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Functional Safety and SOTIF – Principles and Practice

Vector Technology Days 2019 - 2019-10-23, Böblingen, Germany

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Agenda

1.	The Need for SOTIF
2.	Approach of ISO/PAS 21448 of SOTIF
3.	Best Practices to achieve SOTIF
4.	Outlook

***SOTIF: S**afety **O**f **T**he **I**ntended **F**unctionality*

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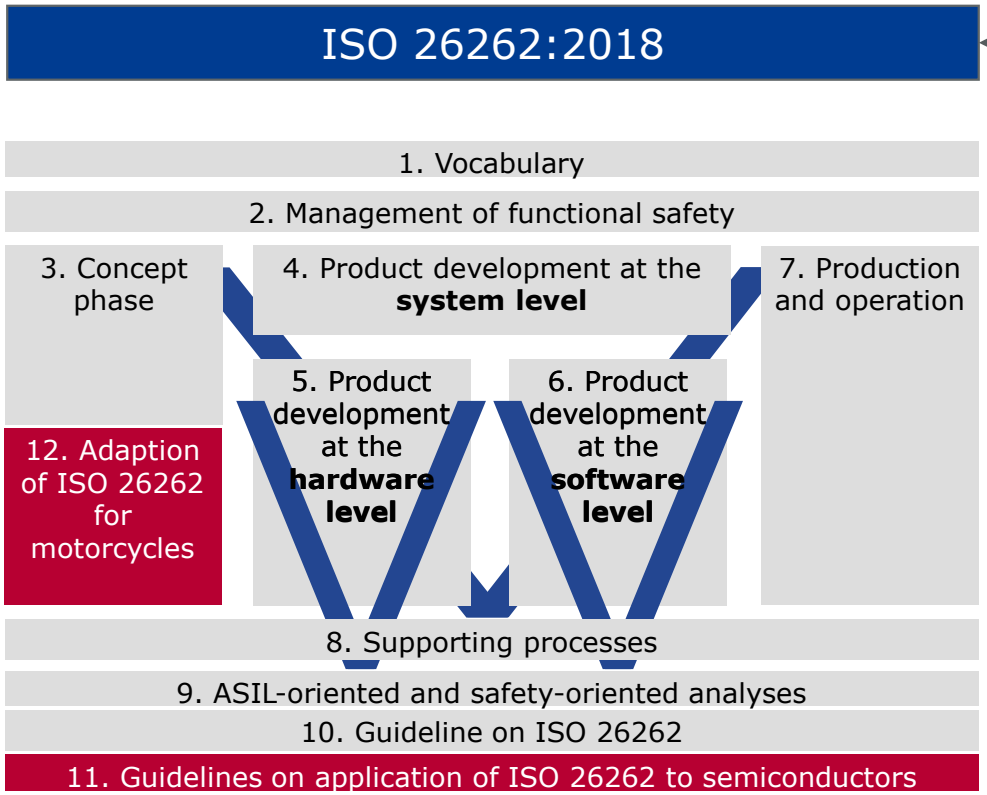
Safety of the Indented Functionality (SOTIF) – Extension of the Safety Scope



