ADS VEHICLE VALIDATION AND APPROVAL: SCENARIOS AND VIRTUAL TESTS

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the brainware company

OBJECTIVE OF THE STUDY

- The objective of this presentation is to provide an overview of the current state of art in demonstrating conformity from a Safety perspective for autonomous vehicles.
- Intecs proposes this topic based on the experience gained in the field by carrying out some activities with customers and integrated with its own considerations reported in this presentation.

VALIDATION AND COMPLIANCE DEMOSTRATION

- **Compliance Assessment**: Before placing products on the market, it is necessary to ensure they comply with European regulations through a risk analysis during the design and production phases.
- **Procedures**:
  - Self-assessment of the product or assistance from a notified body
  - Detailed technical documentation to demonstrate compliance
  - Use of harmonized standards to facilitate compliance

MAIN STANDARDS AND REGULATIONS

- **ISO 26262**: is the leading standard for functional safety in vehicles. It focuses on preventing risks arising from malfunctions of the vehicle's electrical and electronic (E/E) systems. The main scope is to ensure that systems function properly even in the event of failures
- **ISO/PAS 21448**: known as Safety Of the Intended Functionality (SOTIF) focuses on the safety of the intended functionality, especially in the absence of failures. It is particularly relevant for autonomous driving and advanced assistance systems.
- **ISO/SAE 21434**: is a standard for managing cybersecurity in vehicles. It provides a framework for risk assessment, data protection and vulnerability management ensuring that connected vehicles are protected from cyberattacks

- **Regulation (UE) 2019/2144**: This European Union regulation sets out type-approval requirements for motor vehicles and their trailers, as well as for systems, components and separate technical units intended for such vehicles. It includes specific provisions for general safety and the protection of vehicle occupants and vulnerable road users.
- **Commission Implementing Regulation (EU) 2022/1426**: lays down uniform procedures and technical specifications for the type-approval of automated driving systems (**ADS**) of fully automated vehicles. Adopted on August 5, 2022, this regulation is crucial to ensure that autonomous vehicles meet the safety and reliability standards required in the European Union.

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VALIDATION IN ISO/PAS 21448

- Validation in SOTIF requires a systematic and well-defined approach, combining different test, simulation and analysis techniques to ensure that the system is safe and reliable in a wide range of operational scenarios.
- SOTIF defines validation objective as the "**target value to support that the acceptance criterion is met**". The definition of a validation objective depends on the target markets and operational scenarios.
- ISO/PAS 21448 provides several **strategies and methods** for validation within SOTIF to ensure that systems achieve an acceptable level of safety.

VALIDATION STRATEGIES

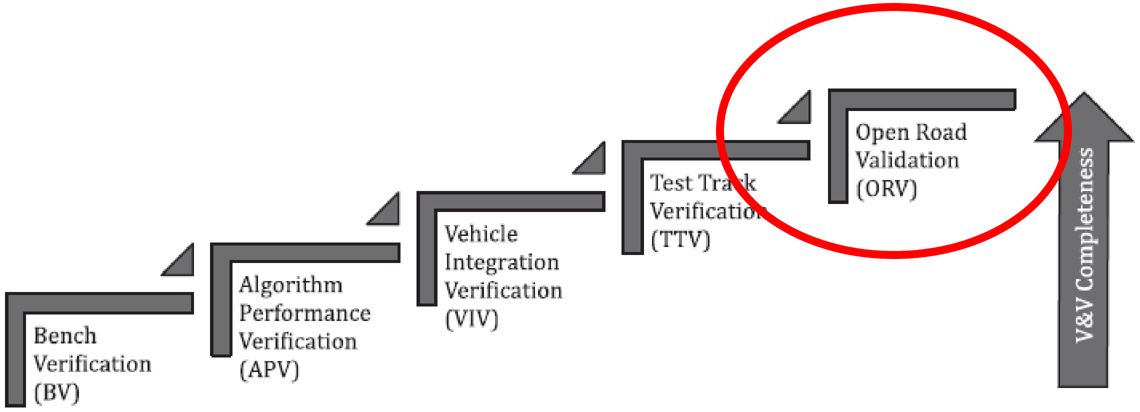
- A verification and validation strategy should be developed to provide evidence that the residual vehicle-level risk, related to SOTIF, is below an acceptable level and that the elements meet their functional requirements.
  - The strategy shall consider the assessment of potentially hazardous scenarios, sufficient coverage of the relevant scenario space, the necessary evidence and procedures for generating evidence.
  - The strategy focuses not only on performance assessment and risk identification within the Operational Design Domain (ODD), but also on boundaries and outside the ODD.
- The process begins with the selection of an acceptance criterion, from which a validation objective is derived based on the system's use case, incident statistics, and a margin of safety.

