# Validation of automated driving systems using scenario-based massive simulations

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# Outline

- **Main Challenges**
- **Scenario-based verification and validation**
- **Complexity handling by other industry sectors**
- **Remarks, Conclusions and Discussions**

# Main challenges

**Technology challenge: build a safe car**

- it can perceive the road environment better than a human driver
- it makes “reasonable” decisions  like a human driver

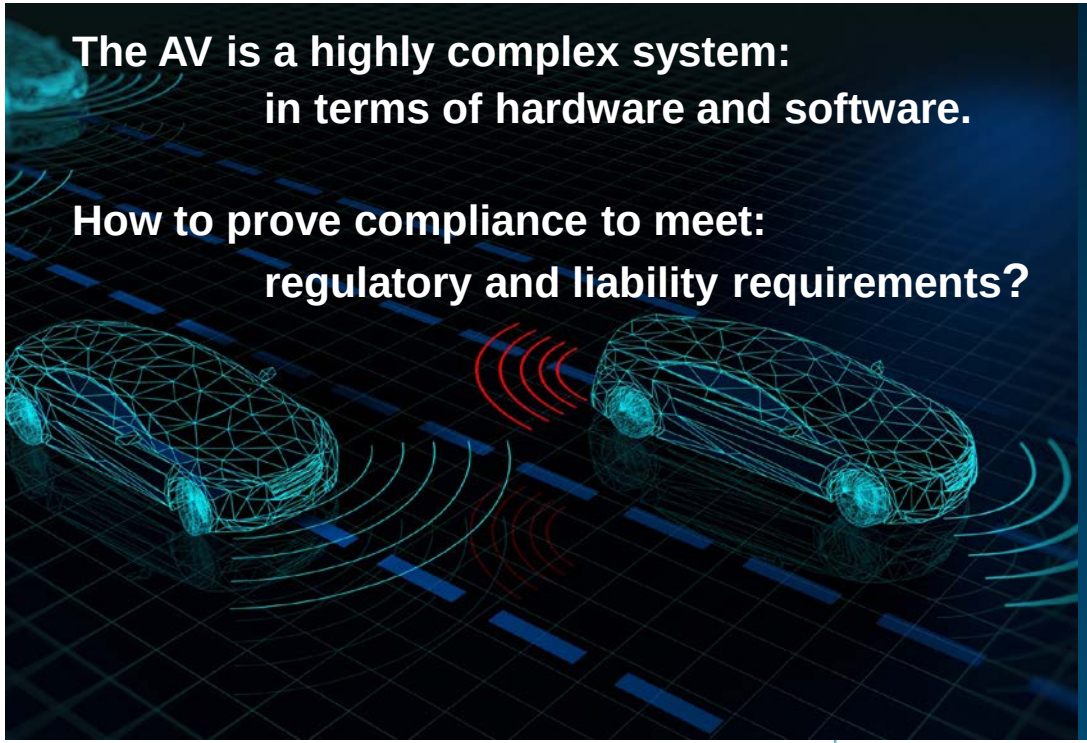
**Regulatory challenge: build a functional car, accepted by society**

- it makes a proper trade-off between safety and functionality – “I am safe if I do not drive but then I am not functional, not accepted“
- it fits into the defined regulatory bounds – ongoing process

**Business challenge: build a cost-effective car**

- it means consumers are willing to switch to driverless car
- it means new business models, and/or redefinition of “mobility”

