D8.1

Final report to vehicle safety bodies

Project short name
SUNRISE

Project full name
Safety assUraNce fRamework for connected, automated mobIlity SystEms

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ABBREVIATIONS AND ACRONYMS

Abbreviation	Meaning
AD	Automated Driving
ADS	Automated Driving System
AEB	Autonomous Emergency Braking
ALKS	Automated Lane Keeping System
ANCAP	Australasian New Car Assessment Program
AQCG	Automated Query Criteria Generation
ASAM	Association for Standardisation of Automation and Measuring Systems
ASLD	Adjustable Speed Limitation Device
AVSC	Automated Vehicle Safety Consortium
BSD	Blind Spot Detection
BSI	British Standards Institution / Blind Spot Intervention
CAM	Cooperative Awareness Message
CAV	Connected and Automated Vehicle
CCAM	Connected, Cooperative, and Automated Mobility
CEN	European Committee for Standardisation
C-ICAP	China Intelligent-connected Car Assessment Programme
C-ITS	Cooperative Intelligent Transport Systems
C-NCAP	China New Car Assessment Program
DDT	Dynamic Driving Task
DF	Data Framework
DIN	Deutsches Institut für Normung (German Institute for Standardisation)
DMS	Driver Monitoring System
DSSAD	Data Storage System for Automated Driving

EC	European Commission
EDR	Event Data Recorder
ELK	Emergency Lane Keeping
EMIP	European Mobility Innovation Platform
EU	European Union
EU-JRC	European Union Joint Research Centre
EuroNCAP	European New Car Assessment Programme
FRAV	Functional Requirements for Automated Vehicles
GRVA	Working Party on Automated/Autonomous and Connected Vehicles
GSR	General Safety Regulation
HARA	Hazard Analysis and Risk Assessment
HMI	Human-Machine Interface
IIHS	Insurance Institute for Highway Safety
ISA	Intelligent Speed Assistance
ISMR	In-Service Monitoring and Reporting
ISO	International Organisation for Standardisation
IWG	Informal Working Group
JNCAP	Japan New Car Assessment Program
JRC	Joint Research Centre
KBA	Kraftfahrt-Bundesamt (German Federal Motor Transport Authority)
K-NCAP	Korean New Car Assessment Program
KPI	Key Performance Indicator
LDW	Lane Departure Warning
LDWS	Lane Departure Warning System
LHS	Latin Hypercube Sampling
LKAS	Lane Keeping Assistance System

NATM	New Assessment/Test Method for Automated Driving
NCAP	New Car Assessment Program
NHTSA	National Highway Traffic Safety Administration
ODD	Operational Design Domain
OEM	Original Equipment Manufacturer
OSI	Open Simulation Interface
PAS	Publicly Available Specification
PDF	Probability Density Function
RCTA	Rear Cross Traffic Alert
RDW	Rijksdienst voor het Wegverkeer (Dutch Vehicle Authority)
RSU	Road Side Unit
SAE	Society of Automotive Engineers
SAF	Safety Assurance Framework
SAS	Speed Assist Systems
SCDB	SCenario DataBase
SUNRISE	Safety assUraNce fRamework for connected, automated mobIlity SystEms
SUT	System Under Test
SUV	Sport Utility Vehicle
TC	Technical Committee
THW	Time Head Way
TR	Technical Report
TRL	Technology Readiness Level
TS	Technical Service/Technical Specification
TTC	Time To Collision
UC	Use Case
UNECE	United Nations Economic Commission for Europe

UTAC	Union Technique de l'Automobile, du motocycle et du Cycle (Technical Service of France)
V2I	Vehicle-to-Infrastructure
V2P	Vehicle-to-Pedestrian
V2V	Vehicle-to-Vehicle
V2X	Vehicle-to-Everything
VCA	Vehicle Certification Agency (UK)
VMAD	Validation Methods for Automated Driving
VRU	Vulnerable Road User
VSB	Vehicle Safety Body
V&V	Verification and Validation
WG	Working Group
WP	Work Package
WP.29	World Forum for Harmonisation of Vehicle Regulations
XiL	X-in-the-Loop

EXECUTIVE SUMMARY

Safety assurance of Cooperative, Connected, and Automated Mobility (CCAM) systems is a crucial factor for their successful adoption in society, yet it remains a significant challenge. It is generally acknowledged that for higher levels of automation, the validation of these systems by conventional test methods would be infeasible. Furthermore, certification initiatives worldwide struggle to define a harmonised safety assurance approach enabling massive deployment of CCAM systems.

The **SUNRISE** project develops and demonstrates a **CCAM Safety Assurance Framework** (SAF). The overall objective of the SUNRISE project is to accelerate the large-scale and safe deployment of CCAM systems. In alignment with international twin projects and initiatives, the project aims to achieve this objective by providing a SAF consisting of three main components: a Method, a Toolchain and a Data Framework. The **Method** is established to support the SAF safety argumentation, and includes procedures for scenario selection, sub-space creation, dynamic allocation to test instances and a variety of metrics and rating procedures. The **Toolchain** contains a set of tools for safety assessment of CCAM systems, including approaches for virtual, hybrid and physical testing. The **Data Framework** provides online access, connection and harmonisation of external Scenario Databases (SCDBs), allowing its users to perform query-based extraction of safety relevant scenarios, allocation of selected scenarios to a variety of test environments, and reception of the test results.

This deliverable presents the outcomes of **Work Package 8** (WP8) of the SUNRISE project, which focused on **engagement with vehicle safety bodies** (VSBs) to ensure that the SAF meets regulatory and industry needs. The document is structured as follows: this document outlines the objectives and approach of WP8, describes the project's collaboration with **UNECE**, the **European Commission and its Member States**, **consumer testing** organisations such as Euro NCAP, and **standardisation** bodies including ISO, ASAM, and SAE. Additionally, this deliverable presents an application example (**SAF mock application**) of the SUNRISE SAF, developed in cooperation with a representative vehicle safety body (Dutch type approval authority, RDW), which demonstrated its practical relevance.

The deliverable shows that WP8 achieved its goals of making VSBs **aware of the SAF** and initiating first steps towards **application** and **adoption**. Structured engagement at international, European, and national levels, combined with direct **cooperation** with RDW, ensured alignment with regulatory practice and demonstrated the SAF's auditability. **Feedback** from regulators, NCAPs, and standardisation organisations confirmed its value as a transparent, harmonised, and scenario-based approach to safety assurance.

In conclusion, SUNRISE has delivered a comprehensive SAF tailored to the validation of Connected, Cooperative, and Automated Mobility (CCAM) systems. The framework **complements** existing and emerging **regulations**, **aligns** with key international **standards**, and bridges the gap between technical development and regulatory application. The consortium recommends that elements of the SAF be **embedded into future type approval processes**, **consumer safety assessments**, and **international standardisation activities**,

thereby supporting the safe and harmonised deployment of CCAM technologies across Europe and beyond.

1 INTRODUCTION

1.1 Project introduction

Safety assurance of Connected, Cooperative, and Automated Mobility (CCAM) systems is a crucial factor for their successful adoption in society, yet it remains a significant challenge. CCAM systems need to demonstrate reliability in all driving scenarios, requiring robust safety argumentation. It is acknowledged that for higher levels of automation, the validation of these systems by means of real test-drives would be infeasible. In consequence, a carefully designed mixture of physical and virtual testing has emerged as a promising approach, with the virtual part bearing more significant weight for cost efficiency reasons.

Worldwide, several initiatives have started to develop test and assessment methods for Automated Driving (AD) functions. These initiatives already transitioned from conventional validation to a scenario-based approach and combine different test instances (physical and virtual testing) to avoid the million-mile issue.

The initiatives mentioned above, provide new approaches to CCAM validation, and many expert groups formed by different stakeholders, are already working on CCAM systems' testing and quality assurance. Nevertheless, the lack of a common European validation framework and homogeneity regarding validation procedures to ensure safety of these complex systems, hampers the safe and large-scale deployment of CCAM solutions. In this landscape, the role of standards is paramount in establishing common ground and providing technical guidance. However, standardising the entire pipeline of CCAM validation and assurance is in its infancy, as many of the standards are under development or have been very recently published and still need time to be synchronised and established as common practice.

Scenario Databases (SCDBs) are another issue tackled by several initiatives and projects, that generally tends to silo solutions. A clear concrete approach should be used (at least at European level), dealing with scenarios of any possible variations, including the creation, editing, parameterisation, storing, exporting, importing, etc. in a universally agreed manner.

Furthermore, validation methods and testing procedures still lack appropriate safety assessment criteria to build a robust safety case. These must be set and be valid for the whole parameter space of scenarios. Another level of complexity is added, due to regional differences in traffic rules, signs, actors and situations.

Evolving from the achievements obtained in HEADSTART and taking other project initiatives as a baseline, it becomes necessary to move to the next level in the development and demonstration of a commonly accepted **Safety Assurance Framework** (**SAF**) for the safety validation of CCAM systems, including a broad portfolio of Use Cases (UCs) and comprehensive test and validation tools. This will be done in **SUNRISE**, which stands for **S**afety ass**U**ra**N**ce f**R**amework for connected, automated mob**I**lity **S**yst**E**ms.

The SAF is the main product of the SUNRISE project. As the following figure indicates, it takes a central role, fulfilling the needs of different automotive stakeholders that all have their own interests in using it.

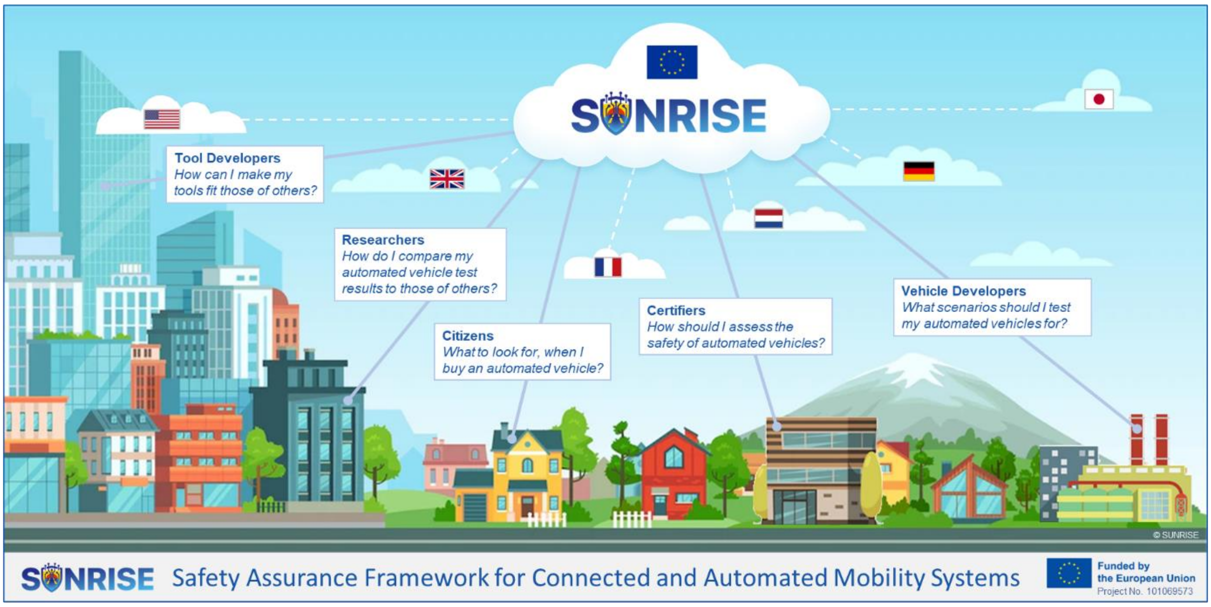


Figure 1: Safety Assurance Framework stakeholders

The **overall objective** of the SUNRISE project is to accelerate the safe deployment of innovative CCAM technologies and systems for passengers and goods by creating demonstrable and positive impact towards safety, specifically the EU's long-term goal of moving close to zero fatalities and serious injuries by 2050 (Vision Zero), and the resilience of (road) transport systems. The project aims to achieve this objective by providing a SAF consisting of three main components: a Method, a Toolchain and a Data Framework. The **Method** is established to support the SAF safety argumentation, and includes procedures for scenario selection, sub-space creation, dynamic allocation to test instances and a variety of metrics and rating procedures. The **Toolchain** contains a set of tools for safety assessment of CCAM systems, including approaches for virtual, hybrid and physical testing. The **Data Framework** provides online access, connection and harmonisation of external Scenario Databases (SCDBs), allowing its users to perform query-based extraction of safety relevant scenarios, allocation of selected scenarios to a variety of test environments, and generation of the test results. The SAF will be put to the test by a series of **Use Cases demonstrations**, designed to identify and solve possible errors, gaps and improvements to the underlying methods, tools and data.

Following a common approach will be crucial for present and future activities regarding the testing and validation of CCAM systems, allowing to obtain results in a standardised way, to improve analysis and comparability, hence maximising the societal impact of the introduction of CCAM systems.

The following figure shows the general workplan of the SUNRISE project.

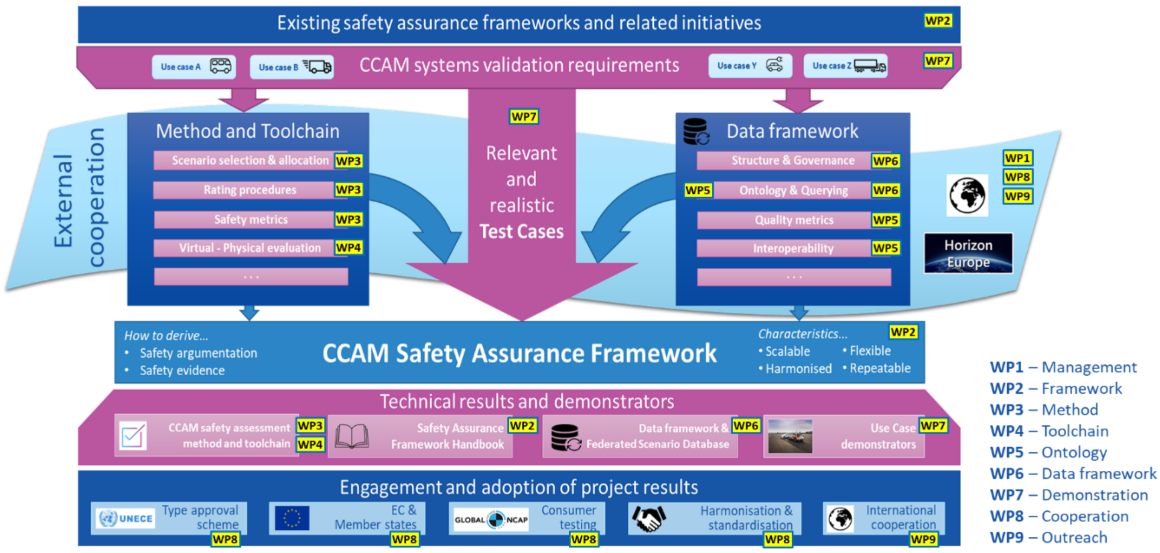


Figure 2: Workplan of the SUNRISE Project

1.2 Purpose of deliverable

A central focus of the SUNRISE project, as outlined in **Objective 8** of the Grant Agreement, is to **collaborate** with **vehicle safety bodies** in Europe and worldwide, considering other industries and domains for harmonisation and standardisation purposes**.** The first goal was to raise **awareness** of the **SUNRISE SAF**, followed by its **adoption** and practical **application**. To support this, the project draws also on methods from other industries and domains to foster **harmonisation** and **standardisation**.

This deliverable provides an **overview** of the **collaboration activities** with four key vehicle safety bodies during the SUNRISE project, along with an executive summary of the project's main findings. This summary is tailored to these organisations, offering **specific recommendations** on **how to apply the SAF**. Its purpose is to clearly and concisely communicate the most important insights, practical guidance, and evidence-based recommendations that have emerged from the project's extensive research. By presenting key outcomes, identifying challenges, and outlining opportunities for future research, the deliverable **supports decision-makers and stakeholders in integrating the SUNRISE SAF** into their practices and advancing vehicle safety standards and policies.

Work Package 8 (**WP8**) of the SUNRISE project plays a crucial role in aligning SUNRISE results with the needs of key vehicle safety bodies, including UNECE [1] contracting parties, the European Commission and its member states, international New Car Assessment Programmes, particularly Euro NCAP [2], and relevant standardisation organisations. WP8 established a **two-way communication process**: **collecting feedback** on stakeholder needs while **sharing project progress and findings** (see overview in Figure 3). This regularly exchange with the vehicle safety bodies was essential to achieving the project's objectives, particularly Objective 8. This deliverable provides an overview of the cooperation activities with these entities, with the aim of raising **awareness of the SUNRISE SAF** and encouraging its **adoption** and **application**.

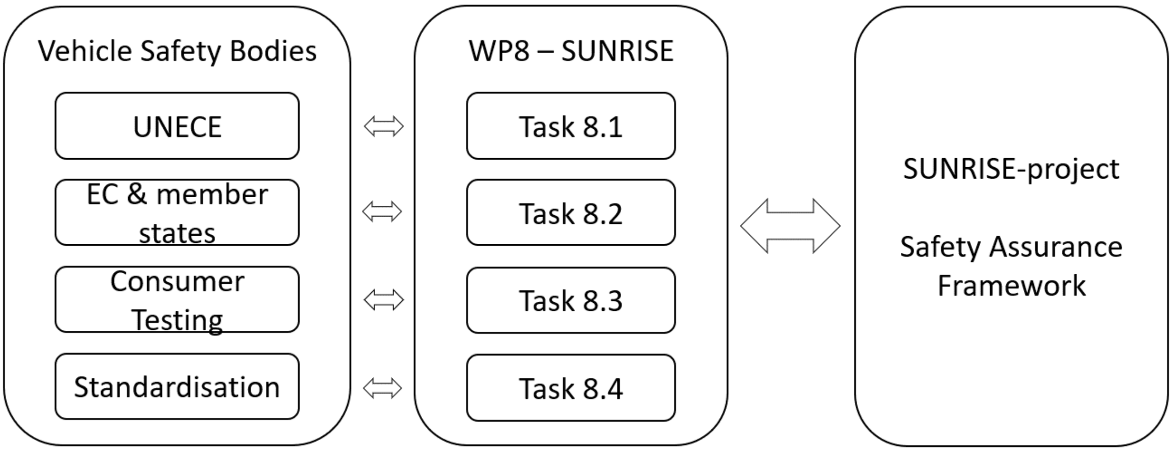


Figure 3: Overview of cooperation information flow between the SUNRISE-project and the vehicle safety bodies during cooperation activities

During the SUNRISE project **WP8** has refined its communication with vehicle safety bodies to include early project results, a draft version of the Safety Assurance Framework, and more detailed elements of that framework. Multiple **workshop** involving WP8 and the technical work packages of the SUNRISE project were held to identify and define these key details. This deliverable provides an **overview of the cooperation activities** carried out inside the SUNRISE project to prepare the cooperation with the VSBs and outside the project between WP8 and the VSBs. In this document the concrete cooperation process is described through which **initial hurdles to the introduction of the SAF in a mock application** were addressed and overcome. These experiences form a **foundation on which further adoption and application of the SAF** can be built.

1.3 Intended audience

The primary audience of this deliverable, consists of external stakeholders responsible for vehicle safety assessment and regulation, including type approval authorities (e.g., RDW, KBA, VCA), consumer safety organisations (e.g., Euro NCAP), and European research institutions (e.g., EU-JRC). These stakeholders are expected to directly benefit from the insights and recommendations presented, as they relate to the future evaluation of evaluation of Cooperative, Connected and Automated Mobility (CCAM) systems within existing and emerging safety frameworks. Figure 4 shows an overview (with exemplary entities) of the two main groups of SAF target users: vehicle safety bodies and industry. The usage of the SUNRISE SAF by these two types of stakeholders might differ, because safety authorities do more auditing than applying all the steps of the SAF by themselves. More details on this topic in chapter 4.

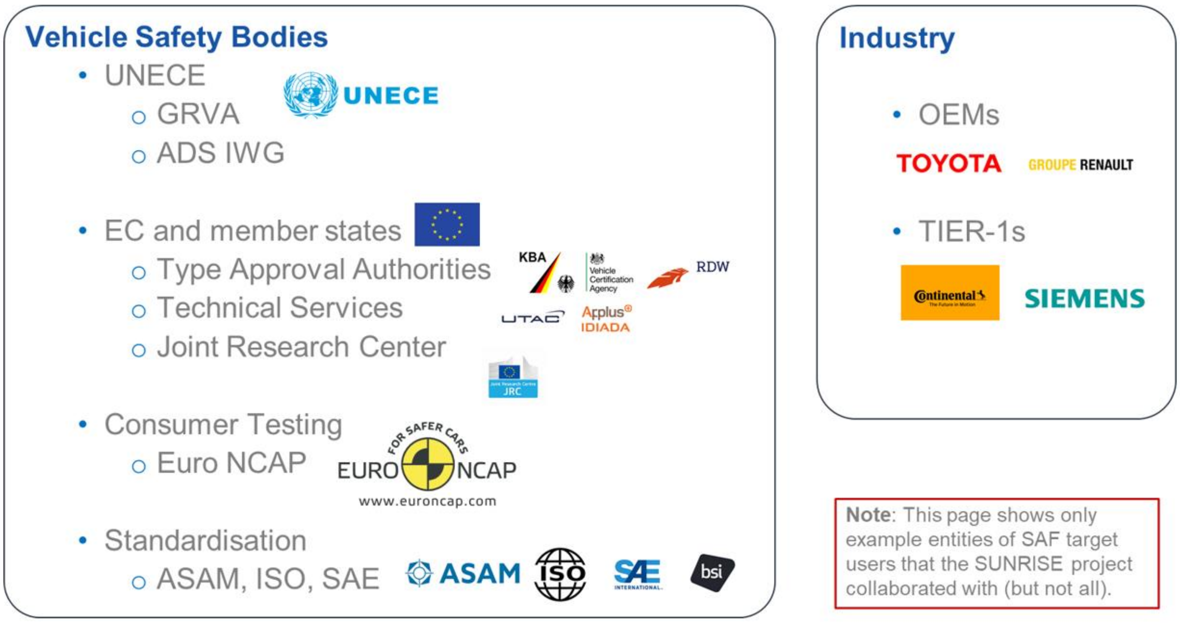


Figure 4: Overview of SAF target users divided in two groups: Vehicle Safety Bodies and Industry

The secondary audience includes internal SUNRISE project partners and other CCAM-related initiatives, who can use this report to align technical developments with regulatory expectations and to inform ongoing work on safety-related research and innovation.

The report addresses the broader needs of both regulatory and non-regulatory stakeholders by providing a transparent overview of the SUNRISE SAF, its objectives, and its potential implications for policy and practice. It is intended for external dissemination and aims to support dialogue and alignment between research, policy, and implementation communities across Europe.

1.4 Deliverable structure and relation to other parts of project

This deliverable is structured to present a comprehensive overview of the SUNRISE project's cooperation with vehicle safety bodies and related stakeholders. It is organised into 10 main chapters and four annexes, each contributing to a logical and progressive flow of information.

The **introduction** (**Chapter 1**) provides foundational context, including the purpose, audience, and relevance of the deliverable within the broader SUNRISE project. It also defines the document's structure, summarises the SUNRISE SAF and introduces the vehicle safety bodies relevant to the project.

Chapter 2 outlines the **process of cooperation** with vehicle safety bodies, divided into three phases—introduction, intermediate, and final—tracing the evolution of engagement throughout the project timeline.

Chapters 3 to 6 present detailed accounts of cooperation with specific stakeholder groups:

- **Chapter 3** covers collaboration at the **United Nations ECE**, focusing on the UN's working groups WP.29 and GRVA
- **Chapter 4** details cooperation with the **European Commission and its member states**
- **Chapter 5** focuses on interactions with **consumer testing organisations**, including Euro NCAP and other NCAPs
- **Chapter 6** addresses engagement with **standardisation bodies**, like ISO, ASAM or SAE

Each of these chapters follows a consistent structure: introduction of the stakeholder, description of the collaboration during the project, stakeholder feedback, and discussion of how project outcomes may be applied or utilised by the respective stakeholder group.

Chapter 7 describes the **SAF mock application** carried out with the Dutch type approval authority (RDW) to test the Safety Assurance Framework in a real-world regulatory context. It evaluates the framework's applicability, the usability of its application guidelines, and how vehicle safety bodies could adopt them, supported by RDW's independent input and requirements.

Chapter 8 provides a **future outlook**, identifying upcoming opportunities for aligning SUNRISE results with regulatory and safety assessment frameworks. **Chapter 9** draws final **conclusions**, and **Chapter 10** lists relevant **references**. Four annexes complement the main chapters:

- Annex 1: **Report on UNECE activities**
- Annex 2: **Executive summaries of key SUNRISE topics**
- Annex 3: **Reports for the SAF mock application**
- Annex 4: **Overview of global NCAPs**

This deliverable is closely related to and dependent on several project work packages, particularly:

- WP2 (**SAF Development**), providing the conceptual foundation of the Safety Assurance Framework
- WP3-6, explaining the **technical results** of the SUNRISE project
- WP7, **validation and demonstration of the SAF** through CCAM use cases
- WP9, **external collaboration** with entities beside the vehicle safety bodies.

The insights and outcomes documented in this deliverable serve as a key link between the technical development of the SUNRISE SAF and its practical relevance for stakeholders in the vehicle safety domain. By capturing the feedback, expectations, and potential use cases from various authorities and organisations, the deliverable ensures that the SUNRISE SAF is aligned with real-world regulatory and assessment needs. In doing so, it supports broader project objectives related to transparency, stakeholder inclusion, and applicability in the evolving field of connected and automated mobility. And it thereby accelerates the application and adoption of the SUNRISE SAF.

1.5 Summary of the SUNRISE Safety Assurance Framework

The **SUNRISE SAF** provides a structured basis for the assessment of CCAM system safety performance. The complete description of the framework, including its underlying concepts, methods and rationale, is available in **SUNRISE deliverable D2.3** [3]. The following section presents only a short summary of the **main 3 SAF building blocks** and their key outcomes. This introduction is intended to give vehicle safety bodies an **overview of the relevant elements**, while detailed explanations and methodological foundations can be found in the referenced SUNRISE deliverables.

The SUNRISE use cases **demonstrating** the SUNRISE SAF can be useful to learn how the SUNRISE SAF including methods and tooling can be applied to assess the safety of CCAM systems. In SUNRISE deliverable **D7.3** “Safety assurance framework demonstration” [4] the results are described in more detail.

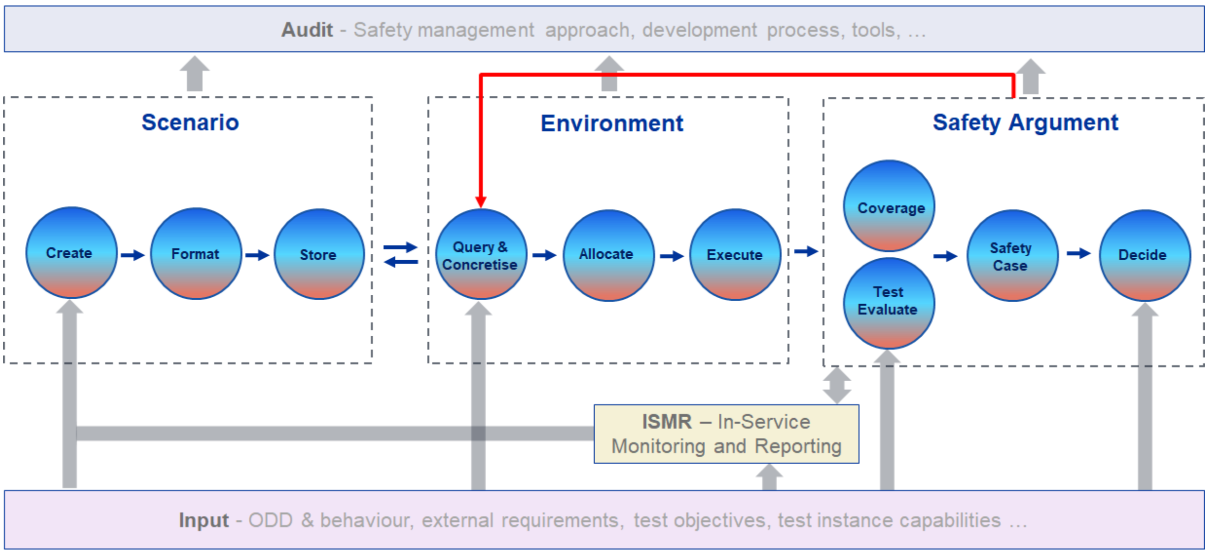


Figure 5 SUNRISE Safety Assurance Framework

- **Scenario block**
    - Data Framework content requirements

      A list of requirements relevant for scenarios, scenario databases and Data Framework have been defined and reported in SUNRISE deliverable **D5.1** “Requirement for CCAM safety assessment data framework content” [5].

- Scenario formats and ontologies

  To ensure accurate information exchange among different entities, methods and tools scenario formats and ontologies are defined within SUNRISE. Harmonised ontologies provide a shared understanding for both users and databases about scenario content. More detailed information can be found in SUNRISE deliverable **D5.2** “Harmonised descriptions for content of CCAM safety assessment data framework” [6].

- Scenario quality metrics

  Within SUNRISE various quality metrics are defined about scenario relevance, scenario criticality, scenario complexity, scenario description, scenario exposure and dissimilarity. Further information about this is reported in SUNRISE deliverable **D5.3** “Quality metrics for scenario database content” [7]. These metrics can be used as part of Scenario block itself but are also applicable for Environment and Safety Argument block, as well as in audit.

- Data Framework

  The Data Framework (DF) developed within SUNRISE can be used by NCAPs to extract information and scenario sets from the linked external Scenario Databases (SCDB). The DF functionalities and details are reported in SUNRISE deliverables **D6.1** “Methodology for SCBD application for generic use cases” [8] and **D6.2** “Define and development of SCDB input and output standards and interfaces” [9]. A demonstrator has been made available at the SUNRISE Final Event.

- **Environment block**
  - Scenario selection

    Multiple sampling strategies to derive a selection of scenarios that can be used for testing are developed and compared within SUNRISE. More information about these strategies can be found in SUNRISE deliverable **D3.4** “Report on Subspace Creation Methodology” [10].

  - Scenario allocation

    How to allocate test cases to the different test instances that are available has been examined within SUNRISE. In SUNRISE deliverable SUNRISE deliverable **D3.3** “Report on the Initial Allocation of Scenarios to Test Instances” [11] a structured approach for allocation is described.

  - Harmonised V&V simulation framework

    A harmonised simulation framework for Verification and Validation (V&V) has been created within SUNRISE. Within that activity SUNRISE deliverable **D4.3**

“Report on CCAM simulation tool landscape” [12] was created providing information on the available simulation tools. More information about the V&V simulation framework itself can be found in SUNRISE deliverables **D4.4** “Report on the Harmonised V&V simulation framework” [13], **D4.5** “Report on the validated core features of the V&V simulation framework” [14] and **D4.6** “Report on the validated hybrid and realworld testing and validation techniques” [15].

- **Safety Argument block**
  - Coverage metrics

    Various metrics to quantify to which extent a set of scenarios cover the relevant aspects of an ODD, so-called coverage, have been defined in SUNRISE. More detailed information about this is reported in SUNRISE deliverable **D5.3** “Quality metrics for scenario database content” [7].

  - Test validation metric

    Metrics that can be used to ensure that test results are valid have been defined within SUNRISE. In SUNRISE deliverable **D3.5** “Report on the Dynamic Allocation and Validation of Test Runs” [16] these are presented in more detail.

