Automated driving - Validation

Challenges & State of the art

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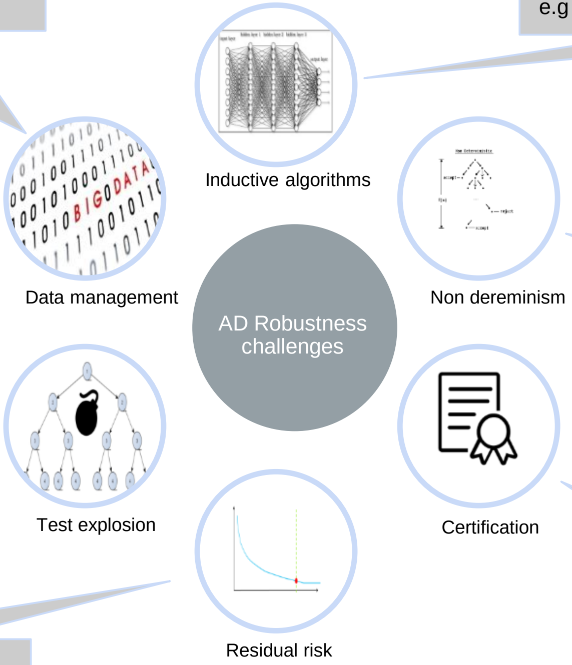
AD ROBUSTNESS CHALLENGES

Data storage, management and annotation is a key challenge

Response of a statistical based learning algorithm in a novel environment e.g black swan problem



Influence parameters are numerous, combining them for testing leads to combinatorial explosion

Stochastic algorithms do not guarantee the same output even in the same input conditions e.g Particle filter

Even after billions of driven miles, remains a risk that needs to be quantified

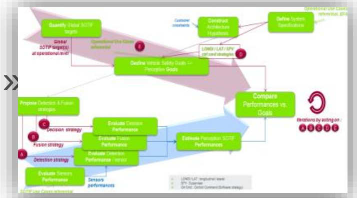
Agree on minimum specification that should be used for certification of AD

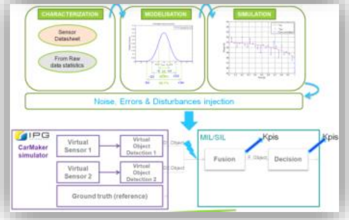
SYSTEM APPROACH

Design

SOTIF methodogy & simulation platform

- **SOTIF methodology** based on dual « bottom up » and « top down »
- **Simulation platform** for robustness & availability testing
- Catalog of **use cases** & realistic **sensors models**