# Interactions among challenges

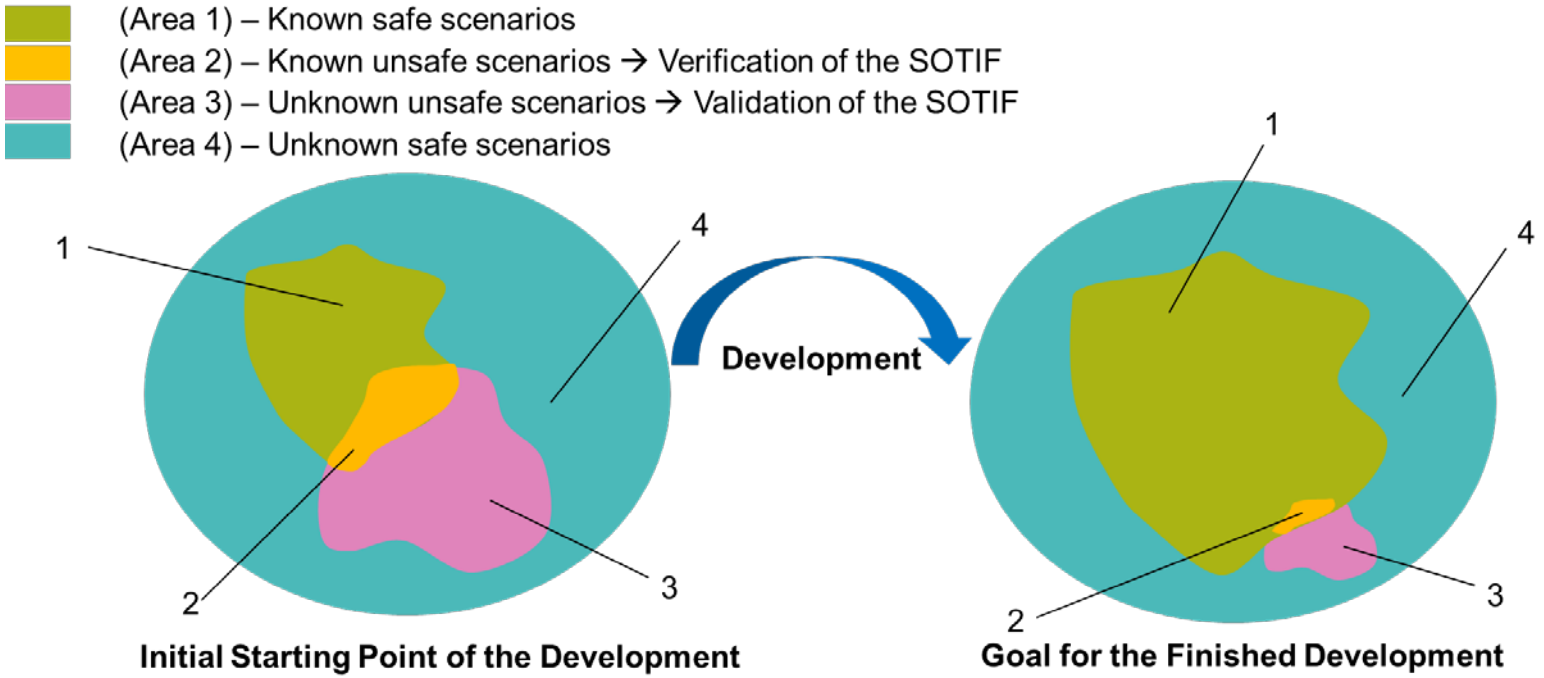



**High complexity requires massive verification and validation cycles.**

**The amount of physical testing will increase but the amount of virtual testing will increase even faster.**

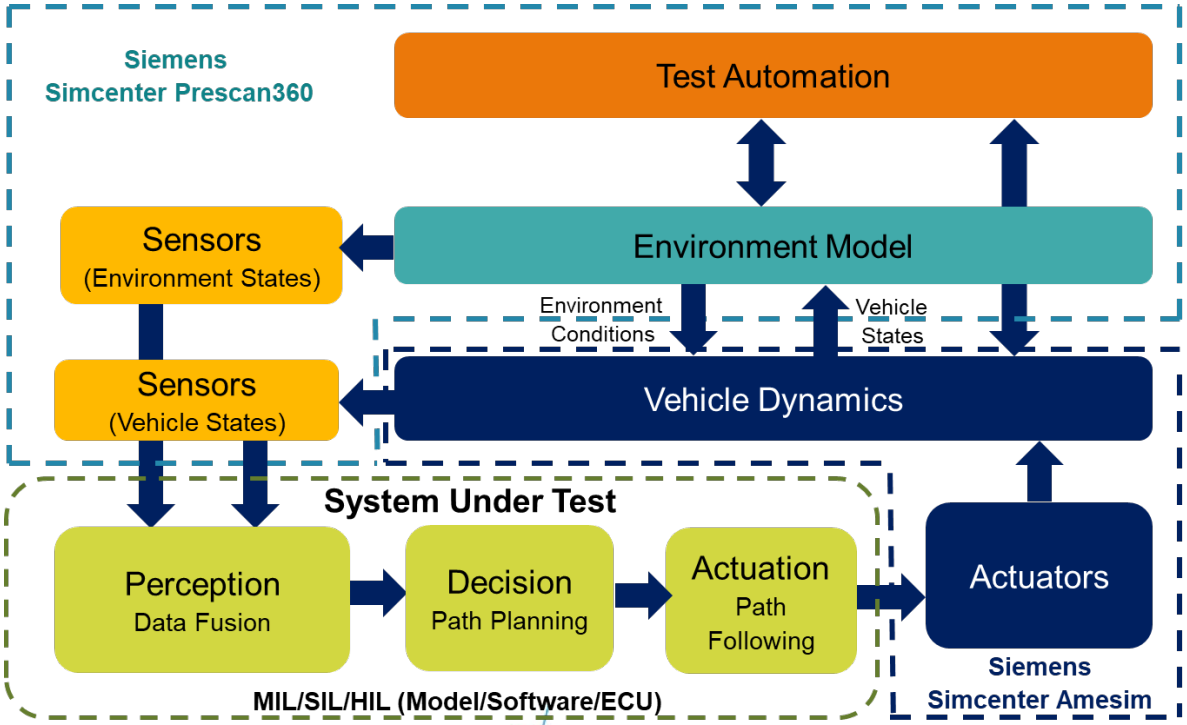
**Business Challenge**

# What is the safety goal of the development?



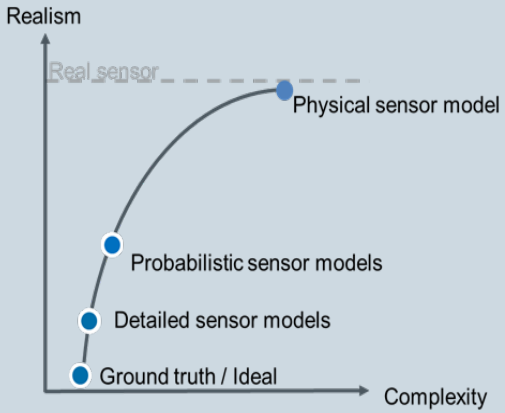

SOTIF - ISO/WD PAS 21448

# What do we need for virtual V&V? – integrated toolchain from Siemens



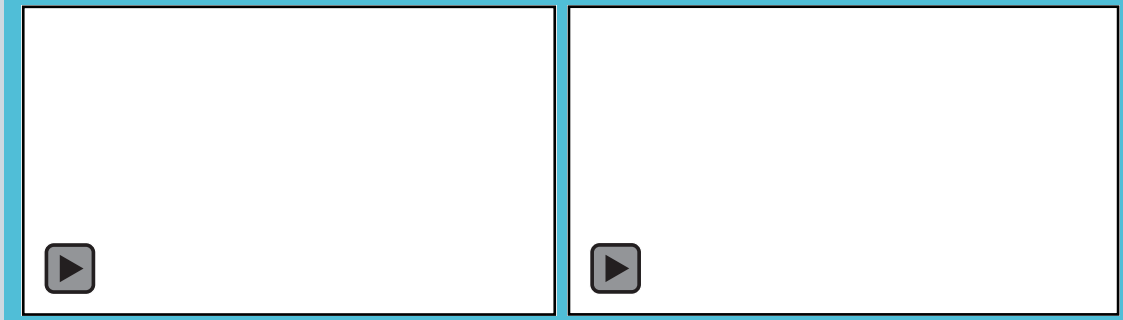