  - Dynamic allocation

    During the assessment in the Safety Argument block it might be required to perform additional tests. How to allocate these additional test cases to the different test instances available has been defined in SUNRISE via ‘dynamic allocation’. Additional insights on this can be found in SUNRISE deliverable **D3.5** “Report on the Dynamic Allocation and Validation of Test Runs” [16].

  - Safety case

    Information about the argumentation and evidence that a CCAM system meets the set safety requirements have been gathered within SUNRISE and are described in SUNRISE deliverable **D2.3** “Final SUNRISE safety assurance framework” [3].

1.6 General Introduction of Vehicle Safety Bodies

In the context of the SUNRISE project, Vehicle Safety Bodies (VSBs) play a critical role in shaping the regulatory, technical, and consumer-facing landscape for vehicle safety—particularly in the evolving domain of Connected and Automated Mobility (CCAM). These bodies operate at different levels (international, European, national) and fulfil diverse but complementary functions in ensuring that vehicles meet high safety standards throughout their lifecycle. This section introduces the four main categories of VSBs relevant to the SUNRISE project: UNECE, the European Commission and its Member States, consumer testing organisations, and standardisation bodies. Each of these groups is directly linked to specific SUNRISE tasks in work package 8 (see Figure 3): UNECE activities are addressed in **Task 8.1**, EU-level initiatives in **Task 8.2**, consumer testing in **Task 8.3**, and standardisation work in **Task 8.4**. This mapping ensures that the project systematically covers the full range of stakeholders shaping vehicle safety.

A note on the difference between **standards** and **regulations**: Standards define an agreed state of the art and good practice and typically are developed by Industry organisations; However, they are not technically a requirement if not referenced in vehicle regulations. UN Regulation documents, however, become legally binding for signatories of the relevant agreement and may become mandatory when referenced from within the EU Type Approval Regulation – vehicles then cannot be registered if they do not fulfil the regulations. EU Regulations such as the Regulation (EU) No. 1426/2022 [17] on Automated Driving Systems that are referenced from within the EU Type Approval Regulation are mandatory in EU as well.

1.6.1 UNECE – United Nations Economic Commission for Europe

The **UNECE**, through its World Forum for Harmonisation of Vehicle Regulations (WP.29), is the key international body responsible for establishing regulations ("UN Regulations" for type approval systems, "Global Technical Regulations" also for self certification, and general guidance documents) for vehicle safety. Within WP.29, the Working Party on Automated/Autonomous and Connected Vehicles (GRVA [18]) focuses specifically on regulatory frameworks for new mobility technologies, including automated driving systems. UNECE regulations are legally binding in many countries and serve as a global reference point for vehicle safety compliance. In SUNRISE, UNECE is particularly relevant for ensuring that project outcomes align with ongoing regulatory developments at the international level. For more details on UNECE activities within the SUNRISE project please read **chapter 3**.

1.6.2 European Commission and Member States

At the European level, the **European Commission (EC)**, together with the type approval authorities of its **Member States** (e.g., RDW in the Netherlands, KBA in Germany) and its research body JRC [19], plays a central role in implementing and enforcing vehicle safety legislation. Through frameworks such as the General Safety Regulation (GSR [20]) and the EU Type Approval System via Regulation (EC) No. 858/2018 [21], the EC ensures that vehicles sold in the EU meet harmonised safety standards (which then often are referenced UN regulations, see above). Member States are responsible for conducting type approval and conformity of production assessments. These stakeholders are crucial for translating technical advances, such as those developed in SUNRISE, into enforceable regulatory measures within the European Union. More details on the cooperation with the European Commission and member states can be found in **chapter 4**.

1.6.3 Consumer Testing Organisations

Consumer testing organisations, such as Euro NCAP [2] and other New Car Assessment Programmes (NCAPs), conduct independent evaluations of vehicle safety performance. Their protocols often go beyond regulatory minimum requirements, pushing manufacturers to achieve higher safety standards and informing consumers through ratings and reports. In the context of SUNRISE, these bodies are valuable not only for disseminating safety information but also for exploring how new methodologies, such as scenario-based safety assessment, could be integrated into future consumer testing protocols. **Chapter 5** outlines the cooperation activities with consumer testing organisations.

1.6.4 Standardisation Bodies

Standardisation organisations such as ISO [22], SAE [23], ASAM [24] and national institutes (e.g., DIN [25], BSI [26]) contribute to the development of voluntary but widely adopted technical standards that support regulatory compliance, interoperability, and innovation. These standards are particularly important for complex systems such as automated vehicles, where common definitions, performance metrics, and testing procedures are essential. In the SUNRISE project, cooperation with standardisation bodies ensures that the developed SUNRISE SAF aligns with ongoing international efforts to harmonise terminology, validation methods, and safety assurance frameworks. To maximise the long-term impact of its results, the SUNRISE project engaged proactively with international standardisation organisations. As automated driving technologies become more widespread, harmonised validation frameworks are essential to ensure safety, interoperability, and regulatory compliance. Task T8.4 coordinates SUNRISE's cooperation with standardisation bodies, working to align the project's Safety Assurance Framework with ongoing developments in ISO [22], ASAM [24], SAE [23] and BSI [26]. **Chapter 6** of this deliverable outlines the key stakeholders, describes the collaborative processes undertaken, summarises feedback received, and documents the early adoption and influence of SUNRISE outcomes across the standards ecosystem.

2 PROCESS OF COOPERATION WITH VEHICLE SAFETY BODIES

During the SUNRISE project, a wide range of cooperation activities were carried out with various national and international vehicle safety stakeholders. At the **UNECE** level, the SUNRISE project was presented at the GRVA [18] session in May 2024. Collaboration was also established with multiple **Type Approval Authorities** (KBA, RDW, VCA, the latter two also acting as technical services), **Technical Services** (UTAC, IDIADA), and the European Commission's **Joint Research Center**. In addition, the project engaged with the **consumer testing organisation** Euro NCAP [2] to support the alignment of consumer safety assessments with the SUNRISE SAF. Several **standards** were aligned with the SAF, reinforcing harmonised approaches to automated vehicle safety. The project also contributed to a **white paper** developed in collaboration with twin projects and initiatives. Notably, alignment was achieved with **twin initiatives** such as VVM [27], SAKURA [28], AVSC [29], Transport Canada [30], and KATRI [31] as well as with European projects like i4Driving [32] and SELFY [33].

2.1 Introduction Phase

In 2023, the SUNRISE initiative took important initial steps to identify key contacts within various vehicle safety bodies (VSBs) who would be relevant recipients of the SUNRISE SAF. A strategy was developed for approaching these stakeholders: the first step involved sending out a general project presentation. The second step, planned for a later stage, foresees re-engaging these contacts with more detailed information once the first results become available.

To support this outreach, a streamlined version of the SUNRISE project overview presentation was tailored specifically for communication with vehicle safety bodies. Based on this, initial discussions were conducted with key organisations such as the JRC, KBA, VCA, UTAC and Euro NCAP during 2023 and 2024. These discussions were held using the initial presentation, which did not yet include project results or detailed methodological information.

After the **introduction** phase all relevant vehicle safety bodies were made **aware of the SUNRISE SAF**.

2.2 Intermediate Phase

In 2024, efforts to present the SUNRISE project with greater methodological depth progressed significantly. As the official technical deliverables of SUNRISE did not yet include concrete elements of the SAF, an internal workshop was held on February 2, 2024, to identify and articulate the key advantages of the SUNRISE framework. Following this workshop, a new and more detailed version of the SUNRISE presentation was developed specifically for communication with vehicle safety bodies.

In-depth discussions took place with RDW, the Type Approval Authority of the Netherlands, KBA, the Type Approval Authority of Germany and VCA, the Type Approval Authority of the United Kingdom over summer 2024. Also, meetings with the Joint Research Centre of the European Commission and technical services like UTAC (France) and IDIADA (Spain and part of the SUNRISE project) have been held during that period. During these meetings, valuable feedback and suggestions were gathered and subsequently incorporated into the project's ongoing development.

In addition, a **presentation** of the SUNRISE project has been given at the **GRVA** in May 2024. SUNRISE has also been presented in the JRC working group for the **interpretation document** of Regulation (EU) No. 1426/2022 [17] on Automated Driving Systems.

There has been conducted a second workshop in autumn 2024 at the SUNRISE general assembly in San Sebastian with the technical work packages to update the presentation for the vehicle safety bodies. After that, a second round of workshops with the previous addressed SAF target users has been done in the final phase of cooperation.

Showing the draft technical results of the SUNRISE project in the intermediate phase could collect a lot of valuable feedback of the VSBs to lay the foundation for **the application and adoption** of the SUNRISE SAF by the VSBs in the final phase.

2.3 Final Phase

In the Final Phase of the cooperation between the SUNRISE project and the vehicle safety bodies a **SAF mock application** of the SUNRISE SAF was realised, to bring the SUNRISE SAF close to a real-world implementation. For that a SAF mock application was conducted with RDW, the Dutch Type Approval Authority, more details on this in section 4.5 and chapter 7. The mock-up application was **presented** at the **SUNRISE Final Event**. This SAF mock application showed an example implementation how a VSB could **apply and adopt** the SUNRISE SAF.

Before the SUNRISE Final Event in June 2025 there has been one final round of **workshops** with the vehicle safety bodies as a preparation before the Final Event. During these workshops the SUNRISE SAF could be presented in an already very mature state.

After the SUNRISE Final Event, there has been a workshop with KBA for a national alignment in Germany on scenario-based testing for Type Approval and SUNRISE has also been presented in this meeting.

So, it was demonstrated in the final phase that the SUNRISE SAF that some VSBs was **applied and adopted** by the VSBs.

3 COOPERATION WITH UNECE

3.1 Introduction of Stakeholder

3.1.1 UNECE WP.29 and GRVA

The United Nations Economic Commission for Europe (UNECE) operates the World Forum for Harmonisation of Vehicle Regulations (WP.29) as part of the Inland Transport Committee ITC. The World Forum serves as the primary global body for developing harmonised vehicle regulations. Within the forum, the Working Party on Automated/Autonomous and Connected Vehicles (GRVA [18]) plays a crucial role in shaping the future of automotive safety and technology standards. Documents such as UN R.157 [34], which regulates Automated Lane Keeping Systems, and the European Regulation 2022/1426 [17] provide the regulatory context for scenario validation and performance assurance. SUNRISE scenarios and test allocation method have been developed with reference to these documents to ensure compatibility with internationally agreed expectations for ADS behaviour, boundary conditions, and compliance verification.

Established during the 175th session of WP.29 in June 2018, GRVA (derived from the French "groupe des rapporteurs" for "véhicules automatisés") was formed in response to the rapid evolution of vehicle automation and connectivity technologies. As a specialised technical body, GRVA is responsible for:

- Developing regulatory frameworks for advanced vehicle systems
- Establishing uniform technical provisions for vehicle approval
- Creating harmonised performance requirements across global markets
- Formulating technical standards for emerging automotive technologies

The updated discussions of the GRVA can be found in [18].

3.1.2 GRVA's Regulatory Scope and Authority

GRVA's mandate encompasses critical safety domains including:

- Vehicle dynamics systems (braking, steering, stability)
- Advanced Driver Assistance Systems (ADAS)
- Automated Driving Systems (ADS) and autonomous vehicle technologies
- Cybersecurity provisions and software update management
- Connected vehicle technologies and their safety implications

The working party operates with significant authority, drafting regulations, guidance documents, and interpretation documents that, once adopted by WP.29, become legally binding under the 1958 Agreement (concerning uniform technical prescriptions) and the 1998 Agreement (concerning global technical regulations) for signatory countries.

GRVA exercises its mandate through a varying number of specialised Informal Working Groups (IWGs) and task forces with a concrete mandate, focused on specific technological areas such as:

- Task Force Advanced Driver Assistance Systems (ADAS): Developing requirements for systems that assist but don't replace drivers
- IWGs on Automatic Emergency Braking and Lane Departure Warning Systems (AEBS/LDWS): Focusing on collision avoidance technologies (finished)
- IWG Event Data Recorder and Data Storage System for Automated Driving (EDR/DSSAD): Establishing data recording standards for safety and accountability
- IWG Functional Requirements for Automated and Autonomous Vehicles (FRAV): Defining functional requirements for automated systems (finished)
- IWG Validation Methods for Automated Driving (VMAD): Creating testing and validation frameworks for automated vehicles

In November 2023, during its 191st session, WP.29 adopted a significant structural reorganisation with the establishment of a new IWG on Automated Driving Systems (ADS). This restructuring represents a strategic pivot toward comprehensive regulation of autonomous technologies, building upon the foundational work of FRAV and VMAD working groups.

The FRAV-VMAD integrated document (GRVA-18-50), adopted by WP.29 in June 2024, represents a milestone in regulatory convergence. Following this, the newly formed ADS IWG has been tasked with drafting complete regulatory text on ADS by June 2026. This ambitious regulatory timeline reflects the increasing urgency to establish global requirements for automated driving technologies that ensure safety while enabling technological innovation across international markets.

3.2 Collaboration and Process during the Project

This project has established collaborative engagement with UNECE authorities through strategic participation and monitoring activities that ensure alignment with evolving international standards.

3.2.1 UNECE Regulatory Landscape Analysis and Monitoring

The project team has maintained continuous monitoring and active follow-up of discussions within the UNECE GRVA Informal Working Group on Automated Driving Systems (ADS), enabling real-time tracking of regulatory developments and emerging requirements that directly impact project objectives. This strategic alignment with evolving international standards ensures that the project remains responsive to regulatory expectations and can anticipate future compliance requirements.

Building upon this regulatory monitoring foundation, the project has undertaken a comprehensive analysis and incorporation of the New Assessment Test Methodology (NATM) documentation released by the FRAV and VMAD Informal Working Groups. The technical integration of NATM principles into the SUNRISE SAF represents a critical step in ensuring alignment with internationally recognised testing and assessment standards. This integration process has enabled the project to bridge the gap between regulatory requirements and practical implementation approaches.

In addition, through its GRVA working groups on FRAV and VMAD [35], SUNRISE reviewed and referenced evolving drafts of UN R.157 [36] and EU REG 2022/1426 [17], which informed how the project approached scenario definition, system boundary management, and performance monitoring. The SUNRISE SAF is compatible with regulatory validation procedures, especially within the context of the New Assessment/Test Method (NATM) [1] framework.

To maximise the value of these regulatory insights, the SUNRISE project team has developed **two specialised reports** designed for partner knowledge enhancement and practical application. These reports systematically document regulatory insights and technical requirements while maintaining a strategic focus on critical scenario-based considerations derived from UNECE discussions. This knowledge transfer approach has materialised through the development of the SUNRISE SAF by SUNRISE, which incorporates NATM alignment and provides concrete tools for scenario-based assessment.

The first report provides an overview of VMAD (Validation Method for Automated Driving) and FRAV (Functional Requirements for Automated Driving) working groups. It details the five-pillar validation approach (audit & assessment, simulation & virtual testing, track testing, Real-World Testing and In-Service Monitoring) and outlines scenario development methodologies with four categorisation layers (functional, abstract, logical, concrete). The report covers subgroup developments in scenarios, virtual testing, audit frameworks, and testing protocols, representing the foundational collaborative effort to establish both requirements and validation methods for automated driving systems.

Report on the IWG ADS (ANNEX 1)

This comprehensive report documents the Automated Driving Systems (ADS) Informal Working Group negotiations and describes the NATM framework and establishes scenario-based safety assessment methodologies (nominal, critical, failure scenarios), performance criteria development including ODD analysis and OEDR requirements, safety model methodologies for collision scenarios, a detailed virtual testing credibility assessment framework, and comprehensive In-Service Monitoring and Reporting (ISMR) templates.

3.2.2 UNECE GRVA presentation

The SUNRISE project achieved a significant milestone through its formal presentation to the United Nations Economic Commission for Europe (UNECE) Working Party on Automated/Autonomous and Connected Vehicles (**GRVA**). This presentation served as a crucial platform to introduce the project's innovative approach to automated driving safety assurance and establish the project's credibility within the international regulatory community.

The presentation to GRVA was strategically designed to showcase the initial SAF developed by SUNRISE and demonstrate its alignment with ongoing regulatory developments. This initiative represented a proactive approach to engage with international regulatory bodies during the early stages of framework development, ensuring that the project's methodologies would be compatible with emerging global standards and regulatory expectations.

The timing of this presentation was particularly significant, as it occurred during a period of intensive regulatory activity within GRVA, coinciding with the ongoing work of the **FRAV** and **VMAD** informal working groups and the establishment of the new ADS Informal Working Group. By presenting the initial SAF at this critical juncture, the SUNRISE project positioned itself as a valuable contributor to the international dialogue on automated driving safety validation.

The SAF presentation highlighted the project's commitment to scenario-based safety assessment and its integration with internationally recognised methodologies, particularly the New Assessment Test Methodology (**NATM**) principles developed within the FRAV and VMAD working groups. This alignment demonstrated the project's understanding of regulatory requirements and its ability to contribute meaningfully to the development of harmonised international standards.

3.2.3 UNECE GRVA representatives in final event

To present the project outcomes to relevant authorities, a strategic stakeholder engagement approach was implemented through the organisation of a dedicated final event. This SUNRISE Final Event celebrated on June 18th 2025 at IDIADA in Spain, served as a culminating platform to showcase the comprehensive results of the project and demonstrate their practical relevance to the international regulatory community working on automated driving systems safety validation.

Strategic Invitation Process

The project team implemented a targeted invitation strategy focusing on key policymakers and stakeholders actively involved in discussions at both UNECE and European Commission levels. This approach ensured that the final event would bring together the most relevant decision-makers and technical experts who could assess the practical applicability of the project outcomes within existing and emerging regulatory frameworks. The invitation process prioritised individuals with direct involvement in GRVA working groups, ADS regulatory development, and related policy formulation activities.

Stakeholder Representation and Participation

The final event successfully attracted participation from multiple stakeholder categories, including representatives from UNECE GRVA working groups, national regulatory authorities, European Commission, technical services, and industry experts involved in automated driving system development and validation. This diverse representation created an ideal environment for comprehensive evaluation of the project outcomes and facilitated meaningful dialogue between researchers, regulators, and industry practitioners.

The **presence of GRVA representatives** such as the JRC, KBA, VCA and other **"Officers of Principal Interest" (OPIs)** participants, was particularly significant, as these individuals brought direct insight into ongoing regulatory discussions and could provide immediate feedback on the alignment between SUNRISE outcomes and current regulatory development priorities. Their participation validated the project's approach to regulatory monitoring and demonstrated the practical relevance of the developed frameworks.

Feedback from the **SUNRISE final event** (June 2025) showed that the SAF is broadly compatible with existing processes and valued for safety argumentation and scenario databases. Participants expressed strong **interest in future use**, especially in virtual and hybrid test environments, though the **lack of legal requirements may slow adoption**. **Alignment with ISO, UNECE, and EU standards** was highlighted as essential for broader uptake. For further details and a summary of the feedback on the SAF presented at the SUNRISE Final Event, please refer to **Deliverable D9.3, chapter 6** [37].

3.3 Potential Usage of the Project Outcomes

3.3.1 UNECE GRVA contribution to ADS interpretation document

The ADS Informal Working Group within UNECE GRVA has made substantial progress in developing a comprehensive UN Regulation on ADS, with the regulatory framework nearing completion. This regulation represents a landmark achievement in international harmonisation of automated driving system safety requirements, establishing binding technical standards that will govern the approval and deployment of automated vehicles across signatory countries. The regulation's development reflects years of collaborative work among international experts, regulatory authorities, and industry stakeholders to create a robust framework for ADS safety validation.

As the primary regulation approaches finalisation, the need for comprehensive interpretation documents has become increasingly critical. These interpretation documents serve as essential guidance materials that provide detailed explanations of regulatory requirements, clarify implementation procedures, and offer practical guidance for manufacturers, testing organisations, and approval authorities. The interpretation document will bridge the gap between high-level regulatory requirements and practical implementation, ensuring consistent application of the regulation across different jurisdictions and market conditions.

The SUNRISE project has identified a strategic opportunity to contribute to the development of the upcoming UN Regulation on Automated Driving Systems (ADS) interpretation document, representing a significant potential impact for the project's research outcomes.

This opportunity emerged through engagement with the Programme Manager for Scientific Research at the European Commission Joint Research Centre (JRC) and partner of the ADS Informal Working Group. This engagement has opened a direct channel for SUNRISE project outcomes to be considered as input for the interpretation document coordinated by the JRC, representing a valuable opportunity to translate research outcomes into practical regulatory guidance.

The collaborative framework established with the JRC demonstrates SUNRISE's commitment to ensuring that research outcomes achieve practical impact within the regulatory ecosystem. By coordinating the interpretation document development process, the JRC provides SUNRISE with direct access to regulatory discussions and an avenue to contribute technical expertise and practical insights gained from the SAF development. This represents a very good opportunity to shape future standards and regulations. To ensure the impact continues beyond the project's lifetime, relevant stakeholders have been informed where to access the documents and outcomes, helping maintain visibility and supporting ongoing engagement after SUNRISE's conclusion.

3.3.2 Project Outcome Summaries for ADS Interpretation Document Contribution

WP8 of the SUNRISE project has developed four specialised technical topics (which have been worked out for the interpretation document) coming from (parts of) the SUNRISE deliverables D3.3 [11], D5.3 [7], D4.4 [13] and D6.1 [8] that directly support the implementation and interpretation of ADS safety validation requirements:

1. SUNRISE Initial Allocation Process (see Annex 2 and SUNRISE D3.3 [11])

This framework presents a systematic methodology for test case allocation to appropriate testing environments (virtual, X-in-the-Loop, proving grounds). Using a hierarchical decision-making approach based on ISO 34503 [38], it balances test execution efficiency with result reliability, ensuring safety-critical scenarios receive appropriate validation coverage through intelligent test instance selection.

2. SUNRISE Scenario Quality Metrics (see Annex 2 and SUNRISE D5.3 [7])

This document establishes five metric categories for scenario quality assessment: testing purpose, scenario description, scenario exposure, (dis)similarity, and coverage. It provides methodologies for measuring scenario relevance, criticality, and real-world representativeness, creating a comprehensive framework for evaluating validation

3. SUNRISE Automated Query Criteria Generation (see Annex 2 and SUNRISE D6.1 [8])

The Automated Query Criteria Generation (AQCG) tool streamlines scenario database searches by automatically generating query criteria based on Operational Design Domain (ODD) definitions and test requirements. This tool reduces manual effort while ensuring systematic scenario selection with clear traceability to safety requirements, supporting comprehensive validation coverage mandated by ADS regulations.

4. SUNRISE Harmonised V&V simulation framework (see Annex 2 and SUNRISE D4.4 [13])

This document establishes the technical foundation for simulation-based validation by structuring the system into five core domains: **sensor set-up** (vehicle state, perception, and ODD attribute sensors), **environment/ODD modelling** (connectivity, scenery, and traffic agents), **software architecture** (sense, plan, and act functions), **hardware architecture** (vehicle dynamics, powertrain, steering, and E/E architecture), and **test case management** to orchestrate interactions between these domains. The approach emphasises harmonisation through standardised interfaces (e.g., ASAM OSI, FMI) to ensure interoperability across simulation platforms, thereby providing essential guidance for implementing comprehensive virtual testing frameworks in support of ADS regulations.

4 COOPERATION WITH EUROPEAN COMMISSION AND ITS MEMBER STATES

4.1 Introduction of Stakeholder

The **European Commission** plays a central role in the field of Connected, Cooperative, and Automated Mobility (CCAM), being crucial in shaping the political and regulatory frameworks for these technologies. The European Commission is responsible for developing and implementing strategies that promote research, innovation, and the deployment of connected, cooperative, and automated mobility systems. It fosters collaboration between member states and industry and ensures that CCAM technologies are developed in line with the EU's goals of sustainability, safety, and competitiveness.

A key step taken by the European Commission was the release of the "Strategic Plan for the Automation of Mobility" and the initiation of programs such as the "Digital Europe" program and Horizon Europe, which provide funding for research projects in this field. The European Commission is also working to create a legal framework that enables the development and testing of automated vehicles and connected transport systems while ensuring public safety and data protection.

The **EU member states** are involved in the implementation of these strategies by developing national plans for the integration of CCAM technologies. They work closely with the European Commission to harmonise technological regulations and create unified regulations that enable cross-border solutions. Collaboration in various research partnerships and the execution of pilot projects are additional important tasks where member states play a key role. Through coordination between the European Commission and the member states, it is ensured that CCAM developments are advanced in a compatible and sustainable manner across the European Union.

Overall, the close cooperation between the European Commission and the member states helps strengthen Europe's competitiveness in the field of intelligent mobility while enabling the transition to a more sustainable and safer transportation infrastructure.

The European Commission also works closely with its **Joint Research Centre (JRC),** which is its in-house science service, providing independent research, methods, and technical expertise to support evidence-based EU policies and regulations, also in the field of CCAM safety. The JRC provides scientific and technical support to EU policies, conducting research and analysis to guide decision-making in the field of automated and connected mobility. It works on evaluating the safety, environmental impact, and potential societal benefits of CCAM technologies, providing evidence-based insights to inform both EU-level policies and national strategies. Through its work, the JRC helps ensure that the deployment of CCAM technologies is both safe and effective, contributing to the overall success of the European Commission's strategic goals.

4.2 Collaboration and Process during the Project

The collaboration potential between the European Commission (EC) and various stakeholders in the field of CCAM is vast and multifaceted. One of the key areas of collaboration is in research and innovation. Through programs like Horizon Europe and the Digital Europe Programme, the EC offers significant funding opportunities for research projects focused on CCAM. These collaborative efforts bring together universities, research centers, and industry players, enabling the development of new technologies, safety standards, and policy frameworks. The Joint Research Centre (JRC) of the EC plays a particularly important role, providing scientific expertise and conducting studies to inform decision-making in CCAM.

Another crucial area for collaboration is in standardisation and regulation. The EC works closely with member states, technical bodies such as CEN and ISO, and industry leaders to develop common standards and regulatory frameworks for autonomous vehicles and connected infrastructure. Harmonising these standards across the EU is essential for ensuring that CCAM technologies are interoperable and can be adopted seamlessly across borders, ultimately helping to foster a single European market for these technologies.

Pilot projects and real-world testing environments also present significant collaboration opportunities. The EC supports various pilot projects, like those within the European Mobility Innovation Platform (EMIP), to test and refine CCAM technologies in practical settings. These projects involve collaboration between member states, industry stakeholders, and the European Commission, generating valuable data on safety, efficiency, and public acceptance, which can help shape future policies and technological development.

Public-private partnerships are another promising avenue for collaboration. The EC encourages cooperation between the public sector and private companies, particularly automotive manufacturers, technology firms, and infrastructure providers. These partnerships enable joint ventures focused on developing and deploying CCAM solutions in a way that balances innovation with societal benefits.

Additionally, the EC's efforts to promote data-sharing platforms and digital infrastructure are critical for CCAM development. The European Data Strategy is one such initiative, aiming to create a unified European data space that facilitates the sharing of mobility data across sectors. This collaboration can lead to the optimisation of intelligent transport systems and enhance the performance of connected vehicles.

Finally, the EC also seeks international collaboration on CCAM, engaging with global partners to address cross-border challenges and promote the alignment of global standards. This international approach helps ensure that Europe remains at the forefront of the global transition to automated mobility.

In essence, the European Commission provides numerous avenues for collaboration, offering opportunities to engage stakeholders across research, industry, regulation, and international cooperation. These collaborative efforts are essential for accelerating the development and deployment of CCAM technologies, ensuring they are safe, efficient, and aligned with societal goals.

Regarding the process of cooperation multiple online and in-person workshops with several VSBs were conducted in multiple phases (see chapter 2). In the first phase, stakeholders were introduced to the SUNRISE project to raise initial awareness. In the second phase, the workshops focused on delivering tailored content based on the specific interests and needs of the stakeholders.

In 2023, the SUNRISE initiative took important initial steps (see section 2.1) to identify key contacts within various vehicle safety bodies (VSBs) who would be relevant recipients of the SUNRISE SAF. A strategy was developed for approaching these stakeholders: the first step involved sending out a general project presentation. The second step, planned for a later stage, foresees re-engaging these contacts with more detailed information once the first results become available. To support this outreach, a streamlined version of the SUNRISE project overview presentation was tailored specifically for communication with vehicle safety bodies. Based on this, initial discussions were conducted with key organisations such as the JRC, KBA, VCA, UTAC during 2023 and 2024. These discussions were held using the **initial presentation**, which did not yet include project results or detailed methodological information.

In-depth discussions (mostly in-person workshops) took place in the second phase (see section 2.2) with RDW, the Type Approval Authority of the Netherlands, KBA, the Type Approval Authority of Germany and VCA, the Type Approval Authority of the United Kingdom over summer 2024. Also, meetings with the JRC and technical services like UTAC (France) and IDIADA (Spain and part of the SUNRISE project) have been held during that period. During these meetings, valuable feedback and suggestions were gathered and subsequently incorporated into the project's ongoing development.

In the Final Phase (see section 2.3) of the cooperation between the SUNRISE project and the vehicle safety bodies a **SAF mock application** of the SUNRISE SAF was realised, to bring the SUNRISE SAF close to a real-world implementation. This SAF mock application was conducted with RDW, the Dutch Type Approval Authority, more details on this in section 4.5 and chapter 7. The mock-up application was **presented** at the **SUNRISE Final Event**. This SAF mock application showed an example implementation how a VSB could **apply and adopt** the SUNRISE SAF.

Before the SUNRISE Final Event in June 2025 there has been one final round of **workshops** with the vehicle safety bodies as a preparation before the Final Event. During these workshops the SUNRISE SAF could be presented in an already very mature state.

After the SUNRISE Final Event, there has been a workshop with KBA for a national alignment in Germany on scenario-based testing for Type Approval and SUNRISE has also been presented in this meeting.

4.3 Feedback of Stakeholder

JRC demonstrated strong and structured interest in the SUNRISE project, particularly in its methodological contributions to future regulations. One key area of focus was the SUNRISE SAF, especially regarding the assignment of secenario to test instances and how this might affect regulatory decision-making. The JRC appreciated the connection between SUNRISE and ongoing standardisation efforts such as ISO TR 17720 (Operational Design Domain definition) and the proposed natural language scenario description work within ISO and UNECE. They also raised questions about scenario selection and the SUNRISE Data Framework, specifically when overlaps occur between databases and how coverage metrics might help distinguish them. The timing and availability of concrete database examples was of interest, particularly in relation to the EU Interpretation Document on regulation EU 2022/1426 [17]. Furthermore, JRC expressed curiosity about specific SUNRISE use cases, such as the “Freight vehicle automated parking” (WP7), and showed interest in preliminary results from methods like those developed in Task 4.6 [15]. Overall, JRC values SUNRISE’s potential to influence both European and international regulatory frameworks and is looking forward to detailed results as they become available.

KBA approached the SUNRISE project from a very practical, implementation-oriented perspective. They emphasised the potential of SUNRISE to simplify and standardise the current safety argumentation process that vehicle manufacturers must follow. At present, these arguments are often built from scratch and differ significantly across submissions. SUNRISE, through its structured SAF and coverage-guided testing strategies, could streamline this process and increase consistency. KBA expressed a need for clarity on how test case selection is optimised within SUNRISE—what logic or algorithm governs this process—and requested illustrative examples (e.g., from Work Packages 2 and 3). Similarly, they asked for further details on the functioning of the coverage and quality metrics. Another open point was whether the tools developed by SUNRISE, particularly interfaces to access the scenario database, would be freely available or come at a cost, and whether a web-based interface was planned. KBA indicated interest in continuing the conversation in a follow-up meeting, once more tangible outputs and examples are available.

