# Shared automation Operating models for Worldwide adoption

## SHOW

### Grant Agreement Number: 875530

## D15.8: Standardisation: alignment, contribution and activities

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under Grant Agreement number 875530

# Executive Summary


The SHOW project aims to support the deployment of shared, connected and electrified automation in urban transport, to advance sustainable urban mobility. During the project, real-life urban demonstrations taking place in 20 cities across Europe, the SHOW consortium implemented the integration of fleets of automated vehicles in public transport, demand-responsive transport, Mobility as a Service and Logistics as a Service schemes.

The present deliverable has the objective to formulate recommendations on the harmonization of requirements for license exemption procedures for public transport vehicles to allow the seamless rollout of shared, connected and electrified automation solutions for urban transport in the EU member states and beyond. For SHOW pilot sites, testing procedures for public transport vehicles implied a lot of extra-efforts and regulatory harmonization is considered of high relevance for future deployment. The main focus in the deliverable lies on minibuses, testing procedures for other vehicle types were considered of less relevance in the SHOW pilot site context.

In chapter 2, the deliverable summarizes the standardization activities undertaken by the project partners. To establish a SHOW standardization landscape, specifications utilized in developing, implementing, and experimenting within the pilot site deployments have been identified and listed. A survey of project partners revealed active participation in Standards Development Organizations (SDOs) and related interest groups, underlining the SHOW partners' commitment to standardized approaches in addressing urban mobility challenges. The key specifications applied in the project are covering a wide range of interest areas from communication, data and vehicle security to ITS related technologies.

Chapter 3 covers the license exemption procedure for public transport AVs by summarizing the state-of-play in general and in the SHOW pilot sites in particular and deriving recommendation on the harmonization of the procedure currently in force:

- Chapter 3.2 focuses on the entities and procedures involved in testing for vehicle license exemption in the SHOW pilot sites. It identifies the entities responsible for conducting the safety critical tests, such as Original Equipment Manufacturers (OEMs), bus companies, and authorities. The chapter highlights the specific tests conducted, including emergency response procedures, track analysis, sensor testing, localization and mapping, obstacle detection and avoidance, vehicle control systems testing, and cybersecurity tests. It also discusses the challenges and barriers faced by the pilot sites in obtaining license exemptions and emphasizes the importance of regulatory frameworks and harmonization for the deployment of autonomous vehicles in public transport.
- Chapter 3.3 focuses on the safety critical tests that were executed for vehicle license exemption in the SHOW pilot sites. It provides detailed information about the tests conducted, including sensor testing, localization and mapping, obstacle detection and avoidance, vehicle control systems testing, cybersecurity tests, and emergency response procedures. The chapter also discusses the entities responsible for conducting the tests, the duration of the approval procedure, and the perceived barrier of license exemption for long-term operation of autonomous shuttle buses.
- The focus of chapter 3.4 is on ongoing efforts for harmonizing license exemptions on the European level, specifically in relation to automated mobility services in public transport. It discusses activities happening at both the national and European levels, highlights the interest of Europe's automotive manufacturing industry, and utilizes the FAME CCAM project and its strategies and action plans for harmonization. The chapter emphasizes the need for harmonization to overcome barriers and challenges in the deployment of connected and automated vehicles in public transport.

- Chapter 3.5 focuses on recommendations for harmonizing vehicle license exemptions based on the findings and experiences from the SHOW project. It summarizes the barriers and challenges identified in previous chapters, including affordability and availability of autonomous vehicles, safety operator and tele-operation requirements, complex and time-consuming permit processes, lack of regulatory harmonization, and commercial deployment.

Overall, the report provides recommendations and needs for further standardisation in three key areas: technical recommendations, recommendations for regulatory affairs, and recommendations for market deployment. The outcomes aim to address the identified barriers and promote the development and deployment of autonomous vehicles in public transport by standardizing regulations, improving technical testing procedures, and creating a favourable market environment. Additionally, the report emphasizes the importance of harmonized test procedures for an economy of scale, where Public Transport Operators can rely on OEM supply chains for electric and automated shuttle buses supporting resilience of public transport services, e.g., for Low Emission Zones and large-scale event transport offerings. The announcement of Renault Group[1] to separate automated mobility research for private passenger cars from those for autonomous public buses is fully in line with the results of this report.

[1] https://www.renaultgroup.com/en/news-on-air/news/autonomous-vehicles-renault-group-opts-for-different-strategies-for-passenger-cars-and-public-transport-vehicles/

## Document Control Sheet

| | |
|---|---|
| **Start date of project:** | 01 January 2020 |
| **Duration:** | 57 months |
| **SHOW Del. ID & Title:** | D15.8: Standardisation: alignment, contribution and activities |
| **Dissemination level:** | PU |
| **Relevant Activities:** | A15.6: Standardisation & certification |
| **Work package:** | WP15: Dissemination, Training and Multiplication |
| **Lead authors:** | Peter Schmitting (ERTICO)<br>Ralf Willenbrock (ERTICO) |
| **Internal Reviewers:** | Joachim Rentel (BOSCH)<br>Biagio Ciuffo (JRC)<br>Maria Gkemou (CERTH) |
| **External Reviewers:** | Advisory Board members |
| **Actual submission date:** | 23/09/2024 |
| **Status:** | Final |
| **File Name:** | SHOW_D15.8_Standardisation_Final.docx |

## Document Revision History

| Version | Date | Reason | Editor |
|---|---|---|---|
| 0.1 | 24/05/2024 | Initial version | Peter Schmitting (ERTICO), Ralf Willenbrock (ERTICO) |
| 0.2-0.5 | June 2024 | Internal working versions | Peter Schmitting (ERTICO), Ralf Willenbrock (ERTICO) |
| 0.6 | 18/07/2024 | Chapter 3 | Ralf Willenbrock (ERTICO) |
| 0.7 | 05/08/2024 | Chapter 2 | Peter Schmitting (ERTICO) |
| 1.0 | 07/08/2024 | Version sent for internal peer review & AB members review | Peter Schmitting (ERTICO), Ralf Willenbrock (ERTICO) |
| 2.0 | 28/08/2024 | Peer reviewed version ready for submission. | Peter Schmitting (ERTICO), Ralf Willenbrock (ERTICO) |
| Final | 23/09/2024 | Final proof-checked Version | Maria Gkemou (CERTH) |

# Table of Contents

# List of Tables

# List of Figures

# Abbreviation List

| Abbreviation | Definition |
|---|---|
| 3GPP | 3rd Generation Partnership Project |
| 5GAA | 5G Automotive Association |
| ADS | Automated Driving Systems |
| AECC | Automotive Edge Computing Consortium |
| ASAM | Association for Standardization of Automation and Measuring Systems |
| ASI | Austrian Standards Institute |
| AUTOSAR | AUTomotive Open System ARchitecture |
| AVAS | Acoustic Vehicle Alerting Systems |
| BNA | Bureau de Normalisation de l'Automobile |
| C2C-CC | CAR 2 CAR Communication Consortium |
| CAM | Cooperative Awareness Message |
| CEDR | Conference of European Directors of Roads |
| CEN | European Committee for Standardization (Comité Européen de Normalisation) |
| CEPT | European Conference of Postal and Telecommunications Administrations (Conférence européenne des administrations des postes et des télécommunications) |
| C-ITS | Cooperative ITS |
| CPS | Collective Perception Service |
| DCC | Decentralized Congestion |
| DENM | Decentralized Environmental Notification Message |
| ECC | Electronic Communications Committee |
| ECTRI | European Conference of Transport Research Institutes |
| EG-ComAD | (ITS) Expert Group on Communications Technology for Automated Driving |
| ERTRAC | European Road Transport Research Advisory Council |
| EV | Electric Vehicle |
| FEHRL | Forum of European National Highway Research Laboratories |
| FG-AI4AD | Focus Group on AI for autonomous and assisted driving |
| FSV | Research Association for Road-Rail-Traffic (Forschungsgesellschaft Straße-Schiene-Verkehr) |
| FUSA | FUnctional SAfety |
| GNSS | Global Navigation Satellite Systems |
| GRSF | Global Road Safety Facility |
| GRSP | Global Road Safety Partnership |
| HTTP | Hypertext Transfer Protocol |
| IAMTS | International Alliance for Mobility Testing and Standardization |
| IEEE | Institute of Electrical and Electronics Engineers |
| IETF | Internet Engineering Task Force |
| IoT | Internet of Things |
| ISO | International Organization for Standardization |
| ITF | International Transport Forum |
| ITS | Intelligent Transport Systems |
| ITU | International Telecommunication Union |
| IVI | In-Vehicle Information |
| LTE | 3GPP Long Term Evolution (4G) |
| M2M | Machine-To-Machine |
| MAP | MapData Messages |
| MCO | Multi-Channel Operation |
| MEC | Multi-Access Edge Computing |
| MVWG | Working Group on Motor Vehicles |
| NR | New Radio |
| OEM | Original Equipment Manufacturer |
| SAAM | Swiss Association for Autonomous Mobility |
| SAE | Society of Automotive Engineers |
| SDO | Standards Development Organization |
| SOTIF | Safety Of The Intended Functionality |

| Abbreviation | Definition |
|---|---|
| SPAT | Signal Phase And Timing Messages |
| TC | Technical Committee |
| UNECE | United Nations Economic Commission for Europe |
| UNRSC | United Nations Road Safety Collaboration |
| UTRA | Evolved Universal Terrestrial Radio Access |
| VRU | Vulnerable Road User |
| WG | Working Group |
| WI | Work Item |
| WP | Work Package |

# 1 Introduction

## 1.1 Purpose of the document

The purpose of the present deliverable D15.8 is to provide information on the standardization and certification efforts of the SHOW project, which is funded by the European Union's Horizon 2020 research and innovation program.

## 1.2 Intended Audience

The dissemination level of deliverable D15.8 is public. The intended readership includes both the partners in the project consortium and also external stakeholders, especially from the European Commission.

## 1.3 Interrelations

There is a strong interrelationship with WP3 and deliverable D3.3 ‘Recommendations for Adapting Regulatory and Operational Strategies for CCAV deployment at Local and Regional Level’ [1] discussing the regulatory gaps and barriers at the EU and national/regional level (see D3.3 [1] Chapter 3). This refers to the technical standards, including new regulations for driverless modes of automated vehicles (SAE Level 4 or Level 5), and to license exemptions needed to operate autonomous mini-buses or shuttles in restricted urban road networks. Further interrelations exist with WP11 ‘Technical verification & pre-demo evaluation’ which describes in deliverable D11.2 ‘Demos safety, reliability and Robustness validation and commissioning’ [9] the verification and validation phases at the SHOW demonstrators.

For SHOW pilot sites and for the Public Transport Operators participating, autonomous vehicles were homologated but due to missing rules related to testing and deployment in the specific pilot site member states, vehicle license exemption practices were rather arbitrary and based on regional preferences. Whereas Austria, e.g., gave priority to operational testing, Germany puts its focus on safety and France on environmental benefits for municipalities. For vehicle manufacturers, this causes extra-efforts hindering economy of scale and competitive price ranges. In general, operators of pilot sites got help from certifying organizations such as TÜV or DEKRA. Nevertheless, tests from certifying entities are based either on tests from non-automated vehicle testing or by arbitrary and non-regulated test procedures for autonomous vehicles.

Compared to D3.3 and D11.2, deliverable D15.8 analyses standardization aspects complemented with vehicle license exemptions found across the European SHOW pilot sites. Results include experiences of SHOW pilot sites partners based on two surveys executed within the work package 15 activity 15.6. All automated vehicles had permission to drive on public roads, therefore the surveys reflect the fragmentation of test procedures and the need for harmonisation.

# 2 SHOW Standardization: Objectives and Achievements

## 2.1 Introduction

SHOW Activity 15.6 ‘Standardization and Certification’ has the objective to report on the adherence to all relevant standards in the technical area under study coming from relevant Standards Development Organizations (SDO) such as ETSI TC ITS, ISO TC204 or CEN TC278 and from industry fora and associations. Furthermore, SHOW partners are tasked to actively represent the project in the most important standardization working groups (WGs) and to contribute to some of them based on results from the SHOW project.

The present chapter is structured as follows:

- First, (see 2.2) a standardization landscape is drafted based on the specifications used in the development of the SHOW functionalities as reported in the deliverables of the SHOW activities and gathered through two partner surveys.
- Second, (see 2.3) contains an overview of the standardization and interest groups in which SHOW partners reported to be actively involved. Active participation and contribution of SHOW partners to SDO working groups are listed showing the concrete impact of the project on standardization and the inclusion of project results into internationally recognized specifications. Including SHOW results in SDO publications makes the SHOW outcomes and recommendations known to a wider audience.
- Finally, (see 2.4) a set of concrete standardization gaps are described as they have been recognized in the SHOW project and have been reported by the partners in the surveys.

## 2.2 SHOW standardization landscape

### 2.2.1 Overview

The information that was used to present the SHOW standardization landscape has been gathered through the study of all SHOW deliverables available at the time of writing the present document, and through two partner surveys that have been conducted to obtain additional inputs from the project partners.

The SHOW project covers a wide range of technologies and consequently uses and adheres to specifications on different topics which are covered by several SDOs and regulatory authorities.

Table 1 below gives an overview of the technology topics of relevance in the SHOW pilots and the corresponding SDOs whose standards were used:

**Table 1: SHOW technology topics and related organizations**

| Technology topic | Organization(s) |
|---|---|
| Communication means | IEEE, 3GPP |
| C-ITS communication protocols | ETSI, ISO (CEN) |
| Safety aspects | ISO + UN/EU regulations |
| Taxonomy | SAE |
| Ergonomics | ISO |
| Secure connections | ISO |
| Data Management | ISO |
| HTTP | IETF |

| Technology topic | Organization(s) |
|---|---|
| Public Transport | CEN |
| M2M/IoT | OASIS |
| Acoustic Vehicle Alerting Systems | UN/US regulations |
| Traffic signs and road markings | Vienna convention, CEN |
| Dynamic maps | ISO |
| Positioning | 3GPP |
| Test scenarios for automated driving systems | ISO |

The standards and technical specifications that were considered for application or used in the SHOW project, under each of the topics in Table 1, are presented in more detail below.

### 2.2.2 Communication means

The SHOW project relies on C-ITS which typically involves communication between vehicles, between vehicles and infrastructure and/or infrastructure-to-infrastructure. WP4 ‘System architecture and tools’ describes the competing technologies in its deliverables, namely D4.1 [2] and D4.3 [3] ‘Open modular system architecture and tools’.