Reference

ISO/PAS 21448

Road vehicles –
Safety of the intended functionality

Scope of ISO/PAS 21448

- SAE J3016 Level 1: Driver Assistance
- SAE J3016 Level 2: Partial Automation

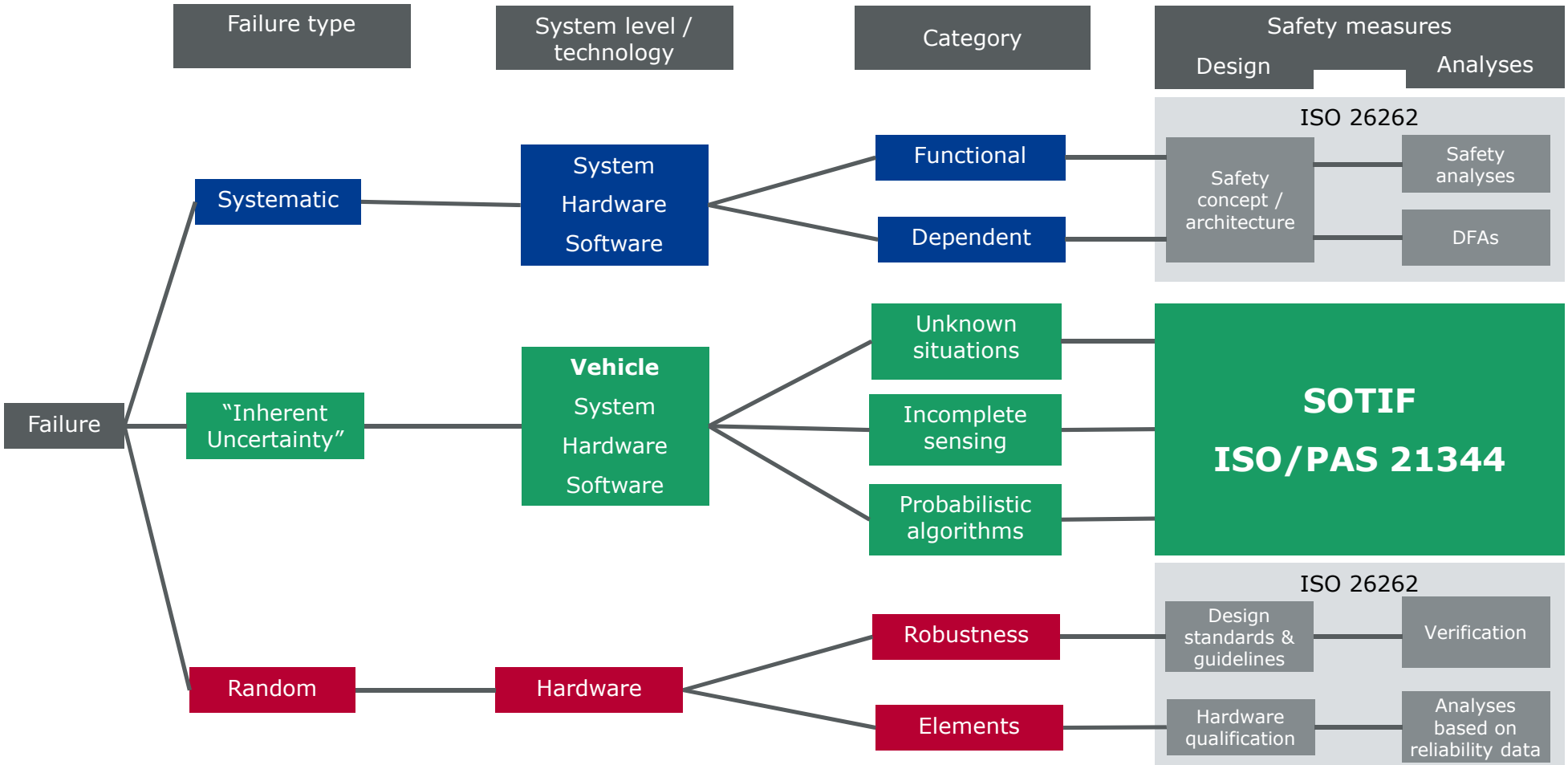
Qualitative approach to uncertainties

- Environment
- Complex sensors
- Algorithms and decisions
- Human machine interaction
- Actuation