RDW provided detailed and constructive feedback, particularly focused on the structure and logic of the SUNRISE SAF. They proposed potential improvements, such as including feedback loops from real-world driving back into scenario development, to reflect the emergence of new edge cases during actual usage. RDW questioned why coverage evaluation only appears late in the workflow and suggested it might be more effective to integrate it earlier, possibly even during scenario generation or test execution planning. They also inquired about the validation status of the toolchain, especially in XiL (X-in-the-Loop) setups, and whether any form of tool qualification (e.g., per ISO 26262 [39]) was pursued or required. On the scenario database, they asked whether minimum data point thresholds are embedded in quality or coverage metrics. Regarding use cases, RDW raised the question of why decision strategies were not assessed in UC1 and highlighted that even subsystem-level functions like perception are relevant for Type Approval, particularly in safety audits. They offered to conduct a mock type approval based on SUNRISE use cases and stressed that the SAF should work with or without simulation software. Additionally, RDW suggested clarifying the term “EU Test Case Library” in project materials, as it might be misleading. They also discussed the potential role of EuroNCAP [2] in rating ADS systems, emphasising the user perception of safety (e.g., use of signals) as a possible metric.

VCA’s feedback focused strongly on regulatory trust and the robustness of the safety argumentation process. They questioned how safety arguments are structured, especially in light of qualitative regulatory requirements, and whether SUNRISE can provide structured, auditable support for fulfilling such requirements. The agency emphasised that manufacturers must present clear, traceable justifications for compliance, and SUNRISE's SAF might aid in standardising these arguments. A notable difference in VCA's approach is their deep scrutiny of perception systems, as VCA also functions as a technical service, conducting hands-on verification beyond what is typical at other approval authorities. VCA expressed interest in using a web-based frontend for the (randomised) selection of test cases to supplement manufacturer-conducted testing, and they asked whether such a frontend is being developed. They also raised questions about how SUNRISE supports mutual recognition of vehicle approvals across different countries, particularly when regulations emphasise processes and audits over clearly verifiable technical requirements. Additionally, they pointed out that SUNRISE should engage actively in ongoing UN-level scenario database discussions, where foundational frameworks are being developed. Other points of interest included the rationale for excluding trucks from use cases (due to availability) and the practical implications of "adoption" of the SUNRISE SAF by regulators and industry—suggesting a softer term like "use" might be more appropriate.

4.4 Potential Usage of the Project Outcomes

The SUNRISE SAF provides a structured, evidence-based approach to evaluating the safety of Automated Driving Systems (ADS), designed to support both regulatory bodies, technical authorities and industry users. For the European Commission and EU Member States, this framework presents a highly valuable approach for **harmonising safety assessment procedures** across the European Union, while remaining adaptable to national contexts.

At its core, the SAF supports a process-oriented regulatory environment, aligning with the structure of current and future EU regulations such as EU 2022/1426 [17]. It facilitates the creation and validation of safety arguments by vehicle manufacturers, enabling authorities to systematically assess compliance, even for non-numeric or process-based requirements. This is especially relevant as many ADS-related regulations rely not only on test results but also on structured documentation, scenario coverage, and audit-based evaluation.

One key benefit of the SAF is its modularity and transparency. By offering tools for test case selection (e.g., risk-based, random sampling), scenario coverage analysis, and traceability across development stages, it supports technical services and approval authorities in making robust, reproducible decisions. Member States can use the SAF to standardise their type approval processes, increasing efficiency and reducing variability between national authorities.

Furthermore, the SAF integrates well with existing and emerging international standards (e.g., ISO TR 17720), and its design encourages participation in ongoing global regulatory and harmonisation efforts, such as those at UNECE or within the UN scenario database initiatives. This alignment not only strengthens the EU's global influence but also lays the foundation for mutual recognition of approvals across jurisdictions.

For the European Commission, the SAF provides a powerful mechanism to guide the interpretation and evolution of EU-level legislation, facilitate cross-border data and scenario sharing, and promote innovation while safeguarding public trust. Through the SUNRISE SAF and Data Framework (see D6.3 [40] section 1.5), the EC can foster industry-regulator collaboration, and ensure that safety assurance keeps pace with rapidly advancing vehicle technologies.

Feedback (see chapter 4.3) indicated that VSBs do not carry out all safety assurance steps themselves; instead, certain steps require **regulatory witnessing** rather than direct execution (see Figure 6). This highlighted the need for clear guidelines on how to witness or audit the SAF steps from an authority's perspective. In response, **application guidelines** were developed and implemented in the online **SAF Handbook** [41] and SUNRISE Deliverable D2.3 [3]. These guidelines support VSBs in applying/auditing SAF steps, such as scenario creation, environmental modelling, and the development of safety arguments, while also allowing them to provide external requirements relevant to safety assurance.

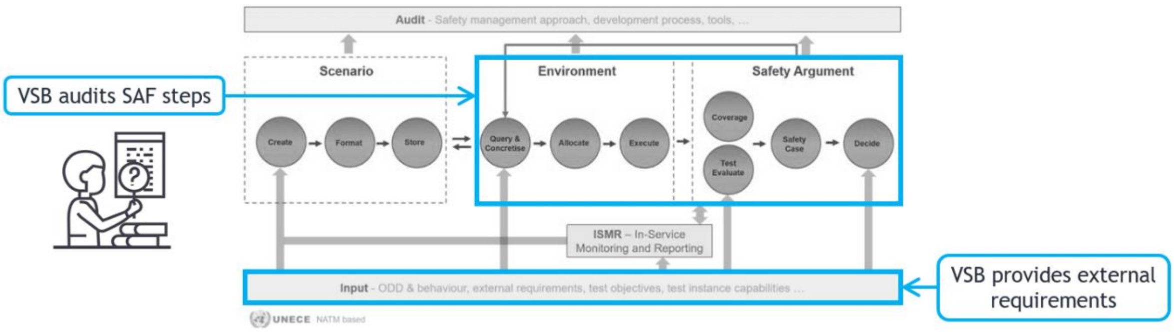


Figure 6: Vehicle Safety Body audits the SAF

In addition, the general usage and **recommendation for the VSBs** for how to apply each individual SAF block and references to the corresponding deliverable can be found in **section 1.5**.

4.5 SAF Mock Application

To validate the practical application and usefulness of the SUNRISE SAF, a **mock-up approval assessment** was conducted in close collaboration with the Dutch Type Approval Authority (RDW). The goal was to **simulate a real-world regulatory process** using the SAF to assess an automated driving system, thereby generating structured **feedback from regulatory experts** and identifying areas for further development. To let this vison become reality several meetings with RDW were scheduled to plan for this mock-up approval assessment (see Figure 7).

Figure 7: SAF Mock Application - Vision (left) & Reality (right)

The mock-up focused on demonstrating how theoretical SAF elements can be implemented in practice, bridging the gap between abstract framework design and regulatory reality. It aimed to build trust among authorities and stakeholders by showcasing how the SAF can support safety argumentation, compliance assessment, and auditing processes.

The process began with RDW acting as the authority, receiving system and use case information from the SUNRISE consortium. In response, RDW derived a set of external requirements by first analysing the System Under Test and its relevant scenarios. Then, regulatory requirements (in this case from UNECE R157.01 [34]) were extracted, adapted to the given use case, and validated for applicability, especially concerning the suitability of prescribed metrics for the use case in question.

Once external requirements were defined, SUNRISE carried out both physical and virtual testing and compiled a safety report. RDW then audited the SAF process, following the authority-oriented **application guidelines** provided within the SAF Handbook [41]. The audit followed five structured steps: understanding the SAF structure, gathering evidence for each SAF block, auditing that evidence against the framework's guidelines, checking for completeness and parameter coverage (including scenario criticality), and summarising findings from a type approval perspective in alignment with ISO 17021 principles.

The selected use case for this mock assessment was **SUNRISE Use Case 3.2**, which provided a concrete, scenario-based highway pilot example to test the SAF structure. The full process helped highlight how regulatory authorities can "witness" or audit a developer's SAF application without needing to reproduce each test themselves, clarifying roles and responsibilities under process-driven regulatory regimes.

From the authority's perspective, key lessons emerged. Most notably, there is **currently no regulatory obligation for developers to follow SAF**; thus, compliance is voluntary unless SAF is embedded into regulation. Additionally, reliance on external scenario databases, which are not yet standardised or regulated, poses a challenge for consistent SAF application. Nevertheless, when used, SAF can form the **basis of a comprehensive safety argument** that covers a wide range of evidence necessary for validation and verification.

From SUNRISE's point of view, the mock-up demonstrated the framework's flexibility to support different types of users—regulators, auditors, developers—and underscored the value of tailored application guidelines. The collaboration with RDW confirmed that real-world regulatory authorities can meaningfully engage with the SAF process, and that such tools can help bridge current gaps in automated vehicle safety assurance.

In conclusion, the **SAF mock application** validated both the relevance and potential impact of the SUNRISE SAF in **supporting future regulatory assessments** of automated driving systems. It also highlighted the importance of harmonising scenario databases, formalising audit procedures, and embedding SAF principles into evolving regulations to fully realise its benefits. More details on the SAF mock application and also the contribution from the Dutch type approval authority RDW can be seen in **chapter 7**.

5 COOPERATION WITH CONSUMER TESTING

5.1 Introduction of Stakeholder

Around the world various organisations provide consumers with an independent assessment of the safety level of vehicles that goes beyond the regulatory requirements. The most known ones are often referred to as New Car Assessment Programmes (**NCAPs**) and are modelled after the New Car Assessment Program, introduced 1979 by the US National Highway Traffic Safety Administration (NHTSA). The NCAPs award 'star ratings' based on the performance of the vehicles in a variety of safety related tests and assessments. Currently there are NCAPs in; Australia, New Zealand, India, Southeast Asia, China, Europe, US, Japan, Korea and Latin America. The organisation behind the different NCAPs varies, where some have a single entity (governmental, insurance, etc.) background and others have a variety of members including governments, consumer organisations, automobile associations and insurance entities.

The different NCAPs vary in application area and have different tests, addressing the area specific safety topics and considering the area specific safety equipment fitment. In general, the assessment is based on the performance of the cars with the standard fitted safety equipment. In some cases it is possible to have more advanced features included in the assessment. Originally the assessments are addressing passenger cars, but in recent years also vans and even trucks are being rated. Especially the assessments of active safety features and assisted driving are based on a scenario-based approach.

The results are published on publicly available websites and published by renowned journalists in large variety of media to inform the general public. Many OEMs also use the NCAP star rating in advertisements to demonstrate the safety performance of their vehicles.

Over the years the requirements to achieve the maximum number of stars (in general 5) increase by more stringent requirements or introduction of additional tests. In the early days the tests were related to passive safety, but in current NCAP programmes active safety, and for some even assisted driving, plays an important role.

Euro NCAP is the single NCAP active in Europe. Euro NCAP has been established in 1997 and is composed of members representing several European governments as well as insurance, motoring and consumer organisations from a variety of European countries. Euro NCAP makes use of several independent test labs spread over Europe to execute the tests.

The protocols used by the Euro NCAP labs for the official assessments are created by so called working groups (WGs). In these WGs Euro NCAP, Euro NCAP member (representatives) and labs work together with industry representatives to create challenging but feasible requirements for upcoming assessment. This to ensure that new requirements have a safety benefit but are also feasible to be introduced by OEMs within the timeline of the protocol introduction.

5.2 Collaboration and Process during the Project

5.2.1 Euro NCAP

Euro NCAP is extending their assessment of active safety features and assisted driving to further improve safety. However, in order to keep the testing by the Euro NCAP laboratory manageable future assessment will more and more use information provided by the OEM in combination with verification tests on test track and public road. This information created by the OEM will increasingly rely on simulation data, as more and more scenarios will be included. In order for Euro NCAP to trust these virtual testing results additional information about the simulation tools and models are required.

The scenario-based approach and usage of virtual testing are also keystones of SUNRISE and collaboration on these topics is therefore of mutual interest.

Euro NCAP itself is an entity with limited number of employees, of which only a few are involved in the technical development and execution of assessments. Most relevant for SUNRISE are the technical director and technical manager that deal with active safety. Besides Euro NCAP directly the community around Euro NCAP that supports the development of upcoming assessment is very relevant for SUNRISE, this consists of Euro NCAP members, Euro NCAP labs and knowledge and industry partners. These parties come together in various Euro NCAP working groups (WGs) in which assessments are discussed and developed. Different SUNRISE partners are participating in these Euro NCAP working groups and they incorporate the SUNRISE developments into the Euro NCAP developments where possible. On a few occasions the SUNRISE developments have been presented in the Euro NCAP WGs.

Most relevant Euro NCAP WGs that are addressing the developments are:

- Euro NCAP Assisted Driving WG
- Euro NCAP Crash Avoidance WG – AEB/AES and LSS
- Euro NCAP Virtual testing for ADAS

Euro NCAP participated in SUNRISE Expert Platform and was present at SUNRISE final event.

Various Euro NCAP labs are SUNRISE partners; BASt, IDIADA, TASS International (Siemens) and TNO and active contributors to the SUNRISE expert platform and SUNRISE final event.

Besides that another Euro NCAP lab, AstaZero, was present at the SUNRISE final event.

5.2.2 Other NCAPs

The independent safety assessment approaches by the NCAPs differ, but in essence have a lot in common, so interaction and exchanging information between NCAPs will be beneficial for all parties. It needs however to be taken into account that Euro NCAP is a front-runner with respect to safety assessment, due to mature market and advanced technologies. Therefor not all NCAPs might already be at the level of Euro NCAP and their added value to SUNRISE might be limited.

5.2.3 Overview of NCAPs

During the SUNRISE project, a comparison has been made of different NCAPs with respect to whether a scenario-based approach has been followed and simulations/virtual testing (by OEM) are part of assessment.

Overall, the inclusion of virtual testing as part of consumer testing is very limited, but several consumer organisations indicated that this is on their roadmap to be considered in near/mid future. To some extend all consumer testing uses a scenario-based approach for the assessment of assisted driving features, mainly emergency features, like AEB and ELK. Automated driving is only addressed by a few, as for many regions not relevant yet and uncertain what exact role consumer testing should play.

In Annex 4 of this deliverable more detailed information about how the different NCAPS use a scenario-based approach and simulation/virtual testing (by OEM) can be found. This information has been used during the SUNRISE project to understand the needs of the different consumer organisation with respect to SUNRISE relevant topics.

5.3 Feedback of Stakeholder

5.3.1 Euro NCAP

Besides active interaction in various Euro NCAP WGs with different participants, Euro NCAP has also been consulted directly to align on the SUNRISE activities. Euro NCAP is part of the SUNRISE Export Platform.

Besides the direct interaction with Euro NCAP and in Euro NCAP WGs there is also much interaction and collaboration with the different entities and companies active in the Euro NCAP scene. The results of these indirect interactions are difficult to describe and quantify but should not be neglected.

Euro NCAP and various Euro NCAP stakeholders indicated the benefit of a common Safety Assurance Framework and added value of assessment methods, tools and quality metrics for scenario definition, scenario databases and virtual testing. Euro NCAP provided general feedback via the SUNRISE expert platform and during the final event, no concrete feedback on SUNRISE results specifically related to consumer testing was received.

5.3.2 Other NCAPs

SUNRISE has reached out to various NCAPs to gather information about their position on scenario-based assessment and in particular with respect to usage of simulation results. Several (entities supporting) NCAPs are part of the SUNRISE Export Platform and are providing feedback on the developments within SUNRISE. No concrete feedback on SUNRISE results specifically related to consumer testing was received from the other NCAPs.

The responses indicated that the consumer organisations are all considering inclusion of virtual testing to some extend in near or mid future, depending on the maturity of their market. Also, more usage of scenario-based approach is expected as assisted driving and even automated driving become more extensive and in scope of consumer testing organisations.

In Annex 4 of this deliverable more detailed information can be found.

5.4 Potential Usage of the Project Outcomes

The collaboration with Euro NCAP and other NCAPs during SUNRISE has shown that project outcomes are most relevant where **scenario-based assessment** and **virtual testing** are being introduced. Euro NCAP, which is already preparing a transition to virtual testing, acknowledged the value of the SUNRISE SAF as a **structured basis for integrating simulation data** into consumer testing.

It should be noted that SUNRISE did not result in recommendations targeted exclusively at consumer testing. This is because consumer testing is essentially an assessment activity with some specific focus areas, but without unique methodological requirements compared to other domains in relation to the scenario-based approach. The feedback gathered confirmed the **relevance of SUNRISE outcomes**, but did **not** point to a **need** for **consumer-testing-specific adjustments**.

Nevertheless, several outcomes of the project are directly relevant for NCAPs as they gradually integrate **scenario-based** methods and **virtual testing** into their procedures. Euro NCAP in particular acknowledged the value of a **structured safety assurance framework** to support the increasing use of simulation. The SUNRISE SAF provides such a structure and was discussed with Euro NCAP stakeholders in working groups, through the Expert Platform, and during the Final Event. The **SAF blocks** and **application guidelines** explained in deliverable D2.3 [3], together with **quality metrics** for scenarios and scenario databases explained in deliverable D5.3 [7], can be applied in the context of consumer testing just as in other assessment settings.

In summary, SUNRISE outcomes are **not tailored exclusively to consumer testing** but remain **highly relevant for NCAPs**. They offer a solid foundation for integrating virtual and scenario-based approaches into future safety assessments.

6 COOPERATION WITH STANDARDISATION BODIES

6.1 Introduction of Stakeholder

A range of key standardisation and regulatory stakeholders are considered to ensure that the SUNRISE SAF aligns with the broader international landscape for safety of automated driving systems. Among the most relevant stakeholders in this context are the International Organisation for Standardisation (**ISO**), the Association for Standardisation of Automation and Measuring Systems (**ASAM**), the Society of Automotive Engineers (**SAE** International) and the British Standards Institution (**BSI**. Each plays a distinct and complementary role in shaping the frameworks and expectations that influence scenario-based validation and safety assurance.

ISO is responsible for international standards development across multiple sectors, including intelligent transport systems and functional vehicle safety. Within the scope of SUNRISE, engagement with ISO technical committees such as **TC204** (Intelligent Transport Systems) and **TC22 SC33** (Functional Safety and Automated Driving) has been highly relevant. Standards including **ISO 34503** [38], which defines an operational design domain taxonomy, **ISO 34502** [42] on scenario-based safety evaluation, and the draft **ISO TS 5083** on structured safety cases are particularly aligned with SUNRISE's SAF. These documents underpin the approach to scenario classification, safety argumentation, and performance verification.

ASAM develops technical standards for simulation, testing, and development processes in the automotive industry. The SUNRISE SAF is closely linked to ASAM's OpenX initiatives, they include **OpenDRIVE** [43], **OpenSCENARIO** [44], **OpenSimulationInterface** [45], **OpenODD** [46], **OpenLABEL** [47], **OpenXOntology** [48]. These initiatives directly support the SAF's use of virtual testing, cross tool interoperability, and consistent scenario based evaluation. Alignment with ASAM ensures that SUNRISE outputs remain compatible with widely adopted simulation standards and contribute to shaping them where gaps exist.

SAE International maintains and develops automotive related standards, particularly in the US and North American context. The SUNRISE SAF aligns with several SAE [23] initiatives, including **J3016** [49], which defines levels of driving automation; **J3244** [50], which supports safety evaluation frameworks; and the emerging **J3279** [51], which aims to provide a best practice for simulation for developing and evaluating automated driving systems. The **J3206** [52] from ORAD committee on V&V is also participated by SUNRISE project members. SAE's emphasis on practical implementation guidance and engineering process integration supports SUNRISE's vision to provide not only methodological frameworks but also operational pathways for deployment and assurance.

BSI serves as the UK's national standards body and has developed several standardisation documents and specifications that are directly relevant to SUNRISE. These include **PAS 1883** [53] for ODD taxonomy, the more recent **BSI Flex 1891** [54] on behaviour taxonomy, and **BSI**

1889 [55] on natural language based scenario format. These documents cover areas such as behavioural modelling, scenario description, and assurance structure.

This network of standardisation and regulatory stakeholders provides the framework within which SUNRISE task T8.4 operates. Their outputs shape the technical and procedural environment for automated vehicle assurance, and their engagement during the project has helped to guide, validate, and align the SUNRISE SAF with the broader regulatory and industrial landscape.

6.2 Collaboration and Process during the Project

The approach was centred on collaborative contributions to standards development, technical alignment with relevant initiatives, and consistent feedback integration from ongoing standardisation activities.

Within the **ISO** domain, SUNRISE contributed to several working groups that are shaping the foundation of scenario-based safety assurance. The project supported the development of a forthcoming Technical Report on ODD boundaries under **ISO TC204 WG14**. Engagement with **ISO TC22 SC33 WG9** enabled alignment with **ISO 34503** [38] (ODD taxonomy), **ISO 34502** [42] (scenario-based safety evaluation), and **ISO 34504** [56], while contributions to **ISO TC22 SC32 WG13** [57] informed the development of **ISO TS 5083** [58], which addresses structured safety case representation. These activities helped align SUNRISE's internal concepts with international best practices and emerging assurance templates.

While SUNRISE did not formally engage with **ASAM** standardisation as a project, its consortium members actively participated in several related technical working groups. Multiple SUNRISE partners were contributors to the **ASAM OpenODD** [46] project, where prior experience with ODD decomposition and taxonomy development helped shape the standard's structure and granularity. Members were also involved in the **ASAM OSI** [45] (Open Simulation Interface) working group, particularly in areas related to sensor and environmental data packaging, which were relevant for SAF modelling and simulation credibility considerations.

Though the **ASAM OpenXOntology** [48] and **OpenLABEL** [47] standards had been finalised before the SUNRISE project commenced, the project adopted and adapted key elements from both. Concepts from OpenXOntology were reused to inform internal taxonomy candidate harmonisation efforts, particularly in the classification of scenario and environment elements. Meanwhile, the **SUNRISE Data Framework** for scenario query was developed using the OpenLABEL structure as its primary backend, supporting consistent metadata and annotation across test types. SUNRISE members were also contributors to ongoing refinements of **OpenSCENARIO** [44] and **OpenDRIVE** [43], two ASAM standards that were under minor revision during the project timeline. These engagements helped ensure that the scenario abstraction and environment representation work in SUNRISE remained consistent with wider industry practices.

The project maintained ongoing alignment with SAE International, particularly through its **On-Road Automated Driving** (ORAD) Committee and the development of **SAE J3279** [51], which addresses simulation-based validation of automated driving systems, and **J3206** [51] which focuses on V&V. SUNRISE members contributed to the simulation task force with input from the SAF's approach to modular simulation environments, layered validation strategies, and systems/subsystem-level safety assessment. These contributions helped strengthen the interoperability between SUNRISE outputs and SAE's developing guidelines.

At the national level, SUNRISE was closely involved in activities within BSI. Partners contributed to the revision of **PAS 1883** [59] , which extends the **ISO 34503** [38] taxonomy for UK application, and played an active role in developing **BSI Flex 1891** [54], focusing on behavioural taxonomies, and **BSI 1889** [55], which defines a format for natural language-based scenario descriptions. These standards have been input into the SUNRISE discussion across tasks and WPs on scenario abstraction, behaviour modelling, and structured safety argumentation.

In parallel, SUNRISE undertook an internal mapping of its SAF against a broad set of existing and emerging standards, including **ISO 34503** [38], **ISO 34502** [42]**, ASAM OpenODD** [46] and **OSI** [45] and **BSI PAS/Flex** [26] [59] publications. This helped identify areas of direct alignment, partial overlap, and potential influence, enabling structured dissemination of project outputs into standardisation dialogues.

Terminology consistency and taxonomy harmonisation were additional areas of focus. SUNRISE reviewed and cross-referenced concepts across **ASAM OpenXOntology** [48]**, OpenLABEL** [47]**, ISO 34503** [38]**, ISO 34504** [56], and relevant BSI standards to ensure that the SAF's representations of ODDs, behaviours, and scenario types could integrate cleanly with industry vocabularies. These efforts supported conceptual coherence across the SUNRISE SAF, from scenario tagging and testbed modelling to assurance documentation and evidence reporting.

ISO 34501
Vocabulary, terminology and concepts for scenario-based CCAM testing

ISO 34502
Definition and validation of scenario-based safety evaluation framework

ISO 34503
Taxonomy and methods for scenario categorization and comparison

ISO 34504
Scenario categorization, test case structuring and inclusion of tags

ASAM OpenScenario
Scenario formatting and description

ASAM OpenDRIVE
Road network description

ASAM OpenLABEL
Scenario tagging, labeling, annotation and metadata

ASAM OSI
Test result description, interfaces and data exchange

ASAM OpenODD
ODD taxonomy and formats

BSI PAS 1883
1. Foundation for ODD taxonomy
2. Integration with ASAM OpenLABEL ontology

BSI Flex 1889
1. Structured natural language format for Level L3+ test scenarios
2. Creation, categorization and communication of test scenarios

Note: This page shows the main (but not all) standards to which the SUNRISE SAF aligns.

Figure 8: Overview standards aligned with and used by the SUNRISE SAF

6.3 Feedback of Stakeholder

In general, the SUNRISE SAF is very aligned across many standardisation activities from different standardisation bodies regarding safety, testing, and virtual test environment. Starting from the SAE J3279 [51] development activities, the SAF is very well perceived as a typical scenario based development and testing workflow, underpinned by ODD and behaviour. Furthermore, since the project concerns the role of simulation within such development and testing activities, a similar simulation framework (as identified within the SUNRISE project) is being discussed and has gained agreement. Within the ISO landscape, the ISO 34503 document (a scenario based evaluation continuum which is very aligned with the SUNRISE SAF), the standardised ODD taxonomy and language have been directly input and implemented within SUNRISE, as part of the SUNRISE Data Framework. Concerning the ISO 34504 [56] document (a testing workflow similar to SUNRISE's), although drawn differently, the key components and flows are very aligned with the SUNRISE SAF. Within the ASAM domain, several standards are directly utilised and implemented within SUNRISE, they are seen as key enablers for various components of the SAF. Within the scenario block, the OpenSCENARIO [44] and OpenDRIVE [43] are two standards that are directly used in SUNRISE. The OpenLABEL [47] is implemented within the SUNRISE Data Framework. The OSI is directly referenced and recommended as part of the harmonised and modularised simulation framework in the Execute block.

6.4 Potential Usage of the Project Outcomes

Figure 9 illustrates how the main building blocks of the SUNRISE SAF, Scenario, Environment, and Safety Argument, are **related to existing and emerging standards**. While several of these standards have already reached publication, most are undergoing revision or extension, and the outcomes of SUNRISE provide concrete input that can shape their evolution. The figure should therefore not be read as a static mapping exercise but as an illustration of how SUNRISE results can be taken up by standardisation bodies and vehicle safety authorities in order to enhance the applicability and consistency of these standards. The individual standard in Figure 9 have been explained in earlier subsections.

In the area of **scenarios**, SUNRISE has demonstrated in the SAF how scenario creation, formatting, and storage can be improved through the use of harmonised ontologies and quality metrics. These results directly contribute to the ongoing development and revision of **OpenSCENARIO** [44], **OpenDRIVE** [43], **ISO 34503** [38], and related standards such as **BSI Flex 1889** [55], and they highlight how scenario descriptions can be made more interoperable and better suited for regulatory use cases.

In the **environment** domain, SUNRISE SAF demonstrates allocating and executing test scenarios as well as querying and concretising abstract scenarios. These methods address key challenges in ensuring consistency and semantic labelling across different domains, and they provide actionable input to the evolution of **OpenLABEL** [47], **ASAM OpenX Ontology** [48], and **SAE J3279** [51], which are central to enabling regulators and technical services to rely on interoperable and transparent test environments.

For the **safety argument**, SUNRISE developed a modular structure that integrates coverage metrics, structured safety cases, and test evaluation. This approach offers direct support for the application and further refinement of **ISO 34505** [60] by showing how scenario-based testing can be linked to structured and reproducible safety argumentation.

Taken together, these activities show that SUNRISE did not merely map its framework to existing standards, but actively contributed knowledge, methods, and demonstrators that standardisation bodies can integrate into their ongoing work. VSBs, in turn, can benefit from this alignment by applying the evolving standards in a more consistent manner and by using the SAF as a bridge between technical validation activities and regulatory assessment. Figure 9 therefore represents a pathway for action: it shows where SUNRISE results can be embedded into international standards and how this, in turn, can support VSBs in achieving transparent, harmonised, and scenario-based safety assurance.

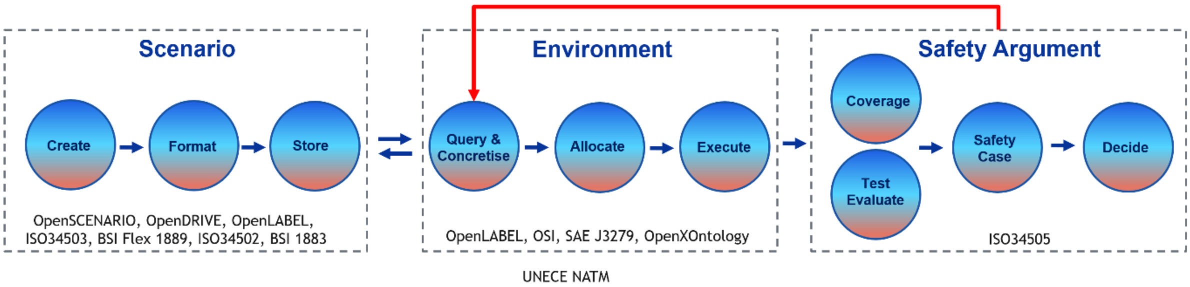


Figure 9: SAF overview with aligned standards to specific SAF blocks

7 SAF MOCK APPLICATION

This section presents the activities undertaken as part of the mock type approval exercise conducted in collaboration between the SUNRISE project and the Dutch national type approval authority, RDW. The primary objectives of this collaboration were:

1. To **assess the applicability of the Safety Assurance Framework** within a regulatory context.

2. To evaluate the relevance and usability of the **application guidelines** developed by the project.

3. To explore how a Vehicle Safety Body or a type approval authority could **leverage the Safety Assurance Framework** and its associated application guidelines.

Within the scope of this collaboration, the type approval authority contributed by defining external requirements and providing an independent perspective on the test results generated by the consortium for the system under evaluation. The mock type approval procedure was conducted in alignment with the regulatory framework proposed by the project [3].

7.1 Drawing Up External Requirements

As part of the collaboration, the Vehicle Safety Body (VSB) was provided with the use cases explored within the SUNRISE project. Use Case 3.2 [4] was selected for the mock type approval for the following reasons:

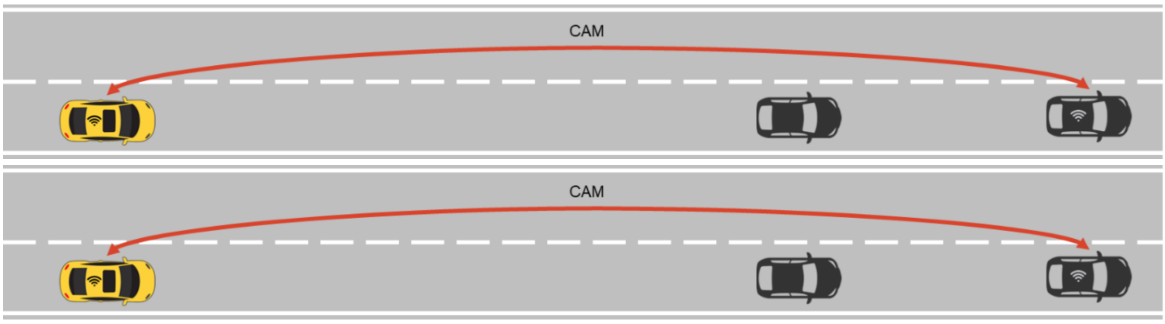
1. Availability of relevant external requirements: The scenario definitions within this use case exhibited strong similarities with those outlined in the UNECE R157 regulation [34].