SHOW uses both competing technologies ITS-G5 and C-V2X which are specified by IEEE and 3GPP respectively.

**ITS-G5:**

**IEEE 802.11p** is the amendment to the IEEE 802.11 ‘Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part II: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification’ [11] that adds wireless access in vehicular environments (WAVE). It defines enhancements to 802.11 (Wi-Fi) required to support intelligent transportation systems applications.

**IEEE 1609** ‘Standard Wireless Access in Vehicular Environments (WAVE) - Multi-Jurisdictional Interoperability Using Security Credentials Originating in Disparate Policy Domains’ [12] is a higher layer standard based on the IEEE 802.11p. It is also the basis of the European standard for vehicular communication known as ETSI ITS-G5.

**C-V2X:**

3GPP specifies this technology as an alternative to ITS-G5. It includes direct and cellular network communications using the deployed 4G/5G networks. Several standards are under preparation in the 3GPP WGs, the specification below has specifically been named during the partner survey:

**3GPP TS 38.300** ‘5G; NR; NR and NG-RAN Overall description; Stage-2’ [13]

### 2.2.3 C-ITS communication protocols

To achieve the objectives of the SHOW project, data exchanges between vehicles and the road infrastructure are an important target to be considered. The message types in the SHOW context are the C-ITS messages as defined by ETSI TC ITS (and also by ISO TC204 and CEN TC278). The specifications in the present chapter have been referenced by several WPs in their deliverables and have also been reported in the survey by a number of partners. Especially, WP8 ‘Infrastructure functions and systems’ cross references the Traffic Management services described in chapter 5.1 of D8.3 ‘Solutions for collaborative TM’ [8] to the relevant C-ITS specifications. The following types of messages are normally being used:

- Cooperative Awareness Messages (CAMs) are messages exchanged in the ITS network between ITS stations e.g. OBUs and RSUs to create and maintain awareness of each other and to support cooperative performance of vehicles using the road network. CAMs contain status and attribute information of the originating ITS station. The messages are defined in ETSI **EN 302 637-2** 'Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service' [14].

- Decentralized Environmental Notification Message (DENM) are facilities layer messages that are mainly used by ITS applications to alert road users of a detected event using ITS communication technologies. DENMs can describe a variety of events that may have been detected by ITS stations. The DENMs are defined in **ETSI EN 302 637-3** 'Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specification of Decentralized Environmental Notification Basic Service' [15].
- MapData (MAP) and Signal Phase And Timing (SPAT) messages are defined in **ETSI TS 103 301** 'Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services' [16]. It should be noted that the main specification work happened in ISO TC204 (and CEN TC278), and ETSI TS 103 301 makes hence strong reference to **ISO TS 19321** 'Intelligent transport systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structures' [17] and **ISO TS 19091** 'Intelligent transport systems - Cooperative ITS - Using V2I and I2V communications for applications related to signalized intersections' [18]. The messages are contextually bound together with the purpose of conveying dynamic information about the state of a signalized intersection, as well as phase and timing information (SPAT) with intersections and/or road segment topologies (MAP).

As a base for the understanding of the message exchanges and the underlying architectures and principles**, ETSI EN 302 636** series 'Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking' [19] is also of importance in the SHOW activities.

It is important to know that the C-ROADS Platform, with the goal of achieving the deployment of interoperable cross-border C-ITS services for road users throughout Europe, developed protocol profiles based on the above listed C-ITS specifications. These profile specifications are freely available through the C-ROADS Releases Website (see https://releases.c-roads.eu/). SHOW partners particularly named the following three C-ROADS specification profiles as relevant to their pilot site deployments.

- C-ROADS 'Common C-ITS Service and Use Case Definitions' Version 1.8.0 (Working Group 2 Technical Aspects, Taskforce 2 Service Harmonization)
- C-ROADS 'C-ITS Message Profiles' Version 1.8.0 (Working Group 2 Technical Aspects, Taskforce 3 Infrastructure Communication)
- C-ROADS 'Roadside ITS G5 System Profile' Version 1.8.0 (Working Group 2 Technical Aspects, Taskforce 3 Infrastructure Communication)

Further references are made to the ongoing ETSI work related to the Cooperative Perception Service (CPS) in **ETSI TR 103 562** 'Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Analysis of the Collective Perception Service (CPS); Release 2' [20] and on the Vulnerable Road Users (VRU) related topic covered in the **ETSI TS 103 300** series 'Intelligent Transport Systems (ITS); Vulnerable Road Users (VRU) awareness' [21].

Finally, SHOW also uses the standard **SAE J2735** 'V2X Communications Message Set Dictionary' [22] which specifies a message set, and its data frames and data elements, for use by applications that use vehicle-to-everything communications systems as applied in the SHOW project.

### 2.2.4 Safety aspects

Safety aspects are essential to the deployment and operation of automated mobility services in general and in the pilot sites in the SHOW project. The partner survey revealed that the specifications developed by ISO TC22 are used to achieve the safety of the intended functionality (SOTIF), which is defined as the absence of unreasonable risk due to a hazard caused by functional insufficiencies. **ISO 21448** 'Road vehicles - Safety of the intended functionality' [23] provides the general argument framework and guidance on measures to ensure SOTIF. The document explicitly excludes safety hazard already specified in the 12-part **ISO 26262** 'Road vehicles - Functional safety' [24] series which covers safety-related systems that include one or more electrical and/or electronic system and that are installed in series production road vehicles.

Safety is also the topic of regulations from the Economic Commission for Europe of the United Nations (UN/ECE). SHOW partner NAVYA named the following safety related regulations that must be followed in the operation of automated shuttles:

- **Regulation No 13** of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles of categories M, N and O with regard to braking [25]
- **Regulation No 39** of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of vehicles with regard to the speedometer and odometer equipment including its installation [26]
- **Regulation No 46** of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of devices for indirect vision and of motor vehicles with regard to the installation of these devices [27]
- **Regulation No 48** of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of vehicles with regard to the installation of lighting and light-signalling devices [28]
- **Regulation No 79** of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles with regard to steering equipment [29]
- **Regulation No 100** of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train [30]
- **Regulation No 107** of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of category M2 or M3 vehicles with regard to their general construction [31]
- **Regulation No 121** of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles with regard to the location and identification of hand controls, tell-tales and indicators [32]

In addition, the following EU regulations apply:

- **Regulation (EU) 2018/858** of the European Parliament and of the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles [33]
- **Regulation (EC) 595/2009** of the European Parliament and of the Council on type-approval of motor vehicles and engines with respect to emissions from

heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information [34]

- **Commission Regulation (EU) No 351/2012** implementing Regulation (EC) No 661/2009 of the European Parliament and of the Council as regards type-approval requirements for the installation of lane departure warning systems in motor vehicles [35]

Of high relevance are also the automated driving systems type approval related regulations found in:

- **Regulation (EU) 2019/2144** of the European parliament and of the council on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users [36]
- **Commission Implementing Regulation (EU) 2022/1426** laying down rules for the application of **Regulation (EU) 2019/2144** of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of the automated driving system (ADS) of fully automated vehicles [37]

### 2.2.5 Taxonomy

To classify and categorize the level of automation of vehicles, SHOW referred to the well-known specification **SAE J3016** 'Recommended Practice: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles' [38] which defines 5 SAE levels of driving automation as shown in the figure below.

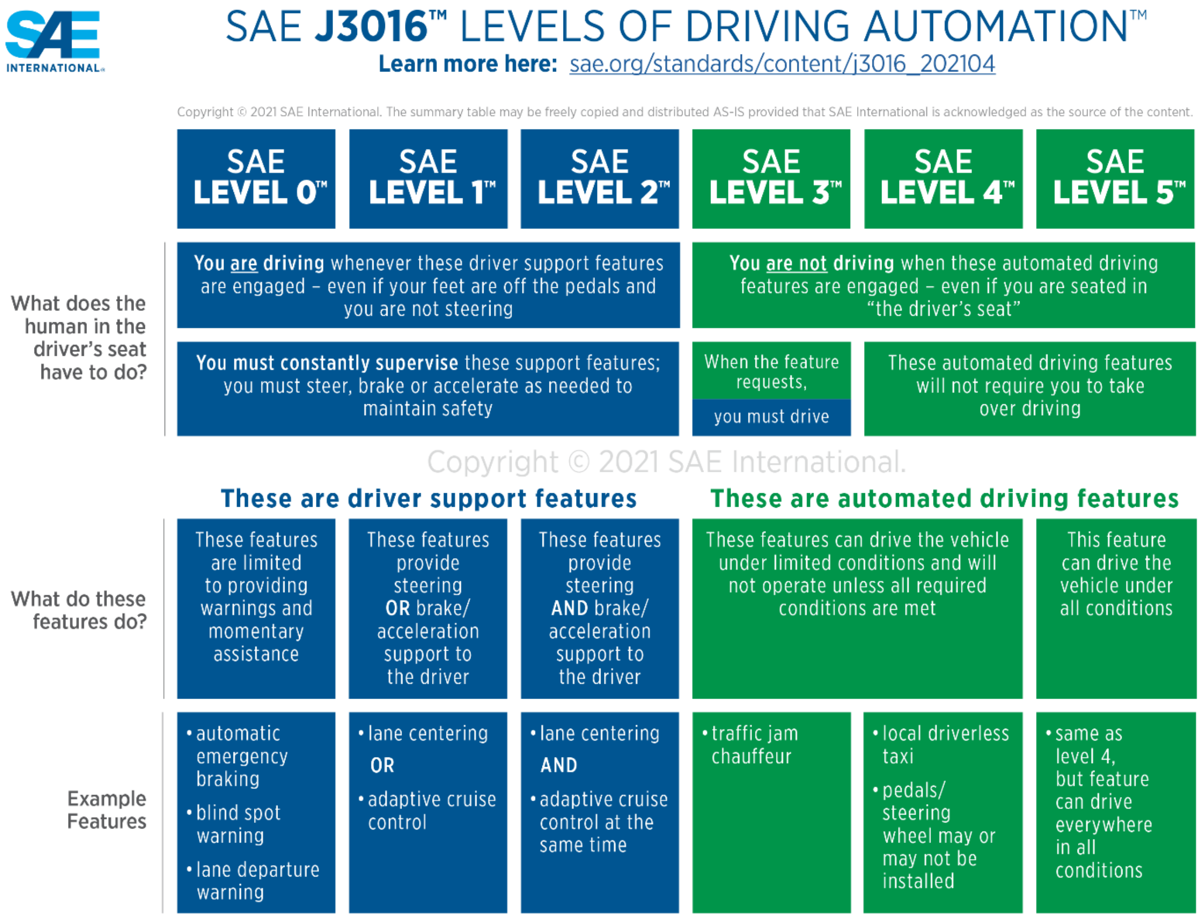


**Figure 1: SAE levels of driving automation (Source SAE J3016™)**

The taxonomy work of the British Standards Institution (BSI) as specified in **PAS 1883** 'Operational Design Domain (ODD) taxonomy for an automated driving system (ADS) – Specification' [39] has also been considered.

### 2.2.6 Ergonomics

SHOW partner TECNALIA pointed out the relevance of external communication between the automated shuttles used in the pilot sites to other (non-automated) road users. ISO TC22 has studied this aspect and has published **ISO TR 23049** 'Road Vehicles - Ergonomic aspects of external visual communication from automated vehicles to other road users' [40] which provides guidance for developers of visual external communication systems for automated vehicles by proposing how automated vehicles can communicate with other road users via an external communication system and discusses the interaction between humans and automated vehicles within roadway environments.

### 2.2.7 Secure connection, Data Management, HTTP, Public Transport, M2M/IoT

SHOW WP4 'System architecture and tools' studied standardization aspects in deliverable 'D4.1: Open modular system architecture and tools - first version' [2] and covered the following topics from Table 1:

- Secure connection
- Data Management

- HTTP
- Public Transport
- M2M/IoT

These are mentioned in more detail in Tables 46 and 47 of D4.1 [2]. The information and the list of relevant standards are therefore not repeated in the present deliverable as Table 46 lists all the relevant standards used in public transport focusing on road transport for the above topics and Table 47 gives a comprehensive overview on ongoing standardization activities related to the Secure Vehicle Interface.

The *secure connection* relevant specification **ISO/IEC 27001** 'Information security, cybersecurity and privacy protection - Information security management systems - Requirements' [41] was also considered in several other SHOW deliverables (e.g. D5.1 'SHOW Big Data Collection Platform and Data Management Portal' [4]) and also named by several partners in the surveys as important for their work in SHOW. The same applies for **ISO/SAE 21434** 'Road vehicles - Cybersecurity engineering' [42] which is referenced in e.g. D11.2 'Demos safety, reliability and Robustness validation and commissioning' [9] and named as relevant by SHOW partner UNIGE in the survey. Furthermore, validation steps for developing and validating automated driving systems based on basic safety principles derived from worldwide applicable publications are reported in **ISO/TR 4804** 'Road vehicles - Safety and cybersecurity for automated driving systems - Design, verification and validation' [43]. Finally, the ongoing work on draft **ISO/SAE PAS 8475** 'Road vehicles - Cybersecurity Assurance Levels (CAL) and Targeted Attack Feasibility (TAF)' [44] has been named by partner UNIGE as relevant to their SHOW activities.

D11.2 [9] also points to the importance of **UN Regulation No 155** 'Uniform provisions concerning the approval of vehicles with regards to cybersecurity and cybersecurity management system' [45] which refers directly to the above-mentioned ISO/SAE 21434 [42], ISO 21448 [23] and ISO 26262 [24] standards.

### 2.2.8 Acoustic Vehicle Alerting Systems

SHOW WP7 'Automated vehicles functions' studied the acoustic interfaces for VRUs in deliverable D7.3 'Interfaces to non-equipped participants' [5]. Acoustic Vehicle Alerting Systems (AVAS) have the objective to alert pedestrians to the presence of EVs at lower speeds.

This security relevant requirements are covered in the following European and US regulations which were observed by the SHOW project.

- **Regulation No 138** of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of Quiet Road Transport Vehicles with regard to their reduced audibility [46]
- **Federal Motor Vehicle Safety Standard No. 141**, Minimum Sound Requirements for Hybrid and Electric Vehicles [47]

### 2.2.9 Traffic signs and road markings

SHOW WP8 'Automated vehicles functions' discusses the Impact of physical infrastructure elements on automated driving in chapter 3 of deliverable D8.1: 'Criteria catalogue and solutions to assess and improve physical road infrastructure' [6]. Main source of information/regulation is the 'Convention on Road Signs and Signals', commonly known as the **'Vienna Convention on Road Signs and Signals'**, which is a multilateral treaty that standardizes the signing system for road traffic (road signs, traffic lights and road markings) and is in use internationally. Additionally, **EN 12899-1** 'Fixed, vertical road traffic signs - Fixed signs' [48] specifies requirements for complete sign assemblies, signs, sign plates and for other major components (retroreflective sheeting, supports and luminaires). National regulations complement the international specifications, they are listed in tables 9 and 10 of D8.1 [6].