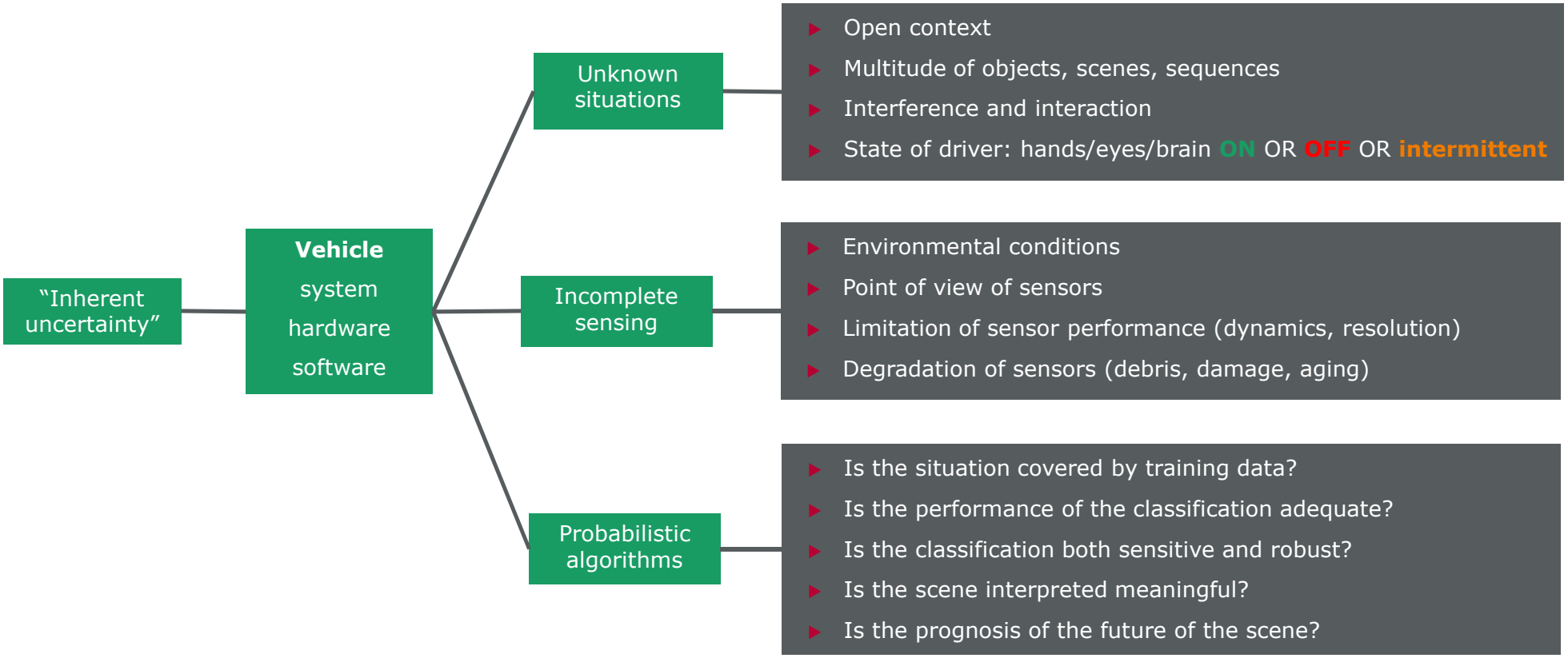
PAS: Publicly Available Specification

ISO/PAS 21448 is related to ISO 26262: Extension of safety for uncertainties

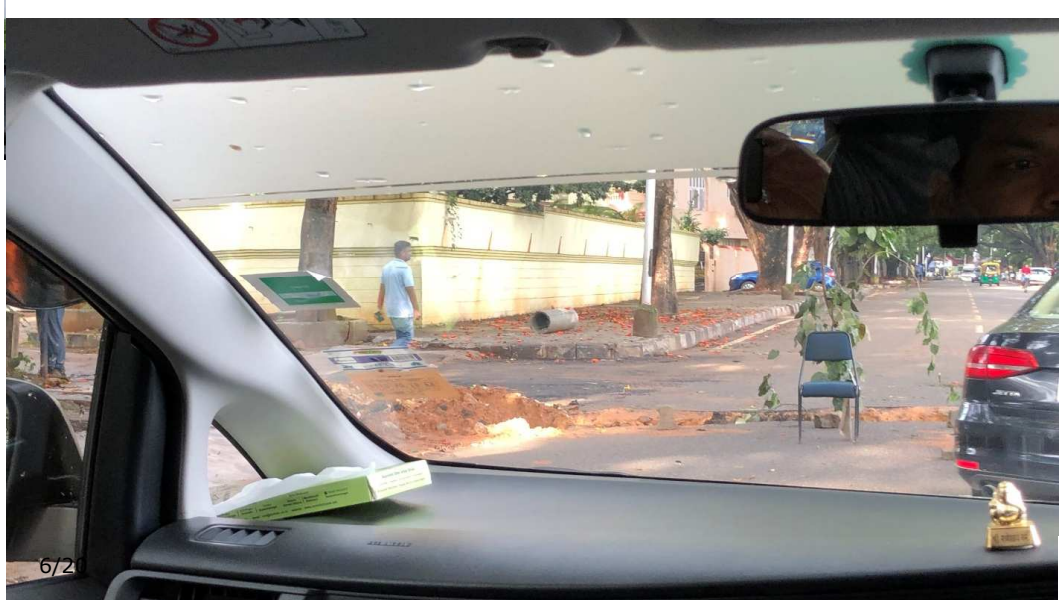
Failures Categories of ISO 26262 and SOTIF



Challenges related to SOTIF



Are the uncertainties addressed by the design covering the real world environment?



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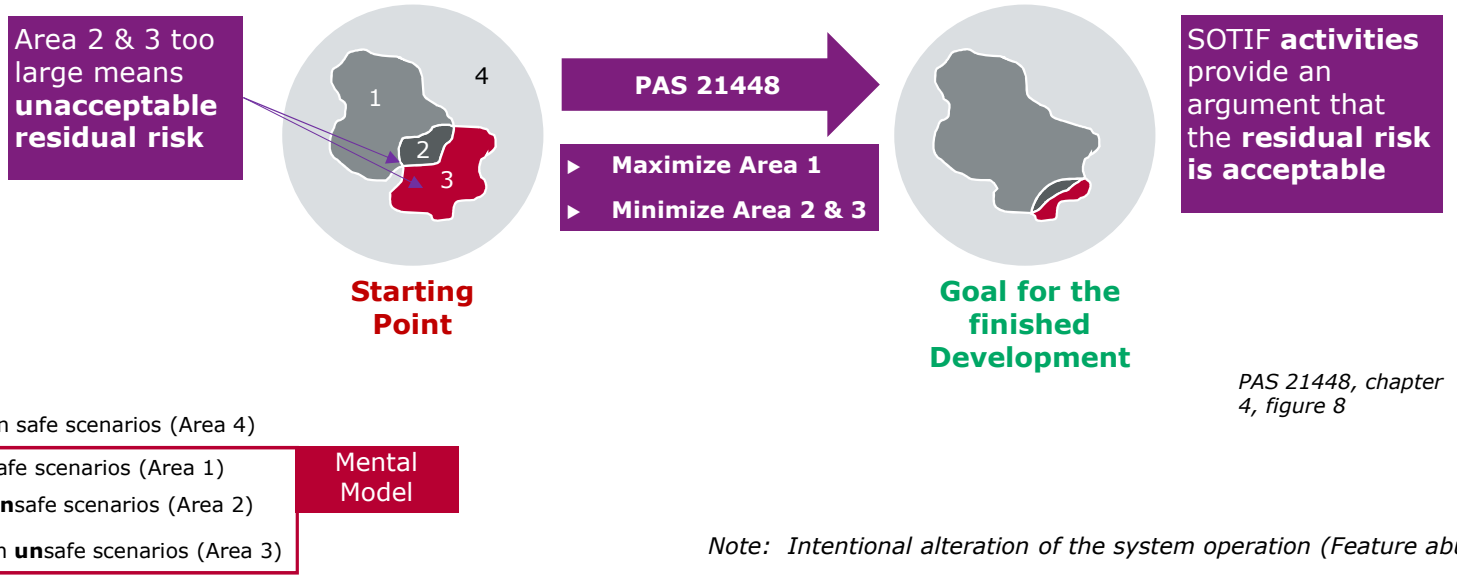
Approach of ISO/PAS 21448 to SOTIF