2. Access to diverse testing environments: The scenarios could be executed across multiple testing platforms, thereby enabling a broader coverage of evidence blocks from the Safety Assurance Framework.

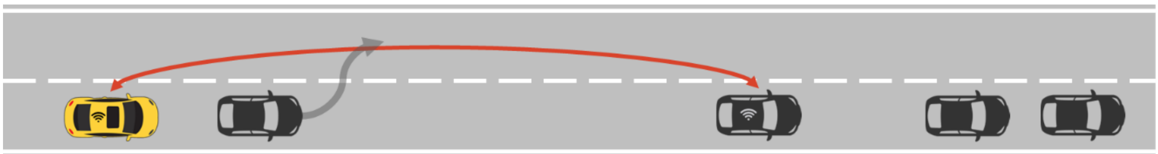
The Use Case is divided into three subcases. In the first, the ACC system detects a hidden, cooperative vehicle ahead of the lead vehicle through V2X communication. The second subcase is similar, but here the cooperative vehicle may be travelling at low speed or decelerating sharply while the lead vehicle performs a cut-out manoeuvre. The third subcase involves a cooperative vehicle performing a cut-in.

In simulations of the third subcase, two variants are considered. In the first variant (C1), the cooperative vehicle communicates its intention to cut in before executing the maneuverer. In the second variant (C2), the cooperative vehicle negotiates the merge and only proceeds once the available gap is deemed safe. This safety assessment is based on two thresholds: one corresponding to a prudent cut-in and the other to a more aggressive cut-in.

A) Cooperative ACC.



B) Cooperative ACC with a challenging vehicle and lead vehicle cut-out.



C) Cut-in of a cooperative vehicle (C1 with declared intention, C2 with negotiation).

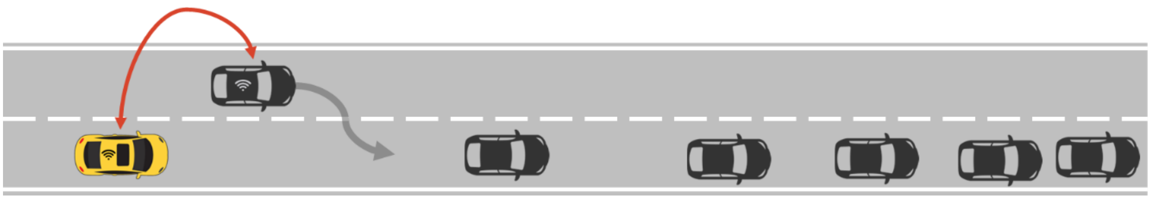


Figure 10: Use Case 3.2 subcases overview [4].

Given the nature of the tests and the characteristics of the available CCAM system, the external requirements had to be adapted to align with the specifics of Use Case 3.2. While UNECE R157 defines requirements for an Automated Lane Keeping System (ALKS), the CCAM system addressed in this use case is a connected Level 4 system. Therefore, only the logical-level scenario abstractions from the R157 [36] regulation could be utilised directly. Modifications were necessary to ensure relevance and applicability to the selected use case. These adaptations included:

- Metrics: One of the primary modifications involved the metrics. The original metrics prescribed in UNECE R157 are tailored to ALKS functionality, which does not align with the characteristics of a connected Level 4 system. Consequently, the metrics were redefined to better reflect the capabilities of the CCAM system and the concrete parameters of the selected scenarios.

- Scenario parameters: As previously mentioned, only the logical-level scenarios from UNECE R157 could be transferred to Use Case 3.2. Due to the differing levels of autonomy and the presence of vehicle-to-vehicle (V2V) connectivity, the concrete-level scenarios had to be specifically curated to match the objectives and constraints of this use case.

Section 7.1.1 presents the adapted external requirements alongside their corresponding entries from UNECE R157, allowing for a detailed comparison and analysis of the deviations introduced.

7.1.1 External Requirements

As previously mentioned, the requirements used in this activity were inspired by the UNECE R157 regulation on Automated Lane Keeping Systems (ALKS). Specifically, the performance requirements from Annex 3 of the regulation were selected for the following reasons:

1. Scenario and metric-based evaluation: These requirements assess system performance through predefined scenarios and associated metrics, which aligns closely with the methodological foundation of the SUNRISE project.
2. Relevance to the selected use case: The requirements correspond well with the characteristics of the chosen use case and required only minimal adaptation to ensure applicability.
3. Regulatory familiarity: UNECE R157 has been an enforced regulation for some time, and both the type approval authority and the technical service involved in the mock type approval process are highly familiar with its content and structure.
4. Regulatory proximity: UNECE R157 represents the closest existing legislative framework capable of capturing the key capabilities of the system under test.

The following requirements from UNECE R157 [34] were used as part of this collaboration:

Table 1: Applicable requirements from UNECE R157

Requirement Number:	Requirement:
Annex 4, Appendix 3, 3.4.1.	For Cut in scenario: The lateral wandering distance the vehicle will normally wander within the lane is 0.375m. The perceived boundary for cut-in occurs when the vehicle exceeds the normal lateral wandering distance (possibly prior to actual lane change)

	The distance a. is the perception distance based on the perception time [a]. It defines the lateral distance required to perceive that a vehicle is executing a cut-in manoeuvre a. is obtained from the following formula; a.= lateral movement speed x Risk perception time [a] (0.4sec) The risk perception time begins when the leading vehicle exceeds the cut-in boundary threshold. Max lateral movement speed is real world data in Japan. Risk perception time [a] is driving simulator data in Japan. 2sec* is specified as the maximum Time To Collision (TTC) below which it was concluded that there is a danger of collision in the longitudinal direction. Note: TTC = 2.0sec is chosen based on the UN Regulation guidelines on warning signals.
Annex 4, Appendix 3, 3.4.2.	For Cut out scenario: The lateral wandering distance the vehicle will normally wander within the lane is 0.375m. The perceived boundary for cut-out occurs when the vehicle exceeds the normal lateral wandering distance (possibly prior to actual lane change) The risk perception time [a] is 0.4 seconds and begins when the leading vehicle exceeds the cut-out boundary threshold. The time 2 sec is specified as the maximum Time Head Way (THW) for which it was concluded that there is a danger in longitudinal direction. Note: THW = 2.0sec is chosen according to other countries' regulations and guidelines.
Annex 4, Appendix 3, 3.4.3.	For Deceleration scenario: The risk perception time [a] is 0.4 seconds. The risk perception time [a] begins when the leading vehicle exceeds a deceleration threshold 5m/s2.

However, due to the difference between the system capabilities in terms of V2V connectivity and different scope of the testing campaign of the use cases the requirements needed to be modified. The modified requirements are as follows (the structure 5.x.x aligns with R157 chapter 5 “System Safety and Fail-safe Response”):

Table 2: Final External Requirements

Use Case	Requirement Number:	Requirements:
5.1: Following a lead vehicle (3.2-A: cooperative ACC)	5.1.1.	The ego vehicle shall detect a connected vehicle traveling in the same lane based on V2V CAM within reliable range of connectivity and after the connected vehicle enters the detection range, within an acceptable detection reliability range under nominal operating conditions.
	5.1.2.	The ego vehicle shall adjust and set its speed to match the speed of both the connected and immediate lead vehicle ahead, based on the received V2V CAM messages and vehicle sensors: a) The deceleration shall be sufficient to maintain a safe time headway and avoid a collision. b) The time 2 sec is specified as the maximum Time Head Way (THW) for which it was concluded that there is a danger in longitudinal direction.
	5.1.3.	The ego vehicle shall maintain its current speed and shall not respond to an acceleration of the immediate lead vehicle if the connected lead vehicle is maintaining a constant speed.
	5.1.4.	The ego vehicle shall initiate a deceleration manoeuvre when the connected lead vehicle is detected to be decelerating, regardless of the speed of immediate lead vehicle.
5.2: Lane change of another vehicle into	5.2.1.	The ego vehicle shall detect a connected vehicle traveling in the same or adjacent lane based on V2V CAM within reliable range of connectivity and after the connected vehicle enters the detection range,

lane (3.2-C: Cut-In into ego's lane)		within an acceptable detection reliability range under nominal operating conditions.
	5.2.2.	The ego vehicle shall adjust and set its speed to match the speed of both the connected and immediate lead vehicle ahead, based on the received V2V CAM messages and vehicle sensors: a) The deceleration shall be sufficient to maintain a safe time headway and avoid a collision. i. The time 2 sec is specified as the maximum Time Head Way (THW) for which it was concluded that there is a danger in longitudinal direction. b) The ego vehicle shall maintain its current speed and shall not respond to an acceleration of the immediate lead vehicle if the connected lead vehicle is maintaining a constant speed c) The ego vehicle shall initiate a deceleration manoeuvre when the connected lead vehicle is detected to be decelerating, regardless of the speed of immediate lead vehicle.
5.3 Obstacle after lane change of the lead vehicle (3.2-B: Deceleration vehicle in front)	5.3.1.	The ego vehicle shall detect a connected vehicle traveling in the same lane based on V2V CAM within reliable range of connectivity and after the connected vehicle enters the detection range, within an acceptable detection reliability range under nominal operating conditions.
	5.3.2.	The ego vehicle shall adjust and set its speed to match the speed of both the connected and immediate lead vehicle ahead, based on the received V2V CAM messages and vehicle sensors: a) The ego vehicle shall initiate a deceleration manoeuvre when the connected lead vehicle is detected to be decelerating, regardless of the speed of immediate lead vehicle. i. The risk perception time is 0.4 seconds. The risk perception time begins upon successful detection of

		lead connected vehicle's deceleration through connectivity. b) The deceleration shall be sufficient to maintain a safe time headway complying with minimum following distances in the country of operation and avoid a collision. c) The ego vehicle shall not respond to acceleration of the immediate lead vehicle d) The ego vehicle shall maintain its speed according to the connected lead vehicle after the immediate lead vehicle performs a cut-out maneuver.

7.2 Gathering information

This chapter lists how SUNRISE partners provided evidence for each SAF block and provided this information to RDW. The chapter is specific to Use Case 3.2 of the SUNRISE project as described in detail in Deliverable D7.3 [4]. What follows are the steps taken and the evidence provided for each individual SAF block:

Scenario

Create

Relevant data and knowledge are collected to generate scenarios. This is done through either data-driven or knowledge-based methods. The scenarios created for this use case originate from knowledge-based generation. A characterisation of the use case was conducted during the activities of task T7.1, resulting in a set of 3 functional scenarios. The following work items in WP7 converted these into logical scenarios, which would be passed forward through the SAF.

Format

Scenarios are initially represented in various formats utilised by consortium members. As a requirement of the SAF the format of the scenarios is unified, therefore, before storage, they are converted into ASAM OpenX representation with logical ranges captured.

Store

The scenarios created for this use case are stored in searchable scenario databases (SCDBs). This process is demonstrated by their upload and storage within Safety Pool^{TM} [61] for this use case. The SCDBs utilised in SUNRISE are required to be accessible via API query from the SUNRISE Data Framework (DF) which serves as the federated interface.

Data Framework

The SUNRISE Data Framework (DF) ensures that scenario databases (SCDBs) can be accessed for querying and concretisation in a harmonised way. The Data Framework is providing a federated interface for scenario access given that certain requirements of the individual databases are met. The prerequisites for interaction with the DF regard interoperability, accessibility, data integrity and compliance. The SCDB interactions in this use case comply with all pre-requisite criteria, though it should be noted that direct use of the DF was not possible within the time constraints of the use case. A central demonstration using the interface of the DF was prepared for the final event but was not directly used in work conducted within the use case.

Environment

Query & Concretise

The query portion of this block of the SAF was demonstrated using the internal querying function of the Safety Pool^{TM} scenario database. The query function demonstrated aligns with that of the wider SUNRISE DF, utilising OpenLABEL tagging format and ISO 34503 [38] based ODD and behaviour taxonomy/ontology for the tags, to search for the appropriate scenario tags. The query was constructed using the ODD definition of use case 3.2 contained in deliverable D7.1 [62], combined with observed behaviours from the specified logical scenarios.

Logical scenarios received from the SUNRISE Data Framework have to be converted into concrete scenario to be used in the Execute component of the SAF. A Latin Hypercube Sampling (LHS) approach was used for this concretisation step. This approach yields good coverage of the parameter space. The number of samples were selected to ensure reasonable execution time in the simulation environment.

Allocate

Two different test instances were available within UC3.2 for the allocation of test cases (according to the ODD-based allocation method described in Deliverable D3.3 [11]). These test instances were physical tests on proving ground and virtual simulations. Because the purpose of the SAF mock application was the demonstration and validation of the SAF, in principle all test cases had low fidelity requirements on the models and could be performed on a virtual simulation test instance. However, a second cluster of test cases was defined for model validation reasons which were allocated to proving ground due to their high-fidelity requirements on the models (need for real components for validation reasons).

Execute

Simulations. Simulations allow for the study of numerous reproducible critical scenarios without safety risk. However, a major limitation is fidelity, which is why selected proving ground tests are necessary to validate results. For UC3.2, the simulation platform used was IPG CarMaker, a proprietary solution that is well-supported and maintained accurately, offering higher reliability (it is ISO 26262 certified). The simulation setup and the system under test (SuT) are also parts that require fidelity assessment (see deliverable D4.3 [12]). Using this tool and following this methodology, thousands of concrete test scenarios were simulated.

Proving Ground. In order to assess the safety of UC3.2 in a high-fidelity environment, IDIADA proving ground has been used to execute a set of representative tests. The execution of tests has been performed with 3 different vehicles:

- EGO: An instrumented vehicle with the automated function integrated.

- Cooperative: A second instrumented vehicle that is communicating through V2V with the EGO vehicle.

- Non-cooperative: A normal commercial vehicle that acts as an external road user.

Further details of the Execution can be found in Deliverable D7.3 [4] or in the handbook.

Safety Argument

Coverage

Simulations. The extensive set of concrete scenarios tested was combined into a surrogate model (see Deliverable D3.4 [10]). This model highlights regions of high and low confidence, showing which parts of the logical scenario require further sampling or if the operational region has been sufficiently covered.

Test Evaluate

Simulations. The Key Performance Indicators (KPIs) are initially evaluated for each simulated concrete scenario. An important aspect is selecting the KPIs, which should be simple, informative, and limited in number. Surrogate KPIs, such as TTC, can be used in proving ground tests. However, collisions and near misses can be assessed through simulations and might be preferred.

Proving Ground. To evaluate each test, a report with the results is created. This report includes different metrics & KPI’s such as the absolute speed, longitudinal acceleration, TTC, etc. In addition, specific key events are tracked on each scenario such as the instant when each vehicle starts decelerating or the start of the lane-change among others.

Safety Case

Simulations. KPIs are combined across the relevant operational subspaces of logical scenarios; e.g., using surrogate models or other simpler methods (refer to deliverable D3.4 [10]). These KPIs are then compared against thresholds, which can be derived from literature or may require conducting experimental studies themselves (see deliverable D7.3 [4] UC3.2 A and B).

Proving Ground. To build a comprehensive safety-case an extensive test report on the test execution on the proving ground is generated, including the requirements addressed, a detailed system description, evidence of the HARA and the methods applied to mitigate those risks & the safety concept applied.

Decide

A critical aspect of decision-making is specifying for which subsets of logical scenarios the system must surpass certain thresholds, and conversely, which types of events are considered unreasonable risks, allowing the pass/fail criterion to be relaxed. This responsibility is delegated to the user of the SAF. To make a decision on the safety of the CCAM function under test, all generated output that contribute to the safety case building has been evaluated, including the fulfilling of the ODD coverage, achieving scenario space coverage, computation of scenario space collision areas and computation of collision rates. After consolidating the evidence from Coverage, Test Evaluate and Safety Case, the combined results from all the test environments show whether the function meets its safety targets or not, which in this case it did and was therefore judged safe. Test report is provided in **Annex 3.1** of this deliverable.

7.3 Auditing Based on Test Report

The primary objective of this collaboration was to assess the application of the SUNRISE SAF using the authority-oriented **application guidelines** (see SUNRISE deliverable D2.3 [3]) developed for each block in the SAF Handbook [41]. The information collected in accordance with section 7.2 was audited using these guidelines, and the following assessment criteria were applied:

- **Completeness**: To assess whether the provided information comprehensively describes the activities performed.
- **Clarity**: To determine whether the information is clearly presented and provides sufficient detail to substantiate the claims made.

- **Coverage**: To verify whether the scope of the information adequately addresses all relevant risks and supports the associated safety claims.

As part of the Execute block within the SAF, the selected use cases were implemented on a test track. The resulting **test report** (**Annex 3.1** of this deliverable**)** was subsequently shared with the Vehicle Safety Body (VSB) for evaluation. The **auditor checklist** created by RDW to assess the SUNRISE use case 3.2 can be found in **Annex 3.2** of this deliverable. More details and feedback from RDW can be found in **section 4.5**.

8 FUTURE OUTLOOK

After the SUNRISE project, future work will focus on addressing key limitations identified during its development. One major area involves increasing the Technology Readiness Level (TRL) of the SAF system through full-scale validation and broader deployment testing. Another possible task is the creation of a comprehensive data base containing a large volume of scenario data. SYNERGIES [63] and CERTAIN [64] aim to tackle these challenges by building on SUNRISE's foundation and reducing dependencies on external components through the development of in-house models and tools. An overview of limitations of the SUNRISE project and other EU-projects that address specific limitations, can be seen in Table 3.

Table 3: SUNRISE limitations and future work

Limitations	Future Work
1. Technology Readiness Level of SAF is 6 - 7 • Successful demonstration of working prototype • No full-scale validation • This could mean having to divert, approximate, apply alternatives, or solve possible limitations of the SAF	
2. No SUNRISE Data Base • External scenario databases connect to the SUNRISE Data Framework that serves as a hub • A SUNRISE Demo Database helps to get connected • No new database with massive amounts of scenarios	SYNERGIES
3. Human-Vehicle interaction needs improvement • SAF addresses safety related to human-vehicle interactions	CERTAIN

• This interaction is especially crucial for SAE L3 systems • Need for improvement especially on HMI interaction	
4. Dependency on external components • Human driver reference models: I4Driving • Cybersecurity safety assurance SELFY and CONNECT • Dependency on results from other projects	

9 CONCLUSIONS

The SUNRISE project has successfully developed a comprehensive Safety Assurance Framework (SAF) tailored to the validation needs of Connected, Cooperative, and Automated Mobility (CCAM) systems. Deliverable D8.1 documents the project's **collaboration with key vehicle safety bodies** (UNECE, European Commission and member states, consumer testing and standardisation) and demonstrates the strategic value of these interactions in shaping a harmonised, evidence-based framework for the safety assessment of CCAM technologies: the **SUNRISE SAF**.

Through **WP8** of the SUNRISE project, all major vehicle safety bodies (VSBs) were not only **informed** about the SAF, but actively **engaged** in its development. This structured outreach ensured broad awareness with international and European stakeholders, via workshops, bilateral meetings and targeted presentations. Cooperation has been done with **UNECE** (chapter 3), the **European Commission** (including **JRC**) and its **member states** (chapter 4), represented by national type approval authorities (RDW, KBA, VCA) or technical services (UTAC, IDIADA), **consumer testing organisations** like Euro NCAP [2] (chapter 5), and **standardisation** bodies (chapter 6: ISO, ASAM [24], SAE [49]). The collaborations played a vital role in ensuring the SAF's alignment with regulatory and industry needs and these interactions helped refine the SAF into a modular, transparent, actionable and (most importantly) a **harmonised** framework that supports scenario-based validation and robust safety argumentation. Importantly, first steps towards **adoption** and **application** were demonstrated: most notably through the **SAF mock application** (see section 4.5 and chapter 7) with RDW, which tested the SAF's auditability and confirmed its potential regulatory value. This shows that the project has gone beyond awareness-raising to provide concrete pathways for VSBs to **apply the SAF in practice**.

WP8 influenced ongoing **policies, regulations, standards, and protocols**. The SAF contributed to discussions at **UNECE GRVA** [18], including the development of the forthcoming ADS interpretation document, ensuring that SUNRISE results are considered in shaping future UN regulations. At the European level, SUNRISE provided input to the **EU's interpretation document** of Regulation 2022/1426 [17], and national **type approval authorities** (RDW, KBA, VCA) explored the SAF's integration into scenario-based type approval processes. Standardisation bodies (**ISO, ASAM, BSI, SAE**) acknowledged SUNRISE's contribution to the refinement of key standards, including ISO 34502 [42], ISO 34503 [38], and ASAM's OpenX suite [24], particularly in areas of scenario quality metrics, coverage, and simulation interoperability. **Euro NCAP** [2] and other NCAPs expressed interest in using SAF methods (e.g., scenario selection and coverage metrics) to support the integration of virtual testing into consumer safety assessments.

These results directly advance the achievement of Project **Objective 8** by raising **awareness** of the SAF among VSBs, demonstrating first **applications** that pave the way for **adoption**, and influencing the evolution of regulatory and standardisation frameworks at international, European, and national levels. The SAF has been designed to **integrate with and complement existing and emerging regulations**. Importantly, the SAF is not only applicable to technical developers but also **provides regulatory bodies with tools** to assess safety compliance systematically, even in cases where qualitative or process-based criteria prevail.

Feedback from stakeholders confirms the relevance and utility of the SAF (see feedback of SAF target users at Final Event in chapter 6 of SUNRISE D9.3 [37]). Regulatory authorities appreciated the structured safety case format and its potential to enable reproducible, transparent assessments. Euro NCAP [2] and other NCAPs expressed interest in **using elements of the SAF**, particularly its scenario selection and coverage metrics, to support the future inclusion of virtual testing in consumer safety assessments. Standardisation bodies recognised SUNRISE as a **valuable contributor to international discussions on harmonised CCAM validation**.

Feedback (see chapter 4.3) indicated that VSBs do not carry out all safety assurance steps themselves; instead, certain steps require **regulatory witnessing** rather than direct execution. This highlighted the need for clear guidelines on how to witness or audit the SAF steps from an authority's perspective. In response, **SAF application guidelines** were developed and implemented in the online **SAF Handbook** [41] and SUNRISE Deliverable D2.3 [3]. These guidelines support VSBs in applying/auditing SAF steps, such as scenario creation, environmental modelling, and the development of safety arguments, while also allowing them to provide external requirements relevant to safety assurance.

Moving forward, several areas of development have been identified. These include increasing the Technology Readiness Level of SAF components through full-scale piloting, expanding scenario databases with harmonised ontologies and quality metrics, and enhancing auditability and regulatory compatibility by incorporating real-world feedback loops. The SAF's integration with the evolving ADS regulatory landscape, including **potential contributions to UNECE's interpretation documents**, further illustrates its strategic value.

Based on the findings of this deliverable, the SUNRISE consortium recommends that regulators consider embedding **SAF elements into future type approval processes**, that NCAPs explore the SAF's application in virtual testing workflows, and that standardisation bodies leverage SUNRISE outcomes to further refine safety-related standards. Moreover, continued stakeholder engagement and **cross-project collaboration will be essential** to sustain **alignment with industry, regulation, and public expectations**.

The **SAF Mock Application** (see section 4.5 and chapter 7) provided valuable insights into both the regulatory and practical aspects of using the SUNRISE SAF. RDW highlighted key challenges such as the gap between regulation and the SAF, the need for harmonisation of scenario databases, and the value of a comprehensive safety argumentation when using the SAF. Meanwhile, the SUNRISE project emphasised the importance of addressing different target users, the need for clear **SAF application guidelines** for Vehicle Safety Bodies (VSBs), and the potential for real-world adoption. The collaboration demonstrated how the **SAF can support both developers and authorities**, bridging existing gaps and contributing to safer deployment of CCAM systems.

From the authority's perspective, key lessons emerged. Most notably, there is **currently no regulatory obligation for developers to follow SAF**; thus, compliance is voluntary unless

SAF is embedded into regulation. Additionally, reliance on external scenario databases, which are not yet standardised or regulated, poses a challenge for consistent SAF application. Nevertheless, when used, SAF can form the **basis of a comprehensive safety argument** that covers a wide range of evidence necessary for validation, verification and approval.

In summary, Deliverable D8.1 demonstrates that SUNRISE has achieved its WP8 objectives by making VSBs **aware** of the SAF, enabling first steps towards **adoption** and **application**, and influencing future **policies**, **regulations**, **standards**, and **consumer** protocols. By bridging the gap between technical development and regulatory practice, the SUNRISE SAF establishes a solid foundation for harmonised, transparent, and evidence-based safety assurance, paving the way for the safe and large-scale deployment of CCAM systems across Europe and beyond.

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ANNEX 1: REPORT ON UNECE ACTIVITIES

1. Introduction

The deployment of new advanced technologies in our society is resulting into a change of paradigm when talking about transport modes. This change of paradigm leads to new vehicle concepts, business cases, propulsion technologies or even a mix of all of them.

The World Forum for Harmonisation of Vehicle Regulations (WP.29), a subsidiary of the UNECE Inland Transport Committee, is a key international body responsible for incorporating these technological innovations into vehicle regulations. Its primary goal is to develop harmonized safety and environmental standards. Since 2018, WP.29 includes the GRVA [18] (Rapporteur Group for Autonomous Vehicles), which focuses on adapting the regulatory framework to the deployment of connected, cooperative, and automated driving technologies. The GRVA works through Informal Working Groups (IWGs), each dedicated to specific topics for a limited period, bringing together experts from various fields.

At its 191st session WP.29 adopted a new working structure with a new IWG on Automated Driving Systems (ADS) and GRVA workshops to launch and to undertake the work on regulatory activities for such systems. This follow-up is based on the activities of the two IWGs Functional Requirements for Automated and Autonomous Vehicles (FRAV) and Validation Methods for Automated Driving (VMAD) and their joint deliverable, namely the FRAV-VMAD [35] integrated document (GRVA-18-50) to be adopted by WP.29 at its June 2024 session.

The IWG main purpose is to draft a regulatory text on ADS (purpose, scope, definition, general requirements, performance requirements, test procedures).

Task 1 of the ADS IWG agenda will be combine the draft regulatory text with the specific administrative provisions and annexes received from GRVA workshops for the generation of the draft UN Global Technical Regulation (GTR) on ADS. Task 2 will be the elaboration of a draft of UN Regulation on ADS. Both tasks must be accomplished for June 2026 and for November 2026 task 3 will consist of drafting and preparing a guiding/interpretation document for both agreements.

2. Purpose of the Document

This document purpose is to provide a clear picture on the state of the negotiations on the newly constituted IWG on Automated Driving Systems (ADS) [65]. An analysis of the 3rd meeting of ADS IWG [66] and of the “Guidelines and recommendations for Automated Driving System safety requirements, assessments and test methods to inform regulatory developments” [67] will be done; focusing on safety assessment, validation, scenarios and requirements.

3. ADS

Overview on the important topics from the WP.29 193rd session on ADS

1. Conditions an ADS might be expected to encounter via a **framework for the development of traffic scenarios** under which an ADS should be assessed.

2. The framework differentiates among **nominal, critical, and failure scenarios**.

3. The framework proposes the use of appropriate **safety models** to enable assessment of ADS performance.

4. The guidelines recommend consolidation of these scenarios into a **scenario catalogue** that may be used under the NATM to systematically validate the safety of an ADS.

5. Guidelines to address the **safety of ADS vehicle users** via sets of requirements.

6. The assessment of an ADS for compliance with these safety recommendations rests on **NATM five validation pillars**.

7. Recommendation on procedures for evaluating the reliability of the manufacturer's **virtual testing tool chains and methodologies**.

8. **Comparison of performance between a virtual test and a track test** when executing the same scenario for the assessment of the accuracy of the virtual testing toolchain.

9. Real-world testing requires attention to **designing test routes** that capture predictable aspects of the ODD.

10. The guidelines **facilitate templates** and recommend that manufacturers monitor the performance of their in-service ADS vehicles and report safety-relevant information to the safety authority.

Scenario and safety performance criteria

These guideline makes an approach that may be used to derive performance criteria for the certification of ADS, based on the manufacturer/ADS developer's description of the ODD. Such criteria would be developed by identifying the expected and verifiable capability of an ADS feature to operate a vehicle within the ODD, known as **behavioural competencies**.

The approach suggests a series of analytical frameworks that could help to derive measurable criteria appropriate for the specific application. These frameworks are divided into:

- ODD Analysis

  An ODD may consist of stationary physical elements (e.g., physical infrastructure), environmental conditions, dynamic elements (e.g., reasonably expected traffic level and composition, vulnerable road users) and operational constraints to the specific ADS application.

  The level of detail of the ODD definition using the ODD attributes will also need to be established.

- Driving Situation Analysis

  ODD is explored in more detail by mapping actors with appropriate properties and defining interactions. The behaviour of other road users and the condition of physical objects within the ODD may fall at any point along a continuum of likelihood. For example, deceleration by other vehicles may range from what is expected and reasonable in the traffic circumstances, to unreasonable but somewhat likely rapid deceleration, to extremely unlikely (e.g., a sudden cut-in combined with full braking on a clear high-speed road). The analysis of the ODD and reasonably expected driving situations within the ODD should make distinctions that include an estimate of the likelihood of situations to ensure that the **ADS's performance is evaluated based on response to reasonably likely occurrences involving nominal, critical and failure situations** but not on the expectation that the ADS will avoid or mitigate the most extremely unlikely occurrences.

- Object and Event Detection and Response (OEDR) Analysis.

  Once the objects and their reasonably expected behaviours have been identified, it is possible to map the appropriate ADS response, which can be expressed as a behavioural competency. The detailed response is derived from more general and applicable functional requirements.

Table 4. Example of elementary behavioural competencies for given events.

Event	***Response***
Lead vehicle decelerating	Follow vehicle, decelerate, stop
Lead vehicle accelerating	Accelerate, follow vehicle
Vehicle cutting in	Yield, decelerate, stop, follow vehicle
Opposite vehicle encroaching	Decelerate, stop, shift within lane, shift outside lane
Lead vehicle cutting out	Accelerate, decelerate, stop
Pedestrian crossing road	Yield, decelerate, stop
Cyclist crossing road	Yield, decelerate, stop

Scenario creation

Scenario creation involves use of assumptions concerning the actions of road users that incorporate realistic parameters. This approach suggests two complementary methodologies to derive reasonably expectable situations which might occur for a given ODD:

- Knowledge-based: A knowledge-driven scenario generation approach utilizes domain specific (or expert) knowledge to identify hazardous events systematically and create scenarios

- Data-based: A data driven approach utilizes the available data (e.g. accident databases, insurance records) to identify and classify occurring scenarios.