# Sensor models – the right fidelity level for scaled-up simulation

## Balancing accuracy and computation time of sensor simulations




Lidar (spinning and solid-state)

Physics-based Radar simulation



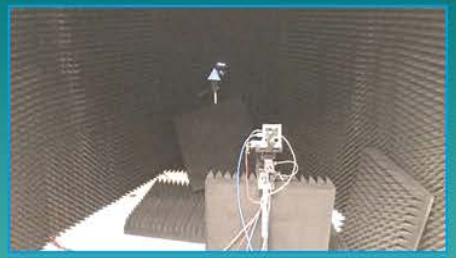
Example: during night-time driving

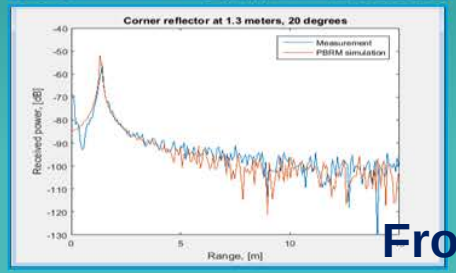
Example: Realistic lighting conditions

Simcenter PreScan Physics Based Camera (PBC) simulation

# Validated models – essential components of a V&V environment

Two projects for radar models validation performed in close collaboration with:
major Dutch Tier2 and Japanese Tier1