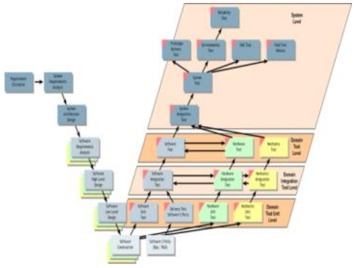


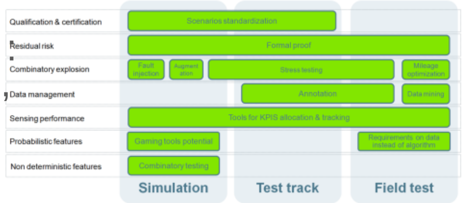


Validation

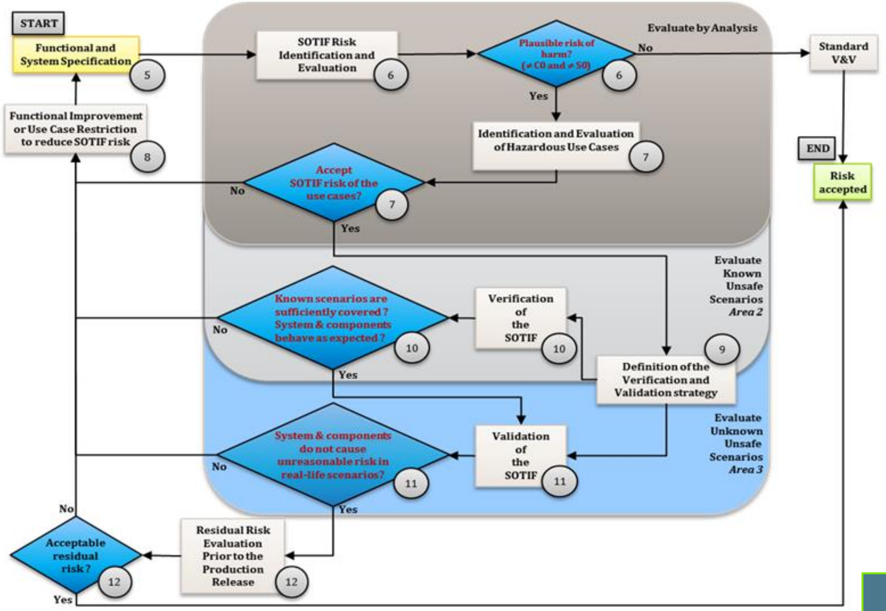
SOTIF steps added to standard process

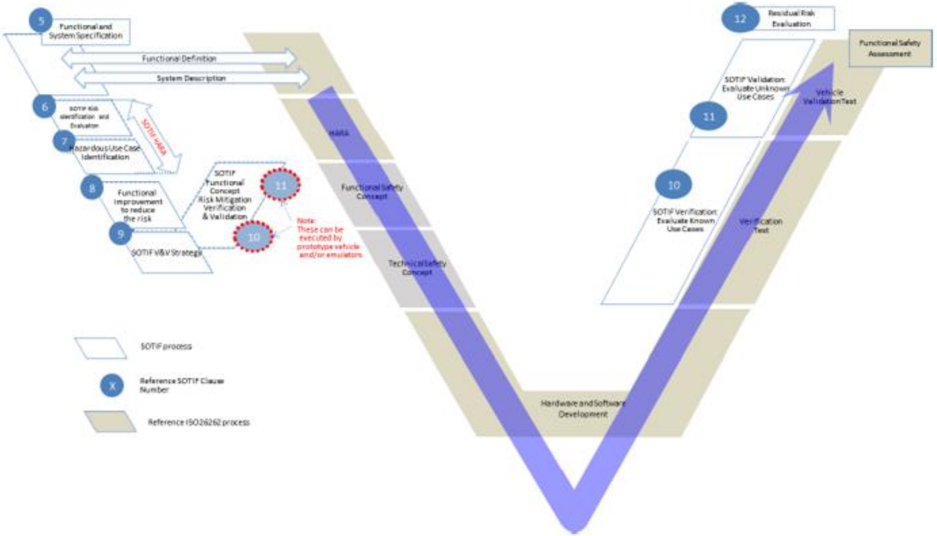
- **Definition of Mileage** by crashes statistical inputs
- **Simulation platform** to assess / replay specific uses cases
- **Testing optimization** by combining methods : Requirements analysis, Stress testing, Error guessing…





SYSTEM APPROACH - SOTIF PAS 21448





Automotive industry standard for Safety of the Intended functionality

AUTOMATED DRIVING VALIDATION - PILLARS

Simulation

- Defined test cases including error injection
- Main goal: functional design

Proving ground

- Deterministic test cases based on requirements
- Main goal: verification of functional development

