Automated driving requires international regulations

A look at the current state of developments

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White paper

Abstract

The rapid launch of automated vehicles on markets worldwide requires uniform global regulations. To date, however, the regulations have varied greatly from region to region, and the development of uniform, internationally binding guidelines has only just begun. The first UNECE regulation for an automated driving system at SAE level 3 is expected to be in force early 2021 - a pioneering achievement and a template for further internationally binding regulations.

This white paper takes the current version of the UNECE regulation for automated lane keeping systems (ALKS) as a basis to examine the development and creation of uniform legal foundations for international partners. It also takes a close look at efforts to approve automated driving functions in the various automotive markets of Europe, the USA, and Asia.

Focus is placed on the system's functionality and requirements for type approval, which form the context for an examination of cybersecurity, software update processes, data storage systems (DSSAD), functional safety, safety of the intended functionality (SOTIF), and simulations. The white paper also explores the issue of physical testing in connection with the type approval procedure for the automated driving function ALKS.

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Introduction

Mobility as we know it is facing disruptive change in industrialised countries. The key phrase in tomorrow's mobility is 'intermodal mobility'. From A to B on the roads, the water, the rails, and through the air - algorithms will play a decisive role. Vehicles will no longer be driven exclusively by people; they will drive autonomously as well. And against the backdrop of the current COVID-19 crisis and social distancing, individual mobility will maintain its place alongside public transport and sharing models in an intermodal context.

Assisted driving functions with a high degree of automated functionality have ceased to be a vision of the future. Emergency braking and traffic jam assist systems, as well as automatic distance control and lane keeping assistance, have been installed in many vehicles. And yet, the step towards automated driving - that is, without the driver continuously monitoring or delegating the responsibility for driving to the system - has many hurdles to overcome, especially with regards to regulations. This becomes clear with the leap to SAE level 3[1], when driving responsibility is temporarily transferred to the automated system and the vehicle must be able to master critical situations without the driver as a direct fallback solution.[2]

As it stands, requirements for the approval of automated driving functions have been regulated very differently worldwide. The requirements are frequently defined only in terms of special permits for automated driving on public roads. One important step on the path to global harmonisation is the first UNECE regulation for approval of an automated lane keeping system (ALKS), published in 2020. Its stipulations on monitoring, functional requirements and tests will become the template for further regulations.[3]

Forging ahead with new, uniform global regulations for approval is the precondition for rapid market introduction of automated vehicles (initially level 3) and thus for joining the field of new mobility. Only if the safety of automated vehicles around the world is uniformly regulated drivers will feel confident. And here, of course, change also means looking at security issues from a completely new perspective. This particularly applies to passive and active safety. The focus for automated driving functions has moved to key safety and security issues such as cybersecurity, data storage systems and software updates - for example, over-the-air updates.[4]

For the rapid introduction of automated driving, product safety and OEM safety and security concepts also play an important role in approval procedures. Uniform regulations, such as those of the UNECE, offer clear guidelines and ensure that the approval process for vehicles runs smoothly in global markets.

In summary, it is safe to say that a few more years are needed before automated driving at level 4/5 is accepted.

In a previous paper an overview about the "approval of automated driving functions with focus on a worldwide regulatory overview, proving ground testing, customer acceptance" has been already given.[5] Here in this white paper an update related to the current status of regulation is provided.

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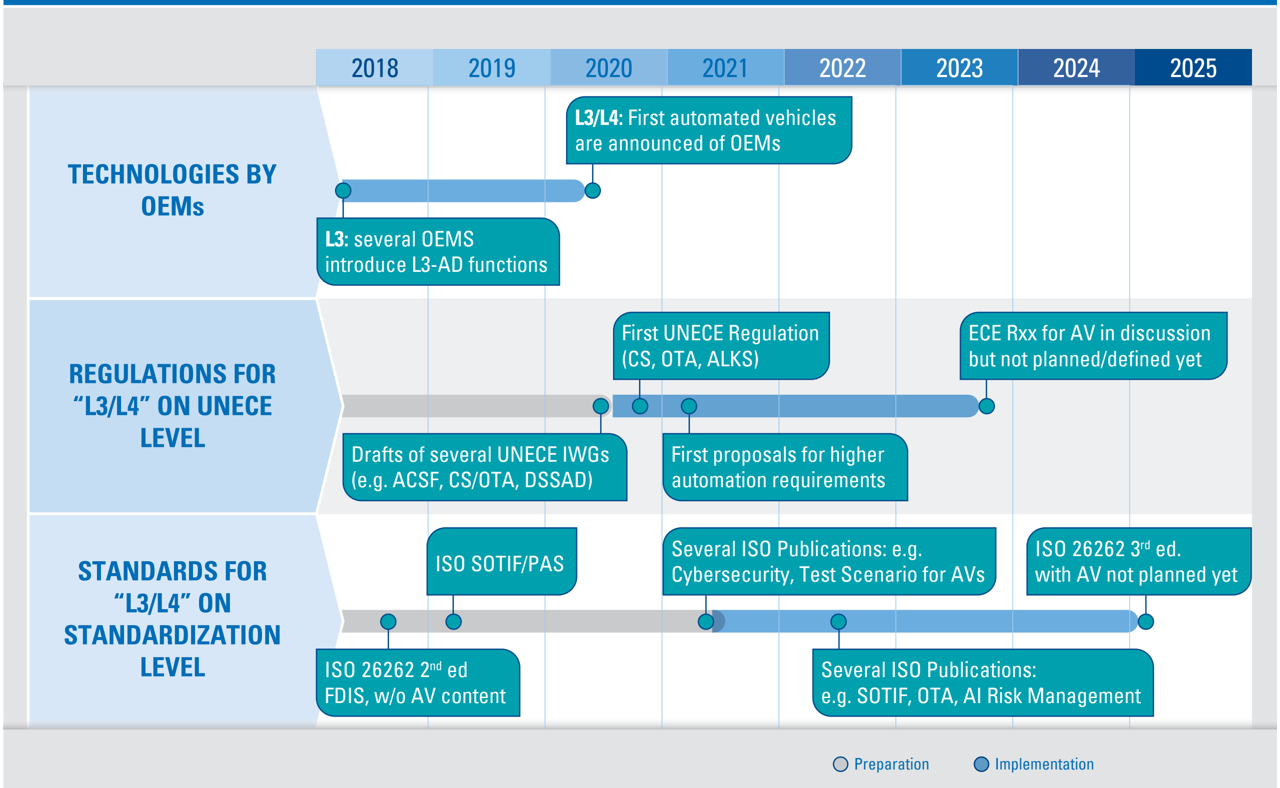
Overview of current developments