**From where do scenarios come from?**

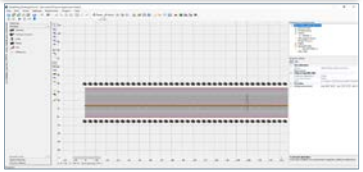
From a lab… To a test track… To the real world…

# From real-world to virtual-world – *OpenScenario/Streetwise* use case

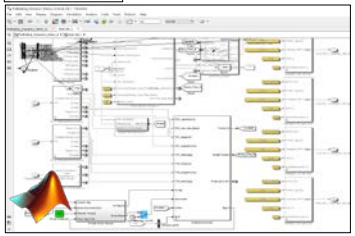
Simcenter Prescan360

**1** Real World to Streetwise Database

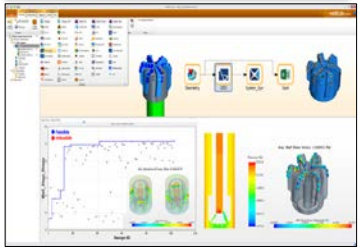
**2** Import Scenarios into Simcenter Prescan

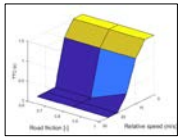


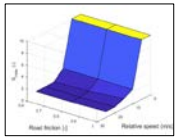
**3** Insert EGO Vehicle + Controller + Sensors