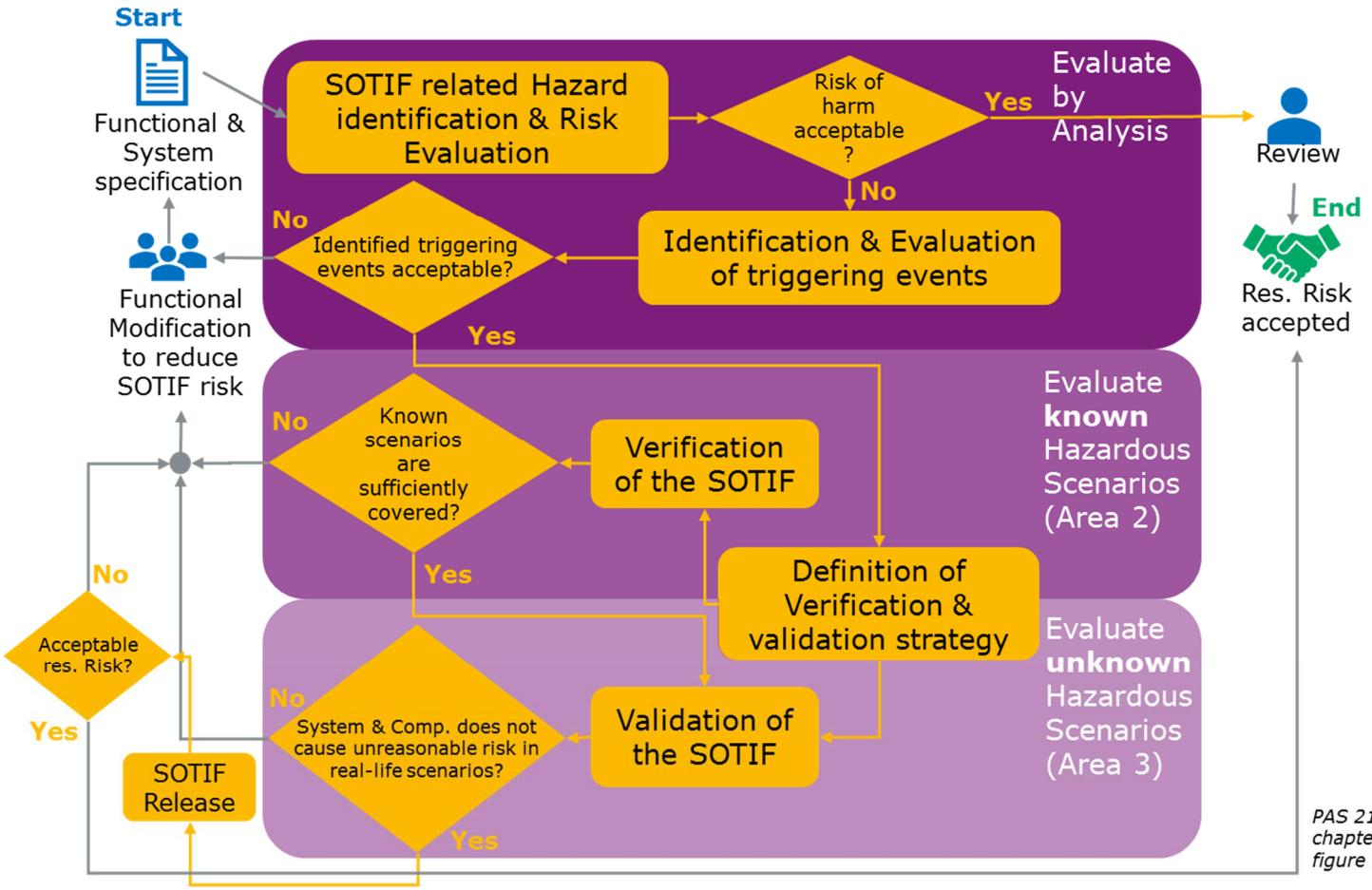
- **Safety of the intended functionality (SOTIF)**
  - The absence of unreasonable risk due to hazards resulting from functional insufficiencies of the intended functionality or by reasonably foreseeable misuse by persons.



PAS 21448, chapter 4, figure 8

Note: Intentional alteration of the system operation (Feature abuse) is not in scope.