Automated vehicles are being developed and tested around the world. However, the requirements for the vehicles, as well as the knowledge of and approaches to traffic rules, certification regulations and test standards, vary from country to country. There are still no uniform or established testing methods and standards for the reliable validation and approval of automated driving functions. This presents a real hurdle for the testing and market launch of automated vehicles, despite OEMs having made considerable technological progress. Since 2018, various manufacturers have advertised level 3 vehicles as individually approved vehicles undergoing testing or even their market launch. As early as this year, test vehicles will be launched with functionalities beyond SAE level 3.[1]

TECHNOLOGY VS REGULATION ROADMAPS



By comparison, a look at the status of the UNECE regulations reveals a clear deficit. The foundations for automated driving were laid and obstacles removed with the adaptation of the Vienna Convention on Road Traffic in 2016. The UNECE's World Forum for the Harmonization of Vehicle Regulations (WP.29) created a basis with its frame-work document.[4] This includes topics such as Automated Commanded Steering Function (ACSF) and cybersecurity for software updates (over the air, CS/OTA). This led to the first UNECE regulation ALKS and two further UNECE regulations for cybersecurity and software update procedures; their adoption was published in the first half of 2020.

This is also the case for standards. Standards such as ISO 24089 for software updates and ISO 21434 for cybersecurity are still in the detailing phase. Their first publications are not expected until the end of 2020.

Despite developers and OEMs driving innovation in these areas, based on these standards and pending regulations, an overview of regulation development reveals that uniform and binding UNECE rules and standards for developing level 3 and level 4 automated vehicles of the levels 3 and 4 can be expected in 2025 at the earliest.

Advancements around the world

EUROPE

The individual European member states have also taken different paths to implementing the amendments to the Vienna Convention. The approach of each country differs primarily in terms of practical implementation. France, the Netherlands, Austria, and Great Britain are leading the way, having implemented the Vienna model primarily following guidelines and regulations for testing automated vehicles (AV) on public roads. Their main focus is on operational safety, functional safety, and cybersecurity.

Although Germany reacted very quickly to Vienna by adopting the Vienna convention's provisions in national law by means of corresponding changes to the Road Traffic Act, technical requirements have not yet been defined. In various funded projects, such as Germany's successfully completed project PEGASUS[6] or its follow-up research consortium VVM (research association for verification/ validation of autonomous driving systems)[7], experts from highly diverse areas of industry and supplier industries are developing legally secure and efficient verification and validation methods for automated driving functions.

Overall, other member states present a heterogeneous picture. Norway, for example, has already implemented the framework conditions for tests, while Spain is still in the early stages of developing specifications. Italy, on the other hand, has already passed its first law for tests on certain roads. Finland is also well advanced in this area, having stipulated the framework conditions for tests and passed the first laws that form the basis for later AV approval.

STATUS OF LEGISLATION IN EUROPE

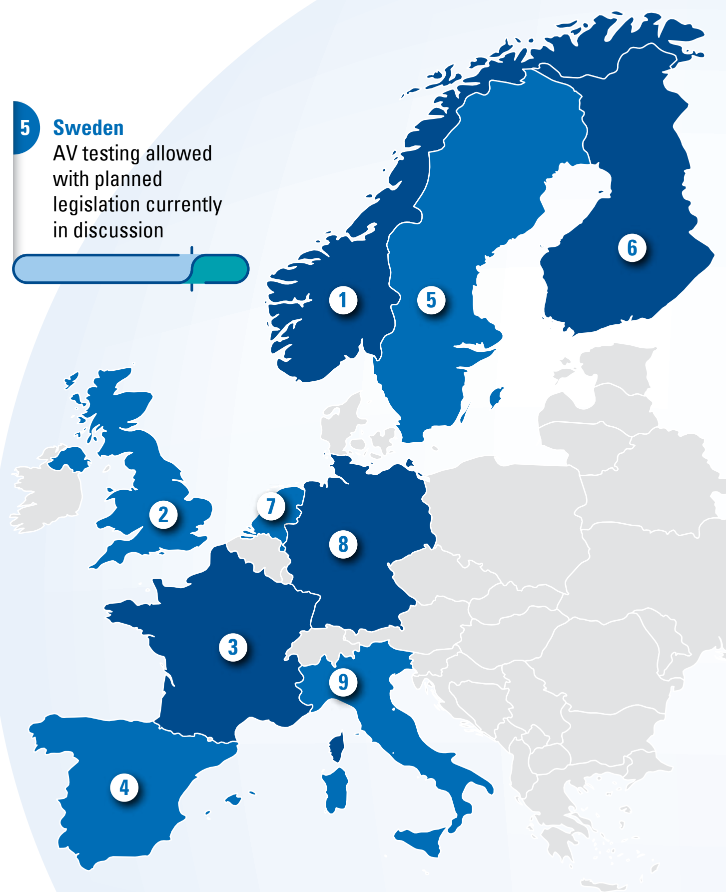
1 Norway
Testing framework available but limited in reviewing technical extremes