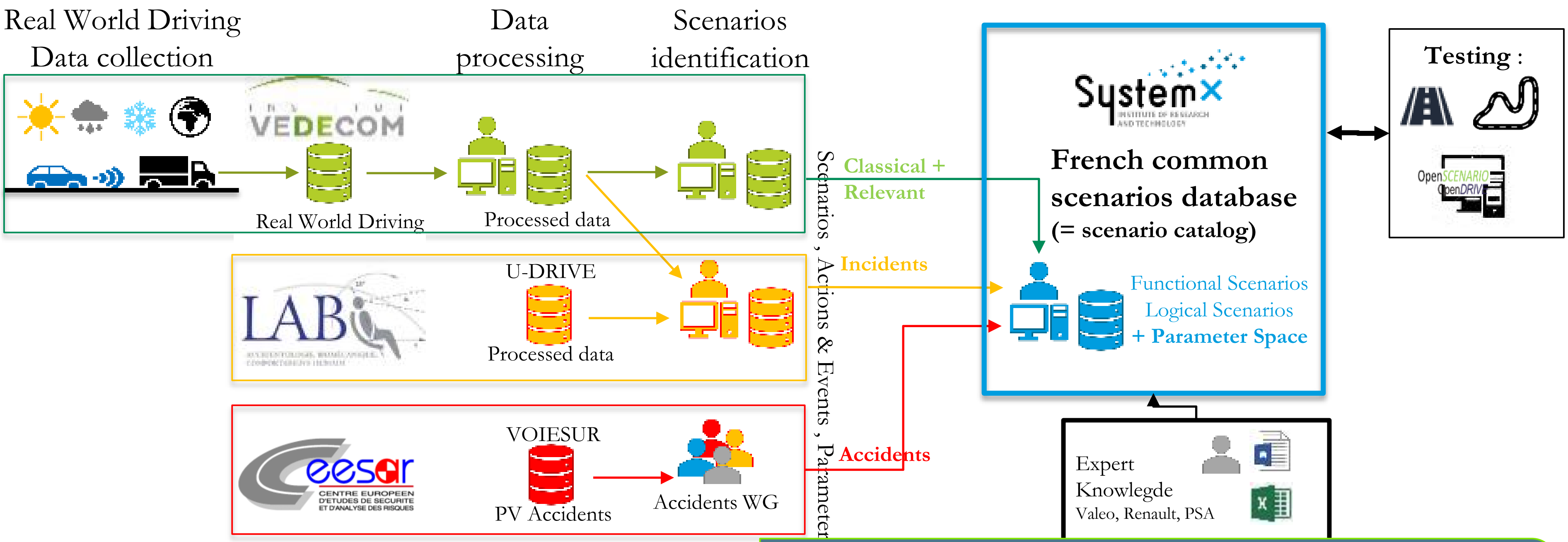
Open road

- Data collection and annotation
- Main goal: validation of statistical values

AD Safety validation will rely on 3 pillars

Valeo

AUTOMATED DRIVING VALIDATION - SCENARIO CATALOG

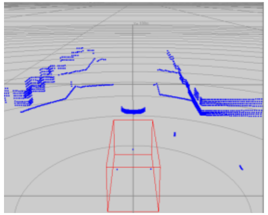


The scenario coverage is a KPI for safety

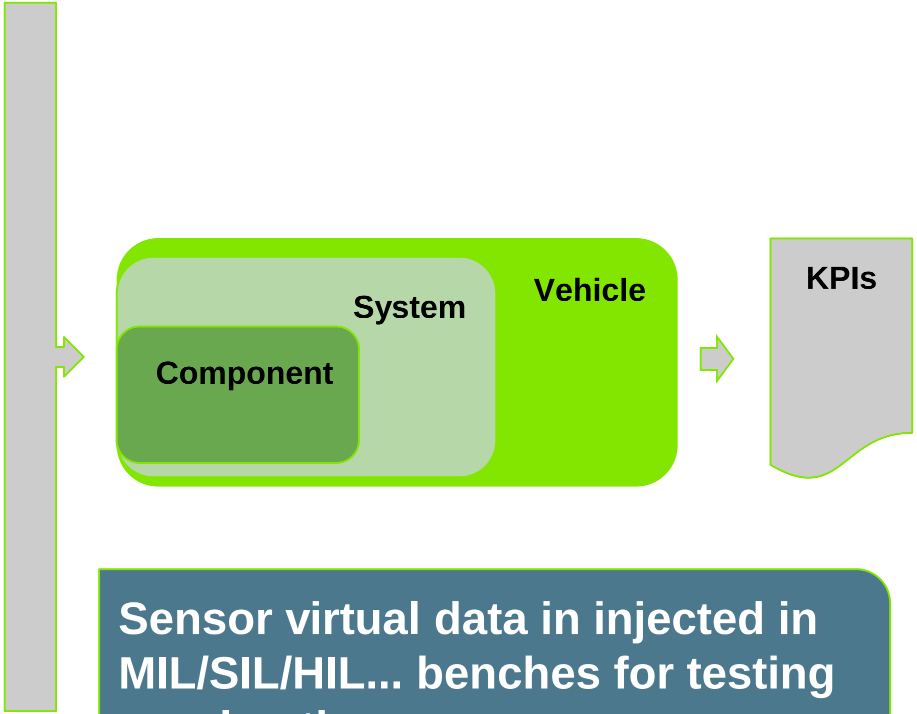
AUTOMATED DRIVING VALIDATION - SIMULATION

Replay

Virtual data



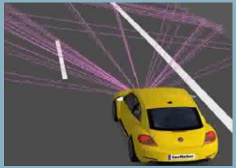
Augmented data



Sensor virtual data in injected in MIL/SIL/HIL... benches for testing acceleration

AUTOMATED DRIVING VALIDATION - SIMULATION FIDELITY

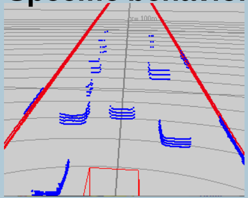
High fidelity



Feature
- Real resolution of physical equation that governs phenomenon at stake (light propagation, EM wave propagation) …

Example
- Ray tracing for light based sensor (Camera and LiDAR)

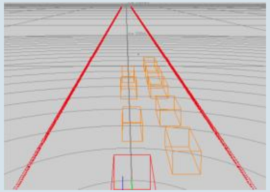
Specific behavior



Feature
- Ideal + take into account basic sensor specific effect
- Do not resolve physical equation that govern the phenomenon but just effect on detection

Example
- Tx/Rx antenna diagram, RCS of targets, object merging , FP, FN …

Low fidelity



Feature
- Perfect Sensor, Detection Range, no specific characteristic
- All traffic attributes are available

Example
- Perfect bounding box Object sensor for any sensor type

Computational need

High fidelity sensor simulation requires high computation resources

AUTOMATED DRIVING VALIDATION - MILEAGE SIMULATION

- Mileage required* for AD estimated ~ 17 Billion Kms
- Industry plan is > 90% by simulation from 2021