Another referenced standard is **EN 1436** 'Road Marking performance for road-users' [49] regarding visibility and retro reflectivity of road markings. It specifies the various levels of performance for road users of white and yellow road markings and also describes test methods and conditions of measuring the various performance characteristics.

### 2.2.10 Dynamic maps and Positioning

SHOW WP8 'Infrastructure functions and systems' studied digital dynamic maps for urban automated driving. Relevant standard is **ISO 20524-2** 'Intelligent transport systems - Geographic Data Files (GDF) GDF5.1 - Part 2: Map data used in automated driving systems, Cooperative ITS, and multi-modal transport' [50]; it specifies the conceptual and logical data model in addition to the physical encoding formats for geographic databases for Intelligent Transport Systems applications and services.

In D8.2 'Solutions for onsite digital and Communication infrastructure' [7] reference is made to two 3GPP specifications on positioning,

- **3GPP TS 36.355** 'LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)' [51] contains the definition of the LTE Positioning Protocol.
- **3GPP TS 37.355** 'LTE; 5G; LTE Positioning Protocol (LPP)' [52] contains the definition of the LTE Positioning Protocol for the radio access technologies E-UTRA/LTE and NR.

It should be noted that maps and positioning are highly dependent on the delivery of accurate data on the road network. Several data types exist and are referenced and used within the SHOW project.

- Datex II: Specified in the **CEN TS 16157** 'Intelligent transport systems - DATEX II data exchange specifications for traffic management and information' [53] series
- TISA: Specified in the **ISO 21219** 'Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2)' [54] series

### 2.2.11 Test scenarios for automated driving systems

Project partners ICCS and Sensible4 answered the survey and stated the use of specifications in the technical area of testing automated driving systems of Level 3 and above. The relevant ISO specifications are listed below.

- **ISO 34501** 'Road vehicles - Test scenarios for automated driving systems - Vocabulary'[55] defines terms in the context of test scenarios for automated driving systems.
- **ISO 34502** 'Road vehicles - Test scenarios for automated driving systems - Scenario based safety evaluation framework' [56] provides guidance for a scenario-based safety evaluation framework for automated driving systems. The framework elaborates a scenario-based safety evaluation process that is applied during product development.
- **ISO 34503** 'Road Vehicles - Test scenarios for automated driving systems - Specification for operational design domain' [57] specifies the requirements for the hierarchical taxonomy for specifying operating conditions which enable the definition of an operational design domain (ODD) of an automated driving system.
- **ISO 34504** 'Road vehicles - Test scenarios for automated driving systems -

Scenario categorization' [58] defines an approach for the categorization of scenarios by providing tags that carry information about the scenarios.

- **ISO 22737** 'Intelligent transport systems - Low-speed automated driving (LSAD) systems for predefined routes - Performance requirements, system requirements and performance test procedures' [59] specifies requirements for the operational design domain, system requirements, minimum performance requirements, and performance test procedures for the safe operation of low-speed Level 4 automated driving systems for operation on predefined routes.

Further details are found in the deliverables of WP11 'Technical verification & pre-demo evaluation', namely in D11.1 'Technical validation protocol' [9] which provides a methodology considering systems involved in SHOW pilots, considering vehicle safety and performance, cybersecurity and the communication of the vehicle with the infrastructure and the Mobility Service management service.

### 2.2.12 Standardization landscape summary

The findings in the chapters above show a comprehensive awareness and use of (~100) specifications within the project showing a good coverage of standardization groups, namely the relevant ETSI and ISO groups on ITS standardization. In the chapters below, concrete SHOW participation in and contribution to standardization work are described in more detail.

It may have been beneficial to promote the SHOW results within the 3GPP community. However, the 3GPP meetings have become so large, with hundreds of delegates and nearly 1,000 technical documents under discussion, that securing a timeslot for a project presentation is nearly impossible. Additionally, attempting to seriously influence the work within a 3GPP group using SHOW findings would require a substantial effort in terms of time (forming alliances with participants, attending numerous meetings) and money (world-wide meetings), which would go well beyond the scope of the SHOW project.

## 2.3 SHOW standardization participation

One of the activities of A15.6 ‘Standardization and Certification’ was to establish an overview of the participation of SHOW partners in standardization activities. Two partner surveys have been performed and a summary of the groups where the SHOW partners participated is given in the table below.

**Table 2: SHOW participation in standardization**

| **Group/ partner** | AIT | CDV | ERICSSON | ERTICO | ICCS | INDRA | KAPSCH | NAVYA | NTUA | SENSIBLE | SITOWISE | UNIGE | VIF | VTT |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5GAA | | | X | | | | | | | | | | | |
| AECC | | | X | | | | | | | | | | | |
| ASAM | | | | | X | | | | | X | | | X | |
| AUTOSAR | | | | | | | | | | | | | X | |
| CCAM Association | X | X | | X | | | | | | X | | | | |
| C2C-CC | | | | | | | X | | | | | | | |
| C-ROADS | | | | | | X | | | | | | | | |
| CEDR | | | | | | | | | X | | | | | |
| CEN TC226 | X | | | | | | | | | | | | | |
| CEN TC278 | | | | X | | | X | | | | X | | | X |
| CEPT | | | | | | | X | | | | | | | |
| ECTRI | X | | | | | | | | | | | | | |
| ERTRAC | X | | | | | | | | | | | | | |
| ETSI TC ITS | | | X | X | | | X | | | | | | | |
| FEHRL | X | | | | | | | | | | | | | |
| GRSF | | | | | | | | | X | | | | | |
| GRSP | | | | | | | | | X | | | | | |
| IAMTS | | | | | | | | | | | | | X | |
| IETF | | | | | | | | | | | | | X | |
| ISO TC 22 | | | | | | | | | | | | X | | X |
| ISO TC 204 | | | | X | | | | | | | X | X | | X |
| ITF | | | | | | | | | X | | | | | |
| ITU-T SG20 | | | | | | | | | | | | X | | |
| MVWG | | | | | | | | X | | | | | | |
| UNECE | | | | | | | | | X | | | | | |
| UNRSC | | | | | | | | | X | | | | | |
| National * | X | | | | | | | X | | | X | X | | |

Legend to Table 2:

- 5GAA: The 5G Automotive Association (5GAA) is a global, cross-industry organization of companies from the automotive, technology, and telecommunications industries (ICT), working together to develop end-to-end solutions for future mobility and transportation services. The membership is comprised of automotive manufacturers, tier-1 suppliers, chipset/communication system providers, mobile operators, and infrastructure vendors.
- AECC: The Automotive Edge Computing Consortium (AECC) works towards a future where all connected vehicle services can deliver the full benefits of big data, enabling intelligent driving, improved safety, increased efficiency and greater reliability by driving the evolution of edge network architectures and computing infrastructures to enable high-volume data services to deliver smarter, more efficient connected vehicle services.

- ASAM: The Association for Standardization of Automation and Measuring Systems (ASAM) promotes standardization of tool chains in automotive development and testing. ASAM standards are developed by experts from the member companies and are based on real use cases. ASAM is the legal owner of these standards and is responsible for their distribution and marketing.
- AUTOSAR: The AUTomotive Open System ARchitecture (AUTOSAR) is a global development partnership with the purpose of developing and establishing an open and standardized software architecture for automotive electronic control units.
- CCAM Association: The CCAM association aims to accelerate the development of new technologies and their deployment in real life, by bringing together all the relevant stakeholders from different sectors such as industry, research, services, public and local authorities, associations, and SMEs.
- C2C-CC: The CAR 2 CAR Communication Consortium (C2C-CC) aims at saving lives by research and development of powerful, reliable, robust and mature safety related C-ITS solutions facilitating to overcome road accidents (vision zero) while supporting highest safety level at improved traffic efficiency anywhere, anytime at lowest costs to the end user and the environment. C2C-CC pursues a seamless evolution path which is required for enabling spectrum efficiency, needed functionalities and technologies driven by innovations and competition while safeguarding already taken investments in vehicles and road infrastructure.
- C-ROADS: The C-Roads Platform is a joint initiative of European Member States and road operators for testing and implementing C-ITS services in light of cross-border harmonization and interoperability.
- CEDR: The Conference of European Directors of Roads (CEDR) is an organization of European national road administrations that promotes Excellence in the Management of Roads.
- CEN TC226: The scope of CEN TC226 ‘Road Equipment’ is the standardization of specifications for safety, traffic control and other road equipment.
- CEN TC278: The scope of CEN TC2786 ‘Intelligent Transport Systems’ is the standardization of specifications in the field of ITS to improve the driving experience and to make major contributions to road safety and to the reduction of energy consumption and pollution. CEN TC278 is the European sister TC to ISO TC204.
- CEPT: The European Conference of Postal and Telecommunications Administrations (CEPT) was established as a coordinating body for European state telecommunications and postal organizations.

  The CEPT Electronic Communications Committee (ECC) is responsible for all radiocommunications, and telecommunications matters. Relevant groups for the SHOW project are listed below.

  The ECC WG ‘Spectrum Engineering’ (WG SE) is responsible for developing technical guidelines and sharing and compatibility arrangements for radio spectrum use by various radiocommunications services using the same or different frequency bands respectively. Within CEPT ECC WG SE exist SE24 ‘Short Range Devices’ and SE45 ‘AS/RLANs in the frequency band 5925 – 7125 MHz’.

  The ECC WG ‘Frequency Management’ (WG FM) is responsible for developing strategies, plans and implementation advice for the management of the radio spectrum. Within ECC WG FM exists the group SRD/MG ‘Short Range Devices’.
- ECTRI: The European Conference of Transport Research Institutes (ECTRI) is the leading European Research Association for Sustainable and Multimodal Mobility with

the mission of pushing for green, safe, efficient and inclusive transport for people and goods.

- ERTRAC: The mission of the European Road Transport Research Advisory Council (ERTRAC) is to provide a framework to focus the coordinated efforts of public and private resources on the necessary research activities for an accelerated development of sustainable, integrated transport solutions.
- ETSI TC ITS: The responsibility of ETSI TC ITS is the development and maintenance of standards, specifications, and other deliverables to support the development and implementation of ITS Service provision across the network, for transport networks, vehicles, and transport users, including interface aspects and multiple modes of transport and interoperability between systems.
- FEHRL: The mission of the Forum of European National Highway Research Laboratories (FEHRL) is to serve society by accelerating the development and facilitating the deployment of collaborative science, technical knowledge and innovative solutions for the road infrastructure sector.
- GRSF: The Global Road Safety Facility (GRSF) - a multi-donor partnership managed by the World Bank - supports efforts in low and middle-income countries to halve their road traffic fatalities and serious injuries.
- GRSP: The role of the non-profit organization Global Road Safety Partnership (GRSP) is to create and support multi-sector road safety partnerships that are engaged with front-line good practice road safety interventions in countries and communities throughout the world to address the global recognition of road crash deaths and injuries as a human-made health crisis.
- IAMTS: The International Alliance for Mobility Testing and Standardization (IAMTS) is a global, membership-based association of organizations that specialize in the testing, standardization and certification of advanced mobility systems and services with the vision of providing a globally accepted validation framework as best practices to scale automated vehicle adoption.
- IETF: The Internet Engineering Task Force (IETF) is a standards organization with the purpose of creating voluntary standards to maintain and improve the usability and interoperability of the Internet. IETF standardizes also in the field of ITS.
- ISO TC22: The scope of ISO TC22 ‘Road vehicles’ is the standardization of all aspects for all types of road vehicles and their interfaces approved for operation on public roads for the whole life cycle concerning safety, security, sustainability, compatibility, interchangeability, maintenance, evaluation of performance and quality.
- ISO TC204: The scope of ISO TC204 ‘Intelligent Transport Systems’ is the standardization of information, communication, and control systems in the field of urban and rural surface transportation, including intermodal and multimodal aspects thereof, traveller information, traffic management, public transport, commercial transport, emergency services and commercial services in the intelligent transport systems field.
- ITF: The International Transport Forum (ITF) offers a platform for discussion and pre-negotiation of policy issues across all transport modes with the mission of fostering a deeper understanding of the role of transport in economic growth, environmental sustainability and social inclusion and of raising the public profile of transport policy.
- ITU-T SG20: The scope of ITU-T SG20 ‘Internet of things and smart cities and communities' is development of international standards for the coordinated development of IoT technologies, including machine-to-machine communications and ubiquitous sensor networks with a focus on the standardization of end-to-end

architectures for IoT, and mechanisms for the interoperability of IoT applications and datasets.

- MVWG: The Working Group on Motor Vehicles (MVWG) assists the Commission in the preparation of delegated acts, legislative proposals and policy initiatives by leading discussions between all stakeholders from governments, industry and consumer associations interested in the regulatory activities concerning motor vehicles.
- UNECE: The United Nations Economic Commission for Europe (UNECE) is to promote pan-European economic integration. Its UNECE World Forum for Harmonization of Vehicle Regulations (WP.29) the task to establish regulatory instruments concerning motor vehicles and motor vehicle equipment.
- UNRSC: The UN Road Safety Collaboration (UNRSC) is an informal consultative mechanism whose goal is to facilitate international cooperation and strengthen global and regional coordination among UN agencies and other international partners to implement UN General Assembly Resolutions on road safety.
- *National associations named by the SHOW partners:
    - AIT: ASI (Austrian Standards Institute), FSV (Austrian Association for Roads, Railways and Transport)
    - NAVYA: Bureau de Normalisation de l'Automobile (BNA), groups FUSA, SOTIF, ADS
    - SITOWISE: Active in Finnish national standards organizations
    - UNIGE: SAAM (Swiss Association for Autonomous Mobility)

Where not all groups in the table are instrumental for the work of SHOW, it shows the strong commitment of the consortium to standardization activities. The following chapter describes concrete actions of SHOW partners in several of the above groups.

## 2.4 SHOW standardization contribution

### 2.4.1 Overview

In the present chapter, the contribution to standardization of SHOW partners is documented based on the feedback received through the partner surveys. This consists of the active presence at the meetings of standardization groups (see 2.4.2) and the contribution of SHOW results in presentations and participation in the drafting work on specifications (see 2.4.3). SHOW partners formulated also some recommendations on future standardization activities (see 2.4.4).