2 UK
Expanded Code of Conduct and aims for fully autonomous car tests by 2021

3 France
Conducts incremental changes to legislation with L5 testing limited

4 Spain
Comprehensive laws are pending; Current framework is very limiting

5 Sweden
AV testing allowed with planned legislation currently in discussion



6 Finland
Framework available and 2 new laws approved that further enable AV

7 The Netherlands
A comprehensive framework for allowing self-driving car tests

8 Germany
Comprehensive framework with expanded legislation being prepared

9 Italy
Passed its first law regulating testing on designated roads

No framework — Comprehensive framework (testing and usage in complete country with L5 tech)

USA

The situation in the United States seems particularly confusing at first glance but follows a familiar pattern. Federalism is particularly pronounced in the United States. The states have considerable independence in matters of transport. To some extent, more variation in traffic regulations exists amongst individual states than has ever been the case in past decades with European countries. A striking example illustrates this: the various American states interpret a red traffic signal in different ways. A red light can have the same significance as a stop sign in certain states; in others, it is comparable to Germany's green arrow sign, which allows drivers to turn right on red when there are no drivers with the right-of-way at an intersection. However, in other states, a red light means the same as it does in Europe. For this reason, it is only logical that the rules for automated test-drives are created at the state level.

Production vehicles equipped for level 3 and above will have to be designed for all regions. However, it is not at all certain that UNECE rules and regulations will find their way into US legislation. This country has always followed its own course with regard to vehicle approval. The reverse is also true. Across the Atlantic, regulations like the Federal Motor Vehicle Safety Standards (FMVSS) of the Department of Transportation (DOT) stipulate the requirements for vehicles and components. There is no homologation comparable to the procedure in countries within the UNECE region. Manufacturers confirm that their products comply with the DOT rules, for example, by printing this on a component. A check by technical service providers or the like is not required.

States on the West Coast, such as California and Nevada, began to create legal frameworks for automated driving and testing over ten years ago. The Department of Transportation has stated its intention to create federal rules.

ASIA

Asia is more advanced in developing regulations, standards and tests than the rest of the world. China is rapidly adapting its legislation, albeit with major differences in the various regions. South Korea and Singapore are at the forefront of development and can boast the first testing and approval standards and regulations in the field of automated driving. One example of this is the four-part TR68 standard from Singapore, developed in connection with activities at CETRAN (Center of Excellence for Testing and Research of AVs) at Nanyang Technology University in Singapore.[8] By contrast, Japan, one of the most significant OEM locations, has only adapted its laws for testing, and efforts are being made to include the first automation functions, such as ALKS, in the national approval process.

Many of the world's national platforms and initiatives that strive for standardisation and uniform requirements, such as the creation of testing methods for automated and connected driving, have formed the International Alliance for Mobility Testing and Standardization (IAMTS) to develop practicable and harmonised standards around automated driving.[9] As a member of the IAMTS, TÜV SÜD is closely involved in the testing and certification of advanced mobility systems and services, and the development of applicable global safety standards which aim to create a commonly accepted framework of regulations. IAMTS's mission is "to develop and grow an international portfolio of smart mobility testbeds that meet the highest quality implementation and operational standards."

Many of the world's national platforms and initiatives that strive for standardisation and uniform requirements have formed the International Alliance for Mobility Testing and Standardization (IAMTS).

THE WORK OF THE UNECE IN AUTOMATED AND CONNECTED DRIVING

For years, the UNECE has been involved in all regional and national efforts to get AV on the road by drafting a uniform regulatory framework for global requirements to approve such vehicles. The reasons:

- Vehicles are global products whose components are produced throughout the world.
- Uniform specifications are a basic requirement for the rapid introduction of AV and their approval in core markets.
- Uniform global regulations engender trust in consumers.

The first steps towards an internationally uniform regulation were the corresponding adjustments to the Geneva and

Vienna Conventions. The various contracting states and their relevant licensing authorities, such as partner organisations NHTSA, the European Commission and CATARC, are collaborating on this, supported by international expert associations including CITA, OICA, and CLEPA in the definition of requirements and design.

The World Forum for the Harmonization of Vehicle Regulations (WP.29) is responsible for the development and formulation of a uniform set of rules for the approval of AV. The international agreements of 1958 and 1998 involve the participation of nearly all countries. The understanding that automated driving would increase overall safety and improve mobility has led to the definition of thirteen key issues for the global harmonisation of regulations and requirements.[4]