ISO/PAS 21448: SOTIF Activities

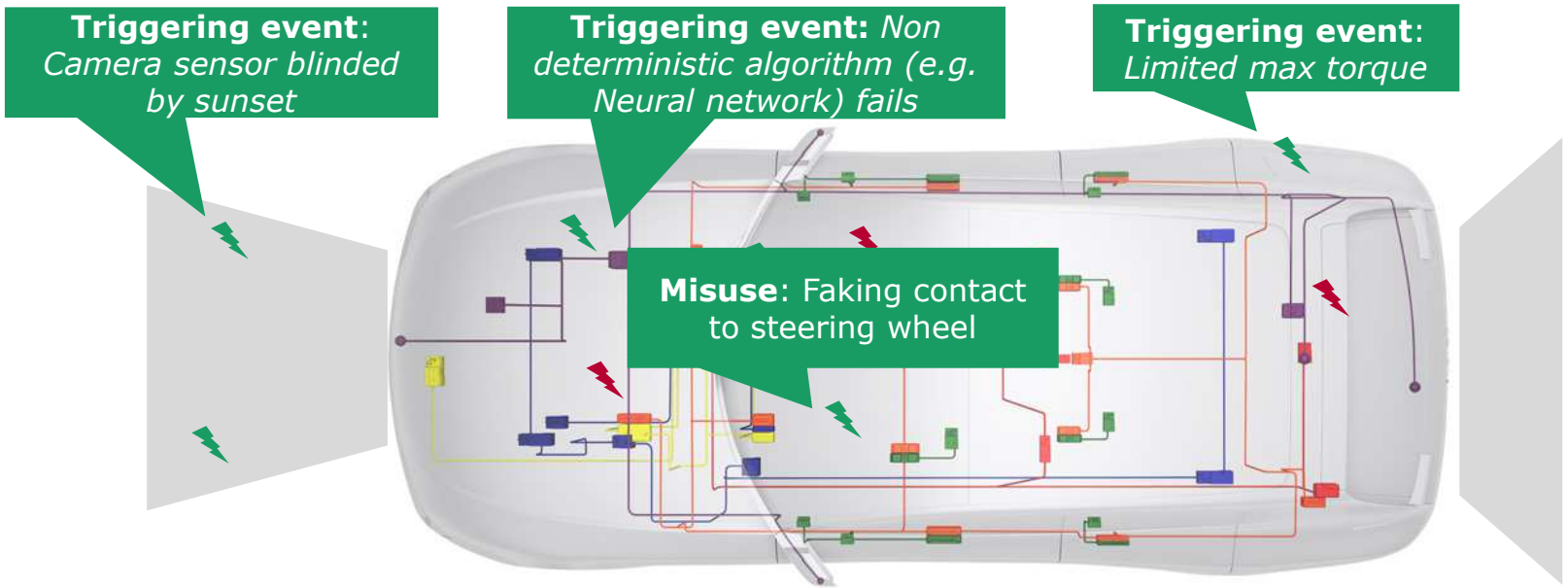


PAS 21448, chapter 5, figure 9

ISO/PAS 21448 – SOTIF Activities: Evaluate by Analysis

1. Systematic identification of the hazards similar to HARA
   Risk evaluation based on exposure, controllability, severity

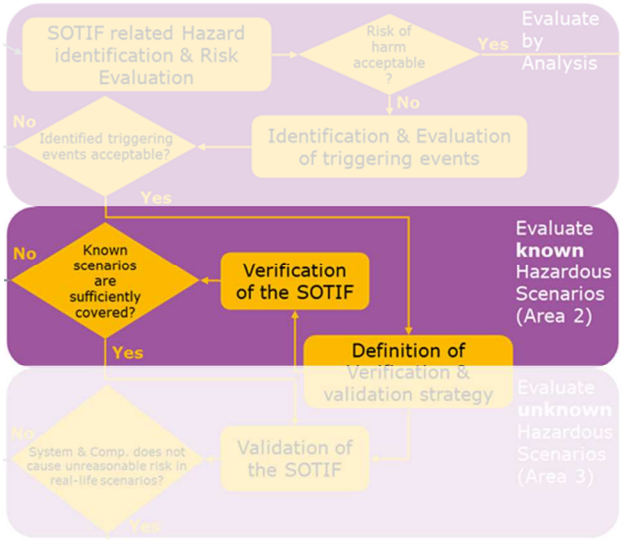
2. Triggering events are identified and analyzed to be acceptable or **function is modified**



= systematic & random faults of HW &SW

= known limitations of sensors, actuators and algorithms, environmental conditions and foreseeable misuse (PAS 214448, Chapter 7.2)

ISO/PAS 21448 – SOTIF Activities: Evaluate Known Hazardous Scenarios (Area 2)