SIMULATION

- Simulation testing can be a significant part of the validation effort, using pre-recorded or pre-built scenarios to validate the system for known scenarios and generating new test cases to test **unknown scenarios**.
- Generating new test cases based on recorded scenarios and simulation can also be used to test unknown scenarios.
- One of the validation methods is **Open Road Validation** (ORV).

OPEN ROAD VALIDATION

- **Open Road Validation (ORV)** is a crucial step in the verification and validation process of perception systems for Automated Vehicles, as specified in ISO 21448.



ORV : SCOPE AND CONDITIONS

Scope	The main scope of the ORV is to validate the performance of the perception system in the target environment, i.e. on roads open to the public (starting from more controlled tests in the laboratory up to real scenarios on the road).
Activities	Continuous collection of representative data across multiple markets and environmental conditions.
	Collecting specific data under rare but perception-impacting conditions, such as adverse weather or low light.
Conditions	Environmental conditions (rain, snow, fog, etc.).
	Lighting (backlight, night, etc.).
	Traffic conditions (environment rich in vulnerable road users compared to the motorway).
	Clutter near the road (multiple light sources or complex street furniture).

SOTIF: EXAMPLE OF SCENARIOS

ISO 21448 provides several examples of SOTIF-relevant scenarios. These include:

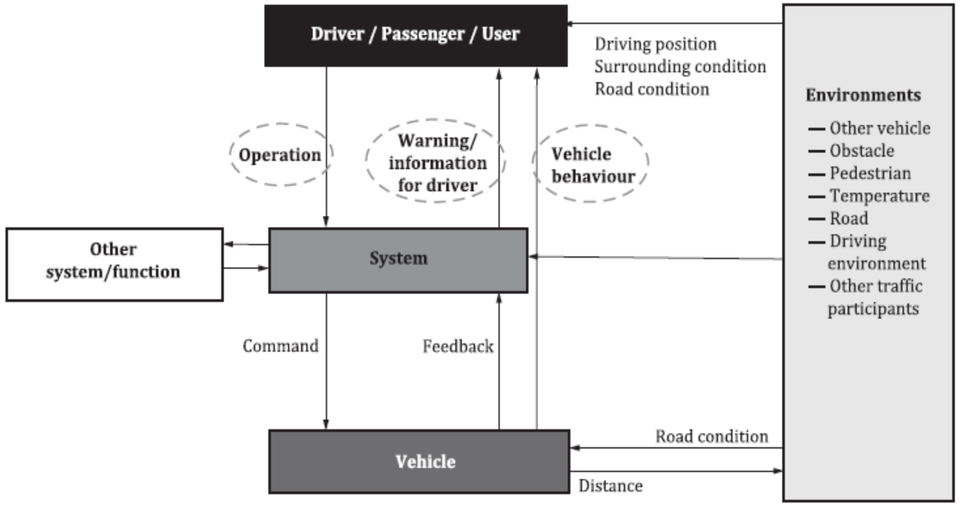
- Functionality intended for highway use only activated in an urban context. In this scenario, the functionality has limitations in recognizing and interpreting the movement of vulnerable road users.
- Self-parking system with an object protruding from the open trunk.
- Unintended activation of AEB at xm/s² for y seconds while driving on a highway. This could lead to a rear-end collision with the following vehicle.
- Examples of SOTIF hazards and mitigations as a function of increasing vehicle autonomy:
    - Driver assistance system (Level 1): Incorrect object detection leads to incorrect braking.
    - Partial driving automation (Level 2): Lack of driver awareness of the situation leads to an inappropriate response.
    - Conditional driving automation (Level 3): Unexpected driving outside the Operational Design Domain (ODD) leads to an inability of the system to handle the situation.

SOTIF: EXAMPLE OF SCENARIOS

ISO 21448 provides several examples of scenarios relevant to SOTIF. Some examples include:

- SOTIF misuse scenarios: These can be derived from lessons learned, expert knowledge and designer brainstorming. The standard provides a methodology to systematically derive such scenarios. An example of the interaction between driver/user, system and vehicle is illustrated in the figure.

- High-speed night driving with poor visibility. In this scenario, approaching a slower motorcyclist from behind can lead to loss of control and serious injury or death. This can cause the vehicle to violate the minimum distance threshold.



SOTIF: SCENARIO ANALYSIS

ISO 21448 mentions the 6 layers in the context of scenario analysis (specifically in Table B.3 et seq. and Table B.4 et seq.)