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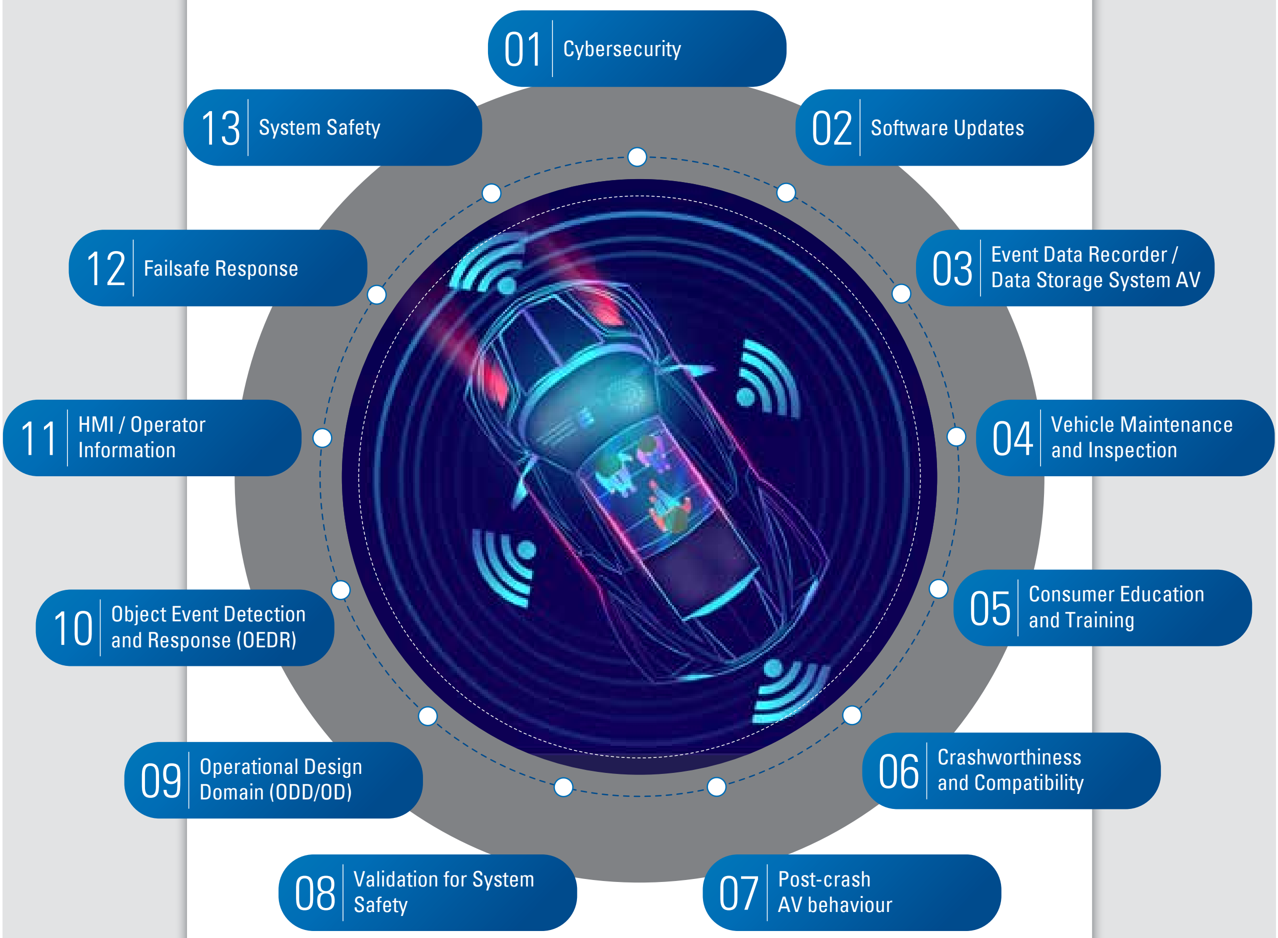
KEY ISSUES AND PRINCIPLES REGARDING UNECE

WP.29 focuses on following issues and principles.
Main parts will be discussed and developed under GRVA.



AV: Automated Vehicles **HMI:** Human Machine Interface

A total of five working groups, part of the Working Party on Automated/ Autonomous and Connected Vehicles (GRVA), were designated to develop the relevant regulations:

- Informal Working Group (IWG) on Automatically Commanded Steering Function (ACSF)
- IWG on Functional Requirements for Automated and Autonomous Vehicles (FRAV)
- IWG on Validation Method for Automated Driving (VMAD)
- IWG on Data Storage System for Automated Driving / Event Data Recorder (DSSAD/EDR)
- Task Force on Cybersecurity and over-the-air issues (CS/OTA)

Their focus is on the functional safety of automated driving functions, as well as new validation methods and systems for storing driving and accident data. Other key issues are cybersecurity and software updates (including over-the-air).

Another participant in the development of uniform global regulations related to autonomous driving is the Global Forum for Road Safety WP.1. National authorities are working closely with teams of experts from OEM, industry, technical services and other specialist areas on international requirements for AV's global approval.

Accordingly, the aforementioned GRVA sub-working groups were able to submit drafts for new regulations on the abovementioned topics in spring 2020, which WP.29 has already adopted in 181st session.

- Automatic steering function
- Functional safety requirements
- Validation methods for automated driving
- Cybersecurity and software updates (over-the-air)
- Data storage system for automated driving

This has resulted in templates for three new UNECE regulations:

- UNECE regulation for uniform testing of software update processes
- UNECE regulation for the uniform testing of vehicles for cybersecurity and cybersecurity management systems
- UN regulation for the first automated driving function: Automated lane keeping systems (ALKS)

Pioneering achievement: First UNECE regulation for a level 3 lane keeping system

After the adopted UN regulations are approved and conveyed to the contracting parties of the 1958 UNECE Agreement, and an accompanying six-month phase for comments has passed, individual countries can incorporate the regulations, such as those for automated lane keeping system (ALKS), into applicable law.

THE UNECE REGULATION IN DETAIL

The ALKS is the first set of rules and regulations for automated driving and as such is initially limited to vehicles of the category M1 - that is, passenger vehicles with up to eight seats plus driver. The regulation is also limited to systems that function at speeds of up to sixty kilometres per hour. This covers the automated driving function which controls the vehicle in the longitudinal and lateral directions, thereby keeping it in the lane without the driver's involvement.

An important aspect of the planned regulation deals with monitoring the driver's condition, also known as 'driver monitoring' or 'driver awareness monitoring'. It must ensure that the driver can follow a request to take over the lane keeping system within a defined period. As long as the system autonomously takes over driving, drivers at level 3 no longer have to keep their hands on the steering wheel, or otherwise prove their attentiveness. Conversely, the driver must be able to intervene at any time and take control again. UNECE is thus following the Vienna Agreement, which always gives the driver priority over an automatic steering function. The same applies to the operation of the brake or accelerator pedal; like manual steering, it switches off the ALKS.

The human-machine interface, and the demands placed on the system to monitor the human driver, are a core element of the new regulation and a real innovation. The regulation requires the system to monitor whether, during system activation, the driver conforms to requirements by sitting in the driver's seat and wearing the seatbelt. Or in the case of an event, such as reaching the system limits, the system can record the situation and take over the driving task responsibly.[2]

The draft gives examples of criteria to be detected:

- Blinking
- Closed eyelids
- Deliberate head or body movements
- Pressing switches and other control elements only within reach of the driver can also serve as a positive indication of attention

At least two independent criteria must be met for the driver to be considered available. The time between checks cannot be longer than thirty seconds. If the driver needs to take over, the design requires the system to instruct them intuitively and unambiguously to take over manual control of the vehicle.