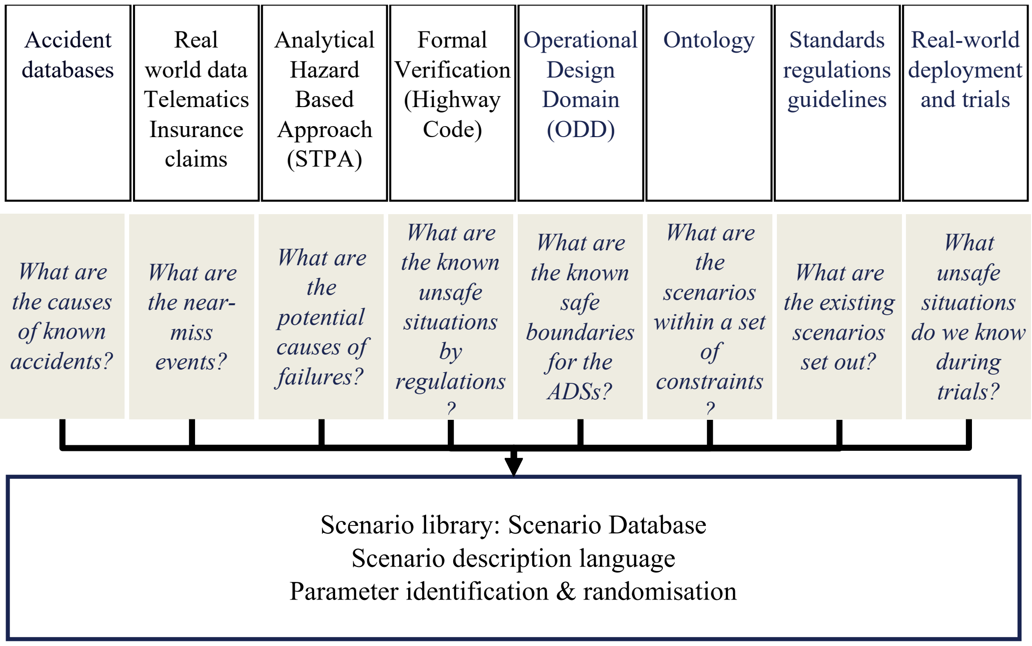


Figure 11. Data-based and knowledge-based scenario generation methods [65]

Application of Rules of Road as Pass criteria and requirements

An approach to define an acceptance criterion related to nominal driving situations is to evaluate the ADS performance against the rules of the road.

Every test scenario definition will have ODD and behaviour competency attributes defined. Every rule of the road will also have ODD and behaviour competency attributes as part of its definition. Therefore, it is possible to map every scenario to a corresponding rule(s) of the road using ODD and behaviour tags or labels in a scenario catalogue.

It is challenging to test against this requirement in the absence of codified rules of the road. Then a **framework for codifying the rules of the road** that govern the behaviour of ADS is suggested.

The process of codification helps identify where “implicit assumptions” about driving behaviour are present in the rules for human drivers and help to turn “undefined” attributes to “defined” attributes in the codified “rules of the road”.

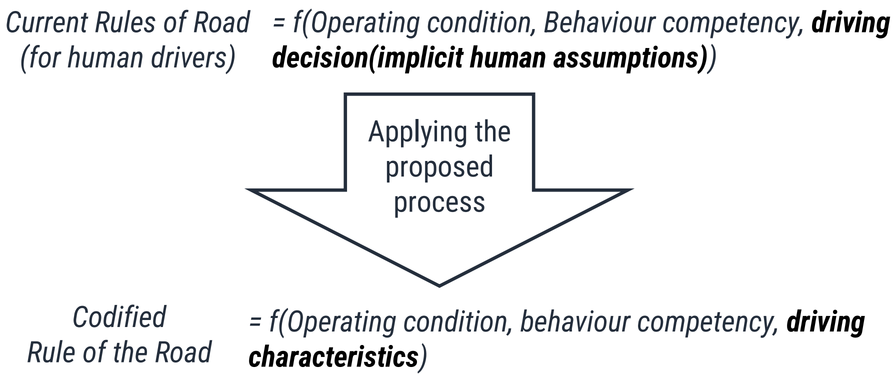


Figure 12. Process of codification of the rules of the road [66]

Taking an example of the UK road rules: Rule 195: *“As you approach a zebra crossing: look out for pedestrians waiting to cross and be ready to slow down or stop to let them cross; you MUST give way when a pedestrian has moved onto a crossing.”*

From this rule, one can extract the “operating condition or ODD” variables, as well as the behaviour competencies. “Zebra crossing” and “pedestrian” define the operating condition; and “slow down or stop” defines the behaviour competency. However, the rule doesn’t mention for how long the vehicle should be stopped, or when it is considered safe to proceed again. There is an “implicit assumption” made based on typical human (the driver behaviour), and it is not considered necessary for the rule to define this. However, for an ADS, such assumptions how long the vehicle is stopped for, and when it moves off again will be determined by the automated driving system and its analysis of the relevant parameters specific to that situation and will need to be specified. For every concrete scenario being tested, the driving decisions exhibited by ADS will need to be explainable.

Safety Models to Derive Verifiable Performance Requirements for Accident Avoidance

The so-called **safety models** provide assumptions how traffic rule violations and misbehaviour by other traffic participants could be dealt with and use physical properties and fundamental driving dynamics to further detail conditions for accident avoidance.

The purpose is to **define a process as to how concrete performance criteria could be developed** for future ADS regulations.

Safety models are a methodology to derive a threshold vector to separate between collisions that have to be avoided and those where only mitigation is required. The aim is NOT to prescribe a specific behaviour of the ADS in any given critical situation. This is only about the expected outcome.

In a mathematical and logical sense, for any given situation, **there will be a function depending on variables** that partly describe a scenario, delivering a Boolean “true” or “false” for whether the collision needs to be avoided, and vice versa for whether mitigation is acceptable:

Avoidance[0;1]=f_safetymodel (scenario variable 1,scenario variable 2,…),

Mitigation[0;1]=1-f_safetymodel (scenario variable 1,scenario variable 2,…).

It is envisioned that concrete ADS regulations, (being) built by using the guidelines as specified here, may contain either a concrete scalar threshold (example: avoid accidents for a driving speed below 42 km/h, see UN R152), or formulate a concrete fsafetymodel where all parameters are specified (simplified example from UN R157: when cut-ins of other vehicles occur before a specific TTC, the collision needs to be avoided, the resulting function as given in the regulation would be:

$$\text{fsafetymodel} = \begin{cases} 1, & TTCLaneIntrusion > \dfrac{vrel}{2.6\ m/s^2} + 0.35s \\ 0, & \text{otherwise} \end{cases}$$

Conclusions on Performance Evaluation and Targets

Nominal situations, which are foreseeable and preventable within a defined Operational Design Domain (ODD**)**, should be handled by the ADS without resulting in a collision. Conversely, **failure situations** test the ADS’s ability to recognize faults in the system. In **critical situations**, where others behave unpredictably and a collision might be unavoidable, safety models are proposed.

The following figure outlines the whole performance and safety framework.

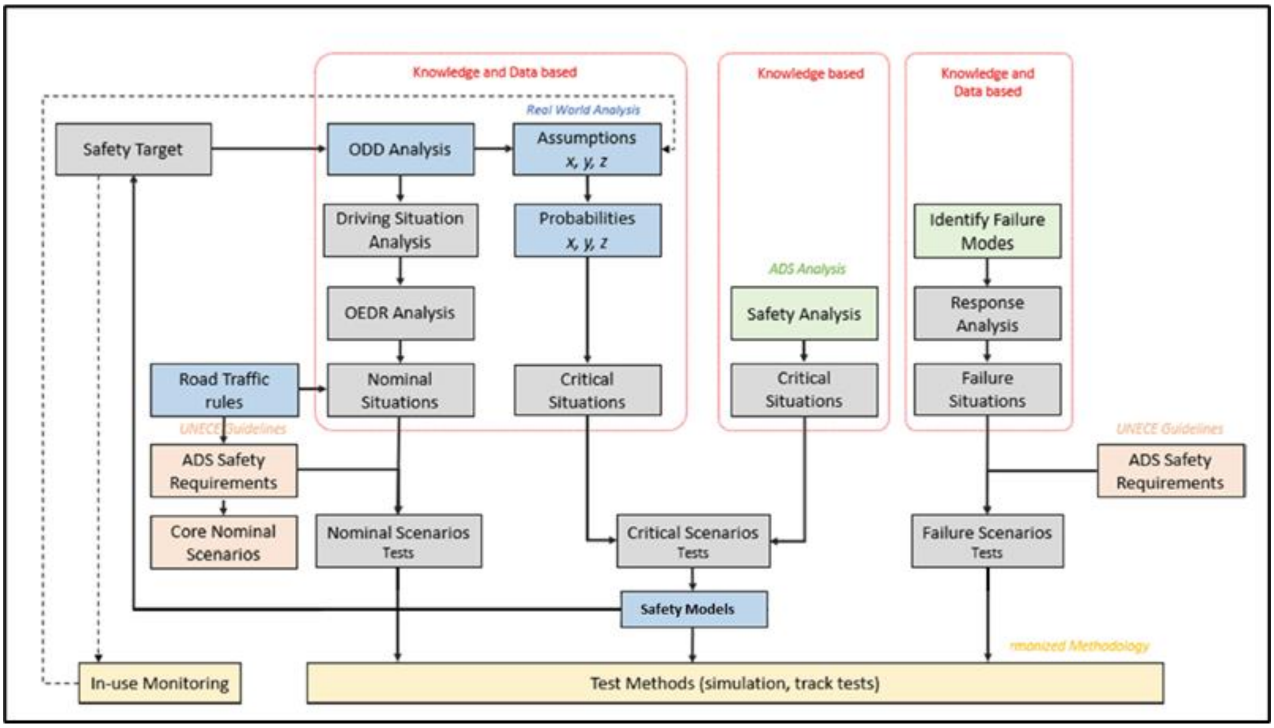


Figure 13. ADS and ODD analysis for the retrieval of nominal, critical and failure scenarios [65]

Traffic scenarios

Scenarios based validation consists of reproducing specific situations that exercise and challenge the capabilities of an ADS-equipped vehicle to operate safely. This will be used to systematically organize safety validation activities in an efficient, objective, repeatable, and scalable manner.

It is recommended that future work will establish a **catalogue of scenarios** that can be used by the various NATM pillars to validate the functional safety requirements established by FRAV. Sufficient coverage is essential to the overall effectiveness and credibility of this methodology as a validation approach. Therefore, Scenarios-based validation methods shall include adequate **coverage** of relevant, nominal, failure, critical, and complex scenarios to effectively validate an ADS.

Because an ADS will need to be responsive to actions by other road users, which may make a crash unavoidable, it is recommended that scenarios are not limited to those that are deemed preventable by the ADS. Unsafe behaviours of other road users (e.g. vehicle travelling in the wrong direction, sudden unsignalled lane changes, and exceeding the speed limit) should be included as part of validation testing.

Classifying scenarios

It is critical that a **standardized and structured language** for describing scenarios is established so that ADS stakeholders understand the intention of a scenario, each other's objectives, and the capabilities of an ADS. One tool for establishing uniform language for describing a scenario is a **template**.

It is recommended to describe scenarios by different **levels of abstraction** as previously proposed on the New Assessment/Test Method for Automated Driving **(NATM).** There are 3 or 4 levels of scenario abstraction: **Functional, Abstract, Logical, and Concrete**. Abstraction supplies the ability to focus the scenario description on specific aspects, while leaving other details for further processing as needed.

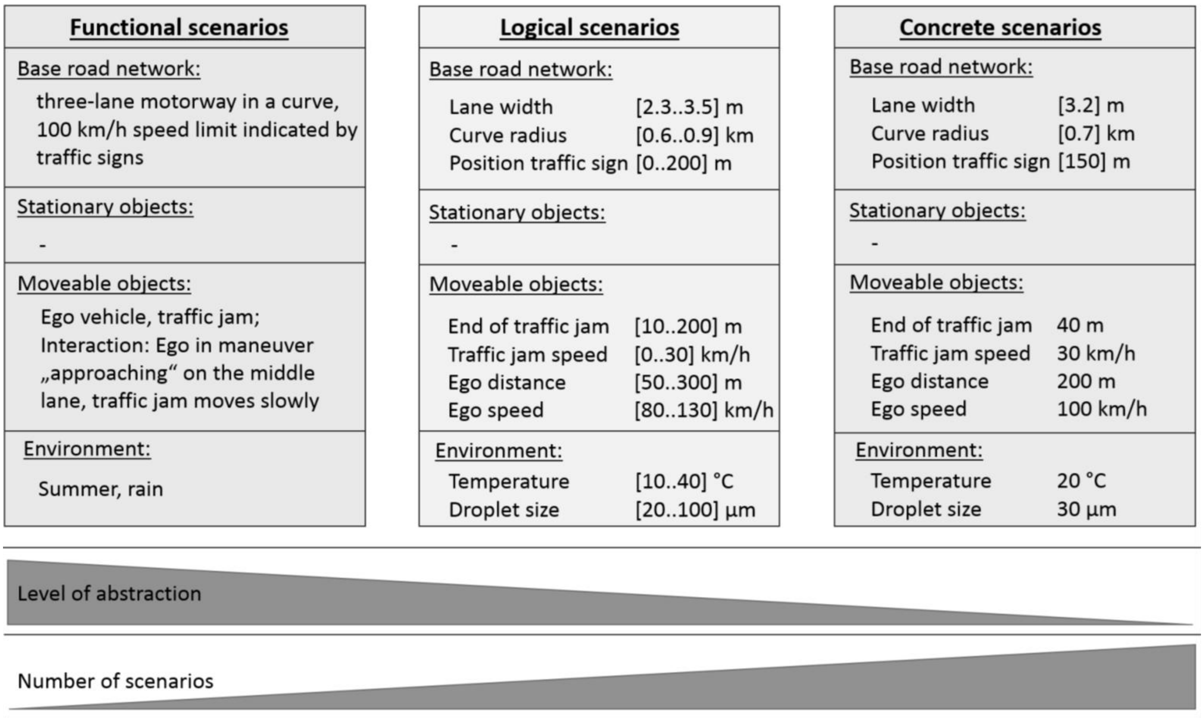


Figure 14. From functional to concrete scenarios descriptive diagram. [65]

Scenario template

It is recommended that scenarios included within a possible future scenario catalogue should follow a common template to ease comparison of scenarios and aid authorities in determining which scenarios are appropriate for testing a particular ADS.

A brief explanation of each scenario item is given next:

- **Scenario Name:** A title describing the scenario.
- **Scenario ID**: Unique identifying number.
- **Contributed by:** Which organisation contributed the scenario.
- **Scenario source:** What is the source of this scenario (e.g., ISMR, synthetic scenario, other regulation, accident database etc)? This includes the geographical location of an original incident (if applicable))
- **Version:** Version of the scenario to track updates, contains date of submission.
- **Figure/Graphic:** A graphic describing the scenario, movements may be represented as well by arrows or other graphics means. This graphic may be 2D or 3D.
- **Functional Scenario Description:** A section with textual description of the scenario. This may include some specific testing and safety evaluation goals. This description could be either structured or unstructured natural language.
- **ODD Tags:** Scenery elements (road details, buildings etc.), Environmental conditions, Dynamic elements (elements in motion)
- **Behaviour Tags:** Ego vehicle behaviour and actions during the scenario. It may also indicate expected responses. Behaviours for all other active actors in the scenario.
- **Type of scenario:** Nominal, Critical, or Failure
- These scenario types are defined by the external conditions rather than the ADS, further work is required in order to determine classification for the catalogue. At the functional level more than one option may be appropriate.
- **Range of applicability:** Range and/or parameter constraints on usage of the scenario
- **Abstract Scenario (Optional):** A formalized, declarative description of the scenario derived from the functional scenario. The specification on the abstract level enables highlighting of the relevant aspects of the scenario while focusing on efficient description of relations (cause-effect).

Virtual testing and credibility assessment

The flexibility of simulation makes it a standard test method during a vehicle's design and the development of this pillar will also make it part of the ADS validation process. For an ADS, it will be impossible to test the vehicle's behaviour in the real world for all possible situations as well as for any subsequent change in the ADS' driving logic. Virtual testing will therefore become an indispensable tool to verify the capability of the automated system to deal with a wide variety of possible scenarios. In addition, virtual testing can be beneficial in replacing real world and proving ground testing where there are concerns over safety-critical traffic scenarios. It is recommended therefore that virtual testing be used to test the ADS under safety critical scenarios that would be difficult and/or unsafe to reproduce on test tracks or public roads.

A limitation of this approach is in its intrinsic limited fidelity as models provide a representation of the reality. Therefore, the validation of the simulation and models used in virtual testing is essential to determine the quality and reliability of the results compared to real-world performance.

Credibility assessment for using virtual toolchain

The following all have an influence on the overall M&S credibility; organizational management of the M&S activity, team's experience and expertise, the analysis and description of the chosen M&S toolset, the pedigree of the data and inputs, verification, validation, uncertainty characterization. How well each of these factors is addressed indicates the level of quality achieved by M&S toolchain, and the comparison between the obtained levels and the required levels provides a qualitative measure of the M&S credibility and fitness for its use in virtual testing.

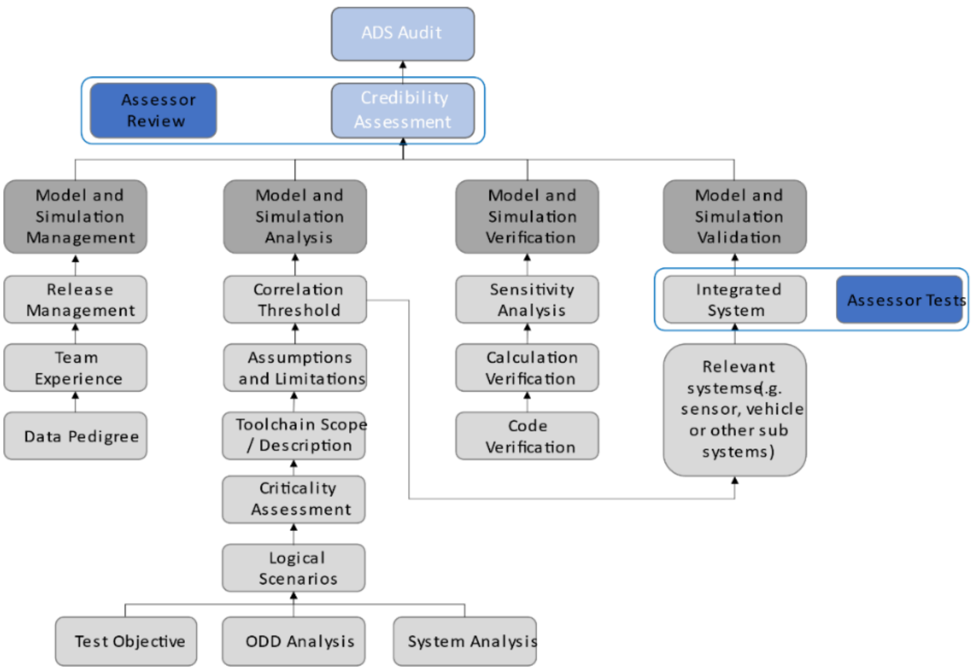


Figure 15. Representation of the relationship among the components of the credibility assessment framework [65]

M&S Management

Releases Management

M&S (Model and Simulation) undergo frequent updates, and it's essential to monitor and document these changes. Each version of the toolchain used for certification purposes should be recorded. The corresponding validation methods and acceptance thresholds should also be documented to ensure credibility. It is vital to maintain data quality, completeness, accuracy, and consistency throughout the toolchain's lifecycle to support verification and validation procedures.

Team's Experience and Expertise

The credibility of M&S is not just dependent on the tools but also on the experience and expertise (E&E) of the personnel involved. Manufacturers need to establish a clear process to assess and maintain competence at both the organizational and team levels. Team members must be adequately trained to validate the M&S toolchain and use it for ADS testing. If external inputs are used, the manufacturer must also ensure and document confidence in their quality and integrity.

Data/Input Pedigree

The quality and traceability of input data used for M&S validation are crucial. The manufacturer must document the data used, covering important aspects like quality characteristics, data coverage, and uncertainty factors. Calibration procedures for fitting model parameters to the input data must also be recorded. Poor input data quality can lead to inaccuracies in model parameters, influencing the final uncertainty analysis.

Data/Output Pedigree

The pedigree of the output data is as important as the input data. Outputs should be traceable to their respective inputs and toolchain versions. The manufacturer must document the scenarios used, output characteristics, and correlation methods. Outputs should ensure the correct execution of validation exercises and reflect the operational design domain (ODD) for accurate ADS virtual assessment. Outputs from stochastic models should be manageable in terms of variance, and deterministic re-execution should remain possible.

M&S Analysis and Description

The M&S analysis and description provide a comprehensive overview of the toolchain used for virtual testing in ADS validation. It outlines the scope, limitations, assumptions, and uncertainties of the models, ensuring their applicability and credibility.

Assumptions, Known Limitations, and Uncertainty Sources

The manufacturer must explain the modelling assumptions that influenced the toolchain design and their impact on its limitations. Justification should be provided for the tolerance between M&S results and real-world data, ensuring acceptable correlation for testing purposes.

This section should also document sources of uncertainty that could affect the results, feeding into the final uncertainty analysis.

Scope

The scope defines how the M&S is applied in ADS validation, ensuring the virtual environment matches the level of fidelity required for certification. The M&S toolchain should act as a "virtual proving ground" for ADS testing, and the manufacturer should list scenarios used for validation, including parameter limitations. An Operational Design Domain (ODD) analysis is crucial to define the parameters that the M&S toolchain must simulate for accurate ADS testing.

Criticality Assessment

The criticality of simulation models is assessed based on the potential safety impact in case of an error. This is aligned with ISO 26262 safety standards. Criticality is measured by the degree of influence the M&S toolchain has on the ADS's final decisions and its consequences on human safety.

Verification

Verification focuses on ensuring that the M&S toolchain is correctly implemented and behaves realistically. The verification process ensures credibility by following a multi-step approach that includes code verification, calculation verification, and sensitivity analysis.

Code Verification

Code verification involves testing to ensure that the mathematical and logical models in the M&S toolchain do not contain any flaws. This includes techniques such as static/dynamic code verification, convergence analysis, and comparison with exact solutions if applicable.

The ADS manufacturer must provide documentation showing that the input parameter space has been thoroughly explored to identify any unstable or unrealistic behaviour in the models. Coverage metrics can demonstrate the exploration's thoroughness.

Calculation Verification

Calculation verification assesses numerical errors (e.g., discretization errors, rounding errors, convergence of iterative procedures) that could affect the M&S toolchain. The ADS manufacturer must document these errors and ensure that they are sufficiently controlled so they do not compromise the validation results.

Sensitivity Analysis

Sensitivity analysis evaluates how changes in input parameters affect the output of the simulation models. It identifies the parameters with the most significant impact on the results. This analysis is essential for understanding the robustness of the models and ensuring that they meet validation thresholds even with small parameter variations.

The ADS manufacturer must demonstrate that the most critical parameters have been identified, calibrated, and their impact on the simulation results is well understood. Sensitivity analysis also helps define the uncertain inputs and parameters that require particular attention.

Validation

Validation ensures that the Model and Simulation (M&S) toolchain accurately represents real-world scenarios for ADS validation. The following elements are key to the validation process:

Validation Methodology

ADS manufacturers must define logical scenarios for testing across the Operational Design Domain (ODD). Validation can focus on subsystem models (e.g., sensors, environment), vehicle dynamics, or integrated systems (combining vehicle and sensor models).

Measures of Performance (Metrics)

Metrics are used to compare the ADS's performance in virtual tests to real-world performance. These include discrete value analysis (e.g., detection rates), time-based analysis (e.g., speed, acceleration), and state changes (e.g., braking initiation).

Statistical methods (Key Performance Indicators, KPIs) can also be used to compare real-world and simulation data.

Independent Validation of Results

An independent assessor may audit the validation results, reviewing any deviations between virtual and physical tests. If necessary, tests may be repeated, and the manufacturer must justify any discrepancies.

Uncertainty Characterisation

Uncertainty in the input data, model parameters, and model structure must be quantified. This helps determine the variability of the results and allows manufacturers to introduce safety margins in virtual testing. This can be classified in:

- Input Data Uncertainty: Estimating the variability of critical inputs using robust techniques.

- Model Parameter Uncertainty: Characterizing uncertain parameters using distributions or confidence intervals.

- Model Structure Uncertainty: Comparing results from different modeling approaches to quantify structural uncertainty.

- Aleatory vs. Epistemic Uncertainty: Differentiating between uncertainties that can only be estimated (aleatory) and those that arise from lack of knowledge (epistemic).

ISMR reporting templates

It is recommended that a mandatory reporting system is established at national level by means of a national database and at international level by means of a harmonized Common Central Repository. To implement the ISMR framework, Contracting Parties are recommended to **designate one or more competent authorities** to put in place a mechanism to collect, evaluate, process and store occurrences reported in accordance with ISMR principles.

The reporting template should be filled with the levels and details of the damages recorded for both the ADS vehicle and other traffic participants/objects. A practical indication of the damage level is found in the aviation practice:

(a) destroyed: the damage makes it inadvisable to restore the vehicle;
(b) substantial: the vehicle sustained damage of structural failure requiring major replacement;
(c) minor: the vehicle can be rendered operational by simple repairs/replacement;
(d) none: the vehicle sustained no damage;
(e) unknown: the damage level is unknown.

In addition, the Collision Deformation Classification (CDC) or the Vehicle Damage Index (VDI) should be provided if applicable.

The reporting form should be filled with details regarding the injury level for the ADS vehicle occupants and each other road user being involved and stated to be injured. Examples from the CADaS taxonomy are:

(a) fatal: death within 30 days of the accident and as a result of the accident;
(b) critical: injured (although not killed) in the road accident & injured person in very serious condition, may need surgery or a long hospital stay to survive;
(c) serious: injured (although not killed) in the road accident and hospitalized for at least 24 hours;
(d) minor: Injured in road accident but no hospitalization required, only first aid;
(e) none: nobody was injured during the occurrence;
(f) unknown: injured in the road accident but the injury level is unknown.

If possible, the additional use of Abbreviated Injury Scheme (AIS) injury classification is recommended, either on single injuries or at the person level, reporting MAIS

SUNRISE RELATED OPEN ISSUES OF ads until THE 3RD MEETING

- What procedures should be stablished to define objective behavioural competencies for DDT performance based on the safety requirements and their application to scenarios and test methods?

- Relationship between In-Service Monitoring and Reporting (ISMR) and the behavioural competencies of the original ADS assessment suggests that data from both blocks should be standardised. How can we ensure that?

- Procedures for establishing the validity of safety models used to assess ADS performance under critical scenarios with regard to avoidable/unavoidable outcomes.

- Further consideration of approaches to developing safety models, including their applicability to assess aspects of ADS performance, and covering FRAV discussions on methodologies such as "state of the art", "careful and competent driver", and "safety envelope" concepts.

- Consideration of a common catalogue or database of traffic scenarios for regulatory use suggests that different SCDB can interact. How this will be approached?

- Development of procedures for establishing track and real-world testing matrices and protocols.

- The document acknowledges the remote and on-board operation of ADS vehicles. How should we select (e.g., untrained, professional, level of experience) and what role will these have?

- Who holds the responsibility for civil liability during real-world testing of ADS systems?

- How should pass/fail criteria be determined in real-world testing environments?

- Reconciliation of track testing and ODD coverage.

- Real-world test routes should be designed to capture predictable aspects of the ODD, including road types, dynamic conditions, and interactions with road users. What requirements or standards should guide the creation of real-world tests (e.g., scenarios, engineered test routes).?

- Consideration of less subjective definitions for nominal and critical traffic scenarios and procedures for classification of traffic scenarios within the context of assessing compliance with safety requirements.

- ODD inputs requirement to the scenario block. Thus, development of harmonised provisions to ensure reasonable uniformity across ODD descriptions is needed. How is this being approached?

- As a general concept, the safety level of ADS shall be at least to the level at which a competent and careful human driver could minimize the unreasonable safety risks to the ADS vehicle user(s) and other road users. What do you understand by competent and careful human driver?

- Who are ADS manufactures responsible for reporting ISMR to the authority? Who are relevant authorities?

- The ADS IWG proposes ISMR templates. How ISMR templates are filled? Automatically by the ADS? By hand on manufacturer responsibility? How is this imported to the scenario framework?

ANNEX 2: EXECUTIVE SUMMARY OF SUNRISE KEY TOPICS

1. Initial Allocation Process

Source: SUNRISE Deliverable D3.3 “Report on the Initial Allocation of Scenarios to Test Instances”[1]

This document describes the process of the initial allocation of test cases to test instances. This process is divided into two parts. In the first part, the requirements of the test case are compared with the capabilities of the available test instances to see where the test cases could be executed. This determines if a certain test instance will be able to execute the specific test case. In the second part of the process, the decision-making with respect to certain metrics is done.

The initial allocation process as displayed in Figure 16 has two inputs. The first input is provided by the Query and concretise block, a prior step of the SUNRISE Safety Assurance Framework. Based on test requirements SUNRISE allows for the user to define a query, which the SUNRISE Framework uses to search connected partner databases and to return relevant logical scenarios. These scenarios are then turned into test cases using the SUNRISE methodology. Test cases have been prepared involving a scenario description and other additional aspects necessary for the execution like the expected behaviour of the system under test (SUT) and pass/fail criteria. The information contained in the individual test cases is extracted to get the requirements for that test case.

The other inputs for the process are the available test instances and their capabilities. Test instances include virtual testing, any form of X-in-the-Loop (XiL) testing and proving ground testing. Field testing is not considered as an option because of the uncontrollable nature of these tests, that makes it hard to reproduce certain scenarios.

The decision-making process includes the comparison of test case requirements and test instance capabilities to evaluate suitable test instances for test cases. Furthermore, it proposes a method to address the trade-off between efficiency of test execution and reliability of the test results, by testing selected scenarios in higher fidelity test instances. This enables comprehensive (large number of test scenarios) as well as reliable assessment of the SUT. As mentioned in the introduction, achieving this assessment of the SUT requires iterative test instance selection in the initial allocation process, as the safety-critical relevance of the test case and the uncertainty of test results in a given test instance, can only be assessed based on test case results. Note that the proposed approach is the initial allocation process and may be extended by the final allocation process. This process may propose additional re-allocation strategies for test scenarios to tackle safety-critical aspects such as incorrect execution of tests, or incorrect identification of test capabilities.

The methodology is based on current industry standards, such as ISO 34503, which provide a framework for structuring the components of a scenario in a tree-like hierarchy. Each leaf of the tree represents a point where a comparison can be made between the test requirements and the available test instances. By traversing the tree, decisions are systematically aggregated, leading to a final selection of the most appropriate test instance.