These layers are used to **classify and define** the different aspects of a driving scenario. The 6 layers are:

- **Layer 1**: Road layout and surface condition.
- **Layer 2**: Traffic guidance infrastructure, such as signs, barriers and markings.
- **Layer 3**: Topology and geometry overlay for temporary construction sites.
- **Layer 4**: Road users and objects, including maneuver-based interactions.
- **Layer 5**: Environmental conditions (e.g. weather and time of day), including their influence on Layers 1 to 4.
- **Layer 6**: Digital information, including its influence on Layers 1 to 5.

These layers help to structure and analyze scenarios, considering all relevant factors that can influence the behavior of the automated driving system.

SCENARIOS FOR APPROVAL

- There can be many different scenarios, which can also change from country to country depending on the road rules. For this reason, the next objective is to create a shared database of public scenarios for different countries and different car makers.

- UNECE has highlighted the need for a single scenario catalogue for all countries (Informal document "**GRVA-18-49" 18th GRVA, 22-26 September 2024 "Agenda item 4(g)**") as scenarios will play a key role in evaluating the performance of an Automated Driving System (ADS).

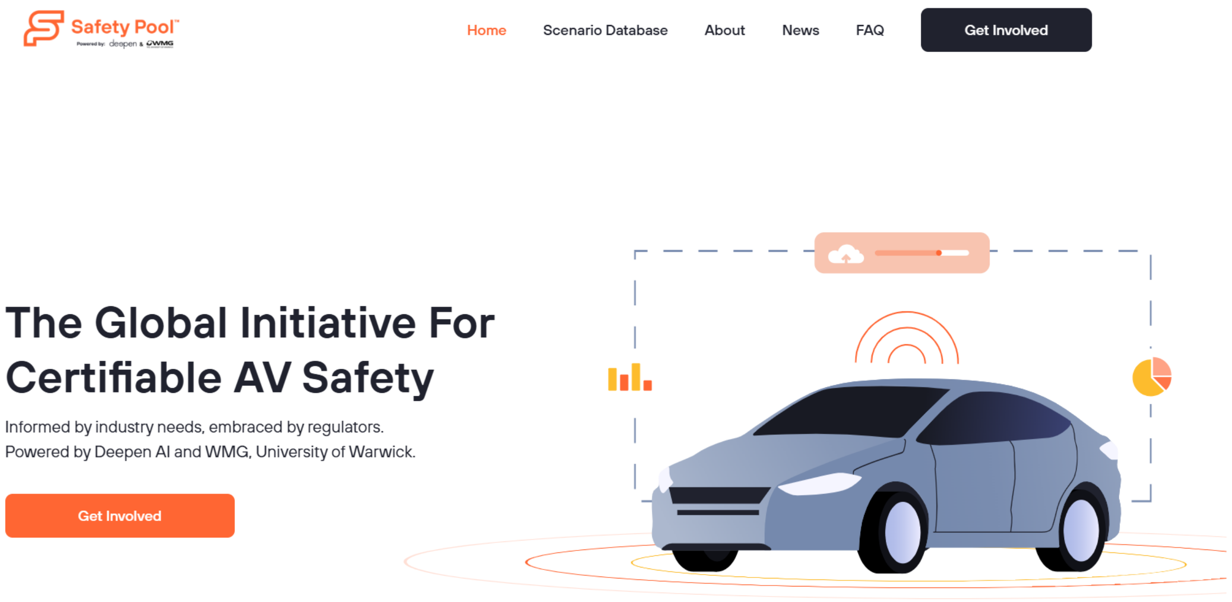
SCENARIO DATABASE

- These scenarios should be independent of the specific Design (ODD) so as to support compliance processes (**WP29** in various meeting sessions takes forward this discussion). This has an impact on the performance evaluation of an Automated Driving System (ADS).
- **Scenario Database** is a digital platform where machine-readable scenarios are stored and managed. The database features include the ability to import/export scenarios and filter them based on their attributes, such as environmental conditions, road infrastructure, scenario classification, actor behavior, related requirements, or scenario variables/variants.
- For example, two databases that are being attempted are:
  - **Safety Pool**
  - **SAKURA project**

SAFETY POOL

Safety Pool (powered by Deepen AI and WMG University of Warwick) envisions a world where the safety of every automated driving system and ADAS can be transparently tested, validated and certified through common processes and infrastructure shared across industry, academia and policy makers around the world.