An automatic lane keeping system for level 3 is a complex system that must first be defined. This can be found in the new regulation. Naturally, this kind of system contains a lot of electronics, software and interfaces, and their safeguarding and inspection are of central importance. In addition to the requirements for complex electronic systems in Annex 4 of the regulation, the ALKS regulation also requires the fulfilment of the two new UNECE regulations for cybersecurity and software updates.

PROTECTION AGAINST ATTACKS

One of the three upcoming regulations is concerned with cybersecurity and the requisite management systems at the manufacturer and its supply chain. This is to ensure that the vehicle's systems and software cannot be compromised. The requirements of the cybersecurity regulation intervene in the three phases of a vehicle's life cycle: during development, in production and afterwards.

The future core element that will check for compliant cybersecurity management systems is a Certificate of Compliance, issued by an accredited organisation such as TÜV SÜD.[10] Vehicle manufacturers have to fullfil the new UNECE Cybersecurity Regulation to receive type approval in the EU from July 2022 for all new vehicle types and from July 2024 for all newly produced vehicles.

SECURITY DURING AN UPDATE

Another UNECE regulation is concerned with software update processes. It specifies how updates should be handled and which management processes must be established. The software used in highly automated vehicles will most likely require regular updates. The reasons for this are manifold. On the one hand, new threats are possible due to previously unknown security vulnerabilities; an update can eliminate them. Also, improvements to ease of use are possible. Changes to legal requirements can be implemented via software updates as well. Until now, these have been installed almost exclusively in workshops. But manufacturers and suppliers have begun working on a so-called over-the-air method (OTA), where the new program code is imported via connected Wi-Fi or a cellular connection. For this reason, the Software Update Management System (SUMS) required by UNECE places high demands on the quality of the procedure. For example, the exclusive transfer of software approved by the vehicle manufacturer must be guaranteed. A check is therefore provided before and after the update to determine whether the program code fits not only the vehicle model but the individual type. The SUMS also requires a Certificate of Compliance.[11]

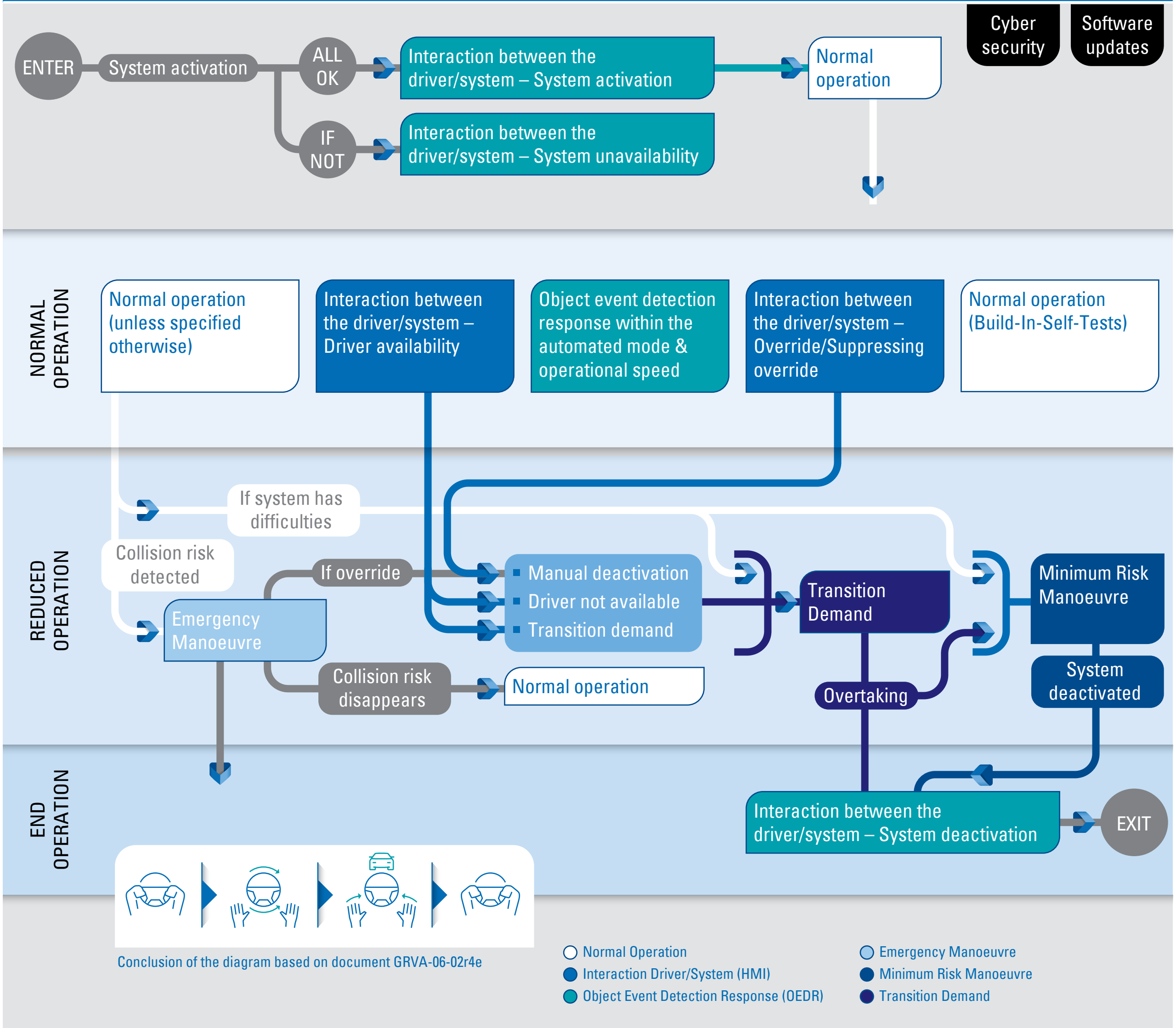
BASIC FUNCTIONS OF A LANE KEEPING SYSTEM FOR LEVEL 3

Based on the regulations under consideration, there are three operational states once the driver has activated the system, which must always be switched on manually. Furthermore, the process must be repeated after each engine start and is accompanied by a self-test. An exception is made for operation using a start-stop system; in this case, activation at the start of the journey is sufficient.