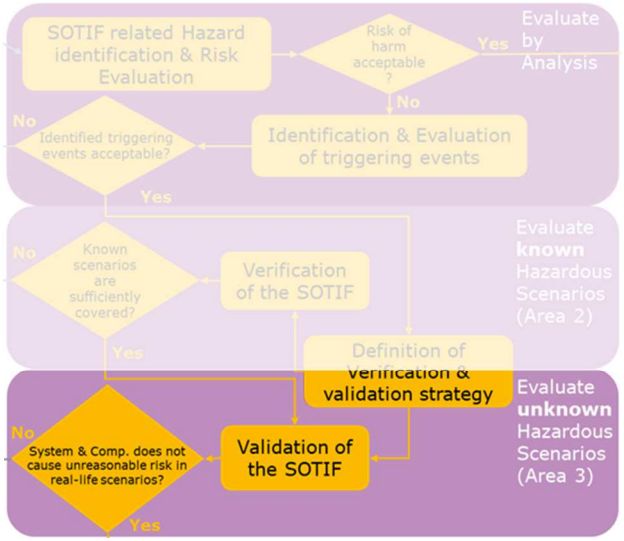
Objective: Verify to the system operates as expected in known hazardous scenarios and reasonably misuse

- 8 methods for **sensor** verification
  - Sensor characterization
  - 7 test methods, similar to ISO 26262 tailored for SOTIF
- 6 methods for **decision algorithm** verification
  - 3 test methods
  - 2 generic methods (simulation, analysis, tests)
  - Analysis of architectural properties including independence
- 6 methods for **actuation** verification
  - Actuator characterization
  - 5 test methods
- 8 test methods for **system** verification

23 out of 28 verification methods rely on tests

ISO/PAS 21448 – SOTIF Activities: Evaluate Unknown Hazardous Scenarios (Area 3)

Objective: Validate to "show" absence of unreasonable level of risk in real-life use cases



- 12 methods for validation
  - 9 test methods including randomization and misuse
    - Most test methods are extensions of ISO 26262 test methods
    - Additional: Fleet tests
    - Extension: Randomized tests
    - Constraint: Appropriate amount of test data and distribution
  - 2 types of analyses
    - Architecture verification including independence
    - Analysis of worst case scenarios
  - 1 simulation of selected scenarios

Exploration of the "unknown" with focus on tests

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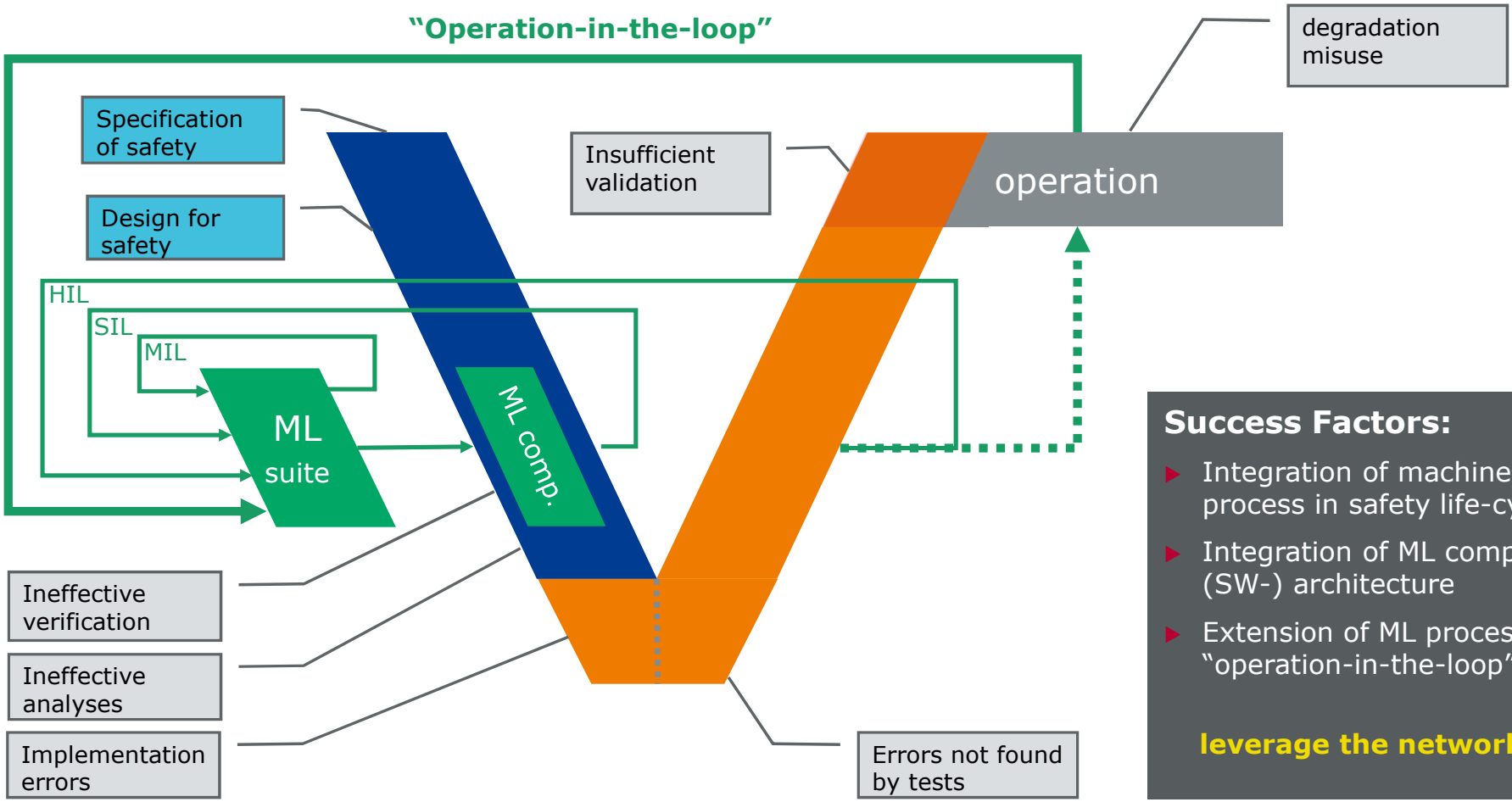
Best Practice (1/3): Achievement of SOTIF in the Safety Life-Cycle