### 2.4.2 Meeting participation

#### *2.4.2.1 ISO*

**ISO TC 204** 'Intelligent Transport Systems' saw a high presence of SHOW partners in its meetings.

SHOW partners SITOWISE and VTT concentrated their presence on the $60^{th}$ TC204 plenary which was held in Tampere (3-7 October 2022) and organized by SITOWISE.

Active participation in the TC204 WGs was reported by UNIGE and ERTICO as follows:

UNIGE is participating in all meetings of ISO TC204 WGs:

- WG1 'Architecture'
- WG8 'Public transport/emergency'
- WG14 'Vehicle/roadway warning and control systems'

- WG18 ‘Cooperative systems’

Kapsch reported its active presence in:

- WG5 ‘Fee and toll collection’
- WG18 ‘Cooperative systems’’

This is complemented by ERTICO’s participation in:

- WG3 ‘ITS geographic data’
- WG10 ‘Traveler information systems’
- WG17 ‘Nomadic Devices in ITS Systems’
- WG19 ‘Mobility integration’
- WG20 ‘Big Data and Artificial Intelligence supporting ITS’

In addition, UNIGE participates in the meetings of the **ISO/SAE JWG** ‘Automotive Cybersecurity Engineering’ where it supports the development of **ISO/SAE PAS 8475** ‘Road vehicles - Cybersecurity Assurance Levels (CAL) and Targeted Attack Feasibility (TAF)’ [44], see also 2.2.7.

Furthermore, VTT also actively follows all meetings related to the development of **ISO 13228** ‘Road vehicles - Test method for automotive LiDAR’ [60] which happens in **ISO TC22** ‘Road Vehicles’ **SC32** ‘Electrical and electronic components and general system aspects’ WG16 ‘Automotive perception sensors’.

#### *2.4.2.2 ETSI*

**ETSI TC ITS** is mainly active in the protocol aspects of C-ITS where radio spectrum matters are jointly covered by WG4 in the maintenance of harmonized standards together with **ETSI TC ERM** ‘EMC & Radio Spectrum Matters’ **TG37** ‘Intelligent Transport Systems’.

SHOW partner Kapsch (KTC) reported participation in all ETSI TC ITS plenary meetings and is also present in the following WGs:

- WG1 ‘Application Requirements and Services’
- WG2 ‘Architecture and Cross Layer’
- WG3 ‘Transport and Network’
- WG4 ‘Media and Medium Related’ including joint meetings with **ETSI TC ERM TG37**

**ETSI TC ITS** has a strong cooperation with the **C2C-CC** and Kapsch consequently follows all joint activities related to the topics Decentralized Congestion Control (DCC) and Multi-Channel Operation (MCO).

It should be noted that ERTICO occasionally followed the proceedings of TC ITS to monitor ongoing standardization activities in the C-ITS field.

#### *2.4.2.3 CEN*

Kapsch has been active in the meetings of **CEN TC278** ‘Intelligent Transport Systems’ where it discusses SHOW relevant topics in the WGs equivalent ISO TC 204 WG5 and WG18 i.e.,

- WG1 ’Electronic fee collection and access control’
- WG16 ‘Cooperative ITS’

In addition, SHOW partner AIT actively supports the work on **CEN TR17828** ‘Road infrastructure - Automated vehicle interactions - Reference Framework’ by participating in the meetings of **CEN TC226** ‘Road Equipment’ WG12 ‘Road interaction - ADAS / Autonomous vehicles’.

*2.4.2.4 ITU*

UNIGE followed the meetings of the **ITU Focus Group** on AI for autonomous and assisted driving (**FG-AI4AD**) until the conclusion of the activities on 29 September 2022. This group focused upon the behavioural evaluation of an AI responsible for the dynamic driving task by supporting standardization activities for services and applications enabled by AI systems in autonomous and assisted driving with the objective of creating an international harmonization on the definition of a minimal performance threshold for such AI systems.

ERTICO is part of the **ITS Expert Group** on Communications Technology for Automated Driving (**EG-ComAD**) and follows the meetings since the foundation in March 2024. The group is dedicated to exploring and advancing communications technologies for automated driven vehicles and aims to enable the equipment of all new vehicles from about 2030 with the necessary communications technology to enable vehicles with ADS active to drive as safely as practical.

*2.4.2.5 C2C-CC*

Kapsch is highly involved in the work of the C2C-CC by participating in all C2C-CC meeting weeks and in the meetings of the C2C-CC COM-COSP group, the C2C-CC city workshops, and acts as technical chair in all meetings that cover the topics of new infrastructure use cases, mapping of infrastructure data formats to DENM, and cooperative green light optimum speed advisory.

*2.4.2.4 Other international groups*

In addition to the above meeting participations, partners reported further involvement in the work of the following groups.

- AIT follows the 3 yearly meetings of the CCAM Association and the plenary meetings of ERTRAC (2), FEHRL (1) and ECTRI (1).
- ICCS is active in ASAM attending all meetings of the ASAM OpenODD concept and standardization groups, the OpenTEST concept project workshops, and the OpenScenario open-to-the-public meetings.
- Kapsch, besides the above-mentioned standardization activities), also occasionally follows the ETSI work in the TC ITS/TC RT 'Rail Telecommunications' Joint Task Force and the IEEE meetings related to the IEEE 802.11 series of specifications. Furthermore, Kapsch follows the proceedings of the CEPT groups WG FM, SRD/MG and some of the meetings of CEPT SE24 and SE45.
- SENSIBLE report participation in the yearly Multicluster meetings of the CCAM Association.

*2.4.2.4 National groups*

UNIGE participated in the national Swiss SAAM days and workshops on regulations and standardization as part of its work in standardization as mentioned above. Moreover, UNIGE reported also participation in the yearly national Swiss Future Mobility Days (La journée suisse de la mobilité du futur/Mobilität der Zukunft") organized by the Swiss standardization body in road and transport engineering.

### 2.4.3 Active contribution and presentation

Several partners reported active contributions to specifications based on the work performed in the SHOW project.

- AIT actively contributed the SHOW experiences to **CEN TR17828** [61] in WG12 of CEN TC226. The TR was published on 22 June 2022 and provides the current road equipment suppliers' visions and their associated short term and medium-term priority deployment scenario and identifies potential functional/operational standardization issues enabling a safe interaction of road equipment/infrastructure with automated vehicles in a consistent and interoperable way.

- ERTICO led the ISO TC204 WG17 work on the standardization of a methodology to obtain information about the energy behaviour per trip which has been developed and applied by T-Systems in a number of pan-European projects. This methodology describes a low-cost solution called Low Carbon Mobility Management (LCMM) service that uses in-vehicle nomadic and mobile devices and a client server architecture where the dynamic speed profile per second is evaluated with fixed vehicle configuration parameters inside the server. With the near real-time communication between the nomadic device and the server, the results of the calculation can be made visible to the driver during the trip for eco-drive purposes. Experience from the SHOW pilot trials fed into the drafting of an ISO specification, which was finally published as **ISO 23795-1** 'Intelligent transport systems - Extracting trip data using nomadic and mobile devices for estimating $C0_2$ emissions - Part 1: Fuel consumption determination for fleet management' [62] on 31 May 2023.

  ERTICO will continue inputting SHOW-generated results into the standardization work of ISO TC204 WG17. ERTICO was appointed in 2022 as convenor of the WG17 subgroup SWG17.2 which is developing a series of international standards which define energy based green ITS services providing urban transport management and smart city mobility applications on nomadic & mobile devices by means of measuring energy consumption and $CO_2$ emissions and also providing information to users on energy capacity in transportation sectors in the smart city. This SWG aims at reducing the environmental impact of traffic and at reducing traffic related emissions and was consequently named "Save the planet"-SWG. Currently work is ongoing on the **ISO 17748** 'Energy-based green ITS services on nomadic devices for smart city mobility applications' [63] series and work items for 4 parts have already been opened at ISO.

- VTT is actively following the work on **ISO 13228** 'Road vehicles - Test method for automotive LiDAR' [60] in ISO TC22 SC32 WG 16 by following the related meetings and discussions and by contributing the SHOW perspective from the Finnish pilot deployment to the document. Additionally, VTT published a technical paper titled 'Testing and Validation of Automotive Point-Cloud Sensors in Adverse Weather Conditions' which investigates proposed validation methods for challenging adverse weather conditions for optical sensing principles in the literature and adopts a common validation method to perform both indoor and outdoor tests to examine how fog and snow affect performances of different LiDARs.

- Kapsch is acting as rapporteur for the following ETSI documents giving high influence potential on their content and excellent opportunity to feed in SHOW project experiences.
  - **ETSI TS 102 792** 'Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range' [64]
  - **ETSI EN 300 674 series** 'Transport and Traffic Telematics (TTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5 795 MHz to 5 815 MHz frequency band' [65]
  - **ETSI TS 102 916 series** 'Intelligent Transport Systems (ITS); Test specifications for the mitigation techniques to avoid interference between Cooperative ITS-G5 and TTT DSRC' [66]

  Additionally, Kapsch has been part of several ETSI Specialized Task Forces which worked on the definition of the specifications on DCC.

- ICCS contributed to the ASAM 'OpenODD: Concept paper' [67] which defines a domain specific language for ODD descriptions taking into account applications for both commercial vehicles and the public transport fleet as demonstrated in SHOW.

Furthermore, SHOW partners presented the SHOW project at standardization related events raising awareness of the project and its results.

- **NTUA** presented the work of SHOW at several conferences and workshops, namely:
    - Innovation in Road Safety Research Workshop (20 May 2021 and 9 January 2023)
    - 10th International Congress on Transportation Research (ICTR) (3 September 2021)
    - Connected Vehicle Conference 2022 (22 February 2022)
    - Transport Research Arena (TRA) (14 November 2022)
- **SITOWISE** organized the 60th ISO TC204 plenary in October 2023 in Tampere and used the opportunity to give a well-received presentation on SHOW and its results.

### 2.4.4 Gaps and recommendations

In the two partner surveys, SHOW partners were asked to name detected standardization gaps and to make recommendations on how the standards on the use of automated shuttles could be made better. The most important findings have been listed below.

- AIT identified the need for a better understanding of the limitations of the sensor technologies for automated vehicles. This would allow better insights on the physical road infrastructure requirements for AVs. This information would be needed from OEMs and Tier 1 suppliers.
- AIT has also pointed to the need for clarification of liability and legal responsibilities for AVs to drive user acceptance. There must be a harmonization of views from the road authorities, from OEMs, and Tier1 suppliers on the business models used to avoid delays in the development of the standards appropriate for wide deployment of AVs.
- Ericsson remarked that it is an open question whether any standardization organization needs to decide on protocols to be used between OEMs and their backends. Different solutions could coexist, and "translation" and "aggregation" could be used to translate between different formats and protocols.
- NAVYA pointed out the gap that there was not a unique regulation for type approval of autonomous shuttles. However, this lack may have been overcome in the meantime by the publication of **Commission Implementing Regulation (EU) 2022/1426** of 5 August 2022 laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of the automated driving system (ADS) of fully automated vehicles.

This list may not be exhaustive as it represents the gaps and weaknesses identified by the SHOW partners in their project activities during the two years of pilot applications. They are nevertheless indicative of the need for further regulation and standardization work that can be done in the near future on the way to making automated mobility a common-day reality.

# 3 Vehicle License exemption procedure for Public Transport CAV Shuttles

## 3.1 Introduction

In the present chapter, the following aspects of vehicle license exemption are covered:

- Chapter 3.2 outlines data and information for registering automated vehicles with license exemptions on a European level, in especially for electric automated shuttle buses as used in SHOW. The main technical building blocks for such registrations are testing procedures and were found as key barriers for market exploitation, as details for duration or equipment tested are arbitrary and not harmonized among different European Member States. Thus, SHOW confirmed the regulatory need for harmonization of testing procedures before license exemption.
- Chapter 3.3 presents in part 3.3.1 the key differences and technical objectives of testing procedures in the specific SHOW pilot countries, covering both Mega-sites as well as selected Satellite sites. Special attention is given to the different building blocks of safety critical testing procedures among the different sites including operation, sensor reliability, vehicle control systems, localisation and mapping, cyber-security and emergency response behaviour. The following part 3.3.2 gives an overview of the outcomes of the survey which was executed in June and July 2024 among the 12 active SHOW pilot sites to find out the challenges of partners to bring their autonomous electric vehicles to regional public road networks. The survey took place via e-mail as questionnaire focusing on technical barriers and time constraints. Thus, results serve as gap analysis for future harmonization efforts needed.
- Chapter 3.4 elaborates an overview of the outcomes of the questionnaires filled in by the SHOW pilot site partners in the 2024 survey regarding license exemption practices among European Member States. The chapter highlights that the barriers to overcome the fragmented situation for licence exemptions have severe impact on market deployment and price ranges for autonomous electric minibuses. Nevertheless, Renault Group announced in [68] to initiate special research for automated fully electric public transport bus products as European cities start implementing Low Emission Zones banning combustion engines in their city-centres. This brings the need for additional Park & Ride transport services, ideal for CCAVs. Pilot programs are in the planning phase and D15.8 outcomes helpful for lessons learned.
- Finally, chapter 3.5 lists recommendations towards harmonization of testing procedures for license exemptions processes which have been derived based on the survey among heterogeneous SHOW pilot sites, their operational challenges and the difficult technical problems to overcome before bringing CCAVs to Use Case demonstrations. Recommendations include technical, regulatory and commercial aspects, covering the outcomes of the WP15.6 activities presented in this deliverable.

## 3.2 Vehicle license exemptions on a national and European level

With 80 automated vehicles, many of them operating in the framework of public transport, the SHOW project brings CCAM to European citizens by showing practical use cases. Besides technical aspects, the vehicles had to be registered by their local authority: either with license plate or with a license exemption. The general regulatory gaps and barriers at the EU and national/regional level were already discussed in SHOW Deliverable D3.3, chapter 3 [1]. Here are the key points and take aways:

1. EU Type-Approval Rules for CCAVs: The deliverable D3.3 [1] highlights that while European type-approval and technical standards for CCAVs are being developed in coordination with the United Nations Economic Commission for Europe (UNECE) and

relevant standardization bodies, the regulatory landscape across European countries is complex and fragmented. This creates a barrier to the deployment of CCAVs across different markets.

2. Regulation of CCAM at Regional Level: In countries where the legal responsibility for approving the testing and deployment of CCAVs is shared between the national and regional level (e.g., Germany), there is a need to clarify the procedure and competences between the vertical administrative levels. Harmonization of requirements between regions in line with European and international developments is also important.
3. Operation of Shared, Automated Transport Services: The document mentions that there are legal aspects that will affect the future operation of shared CCAM services, such as public service obligations, data protection and exchange, and liability. These aspects need to be addressed to ensure the smooth operation of shared CCAM services.