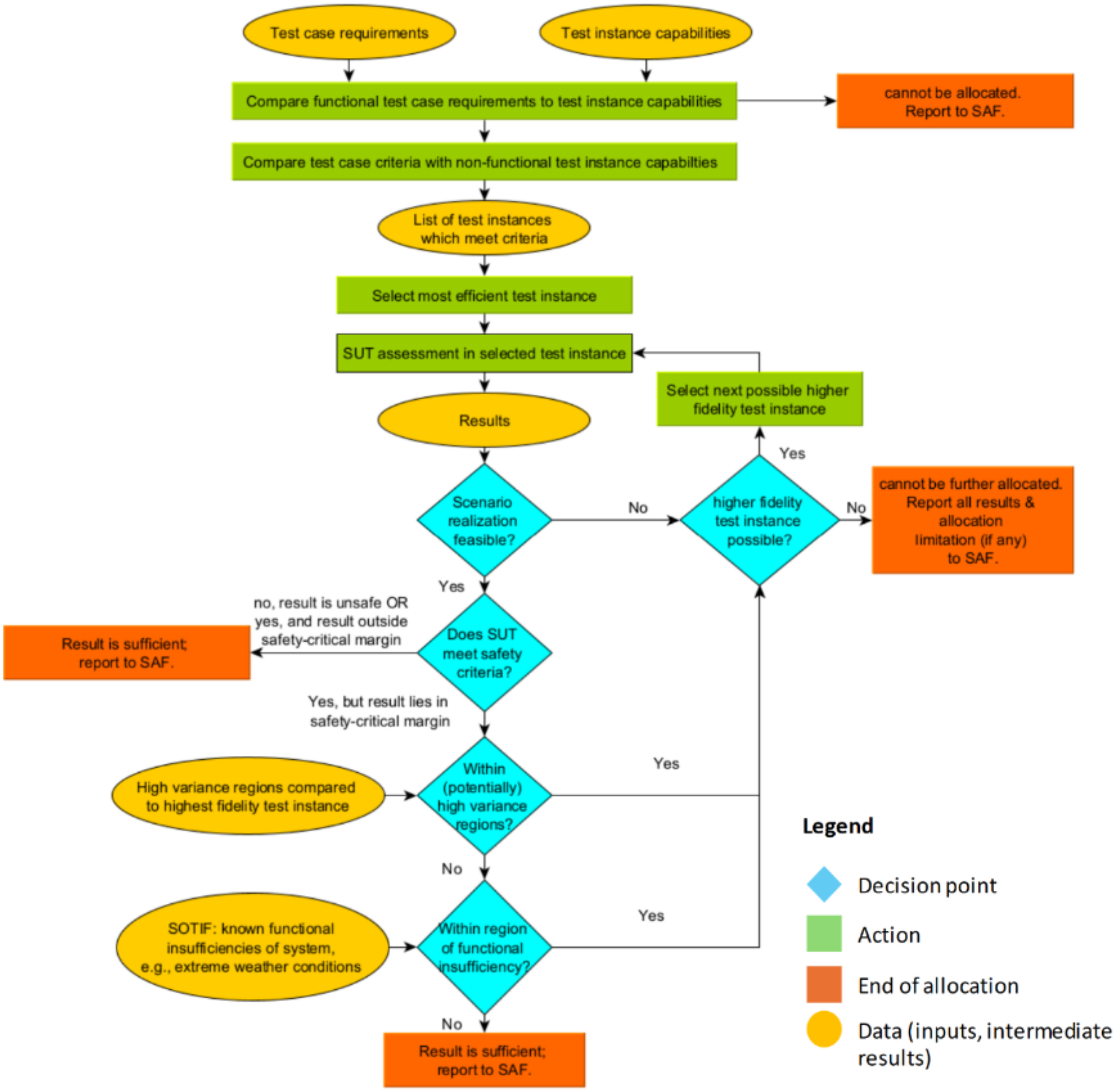


Figure 16: Decision-making process for initial allocation

A decision-making process can include many metrics for the initial allocation. All metrics regarding the comparison of test case requirements to test instance capabilities should be part of a decision-making process since the identification of capable test instances should always be the first step of decision-making of an initial allocation process which means that the test case requirements have to be considered. These metrics compare all test case requirements to the test instance capabilities. However, a decision-making process can include more metrics concentrating on the test instance capabilities and therefore on the comparison of test instance capabilities between each other (see Figure 17).

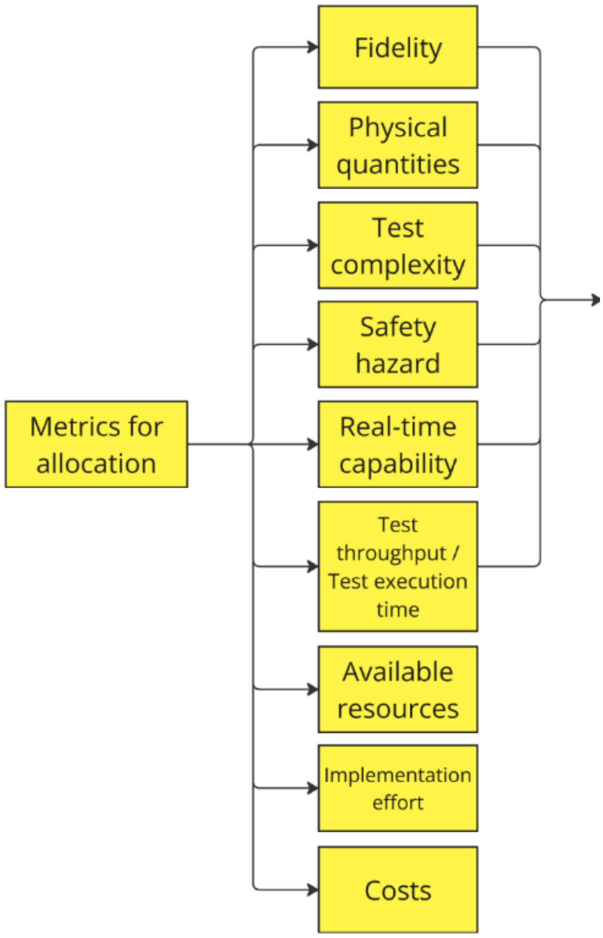


Figure 17: Metrics that can be used for the (initial) allocation of test cases to test instances

2. Scenario Quality Metrics

The emergence of automated driving technology demands a fundamental shift in safety validation approaches. The New Assessment Test Methodology (NATM) establishes a structured framework requiring manufacturers to demonstrate that their automated systems can handle real-world driving complexities without increasing risk compared to human-driven vehicles. This methodology combines simulation-based testing, controlled track testing, and real-world traffic validation to comprehensively assess system safety across the vehicle's Operational Design Domain (ODD).

Manufacturers must develop a comprehensive catalog of scenarios specific to their system's ODD, establish clear validation metrics for each scenario type, and demonstrate sufficient parameter coverage within scenario categories.

The NATM emphasises that manufacturers must not only test specific scenarios but also demonstrate sufficient coverage beyond test cases. This requires systematic scenario identification methodologies, robust coverage metrics quantifying testing completeness, thorough parameter space exploration, and validated testing toolchains. Rather than simply passing predetermined tests, manufacturers must now provide evidence of comprehensive safety across their entire operational domain.

The SUNRISE SAF for automated driving systems employs five key metric categories that support different validation phases.

- Testing purpose metrics (relevance, criticality, and complexity) guide the transformation of logical scenarios into concrete tests, inform test environment allocation decisions, and determine appropriate testing intensity based on scenario importance.

- Scenario description metrics ensure that scenarios contain all necessary information for proper execution in simulation or test environments, with detail levels influencing test platform selection between different testing approaches.

- Scenario exposure metrics quantify the real-world probability of encountering specific scenarios, enabling prioritisation of representative conditions during testing and providing important weighting factors in safety argumentation.

- (Dis)similarity metrics assess how different scenarios are from one another, ensuring that generated scenarios are meaningfully distinct during creation and evaluating diversity during coverage analysis to prevent redundant testing.

- Coverage metrics form the SAF foundation by ensuring scenarios adequately span the system's operational domain, quantifying how thoroughly the scenario set addresses relevant conditions, and supporting completeness arguments in safety case development.

Together, these metrics create a comprehensive framework for thorough, representative, and effective validation of automated driving systems across their intended operational domains.

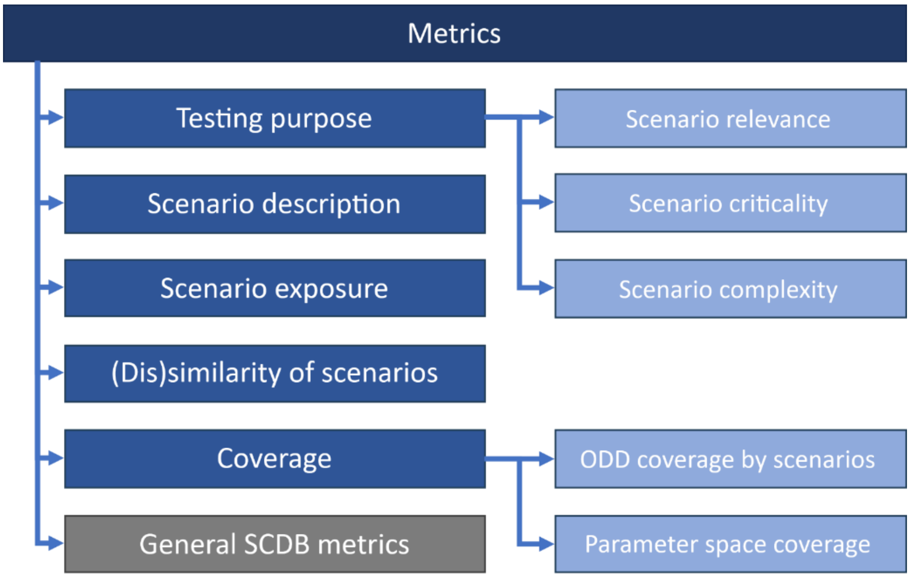


Figure 18: Metrics developed by SUNRISE project

Testing Purpose Metrics

Scenario Relevance Metric: This metric prioritises high-risk scenarios for testing by comparing testing scenarios against the full set of operational design domain scenarios. The process involves selecting scenarios from existing databases, estimating risk based on severity, controllability, and exposure, defining acceptance criteria to filter low-risk scenarios, and evaluating the representativeness of selected scenarios to ensure they reflect critical situations.

Scenario Criticality Metric: The project defines two approaches to assess scenario criticality. The scenario-based approach evaluates characteristics before execution, considering perception-related, traffic-related, and vehicle control-related risk factors. The test scenario outcome-based approach assesses results after execution with a specific system, examining perception outcomes, collective perception, and planner/control metrics like time-to-collision.

Scenario Description Metrics

Scenario Description Guidelines: These guidelines assess completeness through a three-step methodology: ensuring scenarios conform to standardised formats, verifying internal consistency and plausibility, and confirming scenarios contain all information required by the use case.

Consistent Use of Taxonomy: This approach ensures consistent terminology by aligning scenario descriptions with standardised vocabulary, implementing a tagging system with shared keywords, and following established taxonomies like ISO 34503.

Scenario Description Completeness: This metric evaluates completeness at core level (scenario artifact, road definition, scenario parameters) and descriptive level (end conditions, taxonomy classification, descriptions, and actor type definitions).

Scenario Exposure Metrics

These metrics quantify how frequently specific scenarios occur in real-world driving. The project presents two approaches: Kernel Density Estimation for simpler scenarios with few parameters, and Normalising Flows, a deep learning-based approach for complex scenarios with many parameters.

Scenario (Dis)similarity Metrics

These metrics analyse how similar or different scenarios are from each other at three abstraction levels:

- Abstract-Level Similarity: Uses natural language processing to compare high-level scenario descriptions.
- Logical-Level Similarity: Employs structured comparison of scenario parameters and constraints.
- Concrete-Level Similarity: Offers trajectory-based comparison for recorded scenarios and critical scene-based comparison focusing on safety-critical moments.

Coverage Metrics

ODD Coverage by Scenarios: These metrics assess how well scenarios represent an operational design domain through:

1. Tag-Based Coverage: Evaluates coverage using systematic tagging of scenario attributes
2. Time-Based Coverage: Determines if all timestamps in data are represented
3. Actor-Based Coverage: Assesses if all relevant traffic participants appear in scenarios
4. Actor-Over-Time-Based Coverage: Ensures temporal consistency in actor representation

Parameter Space Coverage: This approach transforms complex scenario data into a simplified form while preserving essential characteristics, partitions the data into statistically equivalent subspaces, and identifies gaps in coverage that can be filled with synthetic scenarios.

These metrics collectively provide a framework for assessing and improving scenario database quality, ensuring that validation processes for automated driving systems are comprehensive, efficient, and representative of real-world conditions.

The deliverable represents a significant step toward formalising the quality evaluation of SCDB contents, a critical pillar in the development of a European SAF for CCAM systems. Standards organisations and regulators should consider formal adoption of these metrics as part of future CCAM validation protocols, contributing to a coherent and harmonised European testing ecosystem.

3. Automated Query Criteria Generation (AQCG)

This section presents the development of an automated query criteria generation (AQCG) tool for **SUNRISE Data Framework**. The AQCG tool automatically generates query criteria for searching of scenarios in scenario databases, based on user inputs such as the use case operational design domain (ODD), test requirements, dynamic driving task (DDT), etc.

The tool aims to reduce time-consuming manual querying when searching for scenarios, given the large number of test requirements for automated vehicles. This also reduces human errors in defining query criteria, therefore supporting safety argumentation for scenario-based testing. **An example user workflow** when engaging with the tool is shown in Figure 19. This includes the possibility for the user to view and refine the query criteria, when desired.

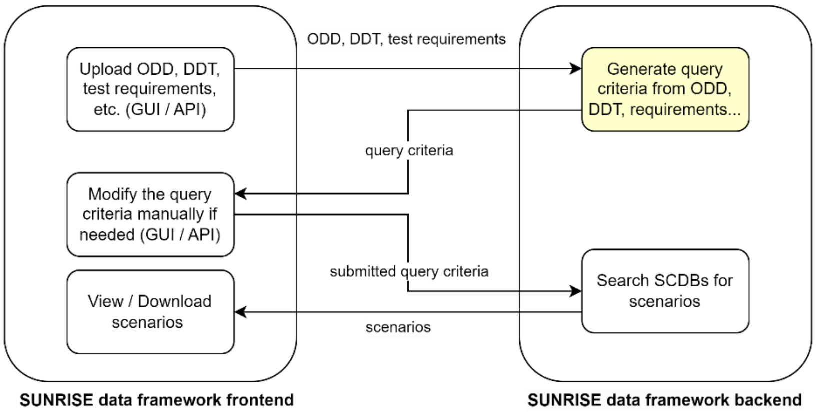


Figure 19: An example of a possible workflow and user interactions when using the AQCG tool. The highlighted block is the AQCG tool.

Based on user needs as identified in **SUNRISE D6.1** [8]**,** the generated query criteria must include dynamic behaviour of both the SUT and target actor - covering common scenario categories, the ODD, the target DDT and system-under-test (SUT), and applicable regulations and standards.

Data formats and ontology

Data formats and ontology for the following **inputs and outputs** of the tool were agreed as part of harmonisation activities in SUNRISE:

ODD definition (Input): ISO 34503 [38] ODD definition language and ontology. Although natural language based, it has simple grammar and three types of statements *(include, exclude, and conditional)*.

Requirements (Input): JSON file format, described using ISO 34503 [38] ontology for ODD related attributes and ASAM OpenLabel ontology for dynamic behaviour attributes.

Query criteria (Output): Uses the same format as described for the requirements input.

Design and Architecture

The tool functionality is specified as follows:

1. Query criteria are defined per test requirement for traceability of the retrieved scenarios with respect to the test requirements.

2. Where an ODD attribute is explicitly covered in a test requirement, the overlap of the attribute values in the requirement is done with the values of the attribute from the ODD definition. When it is not explicitly covered, then all values of an attribute are relevant for testing and are to be included in the query criteria.

3. A query criterion is returned as empty when it is unclear how the requirement should be tested. This feedback is reported to the user / SAF

4. Knowledge-based scenarios as an input (optional): To search scenario databases for similar scenarios, and to retrieve scenarios at a logical / concrete level from databases.

5. SUT / DDT / Protocol as inputs (optional): As scenario databases can be organised per specific SUT / DDT / test protocol, this is also useful for querying.

The functional architecture for the tool (with data formats) is shown in Figure 20. The tool has been implemented in Python.

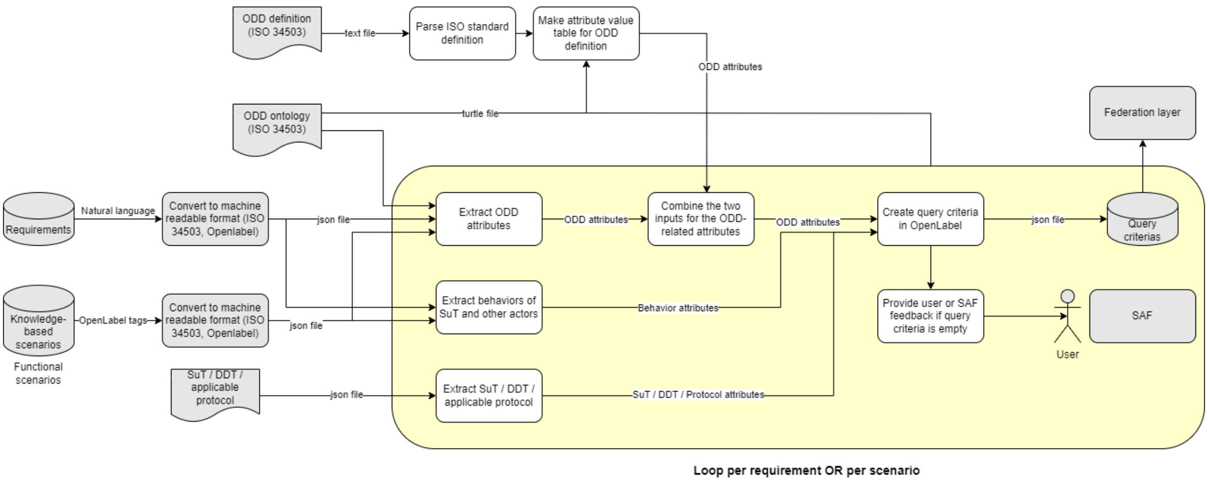


Figure 20: Functional architecture of the tool (extended with some data formats). The white blocks are part of the tool, while the grey blocks are inputs/outputs.

Validation and Future work

The developed AQCG tool has been assessed for a set of examples for use case 1.1 in SUNRISE (see SUNRISE D6.1 [8]). The assessment verifies that the tool functions as per the design specifications. The tool currently operates on inputs formatted in a specific way, limiting its ability to directly work with natural language requirements, such as those specified by regulation authorities. Therefore, future work shall investigate automated handling of natural language requirements. In addition, deducing implicit testing needs from safety requirements allows the tool to provide insightful suggestions for additional query parameters to the user.

Appendix: example demonstrating the tool output

A simple example is presented below to demonstrate the working of the tool.

Extract of ODD definition of the SUT:

Included drivable area type is [minor roads, outdoor parking]
Included agent type is [vulnerable road users, motor vehicle]
Included particulates are [non precipitating water droplets, fog]
…

Example requirement for SUT:

Crossing traffic shall be detected by the radar system in the presence of dense fog.

Extract of generated query criteria by the AQCG tool:

```
“ODD”: {
       "Drivable_area_type": [
              “Minor_roads”,
              “Outdoor_parking”
       ],
       "Agent_type": [
            "Motor_vehicle",
            "Vulnerable_road_users"
        ],
        "Particulates_type": [
            "Fog"
        ],
        …
},
“Behavior”: {“MotionCross”}
```

Rationale for generated query criteria:

- Excludes ‘*particulates types’* which are part of the ODD but need not be tested by the requirement, i.e., non-precipitating water droplets.
- All road users (‘*agent types*’) in the ODD are considered since the requirement does not specify an agent type, referring only to “crossing traffic”.
- All ODD attributes which are not specified in the requirement are fully included in the query criteria. In this example, all values of *‘Drivable area type’* are to be considered for testing of the requirement.

Behaviour attribute is defined using the corresponding tag in the OpenLabel ontology.

4. Harmonised V&V simulation framework

Deliverable D4.4 [13] plays a central role by identifying the essential subsystems required to support a modular and scalable simulation-based framework. This framework is intended to validate CCAM systems efficiently and reliably within both virtual and physical testing environments.

Key Subsystems

The report outlines several crucial subsystems that underpin the simulation framework. The first is perception and environment modelling, which is responsible for generating realistic sensor data, such as LiDAR and camera feeds. This data is used to evaluate the performance of perception algorithms under a wide range of conditions. Another key subsystem is connectivity and Cooperative Intelligent Transport Systems (C-ITS), which simulate V2X communication—encompassing vehicle-to-vehicle, vehicle-to-infrastructure, and vehicle-to-pedestrian interactions. This includes modelling the behaviour of Road Side Units (RSUs) and edge nodes that facilitate data exchange.

The planning and decision logic subsystem focuses on validating how the vehicle interprets its environment and makes decisions, especially in uncertain or rapidly changing situations. Meanwhile, actuators and vehicle dynamics deal with simulating physical responses such as steering, braking, and acceleration, relying on high-fidelity dynamics models. Finally, the scenario management subsystem oversees the configuration, execution, and documentation of simulation scenarios. It ensures that relevant safety metrics are captured and stored systematically.

- P**erception & Environment Modelling**

  Generates sensor data (e.g., LiDAR, cameras) to validate perception algorithms in diverse scenarios. → Matches *Subject Vehicle – Sensors* and *Environment*.

- **Connectivity & C-ITS**

  Simulates V2X communication (V2V, V2I, V2P) and models RSUs and edge nodes. → Linked to *Connectivity / Target Operational Design Domain*.

- **Planning & Decision Logic**

  Validates motion planning and decision-making under uncertainty and varying conditions. → Covers *Subject Vehicle – AD function (Sense, Plan, Act)*.

- **Actuators & Vehicle Dynamic**

  Simulates low-level controls (steering, braking) with accurate dynamics modeling. → Linked to *Subject Vehicle – Vehicle Dynamic* and *Hardware architecture* (Powertrain, Steering, E/E).

- **Scenario Management**

  Responsible for scenario setup, execution, logging, and integration with safety metric databases. → Corresponds to the central role of the *Test Case Manager*.

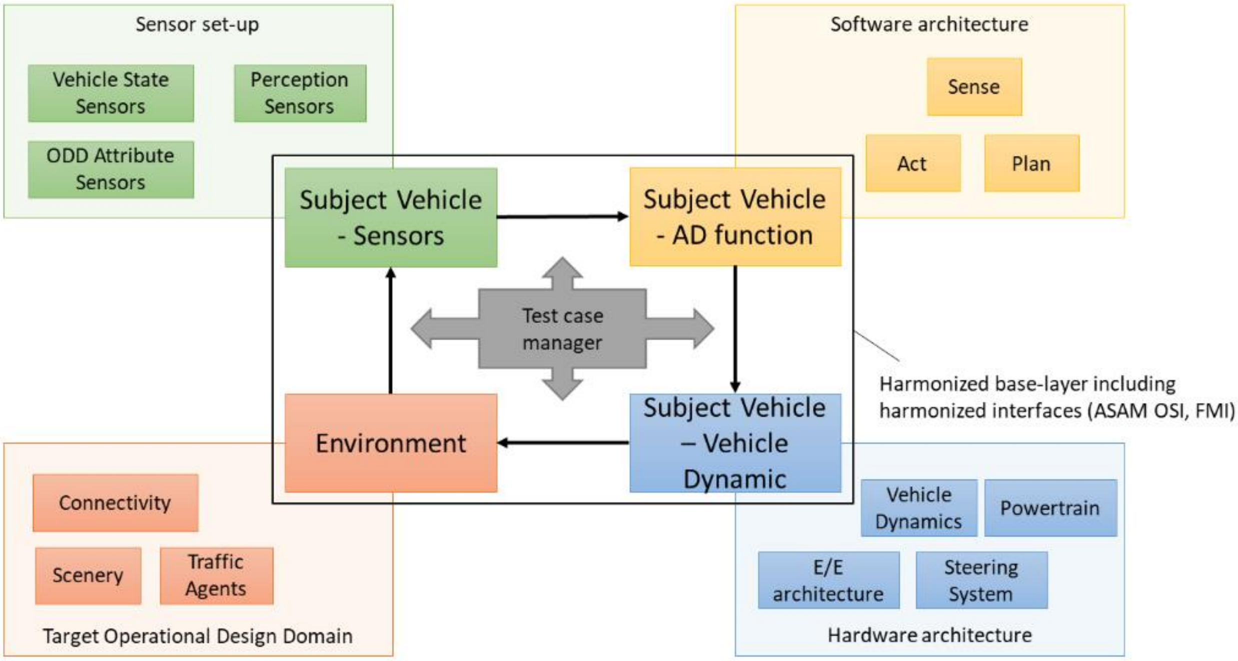


Figure 21: Architecture of the harmonised V&V Simulation Framework [13]

Harmonisation Strategy

To achieve consistency and interoperability across all simulation tools and components, the report emphasises a harmonisation strategy based on three pillars. The first is the standardisation of interfaces, enabling modules to be interchangeable without extensive reconfiguration. The second is the use of common data formats, such as those defined by the Open Simulation Interface (OSI) and standard scenario ontologies. The third pillar is ensuring interoperability among tools, allowing for seamless integration across different platforms, including popular simulation tools like Carla and SUMO.

ANNEX 3: REPORTS FOR THE SAF MOCK APPLICATION

1. Test report from IDIADA for SUNRISE Use Case 3.2

This test report was created by IDIADA representing the executed test runs from **proving ground** for SUNRISE Use Case 3.2 and reported to RDW as a **basis for the SAF mock application.**

TEST REPORT FOR USE CASE 3.2 WITH REGARD TO HIGHWAY COOPERATIVE PERCEPTION AND DECISION MAKING, ACCORDING TO SUNRISE SAFETY ASSURANCE FRAMEWORK

Applicant : SUNRISE Project 101069573

Manufacturer : Toyota Motor Corporation

Commercial description : RAV4

Category : M1

Place and date of issue : L'Albornar, Santa Oliva (Tarragona), 06/06/2025

CONCLUSIONS: The vehicle has been assessed according to the SUNRISE SAFETY ASSURANCE FRAMEWORK, and the results are shown in Annex I.

1.1 TESTED VEHICLE CHARACTERISTIC

Make : Toyota Motor Corporation

Category : M1

VIN : JTMW53FV50J012056

Tyre dimensions : 225-60R18

Documentation package : RDW - Evidence for test report

Documentation reference No. : 3.2-X_YYY

Sample received on : 23/05/2025

Vehicle mass during the tests:

	LADEN (kg)
First axle mass	900*
Second axle mass	850*
Total mass	**1750***

*Indicative vehicle mass based on manufacturer declared mass in running order plus the weight of the installed equipment and hardware. For type approval processes, the vehicle is weighed on a calibrated scale.

Tyre pressure:

	Tyre pressure (bar)
First axle	2.3
Second axle	2.3

1.2 FUNCTIONS DESCRIPTION

General description

Name of the Function:	: IDIADA HWP
Software Version	: Not available
Forward detection range	: Not available
Minimum system activation speed	: 0 km/h
Maximum speed of system	: 120 km/h

Special requirements applied to the functional and operational safety aspects

This section explains how the information and data related to the function is made available and reviewed by the Technical Service. In this case the evaluation has been done according to the evidence provided for the study (not complete package). Information package is not complete since this is a research project, and not a production vehicle.

The first step requires the vehicle manufacturer to provide the Technical Service with a comprehensive documentation package. This package contains an information document and documentation related to functional and operational safety aspects. The information document contains a high-level description of the function, basic performance and operational design domain. In the documentation related to the functional and operational safety aspects all the information listed in points from 3.1 to 3.3.3 included shall be made available, it typically encompasses detailed technical documents, data, drawings, photographs…

Subsequently, the Technical Services reviews the documents mentioned in the previous paragraph and provides feedback to the manufacturer. It's common to engage several loops of documentation submission-revision-feedback until a complete documentation package is obtained.

Once the documentation package is deemed correct and complete manufacturer and technical service shall program a safety audit in order to review the confidential material and analysis data according to paragraph 3.3.4.

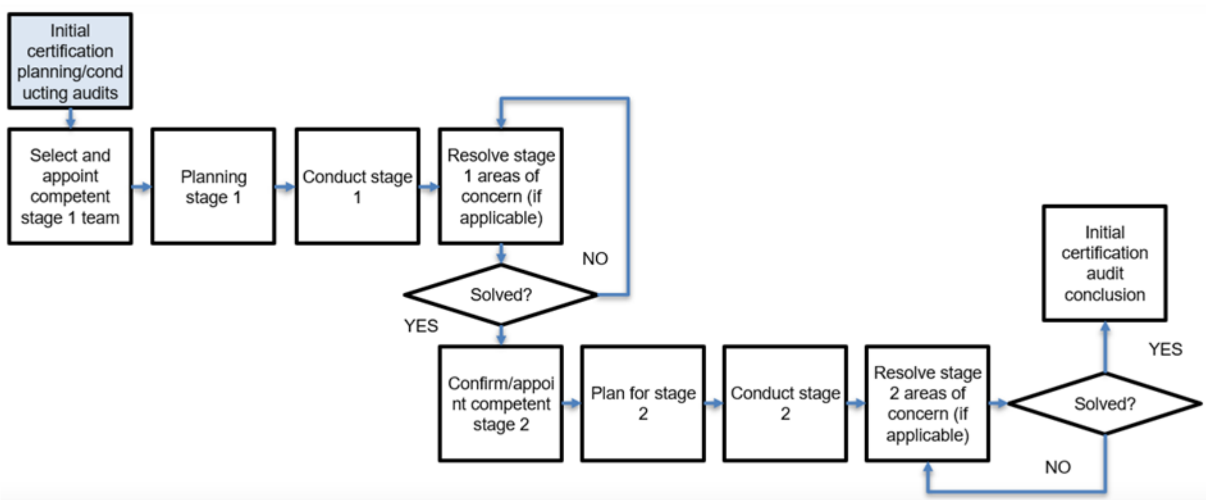
The evaluation process is done according to the ISO/IEC 17021, titled “Conformity assessment – Requirements for bodies providing audit and certification of management systems”.

ISO 17021 essentially provides the framework that ensures certification bodies conduct audits in a competent, consistent, and impartial manner, giving confidence to during the certification process.

The process starts with the application by the manufacturer, of the initial certification:

The audit programme includes two-stage initial audit. The criteria for the determination of the audit time shall be documented, and proportional to the audit scope. The certification body shall have a process for selecting and appointing the audit team, including the audit team leader and technical experts as necessary.

An initial certification audit must include a stage 1, or documentary review, and a stage 2, or onsite audit. The whole prosses is defined below:



Description of the system

The manufacturer provided a documentation package which gives access to the basic design of "The System" and the means by which it is linked to other vehicle systems or by which it directly controls output variables. The function(s) of "The System", including the control strategies, and the safety concept, as laid down by the manufacturer, shall be explained.

NOT AVAILABLE

The document package is shown that "The system" is designed and was developed to operate in such a way that it is free from unreasonable risks for the driver, passengers and other road users within the declared ODD and boundaries.

NOT AVAILABLE

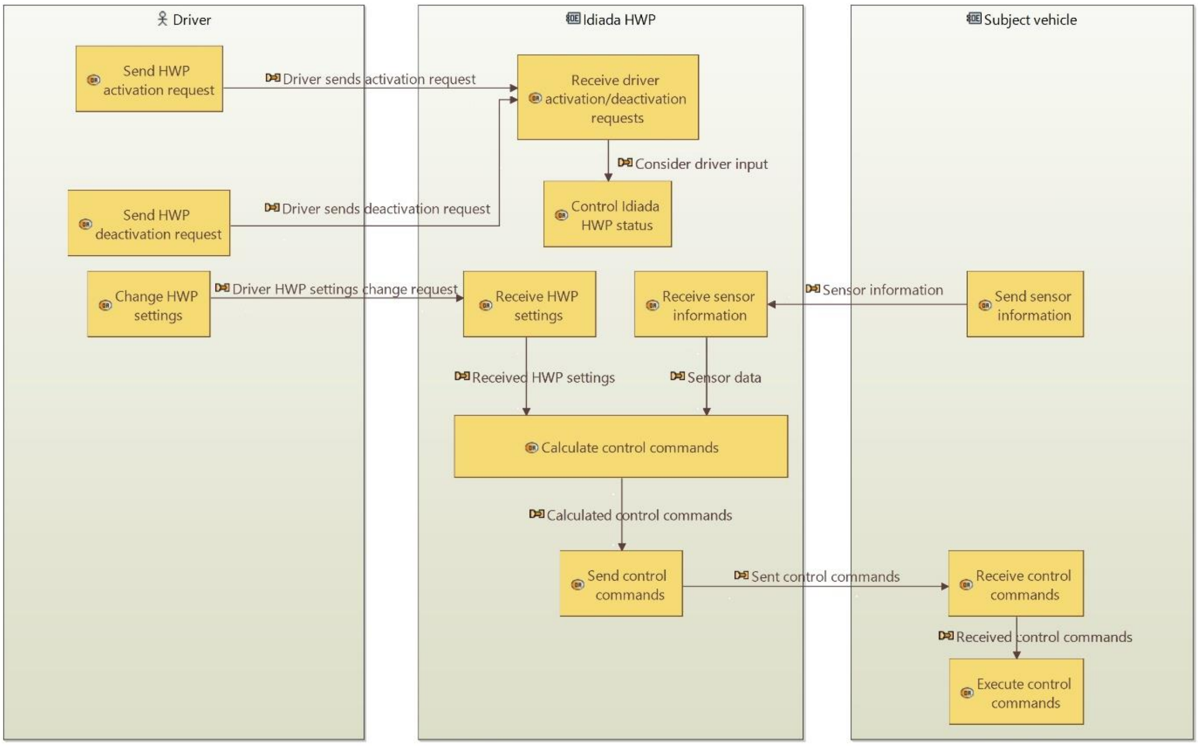
The manufacturer provided a simple explanation of all the functions including control strategies of "The System" and the methods employed to perform the dynamic driving tasks within the ODD and the boundaries under which the automated lane keeping system is designed to operate, including a statement of the mechanism(s) by which control is exercised.