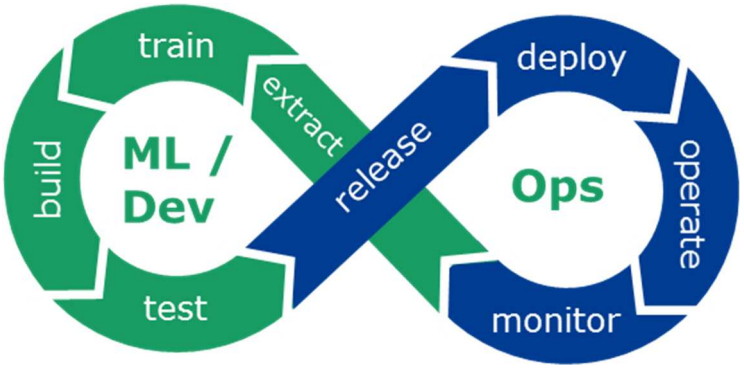


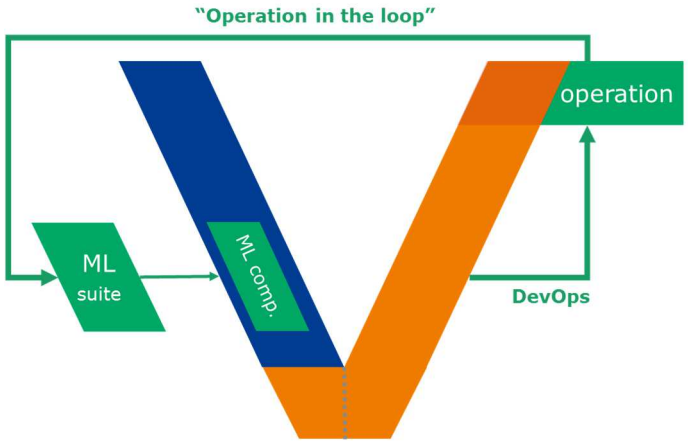
Success Factors:

- Integration of machine learning process in safety life-cycle
- Integration of ML components in (SW-) architecture
- Extension of ML process for "operation-in-the-loop"

leverage the network effect

Best Practice (2/3): Acceleration of the "Safety Performance" in **S**OTIF





- **DevOps** is the tight integration of
  - **Dev**elopment and
  - **Op**eration
- **Effective utilization of DevOps**
  - Accelerates error detection and correction
  - Reduces false change rates
  - Increases efficiency
- **Preconditions**
  - SW design principle beyond ISO 26262 scope
  - Segregation of elements in scope of DevOps
  - Continuous integration established
  - OTA infrastructure and vehicle capability
  - Benchmark execution by embedded systems
- **Straight forward adaption** form classic code-base SW development to ML Learning

DevOps enables "operation-in-the-loop" to accelerate and leverage the network effect

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Best Practice (3/3): Right-Positioning of Testing for SOTIF

- Testing can only proof the **presence of errors, never the absence**
  - Primary intend: Defect detection and exploration of limitations
  - Secondary intend: Demonstrate capabilities and functionality

- Testing has **sampling character** - testing is by nature incomplete
  - Avoid redundant sampling, e.g. by boundary values, equivalence classes
  - Focus on relevant combinations, e.g. classification tree, combinatorial testing

- Practical **tests cannot provide statistical evidence** to comply with target values
  - Compliance with target values is typically provided by quantitative analysis

ISO 26262

- The **test methods of ISO 26262 can be tailored and extended** for SOTIF
  - Randomizing, exploring limitations, out-of-environmental context

- A **systematic approach** enables effectiveness tests
  - 1. Objectives 2. Methods 3. Design/implementation, 4. Execution, 5. Analysis

Considering principles and properties of tests to demonstrate sufficient evidence

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Outlook: The evolution of ISO/PAS 21448 to future Standard ISO 21448

ISO/PAS 21448

published Jan 2019

- Snapshot of ongoing standardization as "public available specification"
- Focus on automation levels 1, 2
- Qualitative approach
- No elaborated architectural approach, no dedicated evaluation of architecture
- Focus of evidence by testing

ISO standard 21448

targeted for 2022

- **Fully elaborated ISO standard** with defined relations to ISO 26262
- Coverage of all automation levels **1 to 5**
  - Focus on **autonomous driving**
  - More safety goals and **higher ASILs**
- Qualitative and **quantitative** approach
  - In addition quantitative methods to indicate probabilities and residual risk
- New **Focus on software architecture**
  - Evolutionary architecture
  - Integration of AI/ML
  - Dedicated evaluation of AI/ML
- Right-positioning of testing
- New Dedicated support processes