Whereas D3.3 [1] has a focus on the Public Transport Operator view, including the Transport Systems of the Municipality, A15.6 analyses the technical constraints and conditions of vehicle license exemptions to have test fields and Go-to-Market strategies towards regular commercial operations. As vehicles on public roads are always viewed as safety critical, traffic authorities impose vehicle registration and license plates for users. In case, vehicles are subject to research on public road networks, usually authorities give access permission to very limited and dedicated test areas, e.g., restricted parking lots.

Therefore, license exemption is a regular praxis with regards to restricted operations of vehicles, therefore a pragmatic way to exploit market opportunities. In the SHOW project, the non-regulated and arbitrary test procedures for license exemption of electric autonomous mini-buses differed from country and service, turning out to be an important technical barrier for OEM go-to-market strategies and exploitation. If OEMs have no clear guideline to register a vehicle to get license or license exemption, the price range of autonomous vehicles is undefined.

In SHOW, most pilot sites, including satellite and follower sites, operate the autonomous e-Minibus Level 3 (L3) (to L4) meaning that the human driver must be present and ready to take over control if the autonomous system encounters a situation it cannot handle. Usually, L3 minibuses run within a predefined operational design domain, which specifies the conditions and environments in which the vehicle can safely operate autonomously. This may include factors such as road types, weather conditions, and traffic density. Regulatory requirements for L3 minibuses typically involve conditional exemptions and strict safety standards. Human drivers may still need to hold a valid driver's license and be trained to operate the vehicle safely.

Under these conditions, the license exemption procedure for Level 3 (L3) autonomous vehicles, in SHOW mainly minibuses, involves a series of regulatory steps and safety evaluations to ensure these vehicles can operate on public roads without a human driver. Here’s a summary of the typical process:

Initial Application: The manufacturer or operator of the L3 minibus must submit an application to the relevant regulatory body (e.g., the Department of Transportation or a local equivalent). This application includes detailed information about the vehicle, its autonomous systems, and the intended area of operation.

Safety Assessment: A comprehensive safety assessment is conducted. This involves reviewing the minibus's autonomous technology, including sensors, control systems, and emergency response mechanisms. The vehicle must demonstrate a high level of safety, at least equivalent to conventional vehicles operated by human drivers.

Testing and Validation: The minibus undergoes rigorous testing in various conditions to validate its autonomous capabilities. This may include closed-course testing, simulation, and limited public road trials. Data from these tests are analysed to ensure the vehicle can handle real-world scenarios safely and reliably.

Compliance with Standards: The minibus must comply with existing vehicle safety standards and any specific autonomous vehicle regulations. This includes hardware and software reliability, cybersecurity measures, and fail-safe mechanisms.

Public Consultation: There may be a public consultation phase where feedback from stakeholders, including the public, local authorities, and industry experts, is gathered. This ensures transparency and addresses any societal concerns.

Conditional Exemption: If the vehicle passes all assessments, a conditional license exemption may be granted. This allows the minibus to operate under specific conditions, such as defined geographic areas, speed limits, and operational hours. These conditions are designed to mitigate risks while gathering more data.

Monitoring and Reporting: Continuous monitoring and regular reporting are required. The operator must provide data on the vehicle’s performance, any incidents, and compliance with the exemption conditions. This helps regulators track the vehicle's safety and make informed decisions about future exemptions or expansions.

Full Exemption (if applicable): After a period of successful operation under the conditional exemption, the operator can apply for a full exemption. This would allow more widespread or less restricted use of the minibus, based on proven safety and reliability.

Throughout this process, collaboration with regulatory authorities is crucial to address any issues and ensure that the introduction of L3 minibuses enhances public transportation safely and efficiently. Whereas the building block of testing procedures needed before licensing are commonly agreed upon member states, details of implementation are national or even regional, leading to the barriers described.

It should be noted here that testing procedures for other types of vehicles follow similar testing procedures when it comes to regular operation on public road networks. Nevertheless, SHOW pilot site partners had to solve a lot of challenges in integrating automated electric minibuses into their public transport service offering. Therefore, the questionnaire focused on license exemption for L3/4 minibuses in an exemplary manner, knowing that other vehicles might have other regulatory and license exemption barriers.

## 3.3 Vehicle License Exemption in SHOW Pilot Sites

### 3.3.1 SHOW general perspective

Figure 2 shows the countries in which the SHOW project has or had autonomous vehicles in public transport operation, either in test mode or in regular operation. For the investigation of vehicle registration, the five countries Germany, Sweden, France, Austria and Spain as well as Finland, Greece and Italy were selected and those responsible for autonomous vehicle operation were interviewed. The aim of the survey was to compare the countries with each other and to determine priorities for vehicle registration.

Before starting, we will analyse based on SHOW’s first survey in 2020 and on public Internet sources, country specific regulatory aspects in autonomous vehicle registration across Europe. For this, we will list the national authority in charge of the licensing procedure and some key topics under investigation.

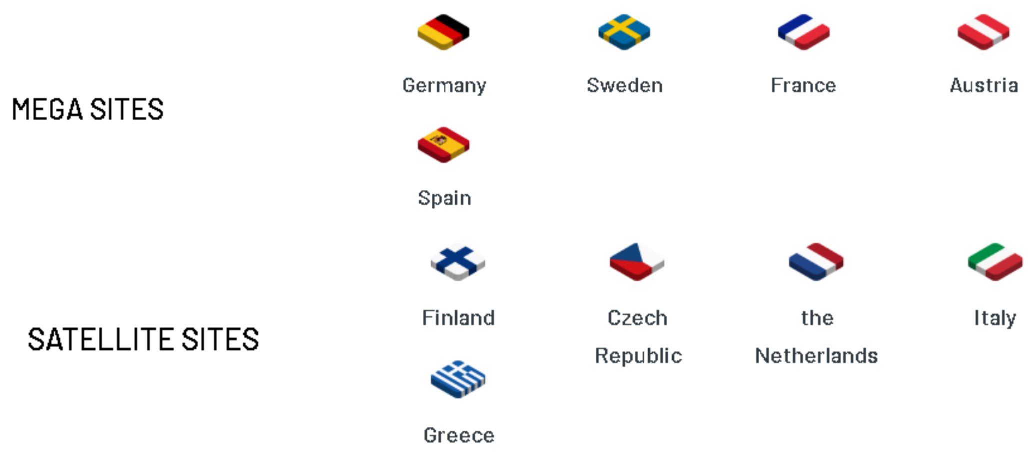


**Figure 2: Overview of countries involved its main pilot sites in the project**

**Germany**

1. Regulatory Body: Federal Motor Transport Authority (KBA) and local transport authorities.

2. Procedure:

- Apply for an exemption under the Road Traffic Act (StVG).
- Provide technical documentation, safety assessments, and proof of vehicle certification.
- Conduct trials in controlled environments before public road testing.
- Obtain approval from the Federal Ministry of Transport and Digital Infrastructure (BMVI) for deployment.

3. Key aspects under consideration:

- Germany has stringent technical standards and requires multiple layers of approval.
- Emphasis on vehicle cybersecurity and data protection.

**Sweden**

1. Regulatory Body: Swedish Transport Agency and the Ministry of Infrastructure.

2. Procedure:

- Apply for an exemption under the Road Traffic Ordinance (Vägtrafikförordningen).
- Submit detailed vehicle documentation, safety assessments, and operational protocols.
- Conduct a risk analysis and coordinate with local municipalities.
- Approval from the Swedish Transport Agency after a trial period.

3. Key aspects under consideration:

- Sweden places a strong emphasis on real-world testing in urban environments.
- Focus on collaboration with local communities and transparency with the public.

**France**

1. Regulatory Body: Ministry of Ecological Transition and the General Directorate for Infrastructure, Transport, and Sea (DGITM).

2. Procedure:

- Submit a comprehensive application including vehicle specifications, safety measures, and operational plans.
- Conduct a risk assessment and provide insurance details.
- Coordinate with local authorities for route approval.
- Undergo a trial phase with periodic evaluations.

3. Key Differences:

- France requires detailed environmental impact assessments.
- High emphasis on integrating the service with public transport systems.

**Austria**

1. Regulatory Body: Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology (BMK).

2. Procedure:

- Apply for an exemption under the Austrian Motor Vehicles Act (KFG).
- Provide comprehensive vehicle documentation, safety analysis, and operational plans.
- Conduct testing in designated test zones followed by public road trials.
- Obtain approval from local authorities and the BMK.

3. Key Differences:

- Austria requires extensive pre-testing in designated zones before public road deployment.
- Focus on sustainable and eco-friendly vehicle operations.

**Spain**

1. Regulatory Body: Directorate-General for Traffic (DGT) and the Ministry of Transport, Mobility, and Urban Agenda.

2. Procedure:

- Submit a detailed application including technical specifications and safety protocols.
- Conduct preliminary tests in designated areas before public road trials.
- Provide detailed operational plans and coordinate with local municipalities.
- Approval from the DGT after successful trials.

3. Key Differences:

- Spain focuses heavily on collaboration with local municipalities.
- Emphasis on integrating autonomous vehicles within smart city frameworks.

There is no uniform procedure for licensing autonomous public transport shuttles across Europe. Each country has its own regulations, making it a complex landscape. Here's an exemplary breakdown for Germany which was used to initiate the survey among eight selected SHOW partner countries in 12 municipalities based on Figure 2:

- **General Process:**

  Countries typically require exemptions from existing regulations designed for conventional vehicles with human drivers. This involves demonstrating the safety and reliability of the autonomous system through testing and approval by relevant authorities.

- **Challenges:**

  The process can be lengthy due to:

  - **New Technology:** Regulatory frameworks are still evolving to accommodate autonomous vehicles.
  - **Infrastructure:** Modifications to road infrastructure for designated shuttle routes might be needed, requiring cooperation with city planners.

- **Safety and Cybersecurity tests:**
  - **Germany:** Autonomous shuttle buses of the SHOW pilot sites Monheim, Frankfurt a.M. and Karlsruhe highlight the need for approvals related to technology, safety, and obtaining standard public transport licenses. Sometimes all the tests were executed by the OEM and an authorized certifying body (TÜV, etc.), then vehicle registration includes license plate number (Monheim), sometimes several stakeholders test, validate and apply for approval until they get a license exemption (Karlsruhe).

- Germany is still navigating the legal landscape for autonomous vehicles, and currently there's no specific license exemption process for operating autonomous electric shuttles on public roads. However, there are pilot programs defined conditions that allow the SHOW partners of Monheim and Frankfurt to operate autonomous shuttle buses locally and fully integrated in the Public Transport offering and ticketing. The outcomes will be analysed and used to pave the way for future regulations.
- Here's a general breakdown of the situation:
  - **Limited exemptions:** Germany allows for testing highly automated vehicles under specific conditions. This requires a permit from the Kraftfahrt-Bundesamt (KBA) - the Federal Motor Transport Authority - following the recommendations of the political recommendation described in Automated Driving Roadmap, see https://bmdv.bund.de/SharedDocs/EN/Articles/DG/act-on-autonomous-driving.html .
  - **Pilot programs:** Cities like Monheim and Frankfurt have hosted pilot programs for autonomous shuttles in controlled environments and are partners in the SHOW-project. These programs typically involve designated routes, limited speeds, and a safety supervisor on board to intervene if needed.
  - **National regulations in development:** The German government is actively working on a legal framework for autonomous vehicles. This includes a new category of vehicle permits and potential exemptions for specific use cases like geo-fenced shuttles in controlled areas.

**Finding the Latest Information:**

- **Federal Ministry of Transport and Digital Infrastructure (BMVI):** They offer updates on the development of regulations for autonomous driving https://bmdv.bund.de/EN/Home/home.html.
- **Local authorities:** Cities like Monheim and Frankfurt might have information on their specific pilot programs and the permitting process they followed. Check their transportation department websites.

**In summary,** obtaining a license exemption for unrestricted operation of autonomous electric shuttles in Germany is not currently possible. However, pilot programs and ongoing regulatory development suggest a future path for controlled or specific use cases.

Even though the license exemption for automated electric minibuses is not harmonized yet, basic procedures to achieve license exemptions are defined and aimed to test and pilot **automated electric minibuses** for public transport, specifically targeting first and last mile trip segments.

Based on examples of common practice for autonomous vehicle registration or registration exemption, here's a summary of the safety-critical test procedures which are likely to be implemented before these buses could be considered for public roads:

**Safety-Critical Tests:**

- **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions.
- **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GNSS to ensure accurate positioning.
- **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response.
- **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions.
- **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems.

**Additional Considerations:**

- **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed.

The legal challenges faced when implementing automated buses in public transport include:

Personal Data Protection: Compliance with data protection regulations, such as the Personal Data Act (PUL) in Sweden and the General Data Protection Regulation (GDPR) in Estonia, is necessary to ensure the protection of personal data collected during the operation of automated buses.

Safety and Technical Regulations: Compliance with safety and technical regulations, such as Regulation (EC) No 661/2009 in Sweden and EU Directive 2007/46, is necessary to ensure that automated buses meet the necessary safety and technical requirements.

Vehicle Regulations: Compliance with vehicle regulations, such as the Vehicle Act (FordL) and Vehicle Ordinance (FordF) in Sweden and others, is necessary to ensure that the vehicles meet the necessary requirements for roadworthiness and safety.

Testing and Permitting: The implementation of automated buses requires obtaining permits for testing and operating. The application process, requirements, and conditions for testing and permitting may vary by country.

Liability and Insurance: Determining liability in the event of an accident involving an automated bus can be complex. Clear regulations regarding liability and insurance for driverless vehicles need to be established to ensure accountability and protect all parties involved.

Criminal Liability: Most participating countries lack specific criminal legislation for automated driving. Clarification is needed regarding the subjects of criminal responsibility and the separation of responsible persons for technical maintenance and vehicle software.

Infrastructure Requirements: Some countries lack specific regulations or guidelines for the infrastructure requirements of autonomous vehicles. This includes provisions for vehicle-to-infrastructure communication and the integration of roadside infrastructure.

Training and Operator Requirements: The operator staff of autonomous buses requires special training to handle the technology and ensure passenger safety. Personal legal requirements for the vehicle operator, such as having a valid driving license and meeting standards for behaviour, must be met.

It is important to note that these legal challenges may vary from country to country and are subject to ongoing updates and changes in regulations.