- **Decision making and planning**: The ego vehicle performs lane-following behaviour by tracking the centreline of the lane, which is derived from the perception system's lines detection. The planning actuation involves generating a trajectory that continuously aligns the vehicle's position with the lane centre, ensuring comfortable longitudinal and lateral control in accordance with highway driving standards.
- **Control execution:** The control adjusts the steering angle and longitudinal acceleration to maintain or correct the vehicle's lateral and longitudinal position within the lane. For longitudinal control, the reference speed is determined either by the speed of the forward vehicle or by the set speed specified by the driver through the Human-Machine Interface, depending on the driving scenario.
- **Object tracks** are used to identify potential obstacles and maintain safe following distances, while lane line information enables accurate lane keeping and consistent alignment with the road geometry.

  (*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED

The manufacturer provided a description of the interactions expected between the system and the driver, vehicle occupants and other road users as well as Human-Machine-Interface (HMI).



The IDIADA Highway Pilot (HWP) system operates through a straightforward sequence of interactions between the driver, the HWP control module, and the vehicle itself.

The process begins when a driver initiates an action, typically by requesting to activate the Highway Pilot through the vehicle's interface. This activation request travels from the driver to the IDIADA HWP system, which receives and processes it. Similarly, if the driver wishes to deactivate the system or modify its settings, these requests follow the same initial path to the HWP system.

Once the IDIADA HWP receives a driver request, it evaluates this input to determine how to adjust the system's operational status. The HWP control module then updates its internal state based on the driver's command, either activating, deactivating, or modifying its behaviour accordingly.

In parallel to processing driver inputs, the HWP system continuously receives sensor information from the subject vehicle. These sensors capture critical environmental data and vehicle status information, creating an awareness of the driving conditions and vehicle state.

With both driver preferences and sensor data in hand, the IDIADA HWP calculates the appropriate control commands. After determining the optimal control actions, the HWP system sends these commands to the subject vehicle. The vehicle receives these instructions and executes them through its various control mechanisms, adjusting steering, acceleration, braking, and other functions as needed.

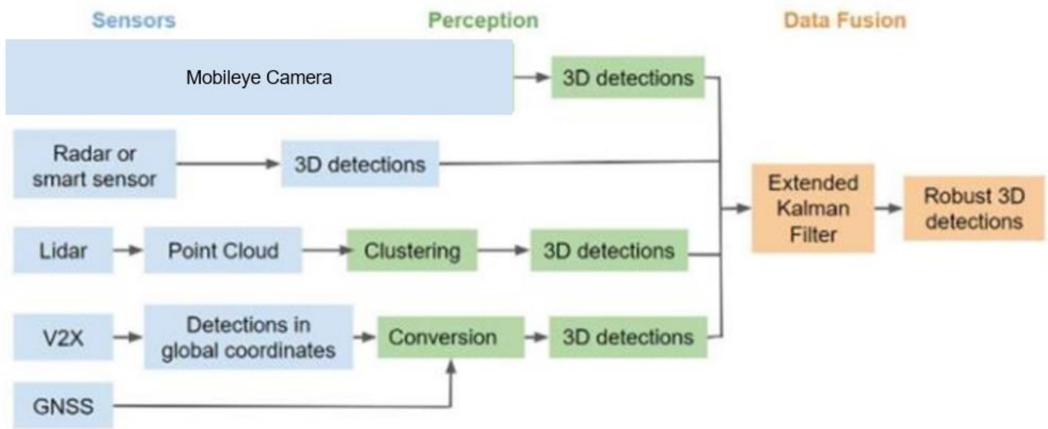
Throughout this process, there is a constant flow of information between the three components. The subject vehicle continues to send updated sensor information to the HWP system, which responds with refined control commands, creating a continuous feedback loop that maintains appropriate vehicle control while allowing the driver to intervene or adjust settings as desired.

This integrated approach ensures that while the Highway Pilot system manages the moment-to-moment driving tasks, the driver remains the ultimate authority with the ability to activate, deactivate, or modify the system's behaviour at any time.

(*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED

The manufacturer provided a list of all input and sensed variables shall be provided and the working range of these defined, along with a description of how each variable affects system behaviour.



V2V communication data is received by the control ECU (Speedgoat) via the User Datagram Protocol (UDP) in the form of Cooperative Awareness Messages (CAMs) and Manoeuvre Coordination Messages (MCMs). CAMs contain information about cooperative vehicle, such as position, heading and speed.

The perception system provides inputs in the form of object track lists and lane line detection lists. Object tracks include attributes such as position, velocity, object classification, heading, width and length. Lane line data comprises polynomial coefficients used to extract curvature among others, view ranges parameters, and identifiers.

The CAN interface provides internal vehicle data that is essential for estimating the vehicle state. This includes signals such as ego vehicle speed, steering wheel angle, yaw rate, longitudinal and lateral acceleration, and the target speed set by the driver via the HMI.

(*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED

The manufacturer provided a list of all output variables which are controlled by "The System" and an explanation given, in each case, of whether the control is direct or via another vehicle system.

- Acceleration command: CAN signal sent to Engine ECU (which performs the low-level control).
- Steering angle command: CAN signal sent to ESC ECU (which performs the low-level control).
- AEB command: CAN signal sent to Brakes ECU (which manages the pressure on the master cylinder of the brakes system).

(*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED

The manufacturer has provided the list of limits that define the limits of functional operation, including ODD limits.

- Infrastructure. The system is specifically designed for highway environments. It assumes the presence of continuous and well-defined lane markings with more than one lane for driving direction and a lane width of 2.5 m to 5.3 m. The minimum detected range of lane marking is 10 m

- Traffic Conditions. The system supports operation in free-flowing highway traffic. It accounts for standard highway driving behavior, including lane changes by surrounding vehicles. Temporary obstructions such as cones or other irregularities introduced are not considered.

- Environmental Conditions. The system is designed to operate under clear weather conditions. It is also capable of operating during both daytime and low-light conditions, including nighttime."

- Speed Range. The supported speed range for the ego vehicle within the HWP scenario is from 0 km/h to 120 km/h.

- Lateral/Longitudinal Acceleration Range. Longitudinal acceleration and deceleration profiles are designed to meet established comfort and safety standards for highway driving. The supported longitudinal acceleration range for the ego vehicle is from –3.5 m/s^2 to 2 m/s^2 and the lateral acceleration range is from –3 m/s^2 to 3 m/s^2.

  (*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED

System layout and schematics

The manufacturer provides a list of all system units and mentions other vehicle systems that are necessary to achieve the control function.

- Toyota RAV4 base vehicle with powertrain, steering, and brake systems
- Planning and control system (PC Nuvo 7006LP, Speedgoat Mobile M3 with IDIADA HWP Software)

- Perception system (multiple Camera Basler units, PC BRAV-7521 with Sensor Fusion Algorithm, Lidar Ouster OS2 64, GPS Settop M1, Radar ARS 548DI, GPS RT)
- V2X Communication System (OBU Cohda Wireless MK6 with various antennas)
- Networking equipment (PoE Switch, Ethernet Switch Netgear GS108)

(*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED

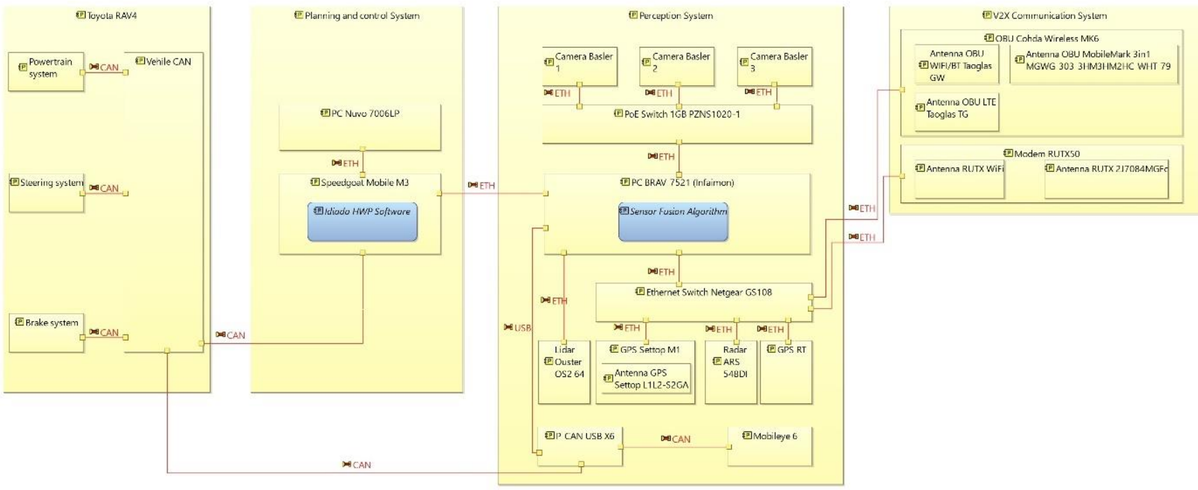
The manufacturer provided an outline schematic showing these units in combination with both the equipment distribution and the interconnections made clear.

This outline includes:

a. Perception and objects detection including mapping and positioning
b. Characterization of Decision-making

(*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED



The function of each unit of "The System" is outlined and the signals linking it with other units or with other vehicle systems are shown. This may be provided by a labelled block diagram or other schematics, or by a description aided by such a diagram.

The schematic depicts three primary subsystems that control the Toyota RAV4 platform and their interaction with the vehicle's native systems. The diagram shows all physical connections between components, including source, destination, and communication protocols used (CAN, ETH, USB).

Two critical software components are highlighted in blue:

The Sensor Fusion system collects and integrates data from all sensors (cameras, Lidar, Radar, Mobileye, GPS) to create a virtual representation of the vehicle's environment. This unified perception data provides a comprehensive understanding of the surroundings.

The IDIADA HWP Software processes the sensor fusion data along with user configuration settings to control the vehicle. This software manages both longitudinal and lateral control, enabling highway driving assistance within defined operational parameters.

(*) REMARK: the information provided is too generic to demonstrate compliance with the requirement of the regulation.

TO BE COMPLETED

Safety concept of the manufacturer

The manufacturer provided a statement which affirms that the "The System" is free from unreasonable risks for the driver, passengers and other road users.

TO BE PROVIDED

In respect of software employed in "The System", the outline architecture is explained and the design methods and tools used are identified. The manufacturer shows evidence of the means by which they determined the realization of the system logic, during the design and development process.

TO BE PROVIDED

The manufacturer provided the Type Approval Authority with an explanation of the design provisions built into "The System" so as to ensure functional and operational safety.

TO BE PROVIDED

The chosen provision selects a partial performance mode of operation under certain fault conditions (e.g. in case of severe failures), then these conditions are stated (e.g. type of severe failure) and the resulting limits of effectiveness defined (e.g. initiation of a minimum risk manoeuvre immediately) as well as the warning strategy to the driver.

TO BE PROVIDED

If the chosen provision selects a second (back-up) means to realise the performance of the dynamic driving task, the principles of the change-over mechanism, the logic and level of redundancy and any built in back-up checking features are explained and the resulting limits of back-up effectiveness defined.

TO BE PROVIDED

If the chosen provision selects the removal of the automated driving function, this are done in compliance with the relevant provisions of this regulation. All the corresponding output control signals associated with this function are inhibited.

TO BE PROVIDED

These documentations the manufacturer provided are supported, by an analysis which shows, in overall terms, how the system will behave to mitigate or avoid hazards which can have a bearing on the safety of the driver, passengers and other road users.

The requirements described in this section shall be made available to the Technical Service. However, since this information is considered, intellectual property of the manufacturer being therefore confidential this information shall be retained by the manufacturer but made open for inspection. The manufacturer shall ensure that this material and analysis data remains available for a period of 10 years counted from the time when production of the vehicle type is definitely discontinued.

The safety audit shall be organized in advance with all relevant stakeholders present. This review may be done on-site at the manufacturer's facilities or online, as adequate.

There are two different outcomes from this audit:

A report will be elaborated with the results of the evaluation without disclosing any confidential data.

A test matrix with the aim to verify the system functionality and the validation of the safety concept presented shall be developed. The system will be tested under non-failure conditions and under failure conditions.

TO BE PROVIDED

Assessment of the application of the analytical approach(es)

(a) Inspection of the safety approach at the concept (vehicle) level. This approach is based on a Hazard / Risk analysis appropriate to system safety.

(b) Inspection of the safety approach at the system level including a top down and bottom-up approach. The safety approach is based on a Failure Mode and Effect Analysis (FMEA), a Fault Tree Analysis (FTA) and a System-Theoretic Process Analysis (STPA) or any similar process appropriate to system functional and operational safety.

(c) Inspection of the validation/verification plans and results including appropriate acceptance criteria. This includes validation testing appropriate for validation. Results of validation and verification is assessed by analysing coverage of the different tests and setting coverage minimal thresholds for various metrics.

TO BE PROVIDED

The inspection confirms that at least each of the following items is covered where applicable under (a)-

i. Issues linked to interactions with other vehicle systems (e.g. braking, steering).

ii. Failures of the automated lane keeping system and system risk mitigation reactions.

iii. Situations within the ODD when a system may create unreasonable safety risks for the driver, passengers and other road users due to operational disturbances.

iv. Identification of the relevant scenarios within the boundary conditions and management method used to select scenarios and validation tool chosen.

v. Decision making process resulting in the performance of the dynamic driving tasks (e.g. emergency manoeuvres), for the interaction with other road users and in compliance with traffic rules.

vi. Reasonably foreseeable misuse by the driver (e.g. driver availability recognition system and an explanation on how the availability criteria were established), mistakes or misunderstanding by the driver (e.g. unintentional override) and intentional tampering of the system.

vii. Cyber-attacks having an impact on the safety of the vehicle.

The manufacturer provided the documentation which itemize the parameters being monitored and shall set out, for each failure condition of the type defined in above, the warning signal to be given to the driver/vehicle occupants/other road users and/or to service/technical inspection personnel.TO BE PROVIDED

The manufacturer provided the documentation which also describe the measures in place to ensure the "The System" is free from unreasonable risks for the driver, vehicle occupants, and other road users when the performance of "The System" is affected by environmental conditions e.g. climatic, temperature, dust ingress, water ingress, ice packing.

TO BE PROVIDED

Safety management system (Process Audit)

The process of certifying the safety management system comprises several stages consisting in documental reviews, on-site audit and action plan. Each stage is correctly documented and specific reports are generated.

For each one of the requirements described in the following paragraphs specific data and files are requested.

In respect of software and hardware employed in "The System", the manufacturer demonstrates to the type approval authority in terms of a safety management system that effective processes, methodologies and tools are in place, up to date and being followed within the organization to manage the safety and continued compliance throughout the product lifecycle.

TO BE PROVIDED

The design and development process are established including safety management system, requirements management, requirements' implementation, testing, failure tracking, remedy and release.

TO BE PROVIDED

The manufacturer institute and maintain effective communication channels between manufacturer departments responsible for functional/operational safety, cybersecurity and any other relevant disciplines related to the achievement of vehicle safety.

TO BE PROVIDED

The manufacturer has processes to monitor safety-relevant incidents/ crashes/collisions caused by the engaged automated lane keeping system and a process to manage potential safety-relevant gaps post-registration (closed loop of field monitoring) and to update the vehicles.

TO BE PROVIDED

The manufacturer demonstrate that periodic independent internal process audits are carried out to ensure that the processes established in accordance with paragraphs above.

TO BE PROVIDED

Manufacturers put in place suitable arrangements with suppliers to ensure that the supplier safety management system comply.

TO BE PROVIDED

1.3 INITIAL INSPECTIONS

Testing conditions

The test is carried out on a flat and dry surface of asphalt or another type of concrete surface that offers sufficient adhesion for the results expected by the test.

FULFILS

The test is performed under conditions that allow the activation of the function

FULFILS

Location:	IDIADA Automotive Technology SA L'Albornar-Apartado de correos 20 E-43710 Santa Oliva (Tarragona)
Test track:	*Dynamic Platform A (DPA)*

Test targets

The car used is a high-volume series vehicle of category M or N. Alternatively, a representative soft target according to ISO 19206-3: 2018 is used.

FULFILS

1.4 ENSAYOS / TEST

(*) REMARK: The test scenarios presented in the SUNRISE project documentation, while valuable for demonstrating basic functionality, are not sufficiently comprehensive to confirm the overall safety of the Highway Pilot system in accordance with type approval requirements. These scenarios primarily focus on normal operational performance but fail to address critical safety verification aspects. For comprehensive type approval the testing methodology should be expanded to include:

- System behaviour under non-failure conditions with particular emphasis on driver override scenarios. The current testing lacks verification of how the system responds when the driver intervenes to take control during automated operation, which is essential for confirming safe transition of control.

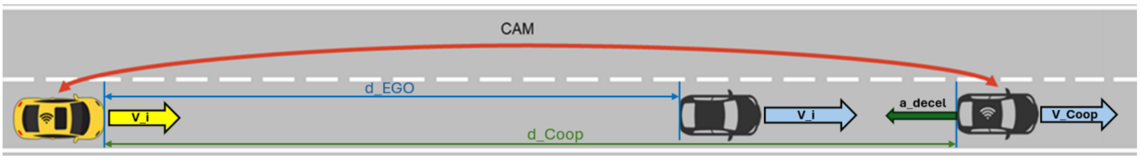
- Verification of the safety concept through fault simulation. The current test plan does not include applying simulated faults to individual units to assess the system's response to internal failures. At minimum, the Type Approval Authority should check the reaction of the system to failures in critical components to verify fault management strategies.

- Assessment of vehicle controllability and HMI aspects, particularly during transition scenarios. The existing tests do not adequately evaluate the human-machine interface during mode transitions or when system limitations are reached, which is crucial for ensuring driver awareness and readiness.

- Critical scenarios for Object and Event Detection and Response (OEDR) and decision-making functions. The current test plan lacks evaluation of challenging detection scenarios (such as difficult-to-detect objects), system behavior at ODD boundaries, and responses to traffic disturbances as defined in the regulation.

To achieve a compliant and comprehensive safety verification, these additional test scenarios must be incorporated into the test plan. Without these elements, the current testing cannot be considered representative or sufficient for confirming the overall safety of the Highway Pilot system as required for type approval.

Following a lead vehicle (3.2-A: cooperative ACC)



WITH A PASSENGER VEHICLE AS LEAD VEHICLE

80 km/h	Time (s)	Ego speed	Non coop speed	Coop speed
Coop brake	5	77.55	78.13	76.79
Ego brake	12.09	75.96	75.01	35.78
Non-coop brake	16.39	63.9	72.09	18.22

80 km/h	Time (s)	Ego to non-cooperative distance (d_EGO)	Non-cooperative to cooperative distance	Ego to cooperative distance (d_coop)
Coop brake	5	36.63	148.2	184.83
Ego brake	12.09	37.12	108.2	145.32
Non-coop brake	16.39	38.81	48.18	86.99

100 km/h	Time (s)	Ego speed	Non coop speed	Coop speed
Coop brake	5	94.88	95.46	95.94
Ego brake	12.26	96.38	96.08	43.49
Non-coop brake	16.43	80.78	90.71	36.36

100 km/h	Time (s)	Ego to non-cooperative distance (d_EGO)	Non-cooperative to cooperative distance	Ego to cooperative distance (d_coop)
Coop brake	5	48.45	187.2	235.65
Ego brake	12.26	49.84	132.3	182.04
Non-coop brake	16.43	55.83	66.06	121.89

The ego vehicle shall detect a connected vehicle traveling in the same lane based on V2V CAM within reliable range of connectivity and after the connected vehicle enters the detection range, within an acceptable detection reliability range under nominal operating conditions.

Due to the nature of the system under test, this requirement cannot be checked. Both vehicles are always connected.

NOT FULFILS

The ego vehicle shall adjust and set its speed to match the speed of both the connected and immediate lead vehicle ahead, based on the received V2V CAM messages and vehicle sensors:

a) The deceleration shall be sufficient to maintain a safe time headway and avoid a collision.
b) The time 2 sec is specified as the maximum Time Head Way (THW) for which it was concluded that there is a danger in longitudinal direction.

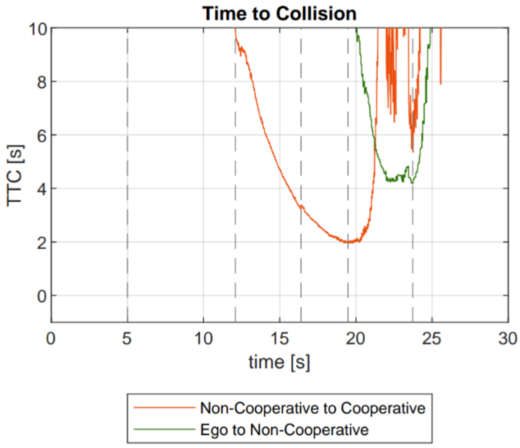


Figure 22. TTC at 80 km/h

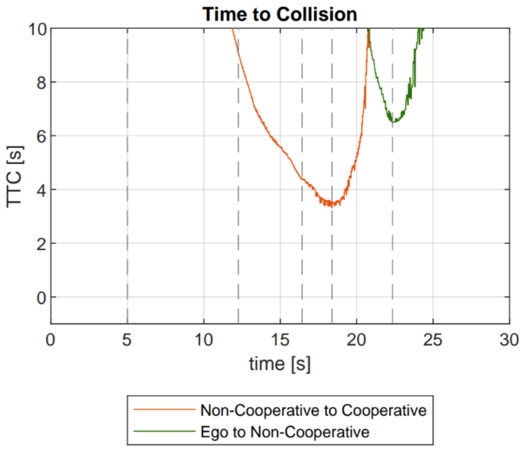


Figure 23. TTC at 100 km/h

FULFILS

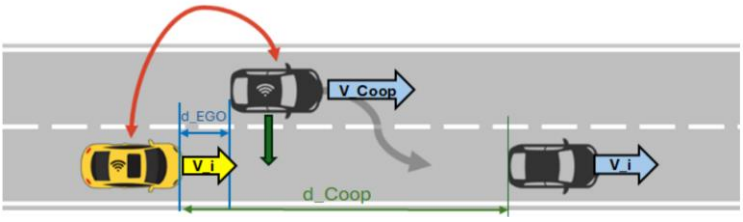
The ego vehicle shall maintain its current speed and shall not respond to an acceleration of the immediate lead vehicle if the connected lead vehicle is maintaining a constant speed.

FULFILS

The ego vehicle shall initiate a deceleration manoeuvre when the connected lead vehicle is detected to be decelerating, regardless of the speed of immediate lead vehicle.

FULFILS

Lane change of another vehicle into lane (3.2-C: Cut-In into ego's lane)



WITH A PASSENGER VEHICLE AS LEAD VEHICLE

ALKS speed (km/h)	Coop vehicle initial speed (km/h)	Coop vehicle final speed (km/h)	Ego vehicle initial speed (km/h)	Ego vehicle cut-in moment speed (km/h)	Distance at cut-in request (m)	Distance in the cut-in moment (Ego – Coop) (m)	Distance when cut in ends (Ego – Coop) (m)	Evitable collision?
80	76,61	77,18	74,53	71,93	0,61	11,00	17,22	Yes ~~No~~
100	95,58	96,55	92,43	89,47	-8.44	9,97	16,02	Yes ~~No~~
120	114,90	115,50	112,5	104,8	-2.92	8,48	21,17	Yes ~~No~~

ALKS speed (km/h)	*Target lane change request (s)*	*Ego breaks (s)*	*Coop starts cut-in (s)*	*Coop ends cut-in (s)*
80	5	5,30	13,9	20,09
100	5	5,30	15,92	19,94
120	5	5,30	11,88	18,86

FULFILS

The ego vehicle shall detect a connected vehicle traveling in the same or adjacent lane based on V2V CAM within reliable range of connectivity and after the connected vehicle enters the detection range, within an acceptable detection reliability range under nominal operating conditions.

Due to the nature of the system under test, this requirement cannot be checked. Both vehicles are always connected.

NOT FULFILS

The ego vehicle shall adjust and set its speed to match the speed of both the connected and immediate lead vehicle ahead, based on the received V2V CAM messages and vehicle sensors:

a) The deceleration shall be sufficient to maintain a safe time headway[2] and avoid a collision.
    i. The time 2 sec is specified as the maximum Time Head Way (THW) for which it was concluded that there is a danger in longitudinal direction[3][4].

FULFILS

b) The ego vehicle shall maintain its current speed and shall not respond to an acceleration of the immediate lead vehicle if the connected lead vehicle is maintaining a constant speed.

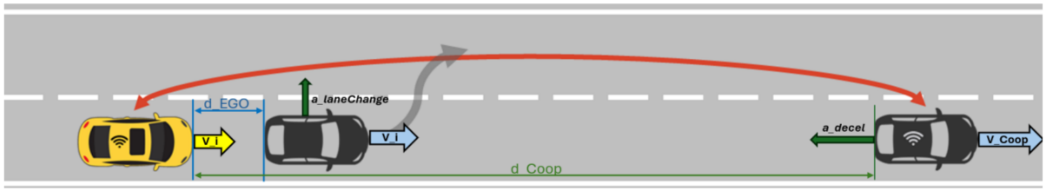
FULFILS

c) The ego vehicle shall initiate a deceleration manoeuvre when the connected lead vehicle is detected to be decelerating, regardless of the speed of immediate lead vehicle.

FULFILS

[2] R157 5.2.3.3
[3] R157 - Annex 4 - Appendix 3 : 3.4.2
[4] Note: THW = 2.0sec is chosen according to other countries' regulations and guidelines.

Obstacle after lane change of the lead vehicle (3.2-B: Deceleration vehicle in front)



ALKS speed (Ego) (km/h)	Non-Coop speed (km/h)	Target speed (Coop) (km/h)	Non-Coop lane change start (s)	Non-Coop lane change end (s)	Ego brake (s)	Ego stabilises its speed to Coop speed (s)
80	80	20	4	5,41	5,45	14
100	100	40	8,5	10,06	1,01	17
120	120	60	13	15,09	6,57	24

ALKS speed (Ego) (km/h)	Non-Coop speed (km/h)	Target speed (Coop) (km/h)	TTC Non-Coop – Coop when lane change ends (s)	Non-Coop – Coop distance when lane change ends (m)	Ego-Coop distance when Ego brakes (m)	Most critical TTC (Ego - Coop) (s)	Distance between Ego and Coop at critical TTC point (m)
80	80	20	1,34	22,96	63,51	2,88	37,91
100	100	40	0,81	16,3	245,20	10,73	101,6
120	120	60	1,15	19,1	209,90	12,64	119,8

The ego vehicle shall detect a connected vehicle traveling in the same lane based on V2V CAM within reliable range of connectivity and after the connected vehicle enters the detection range, within an acceptable detection reliability range under nominal operating conditions.

FULFILS

The ego vehicle shall adjust and set its speed to match the speed of both the connected and immediate lead vehicle ahead, based on the received V2V CAM messages and vehicle sensors:

a) The ego vehicle shall initiate a deceleration manoeuvre when the connected lead vehicle is detected to be decelerating, regardless of the speed of immediate lead vehicle.
   i. The risk perception time is 0.4 seconds. The risk perception time begins upon successful detection of lead connected vehicle's deceleration through connectivity.

Due to the nature of the system under test, this requirement cannot be checked. Both vehicles are always connected. In order to start a cut-in manoeuvre, a request has to be both sent and accepted by the two connected vehicles, therefore, it is not possible to measure the “risk perception” time since the Ego vehicle is already aware that the connected vehicle will perform a cut-in manoeuvre before it drifts more than 0,375 meters from the lane centre and gets out of the wandering zone.

NOT FULFILS

b) The deceleration shall be sufficient to maintain a safe time headway complying with minimum following distances in the country of operation and avoid a collision.

   Considering 2s as a safe time head way

FULFILS

c) The ego vehicle shall not respond to acceleration of the immediate lead vehicle.

FULFILS

d) The ego vehicle shall maintain its speed according to the connected lead vehicle after the immediate lead vehicle performs a cut-out manoeuvre.

FULFILS

Place of test: L’Albornar (Santa Oliva)
Date of test: 23/05/2025

2. Check list from RDW to audit the SAF

This aim of this annex is to summarise the findings of the type approval into conformity assessment, which a type approval authority generally uses before granting a type approval certificate. The compliance to the checklist can be found in the table below. Due to the nature of the project an original certificate is certainly out of the scope of this partnership.

Table 5: Checklist Inspector Assumption

Checklist Inspector Assumption		**Explanation from the auditor**
Check the application is correct in combination with the regulations.	● Yes ○ No ○ Not Applicable	Application is in line with the external requirements only. Regulation is out of scope for this collaboration.
Check the certificate number (correct layout of number, regulation, amendment and supplement number).	○ Yes ○ No ● Not Applicable	No existing certificate is applicable for this collaboration.
Check the correctness of the template of the certificate.	○ Yes ○ No ● Not Applicable	No existing certificate is applicable for this collaboration.
Check the references on the certificate corresponding to the information document and test report. (brand names, serial numbers, test report numbers, etc.).	○ Yes ○ No ● Not Applicable	No existing certificate is applicable for this collaboration.
Check whether the information document is complete in combination with the regulations.	● Yes ○ No ○ Not Applicable	The information document/test report gives thorough information about the system and the tests conducted in line with the external requirements.
Check that there are no inaccuracies and typos in the documents.	● Yes ○ No ○ Not Applicable	None found in the test report.

Check Readability of texts and drawings that are relevant to the assessment.	• Yes ○ No ○ Not Applicable	The test report is readable, and all the graphs gives precise information for us to determine system behavior.
Check whether the certified product has been sufficiently tested.	• Yes ○ No ○ Not Applicable	Compliance with external requirements has been verified through testing, as documented in the test report.
In the case of an extension, correction and revision, check whether the previous version matches.	○ Yes ○ No • Not Applicable	Not applicable as part of this collaboration.
In the event of an extension, correction and revision, check the change(s) given by the manufacturer that is/have actually been implemented.	○ Yes ○ No • Not Applicable	Not applicable as no original type approval has been granted.

ANNEX 4: OVERVIEW OF GLOBAL NCAPS

In order to better understand the approaches and plans of the different NCAPs around the world an overview of current NCAP assessments and future plans has been created within SUNRISE. Below the summary of these surveys.