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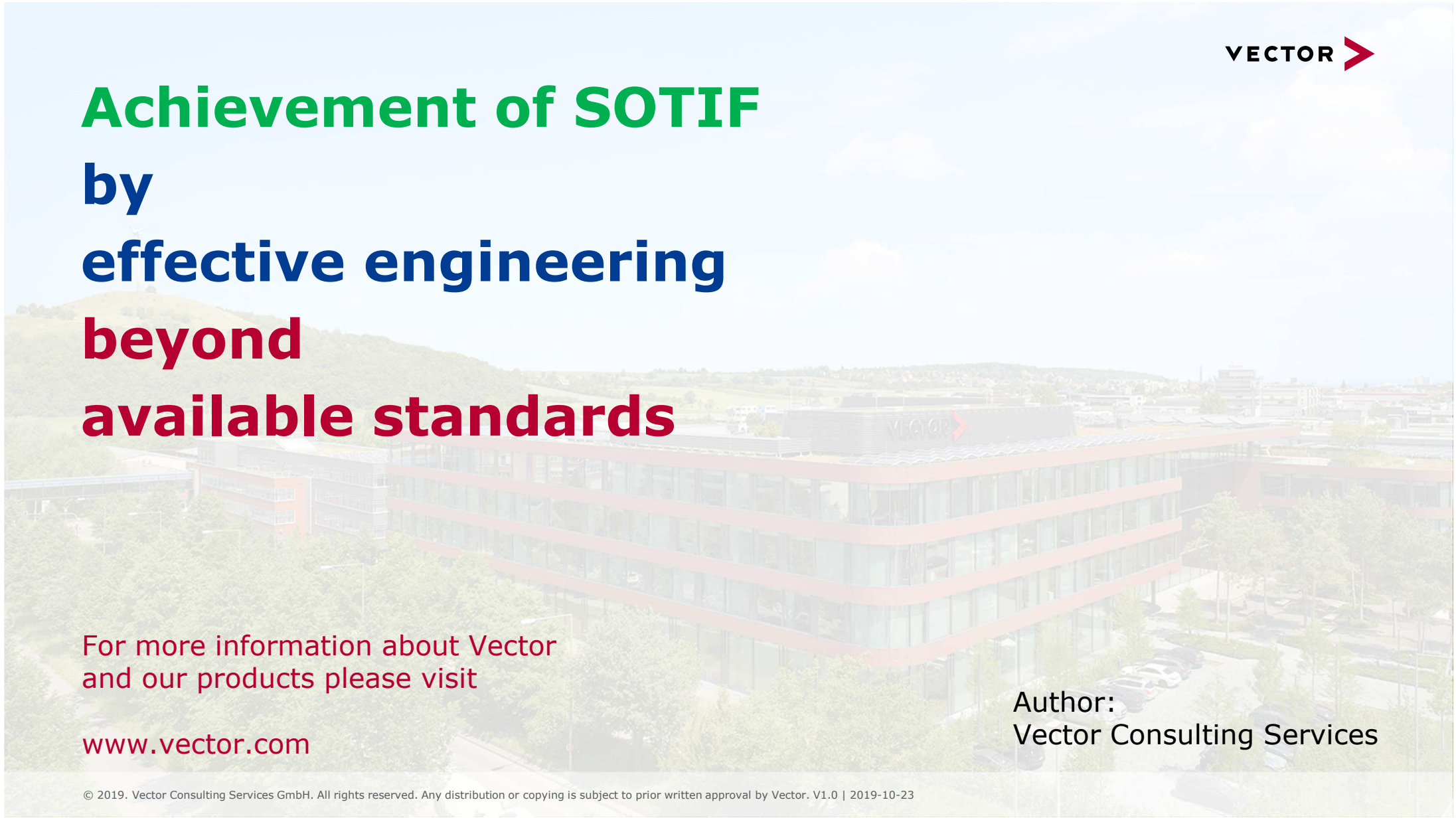
Outlook: A Pragmatic Approach Towards SOTIF

- **Constant**
  - **Principles** of safety engineering and safety concepts
  - **Acceptance of reasonable residual risks** by individuals and societies
  - Practitioner and teams remain endangered by **cognitive biases related to safety**
- **Change**
  - The "inherent uncertainty" of SOTIF constitutes a **new type of failure**
  - Stronger emphasis on **evolutionary software architectures** embedding ML-elements
  - **Continuous learning about SOTIF**, e.g. white paper ‚Safety First for Automated Driving'
- **New**
  - Advent and **progress of machine learning** will further boost SOTIF despite inherent uncertainties
  - **Acceleration of safety** by adoption of agile paradigms: Continuous integration and **DevOps**
  - Evolution of **technologies enabling networked SOTIF**, e.g. semiconductor, 5G, quantum computing

Achievement of SOTIF is a challenging endeavor into the future

Achievement of SOTIF by effective engineering beyond available standards



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