The following Table shows how to proceed for license exemption according to the various project experiences serving as reference for the German regulatory framework under discussion.


**Figure 3: The complex landscape of vehicle license exemption according to the BMVD recommendations**

### 3.3.2 Experiences and safety critical testing procedures for license exemptions in SHOW pilot sites

Based on the results of the previous section 3.2, the first survey of the SHOW test fields and the extensive literature available on the Internet on the subject of vehicle approval of autonomous vehicles, a simple spreadsheet on the subject of approval-relevant safety tests was created for the SHOW partners and sent to the responsible project managers. Figure 4 shows in red the 8 countries with 12 selected pilot sites where the survey took place, whereas Table 3 lists the technical topics addressed.


**Figure 4: SHOW License exemption 2nd survey selected pilot site countries**

**Table 3: SHOW - Second Survey License Exemption Procedure in selected Pilot Sites**

| **Which of the following safety critical tests were executed for vehicle license exemption?** | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | | | | |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | | | | |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | | | | |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | | | | |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | | | | |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | | | | |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | | | |

**Table 4: SHOW - Second Survey License Exemption Procedure in Pilot Site Germany (Karlsruhe)**

| **Which of the following safety critical tests were executed for vehicle license exemption?** | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | FZI shuttles: no U-Shift modular vehicle: yes | DLR; TÜV Süd; Supplier company | 6 months | high   |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | FZI shuttles: no U-Shift modular vehicle: yes | DLR; Supplier company | 7 months | high |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | FZI shuttles: no U-Shift modular vehicle: yes | DLR; TÜV Süd; Supplier company | 5 months | high |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | FZI shuttles: no U-Shift modular vehicle: yes | DLR; TÜV Süd; Supplier company | 7 months | high |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | FZI shuttles: no U-Shift modular vehicle: yes | DLR; TÜV Süd; Supplier company | 3 months | high |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | FZI shuttles: no U-Shift modular vehicle: yes | DLR; TÜV Süd; Supplier company; Bus C | 7 months | high |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | | DLR; single approval was carried out during development | |
| | | | | |
| | FZI shuttles: no vehicle licence exemptions necessary for the SHOW project because vehicles were already licensed and permitted from previous project | | | |

## Table 5 SHOW - Second Survey License Exemption Procedure in Pilot Site Germany (Frankfurt a.M.)

Germany

| **Which of the following safety critical tests were executed for vehicle license exemption?** | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | Yes | OEM / Platform provider | Approval procedures incldues initial tests from 2018 / 2019 when the new platform (EZ10 GEN3) has been tested by an approval body. These tests were used as a basis for the whole approval procedure in that specific project. Therefore it is not possible to calculate the real number of months it took. | Medium |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | Yes | OEM / Platform provider | Approval procedures incldues initial tests from 2018 / 2019 when the new platform (EZ10 GEN3) has been tested by an approval body. These tests were used as a basis for the whole approval procedure in that specific project. Therefore it is not possible to calculate the real number of months it took. | Medium |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | Yes | OEM / Platform provider | Approval procedures incldues initial tests from 2018 / 2019 when the new platform (EZ10 GEN3) has been tested by an approval body. These tests were used as a basis for the whole approval procedure in that specific project. Therefore it is not possible to calculate the real number of months it took. | Medium |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | Yes | OEM / Platform provider | Approval procedures incldues initial tests from 2018 / 2019 when the new platform (EZ10 GEN3) has been tested by an approval body. These tests were used as a basis for the whole approval procedure in that specific project. Therefore it is not possible to calculate the real number of months it took. | Medium |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | Yes | OEM / Platform provider | Approval procedures incldues initial tests from 2018 / 2019 when the new platform (EZ10 GEN3) has been tested by an approval body. These tests were used as a basis for the whole approval procedure in that specific project. Therefore it is not possible to calculate the real number of months it took. | Medium |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | Yes | OEM / Platform provider | Approval procedures incldues initial tests from 2018 / 2019 when the new platform (EZ10 GEN3) has been tested by an approval body. These tests were used as a basis for the whole approval procedure in that specific project. Therefore it is not possible to calculate the real number of months it took. | Medium |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | X | | |

**Table 6: SHOW - Second Survey License Exemption Procedure in Pilot Site Sweden (<u>Linköping</u>)**

| **Which of the following safety critical tests were executed for vehicle license exemption?** | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | yes | OEM and Bus Company (daily operational startup routine) | Over 3 months | Medium |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | yes | OEM and Bus Company (when new hardware or software updates has been carried out) | Over 3 months | Medium |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | yes | OEM and Bus Company (daily operational startup routine) | Over 3 months | Medium |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | yes | OEM | Over 3 months | High |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | yes | OEM | Over 3 months | High |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | yes | OEM and Bus Company | Over 3 months | High |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | | x | |

**Table 7: SHOW - Second Survey License Exemption Procedure in Pilot Site Spain (Madrid)**


| Which of the following safety critical tests were executed for vehicle license exemption? | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | NO | N/A | N/A | N/A |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning | NO | N/A | N/A | N/A |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | NO | N/A | N/A | N/A |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | YES | OEM, AUTHORITY | Couple of months | The vehicle is registered as a "prototype" vehicle. This allows for testing to be performed, but not to use it for public service.<br><br>The process is simple. There is a report that needs to be completed regarding the aditional equipment installed compared to a base vehicle. Then, a periodic technical inspection is performed, and the vehicle is registered as a prototype. A license plate is then issued. |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | NO | N/A | N/A | N/A |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | NO | N/A | N/A | N/A |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | X | | |

**Table 8: SHOW - Second Survey License Exemption Procedure in Pilot Site Austria (Graz, Salzburg, Carinthia)**

| Which of the following safety critical tests were executed for vehicle license exemption? | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | no | | | |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | no | | | |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | no | | | |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | no | | | |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | no | | | |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | no | | | |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | | delays due to amendment of the law in Austria during the application process | |
| | | | | |
| **Track analysis:** Division of the track into segments and detailed track analysis per segment (straight road, traffic circle, intersection, tunnel, ...) required including risk- and hazard-analysis | yes | we | 6 months | 80-page document had to be approved by the authorities |

| | | | | |
|---|---|---|---|---|
| **Track analysis & risk assessment:** in order to receive a test certificate in Austria a detailed track analysis & risk assessment including risk mitigation measurements is obligatory. | yes | Salzburg Research (applicant for the test certificate) | approval approximately 3 months, work on the track analysis approximately 1.5 PM | 350-page document had to be approved (among other necessary documentation) had to be approved by the authorities in order to obtain the test certificates |
| **Track analysis and risk analysis of the test track: dividing the track into segments, analyzing weather conditions, road conditions, hazards, traffic, traffic signs etc. In the test application the vehicle(s), the safety operators and the test track with the test scenario are included.** | **yes** | **we (pdcp - SME)** | **6 months** | **High - for Klagenfurt the risk analysis contained 1500 pages for 81 segments - needs to be approved by advisory board in ministry (only 4 times per year possible)** |

### Table 9: SHOW - Second Survey License Exemption Procedure in Pilot Site Italy (Turin)

| **Which of the following safety critical tests were executed for vehicle license exemption?** | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | yes | OEM (Bus Company verifies correct operation during service) | Over 3 months | Medium |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | yes | OEM (Bus Company verifies correct operation during service) | Over 3 months | Medium |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | yes | OEM (Bus Company verifies correct operation during service) | Over 3 months | High |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | yes | OEM | Over 3 months | High |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | yes | OEM | Over 3 months | High |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | yes | OEM (Bus Company verifies correct operation during service) | Over 3 months | High |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | | X | |

**Table 10: SHOW - Second Survey License Exemption Procedure in Pilot Site France (Crest)**

| Which of the following safety critical tests were executed for vehicle license exemption? | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | No | | France | |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | Yes | OEM provider and ADS providers | 4 month. It is included in the global aprouval | Exemption should be a temporary process in France, as this is clearly a barrier. In the new law, "LOM", there will be identified clear procedure that would allow to have a permanente autorisation. It could take long to put in place but at least it will be clearly identified with clear intrerface and procedure from the différents stakeholder |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | Yes (not exrensive and inc | OEM provider and ADS providers | 4 month. It is included in the global aprouval | same as above |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | Yes | OEM provider and ADS providers | 4 month. It is included in the global aprouval | same as above |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | no | | | |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | Yes (basic) | PTO | 4 month. It is included in the global aprouval | Sale as above |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | | 4 month under emergency procedure | |

**Table 11: SHOW - Second Survey License Exemption Procedure in Pilot Site Greece (Trikala)**

| **Which of the following safety critical tests were executed for vehicle license exemption?** | yes / no | if yes: who was in charge of testing (OEM, Bus Company, Authority)? | if yes: how long did the approval procedure take (number of months)? | if yes: how would you summarize license exemption to be a barrier for long-term operation of autonomous shuttle buses (high, medium, low) |
|---|---|---|---|---|
| **Sensor Testing:** Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment. This might involve simulating various weather conditions, obstacles, and pedestrian interactions. | yes | OEM and ICCS as responsible organisation for technical verification activities as derived from the legislation | over 2 months | At the moment the legislation does not permit the commercial use of Avs for permanent public services but only in terms of pilot and research actions.However this is an action in progress (Medium) |
| **Localization and Mapping:** Verifying the system's ability to precisely locate itself within the environment and follow designated routes. This could involve testing with high-definition maps and GPS to ensure accurate positioning. | yes | OEM and ICCS as responsible organisation for technical verification activities as derived from the legislation | over 3 months | As above |
| **Obstacle Detection and Avoidance:** Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events. This might involve creating scenarios with simulated emergencies and assessing the system's response. | yes | OEM and ICCS as responsible organisation for technical verification activities as derived from the legislation | over 2 months | As above |
| **Vehicle Control Systems:** Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration [1]. This would involve ensuring smooth operation and fail-safe mechanisms in case of malfunctions. | yes | OEM and ICCS as responsible organisation for technical verification activities as derived from the legislation | over 1 month | As above |
| **Cybersecurity Tests:** Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks. This is crucial to prevent any malicious takeover of the vehicle's control systems. | yes | OEM | over 1 month | As above |
| **Emergency Response Procedures:** Developing clear protocols for handling emergencies and system failures. This would involve training personnel on how to safely intervene and evacuate passengers if needed. | yes | OEM and eTrikala as representative of the Municipality that runs the service | over 1 month | As above |
| | | | | |
| | less than 1 month | more than 1 month, less than 3 months | more than 3 months | |
| **How long did you need to get your license exemption procedure?** | | | x | |

Based on the information provided in the document, the following entities were in charge of testing for vehicle license exemption:

- OEM (Original Equipment Manufacturer)
- Bus Company
- Authority
- Research Institutes, e.g., Salzburg Research Institute (applicant for the test certificate) or German Aerospace Agency DLR in Karlsruhe

These entities were responsible for conducting the safety critical tests and obtaining the necessary approvals for vehicle license exemption.

The safety critical tests executed for vehicle license exemption included:

1. Emergency Response Procedures: Developing clear protocols for handling emergencies and system failures, including training personnel on how to safely intervene and evacuate passengers if needed.
2. Track analysis: Division of the track into segments and detailed analysis per segment, including risk and hazard analysis.
3. Sensor Testing: Rigorous testing of LiDAR, RADAR, and cameras to ensure accurate perception of the environment, including simulating various weather conditions, obstacles, and pedestrian interactions.
4. Localization and Mapping: Verifying the system's ability to precisely locate itself within the environment and follow designated routes, including testing with high-definition maps and GNSS.
5. Obstacle Detection and Avoidance: Extensive testing of the system's ability to detect and safely avoid obstacles, including pedestrians, vehicles, and unexpected events, including creating scenarios with simulated emergencies.
6. Vehicle Control Systems: Thorough testing of the software and hardware that control the vehicle's steering, braking, and acceleration, ensuring smooth operation and fail-safe mechanisms.
7. Cybersecurity Tests: Evaluating the system's vulnerability to hacking and ensuring robust protection against cyberattacks.

These tests were conducted to ensure the safe operation of autonomous vehicles SAE level L3/4, including shuttle buses and other vehicles, e.g., passenger cars to obtain the necessary license exemptions for SHOW.

According to the information provided in the document, the summary of license exemption as a barrier for long-term operation of autonomous shuttle buses is categorized as "high." This indicates that license exemption poses a significant barrier for the long-term operation of autonomous shuttle buses. The specific reasons for this categorization are not mentioned in the document. However, it can be inferred that the extensive safety critical tests, the involvement of multiple entities in the testing process, and the lengthy approval procedures (ranging from 3 to 7 months) contribute to the perceived barrier. These factors suggest that obtaining and maintaining license exemptions for autonomous shuttle buses can be a complex and time-consuming process, potentially hindering their long-term operation.

The approval procedure for license exemption took over 1 month in all cases mentioned. The specific durations varied depending on the pilot site and safety critical test. Here are the mentioned durations:

- Pilot Site Austria (Salzburg, Graz, Carinthia): Approximately 3 months for track analysis and risk assessment.

- Pilot Site Italy (Turin): 4 months for localization and mapping, obstacle detection and avoidance, and vehicle control systems.
- Pilot Site France (Crest): Over 2 months for sensor testing and over 3 months for localization and mapping and obstacle detection and avoidance.
- Germany: Over 3 months for sensor testing, localization and mapping, obstacle detection and avoidance, and vehicle control systems.
- Spain: Over 2 months for sensor testing, localization and mapping, and obstacle detection and avoidance.

It is important to note that these durations are specific to the mentioned pilot sites and safety critical tests. The approval procedure duration may vary in different locations and for different tests. There is clear evidence that this arbitrary testing procedures bring a lot of challenges for OEM bus suppliers and Public Transport Operators. In especially, the electrical equipment providers for localisation, environmental sensors, vehicle control systems, connectivity and emergency response systems must be integrated by the OEM bus suppliers, thus making testing even more complex and expensive. In this regard, the different testing approaches in SHOW can serve as reference for future harmonisation.

Based on the results of SHOW D3.3 and D15.8, recommendations for testing procedures will be described to outline how to set the right priorities for standardization and testing procedures of license exemptions.

## 3.4 Ongoing efforts for harmonizing license exemptions on European level

Word wide there are numerous activities to harmonize automated mobility services in public transport. In Europe, these activities happen on national level as well as on European level given the fact that Europe’s automotive manufacturing industry has a strong interest in combining traditional automotive industry with software and artificial intelligence features needed to operate automated public transport services in a safe and reliable manner. In the FAME CCAM project [2] , a lot of Strategies and Action Plans are listed showing the ongoing harmonization with regards to technology, market, regulation, and social acceptance. One is referring to Figure 5 summarizing the difficult landscape of automated mobility solutions in Public Transport.