1. Current NCAP Analysis

The main goal of this analysis is to compare Euro NCAP 2023-2025 protocol with the rest of worldwide NCAP's or consumer testing initiatives. This will provide a good overview for the VSBs over all global consumer testing activities which could apply the SUNRISE SAF and the individual collaboration potential of each organisation.

1.1 Euro NCAP

Euro NCAP 2023 Assisted Driving - Highway Assist Systems. Euro NCAP Assisted Driving - Highway Assist Systems. Test & Assessment Protocol. Version 2.2 January 2024.	
Euro NCAP AD Test and Assessment Protocol v2.2	
Target Markets	EU
Target Features	Adaptive Cruise Control, Collision Mitigation Support Front, Highway Assist Plus, Traffic Sign Information
Remarks	The following must be integrated: - National Highway Traffic Safety Administration, U.S. Department of Transportation: Dynamic Brake Support Performance Evaluation: Brake intervention triggered by fixed distance instead of time after FCW.

Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems. AEB/LSS VRU Systems Test Protocol. Version 4.5.1 February 2024.	
Euro NCAP AEB LSS VRU Test Protocol - v4.5.1	
Target Markets	EU

Target Features	Collision Mitigation Support Front, Collision Mitigation Support Rear, Door Open Warning, Evasive Manoeuvre Assist, Front Cross Traffic Alert, Parking Emergency Brake, RCTA - Rear Cross Traffic Alert
Remarks	

Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems. AEB Car-to-Car Test Protocol. Version 4.3.1 February 2024.	
Euro NCAP AEB C2C Test Protocol - v4.3.1	
Target Markets	EU
Target Features	Collision Mitigation Support Front, Evasive Manoeuvre Assist, Front Cross Traffic Alert
Remarks	

Euro NCAP 2023 Safety Assist - Collision Avoidance - Lane Support Systems. LSS Test Protocol. Version 4.3 December 2023.	
Euro NCAP LSS Test Protocol v4.3	
Target Markets	EU
Target Features	Emergency Lane Occupation Warning, Lane Change Assist, Lane Keeping Aid and LDW
Remarks	

Euro NCAP 2023 Safety Assist - Safe Driving -Speed Assist Systems. SAS Test Protocol. Version 2.0 November 2017.	
euro-ncap-sas-test-protocol-v20.pdf	
Target Markets	EU
Target Features	Adaptive Cruise Control, Traffic Sign Information, Traffic Light Attention, Highway Assist Plus

Remarks	

Euro NCAP 2023 Safety Assist - Safe Driving -Occupant Status Monitoring. Assessment Protocol - SA - Safety Driving. Version 10.4 February 2024.	
Euro NCAP Assessment Protocol - SA Safe Driving - v10.4	
Target Markets	EU
Target Features	Driver Monitoring System
Remarks	Protocol not tested per any specific function. The protocol is tested independently of the manufacturer system.

1.2 ASEAN NCAP

ASEAN NCAP Assessment Protocol. Test Protocol - AEB Systems v1.1 September 2020.	
Target Markets	
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems.

ASEAN NCAP Assessment Protocol. Blind Spot Detection v1.0 November 2019.	
Target Markets	Asia
Target Features	Emergency Lane Occupation Warning
Remarks	Not covered by any NCAP protocol.

ASEAN NCAP Assessment Protocol. Advanced Rear Visualisation v1.1 February 2020.	

Target Markets	Asia
Target Features	Visual Park Assist
Remarks	Not covered by any NCAP protocol.

1.3 US NCAP – NHTSA

National Highway Traffic Safety Administration, U.S. Department of Transportation. Crash Imminent Brake System Performance Evaluation for the NCAP. October 2015.	
Target Markets	USA
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems.

National Highway Traffic Safety Administration, U.S. Department of Transportation. Dynamic Brake Support Performance Evaluation. October 2015.	
Target Markets	USA
Target Features	Collision Mitigation Support Front
Remarks	Partially covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems. Brake intervention triggered by fixed distance instead of time after FCW.

National Highway Traffic Safety Administration, U.S. Department of Transportation. Forward Collision Warning System Performance Test. February 2013.	
Target Markets	USA

Target Features	Collision Mitigation Support Front, Automatic Preventive Braking
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems.

National Highway Traffic Safety Administration, U.S. Department of Transportation. Lane Departure Warning System Confirmation Test and Lane Keeping Support Performance Documentation. February 2013.	
Target Markets	USA
Target Features	Lane Keeping Aid and LDW
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Lane Support Systems.

NHTSA recognizes simulation as a crucial tool in evaluating Automated Driving Systems (ADS). The agency views simulation as a complement to real-world data, extending virtual analysis capabilities. NHTSA's approach to simulation involves developing representations of real-world scenarios at various levels, including individual components, complete vehicles, and traffic simulations.

The agency employs simulation across multiple disciplines and use cases to assess ADS performance in different scenarios. Validation of these simulations is based on the quality and relevance of the model's assumptions, conceptualizations, and constraints. NHTSA utilizes various simulation methods, including advanced closed-loop simulations for systems like automatic emergency braking, advanced driving simulators, human movement modeling during collisions, and vehicle-in-the-loop testing in collaboration with national laboratories.

NHTSA has conducted a comprehensive study of commercially available simulation tools, finding that no single tool is superior and that most developers use a combination of commercial and proprietary tools. The agency recognizes the advantages of simulation, such as increased efficiency, cost reduction, result repeatability for better root cause analysis, and the ability to rapidly accumulate tests with varying factors. However, NHTSA also acknowledges limitations, including challenges with model and virtual environment fidelity, significant computational costs for increasing fidelity, and difficulties in understanding inherent model errors.

In evaluating ADS, NHTSA uses simulation to assess the performance of ADS vehicles in complete scenarios and employs traffic models to evaluate the interaction between human-driven and ADS vehicles. The agency is developing test methods that combine real and virtual elements, such as mixed augmented reality, and is exploring methods to represent real-world conditions through virtual sensor inputs in simulation environments.

Ongoing research at **NHTSA** includes investigating simulation fidelity measurement and its effect on outcomes, developing preliminary concepts for collecting data from on-road deployments, and evaluating real-world performance. The agency is also researching safety metrics that can be used to evaluate ADS performance and is assessing whether the performance of individual ADS capabilities (perception, localization, planning, and control) can be isolated and evaluated independently.

NHTSA recognizes the importance of AI models in ADS and is investigating methods to assess the completeness and robustness of data used to train these models. The agency is actively working on developing and improving test and evaluation methods that incorporate simulation elements, acknowledging the need to validate these simulation methods and researching ways to do so.

In summary, **NHTSA's** current protocol considers simulation as an essential tool in evaluating autonomous driving systems, utilizing a variety of simulation methods while recognizing both their advantages and limitations. The agency is actively working on developing and improving test and evaluation methods that incorporate simulation elements, acknowledging the need to validate these simulation methods and researching ways to do so.

Source: NHTSA Safety Research Portfolio Public Meeting from Fall 2024 (NHTSA Safety Research Portfolio Public Meeting: Fall 2024 | NHTSA)

1.4 Australasian NCAP (ANCAP)

ANCAP Test Protocol 2023 - 2025. AEB Car-to-Car Systems v4.3.1 April 2024.	
Target Markets	Australia & New Zealand
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front, Front Cross Traffic Alert, Parking Emergency Brake, Evasive Manoeuvre Assist
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems.

ANCAP Test Protocol 2023 - 2025. AEB/LSS Vulnerable Road User Systems v4.5.1 April 2024.	
Target Markets	Australia & New Zealand

Target Features	Automatic Preventive Braking, Collision Mitigation Support Front, Collision Mitigation Support Rear, Door Open Warning, Evasive Manoeuvre Assist, Emergency Lane Occupation Warning, Lane Keeping Aid and LDW, Parking Emergency Brake
Remarks	Covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems.

ANCAP Test Protocol 2023 - 2025. Lane Support Systems v4.3 April 2024.	
Target Markets	Australia & New Zealand
Target Features	Emergency Lane Occupation Warning, Lane Keeping Aid and LDW
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Lane Support Systems.

ANCAP Test Protocol 2023 - 2025. Speed Assist Systems v2.0 November 2017.	
Target Markets	Australia & New Zealand
Target Features	Adaptive Cruise Control, Traffic Sign Information
Remarks	Covered by Euro NCAP 2023 Safety Assist - Safe Driving - Speed Assist Systems.

1.5 Japan NCAP (JNCAP)

JNCAP 2023 - Vehicle Safety Performance - Car to Car. Autonomous Emergency Braking System [Car-To-Car] Performance testing method. Revision April 2023.	
Target Markets	Japan
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front

Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems.

JNCAP 2023 - Vehicle Safety Performance - Pedestrian Day-time. **Autonomous Emergency Brake System [For Pedestrian Daytime] Performance test procedure. Revision April 2023.**	
Target Markets	Japan
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems if system performance symmetrical.

JNCAP 2023 - Vehicle Safety Performance - Pedestrian Night-time. **Autonomous Emergency Brake System [For Pedestrian at Night] Performance test Procedure. Revision April 2023.**	
Target Markets	Japan
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Partially covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems if system performance symmetrical. Excluded JNCAP 2020 CPFO night scenario, although may be less critical than Euro NCAP 2023 CPNCO night.

JNCAP 2022 - Vehicle Safety Performance - Lane Departure Prevention. **Lane Departure Prevention System Performance Testing Methods. Revision March 2022.**	
Target Markets	Japan
Target Features	Emergency Lane Occupation Warning, Lane Keeping Aid and LDW
Remarks	Covered by Euro NCAP 2023 if dashed lane pattern is not relevant.

JNCAP 2023 - Vehicle Safety Performance - Peddle Misapplication. **Methods for checking equipment designed to curb acceleration in the event of Peddle Misapplication. Revision April 2023.**

Target Markets	Japan
Target Features	Collision Mitigation Support Front, Parking Emergency Brake, Collision Mitigation Support Rear
Remarks	Not covered by any NCAP protocol.

JNCAP 2023 - Vehicle Safety Performance - Rear View Monitor. Rear View Monitor System Performance test procedure. Revision April 2023.	
Target Markets	Japan
Target Features	Visual Park Assist
Remarks	Not covered by any NCAP protocol.

1.6 China NCAP (C-NCAP)

C-NCAP Management Regulation 2024 Edition. Appendix L – Active Safety ADAS Test Protocol. Paragraph C.6.1. AEB system for Car to Car.	
Target Markets	China (Hong Kong)
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	

C-NCAP Management Regulation 2024 Edition. Appendix L – Active Safety ADAS Test Protocol. Paragraph C.6.2. Pedestrian-AEB system.	
Target Markets	China (Hong Kong)
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Partially covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems. Excluded CPFA-25 day and night-time.

C-NCAP Management Regulation 2024 Edition. Appendix L – Active Safety ADAS Test Protocol. TW AEB???	
Target Markets	China (Hong Kong)
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Partially covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems. Excluded CSFA which is equivalent to Euro NCAP CBFA with a bigger TW target.

C-NCAP Management Regulation 2024 Edition. Appendix L – Active Safety ADAS Test Protocol. Paragraph C.6.3. LSS.	
Target Markets	China (Hong Kong)
Target Features	Lane Keeping Aid and LDW
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Lane Support Systems if GB5768 Road traffic signs and markings regulation is equivalent to European Road traffic signs and markings regulation.

C-NCAP Management Regulation 2024 Edition. Appendix L – Active Safety ADAS Test Protocol. Paragraph C.6.5. Optional audit items TSR, LDW, ISLS, BSD, DOW, RCTA test scenarios and evaluation methods.	
Target Markets	China (Hong Kong)
Target Features	Emergency Lane Occupation Warning, Lane Keeping Aid and LDW
Remarks	Partially covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Lane Support Systems and Safe Driving - Speed Assist Systems. Excluded points C.6.5.4.2 and C.6.5.4.3.

1.7 Korean NCAP (K-NCAP)

K-NCAP Regulations 2023. AEBS – Inter urban v2.0 2023.

Target Markets	Korea
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Car-to-Car Systems.

K-NCAP Regulations 2023. AEBS – City v2.0 2023.	
Target Markets	Korea
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Safety Assist - Collision Avoidance - Cart-to-Car Systems.

K-NCAP Regulations 2023. Adjustable Speed Limitation Device (ASLD) v0.5 2017.	
Target Markets	Korea
Target Features	Traffic Sign Information
Remarks	Covered by Euro NCAP 2023 Safety Assist - Safe Driving - Speed Assist Systems.

K-NCAP Regulations 2023. AEBS – Pedestrian v3.0 2020.	
Target Markets	Korea
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems.

K-NCAP Regulations2023. Blind Spot Detector (BSD) v0.5 2022.	
Target Markets	Korea
Target Features	Emergency Lane Occupation Warning
Remarks	Not covered by any NCAP Protocol.

K-NCAP Regulations 2023. Lane Keeping Assistance System (LKAS) v2.0 2022.	
Target Markets	Korea
Target Features	Lane Keeping Aid and LDW
Remarks	Not covered by any NCAP Protocol. Steering radius and lane marking colors and patterns are different from Euro NCAP LSS test protocol.

K-NCAP Regulations 2023. Intelligent Speed Assistance (ISA) v1.5 2020.	
Target Markets	Korea
Target Features	Traffic Sign Information
Remarks	Covered by Euro NCAP 2023 Safety Assist - Safe Driving - Speed Assist Systems.

K-NCAP Regulations2023. Rear Cross Traffic Alert (RCTA) v0.5 2020.	
Target Markets	Korea
Target Features	Collision Mitigation Support Rear, Parking Emergency Brake, RCTA - Rear Cross Traffic Alert
Remarks	Not covered by any NCAP Protocol.

K-NCAP Regulations 2023. AEBS Cyclist v2.0 2020.	
Target Markets	Korea
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems.

K-NCAP Regulations 2023. AEBS - Night-time Pedestrian (Low Ambient Lighting) v3.0 2020.	
Target Markets	Korea
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front
Remarks	Covered by Euro NCAP 2023 Vulnerable Road User (VRU) Protection Systems.

1.8 Latin NCAP

Latin American & Caribbean New Car Assessment Programme (Latin NCAP). Testing protocols. Version 1.1.0 January 2022.	
Target Markets	Latin America and the Caribbean
Target Features	Automatic Preventive Braking, Collision Mitigation Support Front, Lane Keeping Aid and LDW, Adaptive Cruise Control
Remarks	Covered by Euro NCAP 2023 Safety Assist and VRU Protection Systems test protocols.

1.9 IIHS - HLDI

IIHS Safeguards for Partial Driving Automation Test and Rating Protocol. Version 1 2023.	
Target Markets	USA
Target Features	Automatic Emergency Braking, Collision Mitigation Support Front, Adaptive Cruise Control, Lane Change Assist
Remarks	Partially covered by Euro NCAP: - Test 3: DMS eye tracking – driver's eyes away from the road with the partial driving automation activated (covered by Euro NCAP SA Safe Driving) - Test 4: DMS head tracking – driver's head and eyes looking away from the road with the partial driving automation activated (covered by Euro NCAP SA Safe Driving) - Test 8a: ACC auto resume – timeout (covered by Euro NCAP Assisted Driving - Highway Assist Systems) - Test 8b: ACC auto resume – driver monitoring (covered by Euro NCAP Assisted Driving - Highway Assist Systems)

1.10 C-ICAP

C-ICAP Assessment of Basic Driving Assistance China Intelligent-connected Car Assessment Programme (C-ICAP) (Edition 2024) Detailed Rules for Assessment of Basic Driving Assistance. June 2024	
Target Markets	China
Target Features	Adaptive Cruise Control, Automatic Emergency Braking, Collision Mitigation Support Front, Lane Keeping Aid and LDW, Lane Centering Assist, Emergency Lane Occupation Warning, Highway Assist Plus, Lane Change Assist, Blind Spot Monitoring, Traffic Sign Information
Remarks	Partially Covered by Euro NCAP AEB Car-to-Car test protocol, LSS test protocol and AEB/LSS VRU test protocol except following tests:

	- Lane Centering Control - Low-speed Combined Control - High-speed Combined Control - Accident Vehicle Identification and Response - Conical Barrel Identification and Response - Emergency Avoidance of Front Vehicle on Expressway - Slow Moving Heavy Truck - Fuzzy Lane Changing - Speed Limit Sign Identification - Hands Off Detection and Minimum Risk Maneuver Test - Eye Closure Detection and Head Bowing Detection

C-ICAP Assessment of Navigation Pilot Assistance **China Intelligent-connected Car Assessment Programme (C-ICAP) (Edition 2024) Detailed Rules for Assessment of Navigation Pilot Assistance. June 2024.**	
Target Markets	China
Target Features	Adaptive Cruise Control, Evasive Manoeuvre Assist, Highway Assist Plus, Lane Change Assist, Navigation Pilot Assist, Smart Pilot Assist
Remarks	Not covered by any protocol except test "Daytime-straight road-dotted line-front passenger vehicle cut-in" covered by Euro NCAP AEB Car-to-Car test protocol (Cut-in tests)

C-ICAP Assessment of Basic Parking Assistance **China Intelligent-connected Car Assessment Programme (C-ICAP) (Edition 2024) Detailed Rules for Assessment of Basic Parking Assistance. June 2024.**	
Target Markets	China
Target Features	Parking Emergency Brake, Parking Assist Front, Parking Assist Rear, Remote Parking Assist, Visual Park Assist
Remarks	Not covered by any protocol.

C-ICAP Assessment of Memory Parking Assistance **China Intelligent-connected Car Assessment Programme (C-ICAP) (Edition 2024) Detailed Rules for Assessment of Memory Parking Assistance. June 2024.**

Target Markets	China
Target Features	Autonomous Parking, Parking Emergency Brake, Parking Assist Front, Parking Assist Rear, Remote Parking Assist, Visual Park Assist
Remarks	Not covered by any protocol.

2. Future NCAP Analysis

The main goal of this analysis is to compare Euro NCAP future plans with the plans of other worldwide NCAP's or consumer testing initiatives in relation to the SUNRISE activities, in particular with respect to scenario-based assessment and usage of virtual testing.

2.1 Euro NCAP

Various SUNRISE partners are in close contact with Euro NCAP and its members. Information collected on future plans of Euro NCAP is based on discussions with various Euro NCAP stakeholders and publicly available information.

Euro NCAP participated in SUNRISE expert platform and was present at SUNRISE final event.

The year 2026 will bring a paradigm **shift** in the Euro NCAP protocol, which has traditionally followed a pillar-based approach, categorizing safety features by function (e.g., user types and assistance functions). The updated protocol will adopt a structure based on the **phases of an accident**, aligning with the **Haddon Matrix** framework.

The Haddon Matrix categorizes factors influencing road safety into three temporal phases: pre-crash, crash, and post-crash. This new methodology will validate safety measures at each stage, enabling a more holistic and chronological assessment of vehicle safety. While the primary focus will remain on the vehicle, the updated protocol aims to integrate driver behaviour and system robustness across diverse external conditions.

Figure 24: Euro NCAP's haddon matrix for rating from 2026 [2]

The **pre-crash phase** in the new Euro NCAP protocol is strategically divided into two distinct yet complementary components:

1. **Safe Driving:** This preventive aspect focuses on understanding and mitigating risks before escalation. It encompasses:
    - Driver state monitoring
    - Ensuring proper positioning of child occupants
    - Encouraging adherence to speed limits and other traffic regulations
    - Implementation of various preventive measures to maintain safe driving conditions including partially automated functionalities (ACC, Lane Centring)
2. **Crash Avoidance:** This more active component primarily centres on systems like Autonomous Emergency Braking (AEB). It represents the protocol's approach to averting accidents when risk factors have already been identified.

The division within the pre-crash phase illustrates a comprehensive safety strategy. While Safe Driving emphasizes prevention through monitoring and encouraging safe behaviours, Crash Avoidance focuses on active intervention when a potential accident scenario is imminent. This two-pronged approach aims to maximize safety by addressing both the human factors in driving and the technological capabilities of the vehicle in responding to immediate threats.

The protocol will continue to emphasize **crash protection**, focusing on the vehicle's ability to safeguard occupants during a collision.

- **Crash Protection:** This phase focuses on the vehicle's ability to protect occupants during an actual collision.
- **Post-Crash Phase:** This final phase addresses the critical period immediately following a collision.

In summary, the restructured Euro NCAP protocol for 2026 will result in a new rating system that reflects the comprehensive approach to vehicle safety across all phases of a potential accident:

The integration of autonomous driving technologies into the new Euro NCAP protocol will primarily be addressed within the Safe Driving component of the pre-crash phase, while AEB (Autonomous Emergency Braking) and related systems will be evaluated under Crash Avoidance.

A cornerstone of the 2026 protocol is the introduction of a comprehensive robustness assessment, addressing the gap between controlled test environments and real-world conditions. Key aspects of this evaluation include:

- **Environmental Factors**
- **Decision Making & Vehicle Control**
- **Extended 2D Matrix** (Expansion of current test matrices to include a wider range of speeds and scenarios, focusing on vehicle control aspects)
- **Additional Layers** (Introduction of tests variations addressing perception capabilities)

The robustness assessment is designed to ensure that advanced driver assistance and autonomous systems **perform reliably across a spectrum of real-world conditions**. By significantly **expanding** the test matrices, Euro NCAP aims to drive improvements in both **control systems** (through the extended 2D matrix) and **perception systems** (through the additional layers).

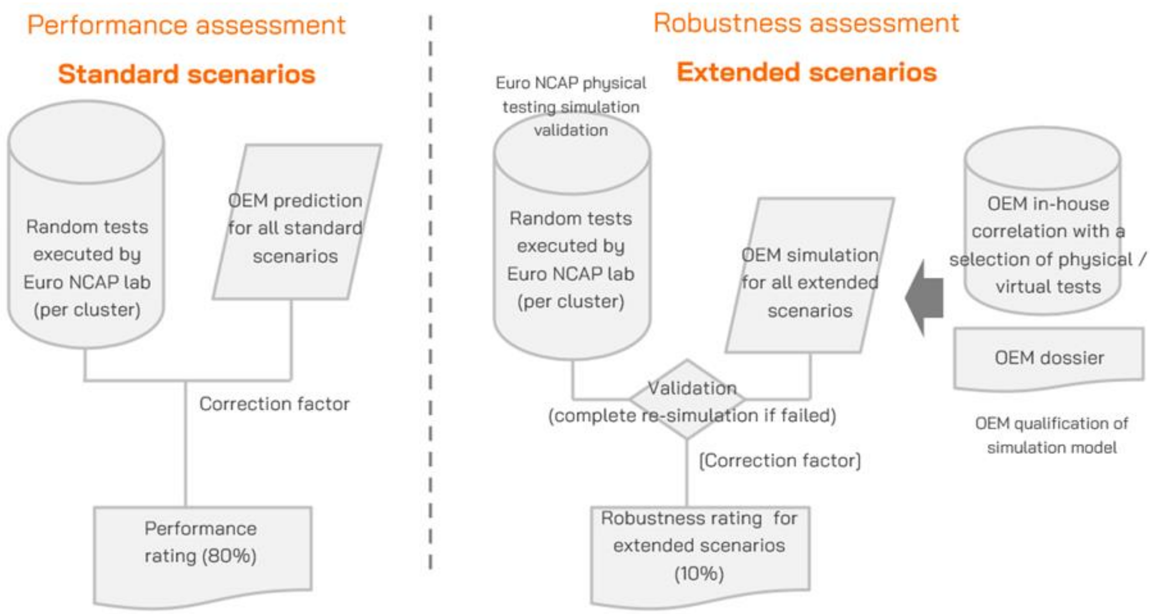


Figure 25: Euro NCAP's scheme for implementation of virtual testing (VTA)

To address the increasing complexity of vehicle systems and scenarios, Euro NCAP is adopting innovative testing methods:

Simulation-Based Testing: Given the extensive growth of test matrices, Euro NCAP is considering the implementation of simulation-based testing methodologies. This approach will encompass:

Utilization of simulations for the extended matrix testing

Requirement for suppliers to submit comprehensive reports demonstrating system functionality across various conditions

Development of a virtual validation process where: a) OEMs will conduct a large portion of the testing via simulation b) Euro NCAP will select random test scenarios that will be executed by Euro NCAP on a test track for comparison with simulation results c) Ratings will be determined based on the correlation between simulated and real-world performance seen on the test track.

Enhanced On-Road Evaluation: To further improve robustness assessment, Euro NCAP plans to implement advanced on-road evaluation techniques:

Post-track testing, vehicles will undergo real-world driving scenarios

Utilization of sophisticated tool capable of identifying test track-like scenarios in real-world environments during actual driving conditions

This approach aims to: a) Detect situations similar to controlled tests in open-road settings b) Compare vehicle behaviour in real-world scenarios to its performance in controlled tests c) Assess the consistency and reliability of safety systems across varied, unpredictable conditions

This hybrid approach, combining advanced simulations with real-world evaluations, ensures a comprehensive, efficient, and realistic assessment of vehicle safety systems. By expanding the scope of testing, the protocol aims to verify that performance observed in controlled environments translates effectively to real-world scenarios.

2.2 ASEAN NCAP

We contacted the relevant consumer testing organisation for this section.

ASEAN NCAP reacted briefly with the following statements:

- According to the current protocol, we do not assess using virtual testing. Similar to other NCAPs, we only address the emergency system.
- However, we are currently working on the basic studies to formulate our road map for 2031-2035. We are exploring the possibility of including other's assessments in our protocol.
- We are open to collecting as much data and information for consideration to include in our protocol.

Information on SUNRISE activities and results was shared as well as invite shared to participate in SUNRISE expert platform.

2.3 US NCAP – NHTSA

We contacted the relevant consumer testing organisation for this section, but did not receive a response in time for inclusion in this deliverable. As a result, this section is based on publicly available information.

This image below presents the U.S. NCAP (New Car Assessment Program) Roadmap, outlining planned updates and developments for vehicle safety testing and assessment from 2021 to 2031.

In the near term, spanning 2021 to 2022, NCAP proposes adding several new safety features to its assessment, including Lane Keeping Support (LKS), Blind Spot Detection (BSD), Blind Spot Intervention (BSI), and Pedestrian Automatic Emergency Braking (PAEB). Additionally, new pedestrian protection impact tests are introduced, focusing on head-to-hood, upper leg-to-hood leading edge, and lower leg-to-bumper impacts.

Moving into 2022-2023, the roadmap suggests the use of new crash test dummies (THOR-50M and WS-50M) and the addition of a frontal oblique test. This period also sees proposals for evaluating adaptive driving beam headlights, upgraded lower beam headlights, semiautomatic headlamp beam switching, and rear automatic braking for pedestrians.

For 2024, NCAP plans to update the Monroney label (the window sticker on new vehicles) and revise the 5-star rating system.

Looking further ahead to 2027-2031, the focus shifts to developing assessments and tests for more advanced safety features. These include intersection safety assist, opposing traffic safety assist, and Automatic Emergency Braking (AEB) for all Vulnerable Road Users (VRU), encompassing bicyclists and motorcyclists.

The roadmap also highlights two specific Request for Comment (RFC) periods: one in March 2022 for the 2021-2022 proposals, and another in May 2023, likely addressing the 2022-2023 proposals.

NHTSA appears to view simulation as an increasingly important component of ADS testing and validation, but not as a complete replacement for physical testing. The agency is actively investing in research to improve simulation methodologies and explore their potential for more comprehensive ADS evaluation.

NHTSA is planning to expand its use of simulation in future testing protocols. They are developing more advanced virtual testing environments and exploring ways to integrate real-world data with simulation models. This indicates a trend towards a hybrid approach, combining virtual and physical testing methods.

NHTSA recognizes the potential of simulation to address the "curse of dimensionality" in ADS testing - the challenge of testing an enormous number of possible scenarios. They see simulation as a way to efficiently test a wider range of scenarios than would be practical or safe in physical testing alone.

However, the agency also acknowledges the current limitations of simulation, particularly in terms of fidelity and real-world representation. They are investing in research to improve the accuracy and reliability of simulation models, suggesting that they see room for significant advancement in this area.

NHTSA is also exploring the use of augmented reality and vehicle-in-the-loop testing as bridge technologies between pure simulation and physical testing. This suggests a future where the lines between virtual and physical testing become increasingly blurred.

NHTSA seems to be moving towards a more data-driven approach to ADS validation, with plans to develop methods for collecting and analyzing data from on-road deployments. This could lead to a future where simulation models are continuously updated and validated against real-world data.

The agency is also focusing on developing standardized scenarios and metrics for ADS testing, which could be applied in both simulated and physical environments. This suggests a future where simulation plays a key role in standardized ADS validation processes.

NHTSA's research into AI and machine learning models used in ADS indicates that they see these as critical areas for future development. They are likely to incorporate specific testing and validation requirements for AI systems in future protocols.

While the webinar doesn't explicitly state that simulation will become mandatory for ADS validation, the significant investment in this area suggests that it's likely to become an integral part of the validation process. However, NHTSA seems to view simulation as a complement to, rather than a replacement for, physical testing.

In conclusion, NHTSA appears to be moving towards a future where simulation plays a more prominent role in ADS testing and validation, integrated closely with physical testing and real-world data collection. They see significant potential in simulation technologies but are also aware of the need for continued development and validation of these methods. The future protocol is likely to involve a comprehensive approach that leverages the strengths of both virtual and physical testing methodologies.

Source: **NHTSA Safety Research Portfolio Public Meeting** from Fall 2024 (NHTSA Safety Research Portfolio Public Meeting: Fall 2024 | NHTSA)

2.4 Australasian NCAP (ANCAP)

We contacted the relevant consumer testing organisation for this section.

ANCAP reacted briefly with the following statements:

- ANCAP and Euro NCAP are partners and share the majority of their testing and assessment protocols.
- With respect to ADAS protocols/scenarios, ANCAP is currently, and will continue to be fully aligned with Euro NCAP.
- The only area where there is some difference is Speed Limit Information Function (SLIF) recognising the different environment in Australia/NZ with respect to speed signs compared to Europe.

- Regarding virtual testing, ANCAP will adopt the same requirements for 2026-onward as Euro NCAP.

2.5 Japan NCAP (JNCAP)

We contacted the relevant consumer testing organisation for this section.

JNCAP reacted briefly with the following statements:

- JNCAP has not started considering virtual testing.

2.6 China NCAP (C-NCAP)

We contacted the relevant consumer testing organisation for this section, but did not receive a response in time for inclusion in this deliverable. As a result, this section remains empty due to the unavailability of official information.

2.7 Korean NCAP (K-NCAP)

We contacted the relevant consumer testing organisation for this section, but did not receive a response in time for inclusion in this deliverable. As a result, this section remains empty due to the unavailability of official information.

2.8 Latin NCAP

We contacted the relevant consumer testing organisation for this section, but did not receive a response in time for inclusion in this deliverable. As a result, this section remains empty due to the unavailability of official information.

2.9 IIHS – HLDI

During a meeting between several people from IIHS and several SUNRISE partners the current and future plans of IIHS in relation to scenario-based testing and usage of virtual testing and how the SUNRISE results could be applied were discussed, IIHS indicated to follow a scenario based approach already and would like to extend that in coming year. In pursuit of more robust systems IIHS plans to have more generalisable tests that cover larger ranges of parameters. They would also like to optimise their test track testing to cover as much as possible of the real-world situations. In combination with information on performance of the vehicle by OEM (possibly by virtual testing), this will ensure that systems can be assessed in larger operational envelope. These activities can be very well supported by the SUNRISE SAF and related SUNRISE activities.

2.10 C-ICAP

We contacted the relevant consumer testing organisation for this section, but did not receive a response in time for inclusion in this deliverable. As a result, this section remains empty due to the unavailability of official information.