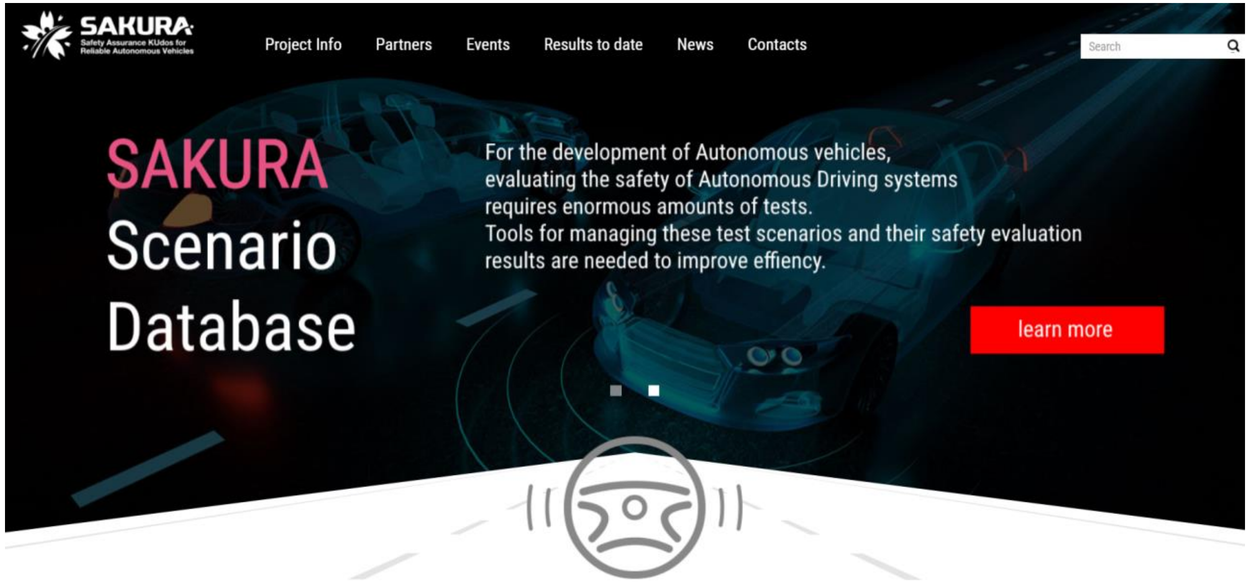
- Safety Pool - Powered by Deepen AI and WMG University of Warwick



SAKURA PROJECT

The SAKURA project gathers evidence for safety topics by collecting and analyzing various data and collaborating with other countries to create new safety evaluation methods. It also develops a database for safety evaluation/test scenarios (highway and urban) and studies their practical application through collaboration between industry, government, and academia from across Japan, while helping to accelerate the development of automated driving technology in Japan.

- SAKURA Project



VIRTUAL TEST APPROACH

A simulation approach based on **Virtual Tests or Digital Twin representations** would certainly allow:

- To **lower costs** and tests as many cases (**scenarios**) as possible
- It would be **sustainable for the environment** with regard to emissions since a significant number of Kms would be avoided
- **Reducing** physical **risks** for testers
- The simulation would take into account the **scenarios** proposed by **centralized databases**. These databases would contribute to centrally and unambiguously regularizing vehicle approvals in **all countries**.

ESA: P-CAR LABORATORY

- The new P-CAR laboratory – financed by the Italian Space Agency, **ASI** through **ESA**'s Navigation Innovation and Support Programme, NAVISP – will support the goals of EMERGE as an independent venue for testing devices supporting autonomous and connected driving.
- The objective of **P-CAR** (PNT Center for Automated Road-Transport) is to realize a PNT **laboratory for testing and validation** of Connected Autonomous Driving functions in synergy with the EMERGE-Navigation project under development in the Abruzzo Region. The accredited laboratories are essential facilities to support the certification process and, similarly to the rail domain, P-CAR aims to fill this gap for the automotive applications by developing the core technologies for a future accredited public PNT Centre in Italy.
- ESA - ESA-backed autonomous driving lab set for Italy
- P-CAR-Laboratorio di guida autonoma sostenuto dall'ESA |

INTECS SUPPORT FOR P-CAR

The goal of Intecs involvement in P-CAR was to define a Concrete and Certified Testing Methodology that the Laboratory could apply to test the Autonomous Driving System Functionality (ADSF).

The key points of the collaboration were:

- To define a structured testing procedure for ADSF Regulation.
- To define how to create a preliminary testing scenarios catalogue for different ADSFs.
- To support the creation of a Proof Of Concept demonstrating the feasibility of the Testing Methodology.

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THANKS!

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