**Figure 5: List of main areas where harmonization of regulatory regimes is necessary (need for Strategies and Action Plans in CCAM for Public Transport)**

*Note to Figure 5: See [https://www.connectedautomateddriving.eu/wp-content/uploads/2023/06/european-ccam-outlook-2023.pdf](https://www.connectedautomateddriving.eu/wp-content/uploads/2023/06/european-ccam-outlook-2023.pdf)*

[2] https://www.connectedautomateddriving.eu/roadmaps/list-strategies/

With regards to technology, it can be said the technological performance of the vehicles is often lagging regulatory frameworks for vehicle registration of non-automated vehicles. The factors that contribute to the **technological performance gap** of CCAM vehicles include:

Sensor Technology: Limitations in sensor range, resolution, and ability to handle adverse weather conditions can impact the performance of CCAM vehicles.

Data Processing and Fusion: Challenges in developing efficient algorithms for object detection, tracking, and decision-making can contribute to the performance gap.

Connectivity and Communication: Limitations in communication technologies, network coverage, and data transmission speed can affect the performance of CCAM vehicles.

Artificial Intelligence and Machine Learning: The complexity of developing accurate and reliable AI models, as well as the need for continuous learning and adaptation, can contribute to the performance gap.

Cybersecurity: The need to develop robust cybersecurity measures to protect vehicles and ensure data integrity and privacy can impact the performance of CCAM vehicles.

In the SHOW project, the different pilot sites managed testing procedures for license exemption or authorized vehicle license permission. In chapter 3.3, the specific procedures to bring CAVs onto dedicated or public municipal roads are summarized by the different stakeholders contributing to the targeted automated Public Transport mobility services.

Regulations is not limited to the vehicle itself; it also includes the external infrastructure readiness: an important regulatory barrier is the limited availability and readiness of the physical road and connectivity infrastructure to support CCAM operations, which can widen the performance gap. With reduced infrastructure performance, CCAVs tend to drive cautiously, prioritizing safety, which can result in reduced speed and traffic fluidity. The worst is hyper-cautious driving: CCAVs often choose risk-averse options in traffic situations, making them appear clumsy and nervous. Due to limitations in accurately distinguishing obstacles and non-relevant objects on the road, the operational acceptance is refused, and municipalities reject to introduce automated mobility services.

A good example of this, is the experience of automated shuttle services piloted during the EU funded project Autopilot, where the planned operation of a CAV was giving up due to the limited operational speed of maximum 18 km/h considered as not acceptable for daily public transport users in the suburb of the municipality of Versailles.

Regulatory framework gaps include all type of vehicle licensing summarized for testing and validating the different elements and components of a vehicle as presented in Figure 6.

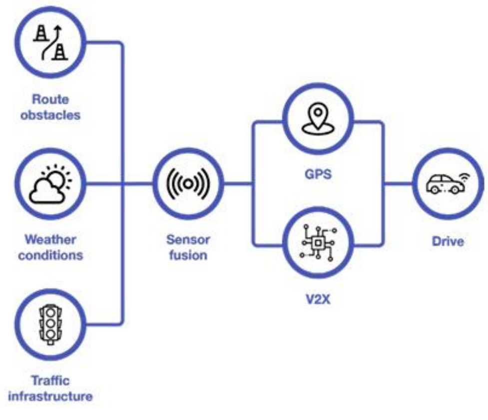


**Figure 6: Elements and components influencing any proper CCAM operation**

Testing and Validation: Challenges in conducting comprehensive and standardized testing procedures, including real-world scenarios and edge cases, can contribute to the performance gap.

Mapping and Scanning Challenges: Changes in the surrounding environment can affect the accuracy and responsiveness of the vehicle's sensors.

Integration of GNSS and V2X Systems: The interplay between GNSS and V2X systems and the vehicle's sensor systems needs to be optimized for optimal performance.

Traffic Infrastructure: The existing traffic infrastructure can impact the technological performance of CCAVs.

Bringing a regulatory framework to all aspects of Figure 6**Error! Reference source not found.** is the only chance to overcome fragmented testing procedures in the registration process of vehicle licence exemption. As many situations are based on interactions between the vehicle and a complex physical infrastructure including traffic infrastructure, weather and route obstacles, testing and validation must clearly prioritize the interaction of vehicle and external infrastructure, thus setting up new regulatory frameworks.

Figure 5 also mentions **market performance gaps,** which has a direct impact on implementing successful business cases. Here, the key performance indicator to any market deployment is affordability and commercial availability! And the limited availability and high cost of CCAM technology contribute to the existing performance gap. Even though numerous pilot sites were set up in the last decade, there are still no autonomous vehicle products available off the shelf in the automotive market and even powerful stakeholders stepped out in R&D to bring automated vehicle bus products to market.

As the scalability did not take place, public transport operator cannot order CAV vehicles or CCAM components in the competitive landscape of automotive products. This severe market performance gap is closely linked to the technical complexity and the missing regulatory frameworks with regards to CCAM markets in general, and specifically for autonomous minibuses as targeted in the SHOW project.

Safety Operator and Tele-operation Requirements: for public transport operators, the shortage and costs related to bus drivers must be considered as strong motivator for implementing autonomous driving solutions in public transport. Unfortunately, national and European regulations often require the presence of safety operators and tele-operation, adding to the complexity of deployment.

Enhanced Mobility Performance: CCAM vehicles need to demonstrate improved mobility performance in terms of speed, driving fluidity, and the ability to navigate complex traffic situations. Autonomous vehicles operated in real traffic showed too limited speed and driving capabilities to convince public transport operators to be rolling them out widely in their municipality.

Advanced Accessibility Features: The lack of advanced accessibility features in current CCAM vehicles contributes to the performance gap. In-Vehicle Safety Concerns: Ensuring robust in-vehicle safety features and systems is crucial to bridge the performance gap. For profitable markets accessibility is a requirement to guarantee economy of scale. Unfortunately, autonomous vehicle markets are not yet in this stage of economic development.

Figure 5 mentions **social acceptance** which was not monitored by the survey among pilot sites as there is not a direct link to licensing autonomous electric buses.

## 3.5 Recommendations for harmonizing vehicle license exemptions based on SHOW

Summarizing the previous chapters, it can be said that fragmented and not harmonized testing procedures for vehicle license exemptions among EU Member States is a severe barrier regarding rolling out CCAM in public transport. Complex and time-consuming permit processes, and lack of regulatory harmonization bring down affordability and availability of CCAVs, in especially of electric autonomous minibuses interesting for public transport operators.

Renault announced in a recent press release, see [68], consequences for its automotive research activities. Renault's product development for autonomous private passenger cars will be strictly separated from research and development of automated electric buses in public transport. The French OEM sees a market in European cities, where Low Emission Zones ban combustion engine driven vehicle, starting in 2025 with restricting Diesel followed by "Electric Only" vehicles in these zones beginning in 2030.

Under these conditions, automated electric mini-buses play an important role to complement public transport services for new Park & Ride hub to guarantee seamless mobility from sub-urban areas to the Low Emission Zone in the city-centre. New pilot research projects are under preparation and aspects of license registration will be an important element of technical tests.

In this context, results of license exemption in SHOW pilot sites can be considered of importance and lessons learned. In this chapter, the outcomes of the survey are presented.

**Table 12: Partners involved in SHOW license exemption survey in 8 EU countries and 12 pilot site municipalities**

| Country | SHOW-Pilotsite | Special notes and remarks |
|---|---|---|
| SWE | **Linköping**: anna.anund@vti.se | 3 tests by bus company and OEM |
| FIN | **Tampere:** mika@remoted.fi | All test by OEM |
| SP | **Madrid:** lucia.isasi@tecnalia.com; Sergio.Fernandez@emtmadrid.es | Only Vehicle Control Systems tests |
| GER | **Frankfurt**: Sofia.Pavlakis@rms-consult.de; Katharina.Karnahl@dlr.de | All tests by OEM |
| GER | **Karlsruhe**: ochs@fzi.de; Katharina.Karnahl@dlr.de | U-Shift: DLR, TÜV, Supplier + OEM alone |
| GER | **Monheim**: A.Bergweiler@bahnen-monheim.de; A.Holdermueller@bahnen-monheim.de; Katharina.Karnahl@dlr.de | All tests by OEM |
| GR | **Trikala:** anna.antonakopoulou@iccs.gr | All tests by ICCS and OEM |
| AUT | **Carinthia:** petra.schoiswohl@suraaa.at | No direct tests, track & risk analysis |
| AUT | **Salzburg**: markus.karnutsch@salzburgresearch.at; cornelia.zankl@salzburgresearch.at | No direct tests, track & risk analysis |
| AUT | **Graz**: Karl.Lambauer@v2c2.at; allan.tengg@v2c2.at | No direct tests, track & risk analysis |
| IT | **Turin:** brunella.caroleo@linksfoundation.com | OEM and bus company |
| FR | **Crest & Escrennes**: benjamin.beaudet@bertolami.fr; Jean-Christophe RIOTTE jc.riotte@bertolami.fr; pierre.chehwan@beti.team | OEM, Supplier and bus company |

In Table 12 the pilot site survey is listed per country and municipality. One can see in column "special notes and remarks", that testing procedures took place by different stakeholders, in Germany tests were executed either by OEM or by PTO and research partner DLR showing the different practices in testing.

In Sweden, the vehicle tests addressed in the survey were executed by the bus company and the OEM in parallel, with components such as sensors, connectivity or geo-location executed by the OEM alone. Compared to this, Spain only tested the vehicle control systems, all other tests were not mandatory if the bus is operated exclusively on research level. On the other hand, Finland and Germany (Monheim, Frankfurt a.M.) gave overall test and technical responsibility to the OEM. In Frankfurt, vehicle provider Easymile went through the approval procedure with an approval body, the same in Monheim.

Easymile refers to initial approval test procedures in place since 2017/2018 for the first vehicle generation. These tests will be replaced by new procedures for the next vehicle generations. Additionally, Karlsruhe executed tests with different stakeholders including the bus company, certifying bodies, suppliers and German aerospace research institute DLR. In the French and Italian pilot sites (Crest, Turin), the OEM executed all test procedures and approvals jointly with the bus company, whereas in Greece (Trikala) research institute ICCS tested jointly with the bus company.

A completely different approach took place in the 3 pilot sites Graz, Salzburg and Carinthia in Austria, where all testing was targeted to track and risk analysis on the test track. For this purpose, the test track was divided into segments, analysing weather and road conditions, hazards, traffic and traffic signs as well as vehicle related test scenarios including the safety operator. Nevertheless, the duration and complexity of testing was different, also reflected in the documentation which had 80 pages in Graz, 350 pages in Salzburg and 1500 pages in Klagenfurt. In Klagenfurt and Graz, time to approval was 6 months compared to 3 months in Salzburg.

The result of the survey confirms the strong need to harmonize license exemptions of autonomous vehicle operation in Europe's public transport. At the first glance, the following recommendations can be considered:

1. **Technical recommendations:** The greatest difficulty is to ensure the complex interaction of the vehicle with its special functions of automated driving, the diverse environmental sensors for detecting disturbing objects on the road, the reliability of the object detection but also the accuracy of data fusion and false negative or positive result handling in the decision layers of the autonomous driving systems. Here it is necessary to carry out tests on the reliability of the sensors, connectivity and localization, object detection and collision avoidance, the vehicle-side control systems and functions, data security and emergency functions. Figure 7 outlines, just as one example, the complexity of connectivity interactions of vehicles with external systems involved. With the appropriate acceptance of such tests, approval for the defined road traffic areas can then be granted and a decision can be made on risk detection and avoidance before commissioning. It should be noted that such a risk assessment is also carried out for other vehicle types without autonomous driving functions and that it is primarily about identifying the residual risk when registering license plate vehicles.

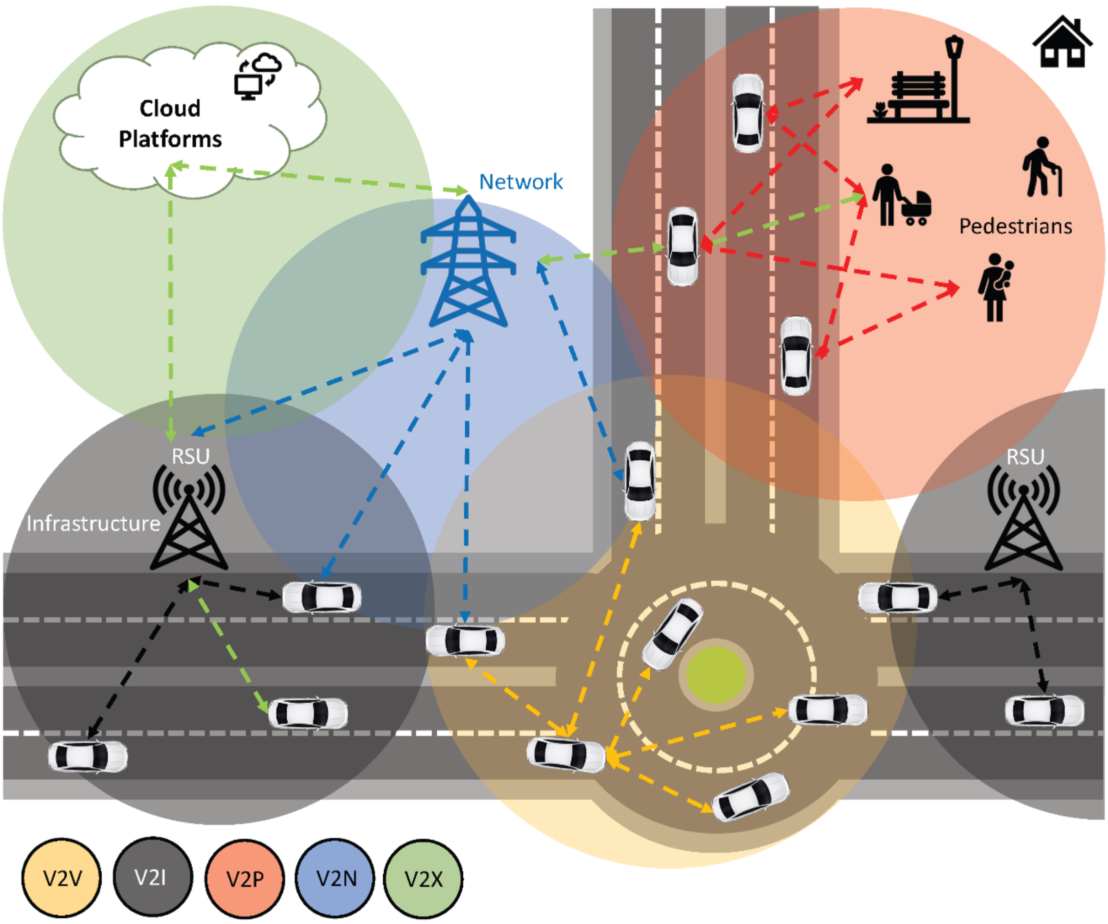


**Figure 7: Complex interactions of CCAM objects and cyber-physical infrastructure**

2. **Recommendations for regulatory affairs:** Standardize regulations for vehicle registration and vehicle registration exemption! This includes the development of standardized regulations and guidelines for test procedures of CCAM related vehicles in public transport across Europe in different countries, regions and jurisdictions. It would be helpful if, for example, it was clearly defined which measures are necessary to operate autonomous vehicles in scheduled public transport and which practical tests and road traffic conditions, including safety and accident prevention, need to be carried out. The registration authorities can then issue a license plate or a license plate exemption after presentation of authorized inspection centres and inspection documents and allow local public transport to operate a bus in scheduled or test operations. Here the process described in Figure 3 might serve as a first step for such a regulatory framework.
3. **Recommendation for Market deployment:** The market for autonomous shuttle vehicles in local public transport can only develop if the technical and regulatory framework conditions from 1 and 2 are in place. For many vehicle manufacturers, there is no investment security in the current market environment of small quantities and random orders and the risk of total economic failure is high. The vehicle market for autonomous vehicles and driving functions can only develop if there is a clear cost-benefit analysis and vehicles can be easily and inexpensively converted so that they meet the requirements of local public transport but at the same time significantly lower production costs can be achieved. This particularly affects the registration and operating speed of the vehicles as well as remote teleoperation that replaces the safety driver by the autonomous driving function and a remote teleoperator. This can only be achieved by having accessible and affordable CAV available for the public transport operator. Vehicle license registration or license exemption is a cornerstone for this.