Afterwards, the system is running in one of three states:

Normal operation. The automated driving function records all necessary data and information via sensors, and carries out the driving task independently by controlling lateral and longitudinal movements.

GENERIC FUNCTION DIAGRAM OF THE LEVEL 3 ALKS SYSTEM



Conclusion of the diagram based on document GRVA-06-02r4e

The interaction between the system and the driver is running undisturbed. The driver-condition monitoring system reports that the requirements for the driver to operate the ALKS are met, and he/she could intervene if necessary. Deliberate corrections, such as a brief change in speed, are also possible.

Reduced operation. A problem has occurred, and the driver is warned. At the same time, the system tries independent countermeasures such as evasive action within its own lane. If this succeeds, it will go back to normal operation. Otherwise, the driver receives a takeover request. If he/she does not intervene, a driving manoeuvre will be initiated to minimise risk, which ends when the vehicle comes to a stop. The system always follows the primary goal of avoiding a collision.

Deactivated. The system is ready for operation, but the driver is steering or has perhaps assumed responsibility for driving, following a request for system takeover.

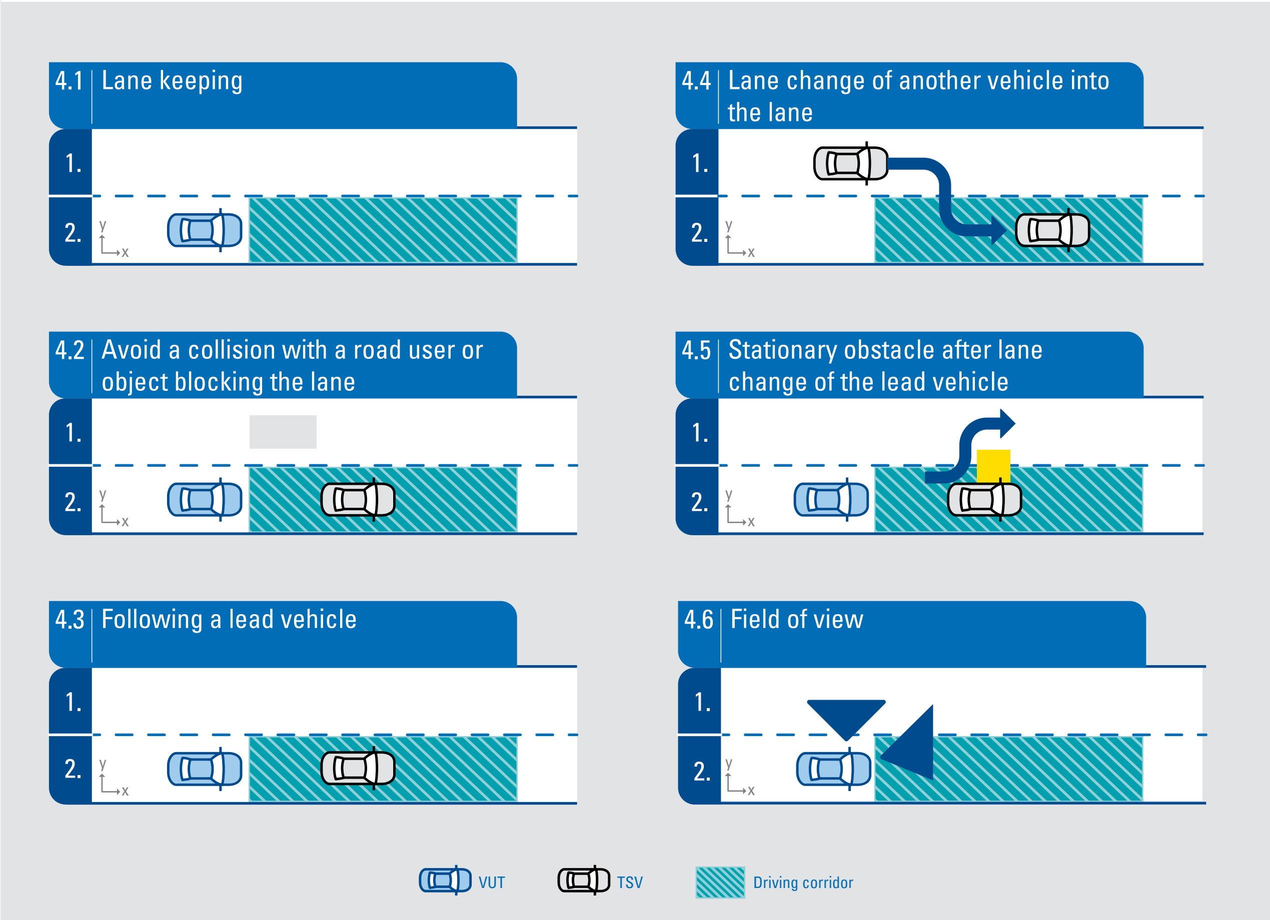
DEFINITION OF TEST CRITERIA

The basic requirement for a complex electronic system is that it must follow the prompts it receives. In the case of an automatic lane keeping system, this means that after explicit activation by the driver, the system processes the longitudinal and lateral functions while driving and monitoring the driver. This includes checking via condition monitoring whether the driver is available. The system then performs its normal task via sensors and actuators, to keep the vehicle in the selected lane. As soon as an intervention becomes necessary, or the driver deliberately intervenes, the automated driving function must switch to emergency mode.