		Benchmark Failure Rate		
Statistical Question	**How many miles (years[a]) would autonomous vehicles have to be driven…**	**(A) 1.09 fatalities per 100 million miles?**	**(B) 77 reported injuries per 100 million miles?**	**(C) 190 reported crashes per 100 million miles?**
	(1) without failure to demonstrate with 95% confidence that their failure rate is at most…	275 million miles (12.5 years)	3.9 million miles (2 months)	1.6 million miles (1 month)
	(2) to demonstrate with 95% confidence their failure rate to within 20% of the true rate of…	8.8 billion miles (400 years)	125 million miles (5.7 years)	51 million miles (2.3 years)
	(3) to demonstrate with 95% confidence and 80% power that their failure rate is 20% better than the human driver failure rate of…	11 billion miles (500 years)	161 million miles (7.3 years)	65 million miles (3 years)

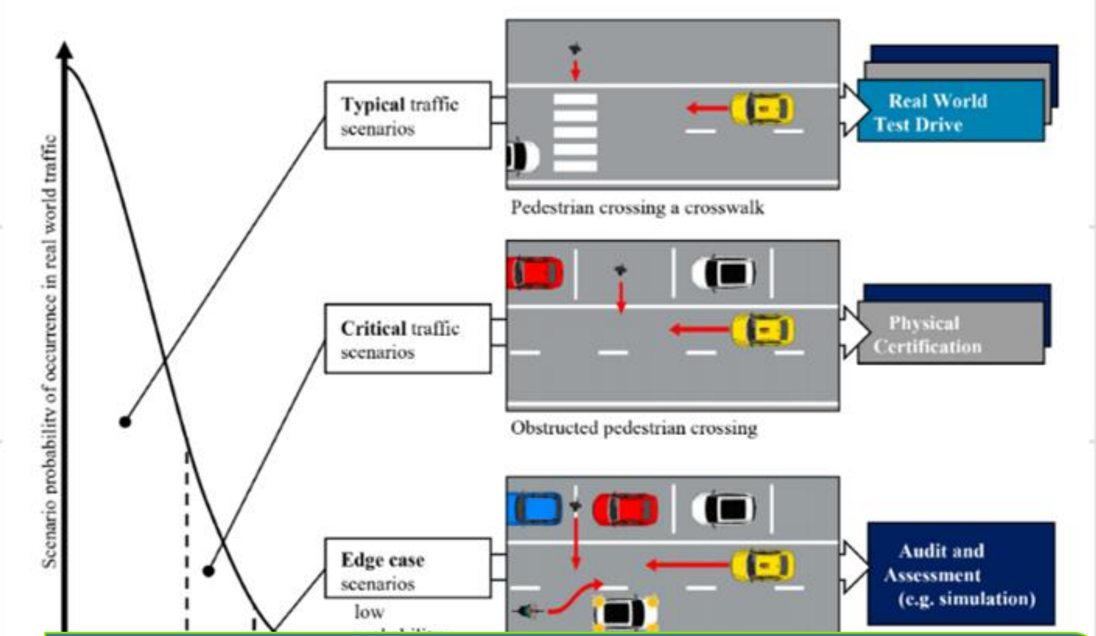
[a] We assess the time it would take to compete the requisite miles with a fleet of 100 autonomous vehicles (larger than any known existing fleet) driving 24 hours a day, 365 days a year, at an average speed of 25 miles per hour.

Need of a framework, for accumulation of virtual mileage in a reasonable time

*Kalra, N. and Paddock, S., "Driving to Safety: How Many Miles of Driving Would it Take to Demonstrate Autonomous Vehicle Reliability?" Rand Corporation Report posted 2016;

AUTOMATED DRIVING VALIDATION - CERTIFICATION

Pillar	Description	Risk distribution
Real- World-Test Drive	- Overall impression of system behavior on public roads - Assessment of system's ability to cope with real world traffic situations with a standardized checklist - „Driving license test" for automated driving system - Guidance through given set of situations which shall be passed	
Physical Certification Tests	- Matching of audit/assessment results with real world behavior - Assessment of system behavior in fixed set of challenging cases, which either aren't testable on public roads or cannot be guaranteed to occur during the real world test drive. - Reproducibility of situations is given	
Audit and Assessment	- Audit of development process (methods, standards) - Assessment of safety concept (functional safety, safety of use) and measures taken - Check of integration of general safety requirements and traffic rules - Use of simulation results (high mileage approval, capability to cope with critical situations, which aren't testable on proving grounds or in public) - Assessment of development data/field testing, OEM-self-declarations	



Simulation, especially for high mileage is planned to be used as a safety argument for AD certification

SMART TECHNOLOGY
FOR SMARTER CARS