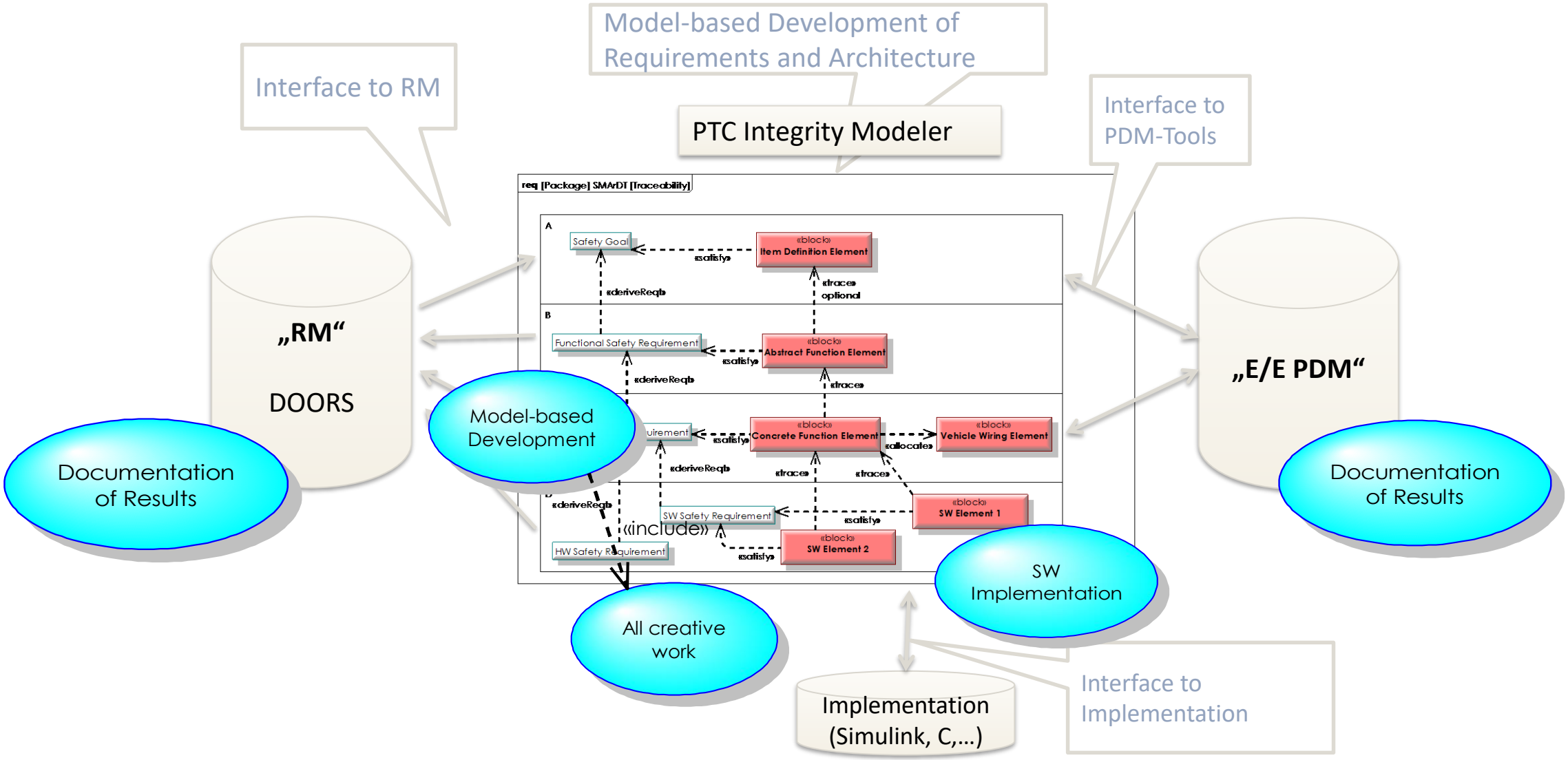
# INTEGRATION WITH EXISTING DEVELOPMENT TOOLS.



# SMARDT EXPERIENCE.

SMArDT productive application in series development:

- Introduced in 2013 in the area of Driving Dynamics
- Introduced in 2014 in area of Powertrain / Electric Drive
  - First focus on new Powertrain functions
  - Now step-by-step transformation of legacy functions (i.e. re-engineering of existing functions)

Lessons of rollout:

- New working paradigm, therefore intense training and coaching is necessary
- User buy-in through experiencing benefits for their own work / project
- Early adopters become multiplicators

# QUESTIONS AND ANSWERS

Description

Q&A Session starts

loop

Question

Answer

end loop