Test scenarios for the automated lane keeping system

To verify the safety of the complex overall system, the ALKS regulation requires an audit of the safety concept for its functional and operational safety; verification is achieved using simulations and real tests. The documentation required for the audit is provided by the manufacturer, the responsible licensing authorities, or the designated technical service providers. Further requirements include a series of physical tests, listed in Annex 5, which are carried out by a designated technical service provider or in cooperation with the manufacturer. In addition to normal lane guidance in longitudinal and transverse directions, tests primarily deal with disturbances caused by stationary objects on the road and by other vehicles, such as moving into or out of the vehicle's lane. It will also be important to assess the area covered by the system.

6 TEST SCENARIOS TO ASSESS THE PERFORMANCE OF ALKS REGARDING THE DYNAMIC DRIVING TASK



The validation requirements relate to the main criteria of human-machine interface, normal function, dealing with emergency situations and the identification of objects. These are first checked during the audit and assessment according to Annex 4 of the regulation.[3] Audit results serve as the basis for the actual tests. The function itself and the manufacturer's safety concept must be confirmed. The methods used, of driving on test tracks and operation in real traffic, are tried and tested. The design also opens the possibility of using simulations in the type-approval process, for example, to verify valid system behaviour in a critical situation, or to test a very broad range of parameters.[12]

MERGING PHYSICAL AND VIRTUAL TESTS

Some scenarios are too complex to test on a test track or even on public roads. Simulation can provide a valuable service in such cases. This calls for the creation of appropriate tools and the guarantee that the simulation models sufficiently adhere to reality.[13] The results of real test-drives are combined with the simulations, allowing experts to make statements about the overall performance of the systems. This enables them to conclude from correct reactions, in physical and simulated test operations, that other requirements are also correctly fulfilled.[13] Detailed documentation is included in the expert's report. Hence, the requirements, the range of functions, the manufacturer's security and management concept, and information for the end user are thoroughly appraised. The overall aim is to determine the suitability of the system for use on public roads. Approval by an approval authority then takes place via the technical service documentation.

DYNAMIC TESTS

Six basic scenarios are used to check the automated driving function's system behaviour in reaction to defined traffic situations, from common to critical, according to Annex 5 of the regulation. This includes dealing with motorcycles, but also awareness for traffic light systems, emergency vehicles and construction sites, as well as correctly reacting to people on the road.

VALIDATION ON THE ROAD

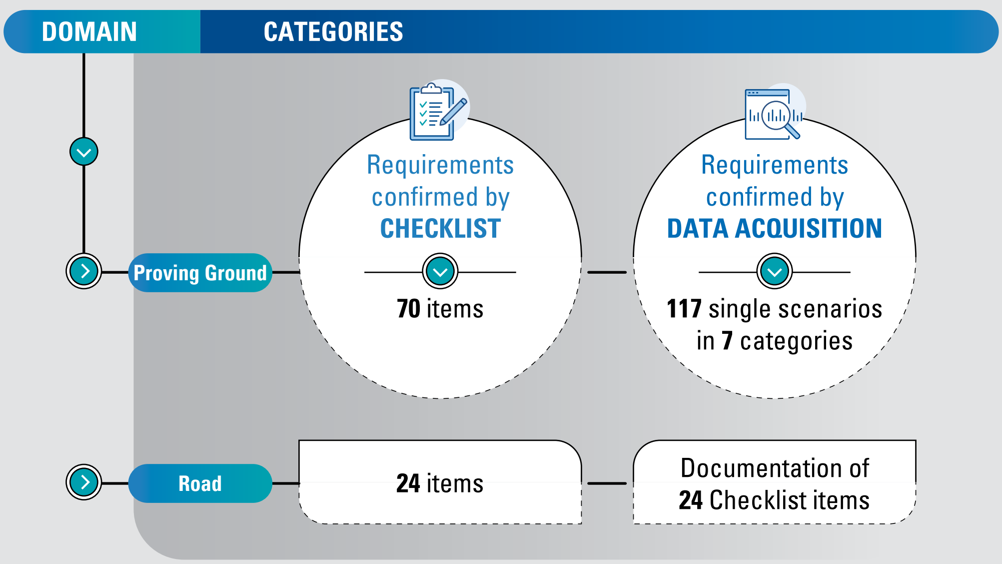
Regarding the issue of what, where and under what conditions a vehicle is being tested, strict security conditions apply. Critical driving manoeuvres prohibited in public traffic areas are possible on closed test tracks. It is also possible to predict the behaviour of a vehicle and its systems in other environments.

However, only public roads provide a range of realistic conditions, without which a comprehensive assessment is not possible. Therefore, the appropriate procedure is to validate the knowledge gained on the test track on the road.

SCOPE OF TESTS ON ROAD AND TEST TRACK

The steps for testing on the test track are far more extensive than for those in public traffic. On their premises, the experts work through a checklist of more than seventy points. Data read or recorded from seven categories must deliver results across 117 scenarios, whereas a checklist of around twenty-four criteria applies on general roads.

WHAT TESTS ARE REQUIRED?



The regulations define criteria not only for an automated lane keeping system but also for the test procedures and their environment. At first glance, the challenge inherent in the regulation is that it does not define any explicit tests and requirements. However, ninety-six testing verification points can be derived from the requirements in the regulation's main text and the corresponding annexes that address the requirements for the complex electronic system, as well as the test specifications. Some points do not require a complex test setup, with test drivers simply buckling up and the vehicle registering this. Even this must be considered and documented in a test plan. The validation of the test environment has a larger scope. Is it safe to use? Are the required speeds and distances drivable? This includes observing the weather and road conditions.

TEST SPECIFICATIONS FOR ALKS - HOW DO CHECKLIST REQUIREMENTS LOOK LIKE?