# 4 Conclusions

The present deliverable D15.8 'Standardization: alignment, contribution and activities' has two objectives:

- Provision of information on the standardization and certification efforts of the SHOW project,
- Recommendations on the harmonization of license exemption procedures.

The deliverable contains the SHOW standardization landscape acknowledging the extensive use of international specifications developed by the leading SDO like ETSI, ISO and CEN proving the profound understanding of existing specifications in the SHOW relevant technological domains. Furthermore, active participation of SHOW partners in ISO, ETSI and CEN working groups has contributed to shaping existing and future standards for autonomous/automated vehicle applications, which proves the project's commitment to standardization.

SHOW project partner will continue the monitoring of ongoing standardization, the pre-standardization landscape and regulatory activities even after the end of the project, as these activities are continuously ongoing and not bound to the project's lifetime.

Where CCAM standardization includes complex technical aspects, vehicle license registration deals with regulatory conditions bringing autonomous vehicles on the road. In this context, the document delves into the safety critical tests conducted for vehicle license exemption in various pilot sites across different countries, emphasizing the rigorous testing required for autonomous vehicles. It highlights the challenges in obtaining license exemptions, the importance of standardization efforts, regulatory compliance, and collaboration among stakeholders.

The chapter underscores the significance of addressing regulatory gaps among Member States, ensuring safety standards, and navigating legal aspects to enable the smooth operation of autonomous vehicles in public transport systems. Recommendations are provided to overcome barriers related to technology, national regulations, and market performance. Giving, on the one hand, the complex Member State practice regarding testing procedures for licence exemption, on the other hand, compelling market events appear in the context of Low Emission Zones where complementary automated fully electric public service offerings are under preparation by automotive OEMs, see, e.g., [68]. Thus, D15.8 is aiming to facilitate the successful integration of autonomous vehicles into public transport systems by closing gaps found in both areas of analysis done, "standards" and "testing procedures for license exemptions".

For European Member State stakeholders, the challenges found need close co-operation and willingness to accept harmonization of standards and vehicle registration covering technical, regulatory and commercial aspects all together. This is to ensure that Europe will not lose track and, thus, falling behind competitive markets in US and Asia, where regulatory frameworks are usually less complex than among EU Member States facilitating market deployment much faster.

# References

**Deliverables of the HORIZON-2020 SHOW project, Grant Agreement No. 875530**

[1] D3.3 ‘Recommendations for Adapting Regulatory and Operational Strategies for CCAV deployment at Local and Regional Level’
[2] D4.1 ‘Open modular system architecture and tools – first version’
[3] D4.3 ‘Open modular system architecture and tools - second version’
[4] D5.1 ‘SHOW Big Data Collection Platform and Data Management Portal’
[5] D7.3 ‘Interfaces to non-equipped participants’
[6] D8.1 ‘Criteria catalogue and solutions to assess and improve physical road infrastructure’
[7] D8.2 ‘Solutions for onsite digital and Communication infrastructure’
[8] D8.3 ‘Solutions for collaborative TM’
[9] D11.1 ‘Technical validation protocol’
[10] D11.2 ‘Demos safety, reliability and Robustness validation and commissioning’

**Standards, specifications and regulations**

[11] IEEE 802.11 ‘Standard for Information Technology - Telecommunications and Information Exchange Between Systems - Local and Metropolitan Area Networks - Specific Requirements - Part II: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specification’
[12] IEEE 1609 ‘Standard Wireless Access in Vehicular Environments (WAVE) - Multi-Jurisdictional Interoperability Using Security Credentials Originating in Disparate Policy Domains’
[13] 3GPP TS 38.300 ‘5G; NR; NR and NG-RAN Overall description; Stage-2’
[14] EN 302 637-2 ‘Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 2: Specification of Cooperative Awareness Basic Service’
[15] ETSI EN 302 637-3 ‘Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Part 3: Specification of Decentralized Environmental Notification Basic Service’
[16] ETSI TS 103 301 ‘Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Facilities layer protocols and communication requirements for infrastructure services’
[17] ISO TS 19321 ‘Intelligent transport systems - Cooperative ITS - Dictionary of in-vehicle information (IVI) data structures’
[18] ISO TS 19091 ‘Intelligent transport systems - Cooperative ITS - Using V2I and I2V communications for applications related to signalized intersections’
[19] ETSI EN 302 636 series ‘Intelligent Transport Systems (ITS); Vehicular Communications; GeoNetworking’
[20] in ETSI TR 103 562 ‘Intelligent Transport Systems (ITS); Vehicular Communications; Basic Set of Applications; Analysis of the Collective Perception Service (CPS); Release 2’
[21] ETSI TS 103 300 series ‘Intelligent Transport Systems (ITS); Vulnerable Road Users (VRU) awareness’
[22] SAE J2735 ‘V2X Communications Message Set Dictionary’
[23] ISO 21448 ‘Road vehicles - Safety of the intended functionality’
[24] ISO 26262 series ‘Road vehicles - Functional safety’
[25] Regulation No 13 of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles of categories M, N and O with regard to braking, https://op.europa.eu/en/publication-detail/-/publication/0a43f880-d612-11e5-a4b5-01aa75ed71a1/language-en
[26] Regulation No 39 of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of vehicles with regard to the speedometer and odometer equipment including its installation, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A42010X0513%2803%29

[27] Regulation No 46 of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of devices for indirect vision and of motor vehicles with regard to the installation of these devices, https://op.europa.eu/en/publication-detail/-/publication/780cbf09-1ec1-11e4-8c3c-01aa75ed71a1
[28] Regulation No 48 of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of vehicles with regard to the installation of lighting and light-signalling devices, https://op.europa.eu/en/publication-detail/-/publication/192086c4-870f-11e6-b076-01aa75ed71a1/language-en
[29] Regulation No 79 of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles with regard to steering equipment, https://op.europa.eu/en/publication-detail/-/publication/3f7415ac-ff32-11e8-a96d-01aa75ed71a1
[30] Regulation No 100 of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles with regard to specific requirements for the electric power train, https://op.europa.eu/en/publication-detail/-/publication/eb499880-5d48-11ec-9c6c-01aa75ed71a1/language-en
[31] Regulation No 107 of the Economic Commission for Europe of the United Nations (UNECE) - Uniform provisions concerning the approval of category M2 or M3 vehicles with regard to their general construction, https://op.europa.eu/en/publication-detail/-/publication/51888617-1872-11e8-ac73-01aa75ed71a1/
[32] Regulation No 121 of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of vehicles with regard to the location and identification of hand controls, tell-tales and indicators, https://op.europa.eu/en/publication-detail/-/publication/0ba565c5-b5cd-11e5-8d3c-01aa75ed71a1
[33] Regulation (EU) 2018/858 of the European Parliament and of the Council on the approval and market surveillance of motor vehicles and their trailers, and of systems, components and separate technical units intended for such vehicles, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018R0858
[34] Regulation (EC) 595/2009 of the European Parliament and of the Council on type-approval of motor vehicles and engines with respect to emissions from heavy duty vehicles (Euro VI) and on access to vehicle repair and maintenance information, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009R0595
[35] Commission Regulation (EU) No 351/2012 implementing Regulation (EC) No 661/2009 of the European Parliament and of the Council as regards type-approval requirements for the installation of lane departure warning systems in motor vehicles, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012R0351
[36] Regulation (EU) 2019/2144 of the European parliament and of the council on type-approval requirements for motor vehicles and their trailers, and systems, components and separate technical units intended for such vehicles, as regards their general safety and the protection of vehicle occupants and vulnerable road users, https://eur-lex.europa.eu/eli/reg/2019/2144/oj
[37] Commission Implementing Regulation (EU) 2022/1426 laying down rules for the application of Regulation (EU) 2019/2144 of the European Parliament and of the Council as regards uniform procedures and technical specifications for the type-approval of the automated driving system (ADS) of fully automated vehicles, https://eur-lex.europa.eu/eli/reg_impl/2022/1426/oj
[38] SAE J3016 'Recommended Practice: Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles'
[39] BSI PAS 1883 'Operational Design Domain (ODD) taxonomy for an automated driving system (ADS) – Specification'
[40] ISO TR 23049 'Road Vehicles - Ergonomic aspects of external visual communication from automated vehicles to other road users'

[41] ISO/IEC 27001 ‘Information security, cybersecurity and privacy protection - Information security management systems - Requirements’
[42] ISO/SAE 21434 ‘Road vehicles - Cybersecurity engineering’
[43] ISO/TR 4804 ‘Road vehicles - Safety and cybersecurity for automated driving systems - Design, verification and validation’
[44] ISO/SAE PAS 8475 ‘Road vehicles - Cybersecurity Assurance Levels (CAL) and Targeted Attack Feasibility (TAF)’
[45] UN Regulation No 155 ‘Uniform provisions concerning the approval of vehicles with regards to cybersecurity and cybersecurity management system’, https://unece.org/transport/documents/2021/03/standards/un-regulation-no-155-cyber-security-and-cyber-security
[46] Regulation No 138 of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of Quiet Road Transport Vehicles with regard to their reduced audibility, https://op.europa.eu/en/publication-detail/-/publication/84e9768e-d95c-11e6-ad7c-01aa75ed71a1/language-en
[47] Federal Motor Vehicle Safety Standard No. 141, Minimum Sound Requirements for Hybrid and Electric Vehicles, https://www.federalregister.gov/documents/2018/02/26/2018-03721/federal-motor-vehicle-safety-standard-no-141-minimum-sound-requirements-for-hybrid-and-electric
[48] EN 12899-1 ‘Fixed, vertical road traffic signs - Fixed signs’
[49] EN 1436 ‘Road Marking performance for road-users’
[50] ISO 20524-2 ‘Intelligent transport systems - Geographic Data Files (GDF) GDF5.1 - Part 2: Map data used in automated driving systems, Cooperative ITS, and multi-modal transport’
[51] 3GPP TS 36.355 ‘LTE; Evolved Universal Terrestrial Radio Access (E-UTRA); LTE Positioning Protocol (LPP)’
[52] 3GPP TS 37.355 ‘LTE; 5G; LTE Positioning Protocol (LPP)’
[53] CEN TS 16157 series ‘Intelligent transport systems - DATEX II data exchange specifications for traffic management and information’
[54] ISO 21219 series ‘Traffic and travel information (TTI) via transport protocol experts group, generation 2 (TPEG2)’
[55] ISO 34501 ‘Road vehicles - Test scenarios for automated driving systems - Vocabulary’
[56] ISO 34502 ‘Road vehicles - Test scenarios for automated driving systems - Scenario based safety evaluation framework’
[57] ISO 34503 ‘Road Vehicles - Test scenarios for automated driving systems - Specification for operational design domain’
[58] ISO 34504 ‘Road vehicles - Test scenarios for automated driving systems - Scenario categorization’
[59] ISO 22737 ‘Intelligent transport systems - Low-speed automated driving (LSAD) systems for predefined routes - Performance requirements, system requirements and performance test procedures’
[60] ISO 13228 ‘Road vehicles - Test method for automotive LiDAR’
[61] CEN TR17828 ‘Road infrastructure - Automated vehicle interactions - Reference Framework’
[62] ISO 23795-1 ‘Intelligent transport systems - Extracting trip data using nomadic and mobile devices for estimating C02 emissions - Part 1: Fuel consumption determination for fleet management’
[63] ISO 17748 series ‘Energy-based green ITS services on nomadic devices for smart city mobility applications’
[64] ETSI TS 102 792 ‘Intelligent Transport Systems (ITS); Mitigation techniques to avoid interference between European CEN Dedicated Short Range Communication (CEN DSRC) equipment and Intelligent Transport Systems (ITS) operating in the 5 GHz frequency range’

[65] ETSI EN 300 674 series 'Transport and Traffic Telematics (TTT); Dedicated Short Range Communication (DSRC) transmission equipment (500 kbit/s / 250 kbit/s) operating in the 5 795 MHz to 5 815 MHz frequency band'
[66] ETSI TS 102 916 series 'Intelligent Transport Systems (ITS); Test specifications for the mitigation techniques to avoid interference between Cooperative ITS-G5 and TTT DSRC'
[67] ASAM 'OpenODD: Concept paper', https://www.asam.net/index.php?eID=dumpFile&t=f&f=4544&token=1260ce1c4f0afdbe18261f7137c689b1d9c27576
[68] See press release https://www.renaultgroup.com/en/news-on-air/news/autonomous-vehicles-renault-group-opts-for-different-strategies-for-passenger-cars-and-public-transport-vehicles/