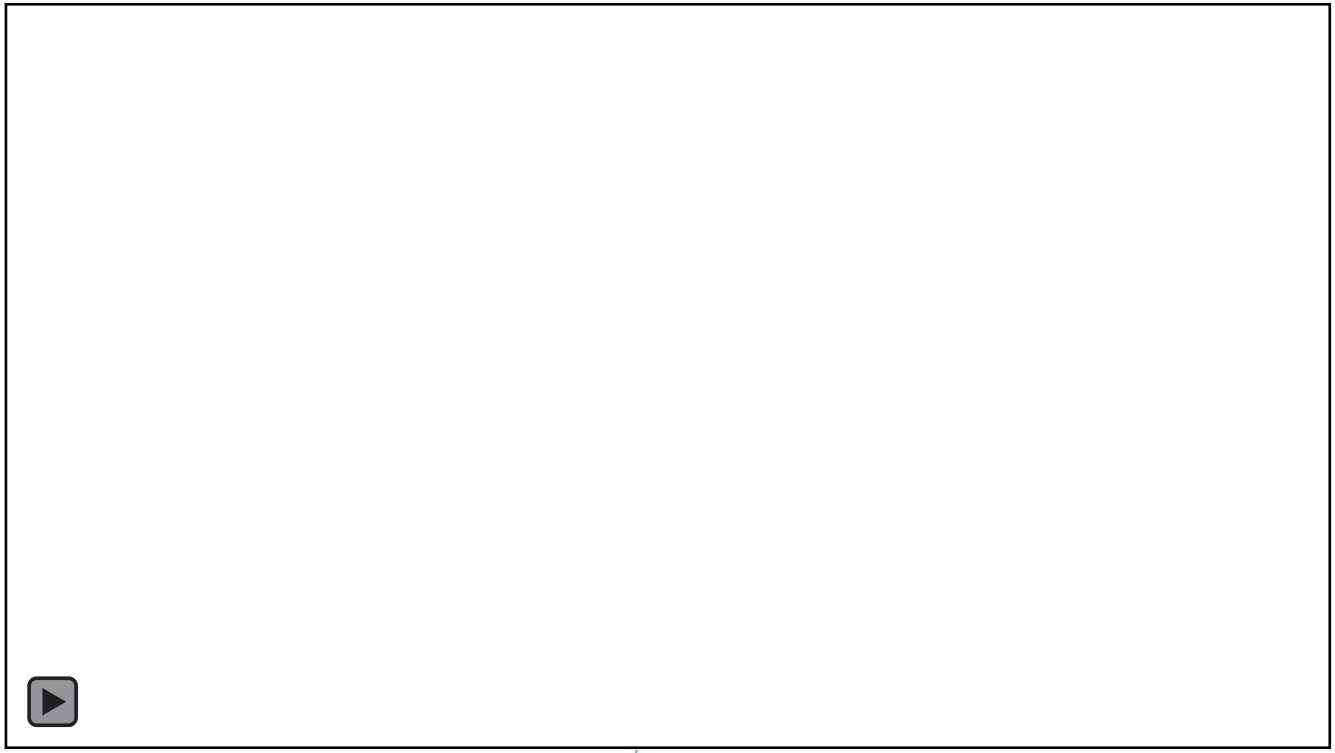
**4** Run Scenario Variants







# Test Automation – Step 4



# How complex systems are tested in other industries?

**Goals (common for all industries):**

- use time and resources efficiently
- control the risks – calculated risk approach
- know what was tested … and what was not tested
- take a demonstrably smart approach – not like: “test all possible combinations”

**Approach: Combinatorial Test Design (CTD)**

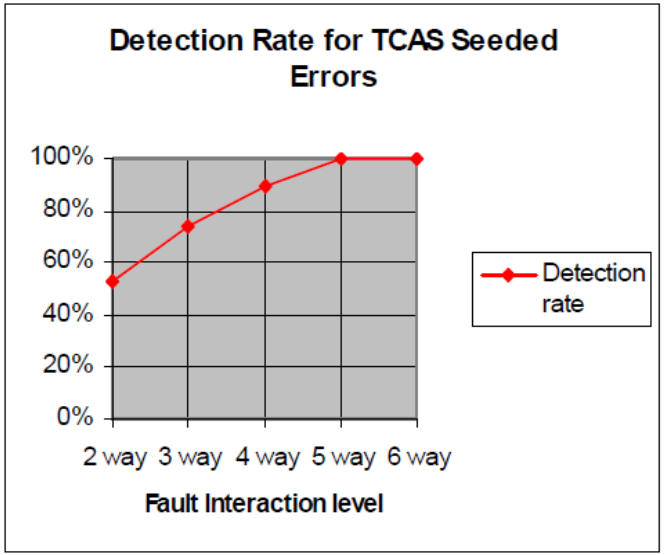
- dramatically reduce the number of test cases needed
- handles coverage concerns when defining the test plan
- easy to review and minimizes omissions

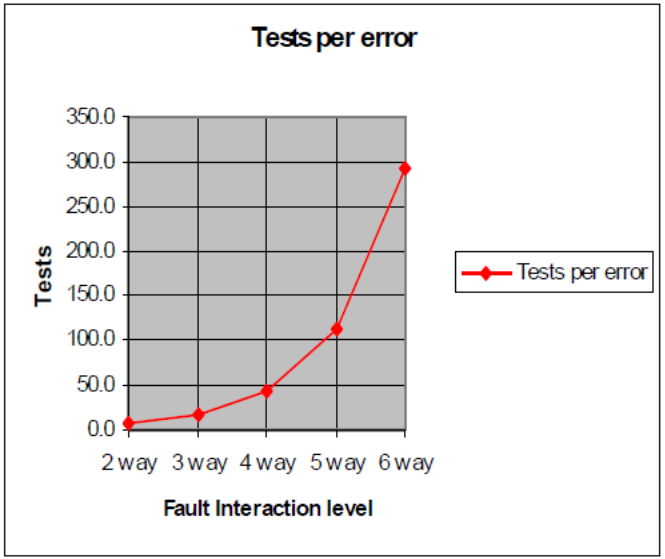
**Software industry**

**Manufacturing industry**

# What is the idea behind? - testing n-way combinations

If all faults are triggered by the interaction of *n* or fewer variables, then testing all *n*-way combinations can provide strong safety assurance.




**Source: U.S. National Institute of Standards and Technology (NIST)**

# Conclusions and Remarks

**Conclusions (state-of-the-art):**

- high complexity requires massive verification and validation
- integrated toolchains to perform massive V&V are available on the market
- test execution using high performance computing (cluster/cloud) is possible.

**Remarks (challenges):**

- validated models with proper fidelity require engineering effort and know-how
- definition and acceptance of safety metrics – at industry and regulatory level
- taking a smart approch in virtual V&V - other industries might be a source for inspiration

# Thank you for your kind attention.

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