CHAPTER	NUMBER	EXCERPT FROM THE REGULATIONS TEXT	NUMBER OF TEST POINTS	COMMENT
Annex 5 Test specifications	6.1.3.1	Criteria for deeming driver available	5	Single points described in 6.1.3.1
	5.1.3	Driver support system active	3	Single points described in 5.1.3 like wiper, …
	6.3.1.1	Driver attentiveness	3	Points redundant
	5.5.	System behavior during a Minimal Risk Manoeuvre […] Driver take over […] Standstill (hazard lights) […] Reactivation disabled if reached standstill	3	Sum point for tests required in Annex 4 and can be transferred to checklist tests
	5.1.4	Transition demand and behavior/escalation	3	Sum valuation per observation
	…	…	…	…

TEST-DRIVES IN REALITY

The seven main categories to be assessed are:

- Staying in the lane
- Detection of static objects
- Detection of moving objects
- Following a leading vehicle
- Entering a lane
- Leaving a lane
- Areas monitored by the system (field of view)

In the 117 scenarios, individual points are checked at different speeds, distances, and environments. Different static and dynamic obstacles to which the automated driving function must accurately react are also used.

ENABLING DETERMINISTIC STATEMENTS

It is not possible to check all events and conditions that are conceivable and inconceivable in real traffic. This would require many millions of kilometres of test-drives. A deterministic approach is therefore required to conclude that an automated driving system will master all practical requirements.

To achieve this, a number of requirements must be met in the real tests. These include 100 per cent precision, guaranteed repeatability, and absolute secure control during execution. In this case, precision means that dynamic objects on the test premises achieve an accuracy within ten centimetres for measurements in the longitudinal direction and three centimetres for the lateral direction, which places special demands on the localisation and control of dynamic objects. The right safety concept is crucial for the safe execution of the tests. At a certain level of criticality, the tests are carried out with controlled self-driving platforms, thus reducing the risk for drivers in the event of a collision. This is the only way to test automated driving functions safely up to the system's limit.

The appropriate high-quality equipment for the test site and laboratories is naturally of the utmost importance.

Summary

The UNECE has not only created the first mandatory requirements for an automated lane keeping system, it also calls for measures to prevent cyber threats or faulty software updates, as well as a data-storage system that ascertains who was responsible in each respective driving situation. These points thus become an essential part of the homologation.

The UNECE regulation for ALKS is an important first step in the rapid implementation of automated driving, and in enabling internationally uniform and simplified market access for AV. This development also demonstrates that it will take some time for AV to become a ubiquitous presence on our roads. One reason for this relates to the regulations' adoption into applicable law, such as the EU directive coming into effect in the autumn of 2020. Another reason is that regulations for automated driving functions beyond the scope of ALKS have yet to be drafted.

Until then, an increasing number of individual permits for automated vehicles will ensure that people will be able to experience tomorrow's mobility. Trust in the new technology is another fundamental requirement for market success.

An example of this can be found in the spa town of Bad Birnbach in Lower Bavaria, where the first fully automated public buses have shuttled spa guests between the market square and the spa for the last two years, and since last year, between the train station and the city centre. This system conveys more than 130 people per day safely through a wide variety of traffic situations. To be able to operate on public roads, a single-vehicle approval according to §21 StVZO (Germany's road traffic licensing act), in connection with exceptions according to §70 StVZO, was necessary for every bus shuttle. The exceptions according to the StVZO are necessary because the automated vehicles do not fully meet the requirements of the StVZO. To evaluate the underlying safety concept of the vehicles and to justify the necessary exceptions (e.g., for the braking system), the TÜV SÜD technical inspection body in Bavaria accompanied the approval process.

Vehicle safety, functional safety, SOTIF and cybersecurity - similar to the UNECE regulation, these are important key issues. In addition to preliminary examinations and vehicle tests, the programme also includes in-depth document reviews. These are supplemented by comprehensive dynamic tests in which driving functions are tested in a variety of real and simulated situations. This ultimately ensures that the vehicle always reacts safely and reliably. A detailed safety report from TÜV SÜD on the vehicle's use and functional safety, along with the required expert reports, closes the regulatory gap for the recommended approval for road use.

With the existing national possibilities for automated vehicles for testing purposes on public roads and the UNECE regulation for the first automated driving function in production vehicles, the legislators have taken a major step toward closing the gap between technology and legislation. This presents an opportunity for society to accept and increasingly trust the technology, thus allowing automated driving to establish itself and continue to develop, step by step.

GLOSSARY OF ACRONYMS

ACSF – Automated Commanded Steering Function
ALKS – Automated Lane Keeping System
AV – Automated Vehicle
CATARC – China Automotive Technology and Research Center
CETRAN – Center of Excellence for Testing and Research of AVs
CITA – International Motor Vehicle Inspection Committee
CLEPA – European Association of Automotive Suppliers
CS/OTA – Task Force on Cybersecurity and Over-the-Air Issues
DSSAD/EDR – Data Storage System for Automated Driving / Event Data Recorder
DOT, or frequently USDOT – Department of Transportation
FMVSS – Federal Motor Vehicle Safety Standards
FRAV – Functional Requirements for Automated and Autonomous Vehicles
GRVA – Working Party on Automated/Autonomous and Connected Vehicles
IAMTS – International Alliance for Mobility Testing and Standardization
IWG – Informal Working Group
NHTSA – National Highway Traffic Safety Administration
OICA – International Organization of Motor Vehicle Manufacturers
OEM – Original Equipment Manufacturer
OTA – Over-the-air
PMO – Project Management Officer
SAE – Society of Automotive Engineers
SOTIF – Safety of the Intenden Function
STW – Super Touren Wagen
SUMS – Software Update Management System
UNECE – United Nations, Economic Commission for Europe
VMAD – Validation Method for Automated Driving
VVM – Research Association for Verification/Validation of Autonomous Driving Systems
WP – Working Paper

FOOTNOTES

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