

New Assessment and Testing Methodology for vehicle type approval

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ABSTRACT: In the context of a deep transformation in the automotive technology, specially with the wide introduction of ADAS functions and the first commercially available vehicle with automated functions, the classic type-approval procedures have been challenged and new methodologies are required.

This paper describes the actions being carried out at different levels in order to tackle such challenge, as well as the main future trends with regards to the new assessment and testing methodologies for the type-approval of vehicles and their systems.

KEY WORDS: Automated driving, homologation, testing, simulation, functional safety, SOTIF

1. INTRODUCTION

Technological innovations in the field of Connected and Automated Driving have a strong impact in different areas in the automotive industry. Among those areas, the effect on vehicle homologation procedures is game changing, in a way that requires a brand new approach. Traditionally, the homologation process based on the UNECE Regulatory framework has been a single step at the end of the development phase, where regulations normally defined a series of repeatable scenarios to be evaluated, where the effect of the driver is typically suppressed by means of the measurement of the inputs on the vehicle commands or by means of the use of driving robots.

In such context, the evaluation process could be scenario oriented: A limited amount of repeatable scenarios where reproduced under controlled conditions, and the performance of the vehicle/system alone was evaluated, in equal conditions.

This approach was initially challenged by the introduction of assisted systems, such as Advance Emergency Brake. Those systems are commanded by Electronic Control Systems which, in some circumstances, may control certain vehicle functions, such as braking or steering. The introduction of those functions required a different approach to the vehicle type approval, in order to evaluate possible failures associated to the Electronic Control Systems.

In such context, concepts such as Functional Safety (FuSa) or Safety Of The Intended Functionality (SOTIF) were introduced as part of the type approval process. This new approach turned the technical evaluation of the compliance from a testing activity in selected scenarios into a combination of testing and assessment of the manufacturer safety concept.

The vehicle is still under control of the human driver at all times, but the reaction of the vehicle may depend on the interventions of complex electronic systems. It is then necessary to guarantee that manufacturers have designed and built the vehicle to take safe decisions both in normal operation and failure conditions.

This methodology was already introduced in Regulation such as UN Regulation N. 13 and UN Regulation N. 13H, where systems like EBS or ESP may activate the braking system without intentional action from the human driver.

2. THE CHALLENGE OF AUTOMATED VEHICLES TYPE-APPROVAL

The introduction of the first SAE L3 functions into the market add a new layer of complexity into the type approval methodology. Such technologies replace the human driver during certain dynamic driving tasks, within an unlimited number of scenarios.

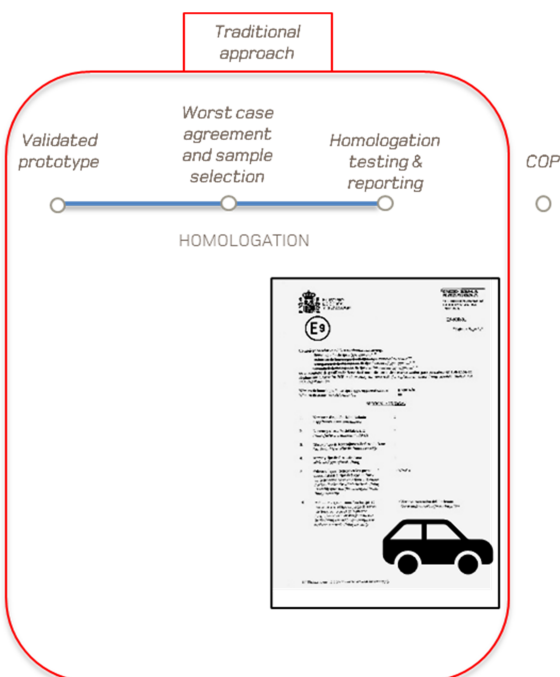


Figure 1 Traditional approach to type approval

This circumstance does not allow the classic strategy of removing the human effect from the test scenarios, and requires a second loop in the modification of the type approval processes, so as to move from an evaluation of the performance to an evaluation of the behaviour of the vehicle.

In this case, there are two main aspects that the traditional approach could not solve efficiently:

- a) The driving strategy: In vehicles operating in automated mode, the dynamic driving tasks are responsibility of the vehicle itself, without any human intervention. That means that the vehicle is not only responsible for the performance but also for the decisions on how to react to the inputs, assuming the role of the driver. In such circumstances, a classic type-0 braking test is not representative to evaluate the safety of a vehicle, because a vehicle with a lower mechanical braking performance may follow a more conservative driving strategy, so that will avoid the need for emergency braking in most of the possible scenarios, while a vehicle with a more performant braking system, but with a much more aggressive driving strategy may not be as safe.
- b) The number of scenarios: In vehicles corresponding to SAE Level 2 or lower, a reduced number of scenarios is tested to evaluate the safety of its systems. As the human driver influence in the safe operation of the vehicle has a majoritary weight on the overall safety, over the system performance itself, it is possible to evaluate the safety of the system by excluding the human effect, by means of a limited number of test cases under repeatable and controlled conditions. However, if the driver effect can not be excluded, as in the case of automated driving vehicles, it cannot be guaranteed that vehicles which are similar from the mechanical point of view will have similar performance under different scenarios, as the driving strategy may be variable depending on the scenario, affecting the behaviour of the vehicle and, as a consequence, the performance.

3. THE RULEMAKING STRUCTURE

The main activities with regards to the definition of a type approval of automated driving vehicles for the European Union market are being developed in two different forums:

3.1. European Commission

The European Commission is responsible for the definition of the vehicle type approval within the European Union.

Currently, Regulation (EU) 2018/858 defines the framework for the administrative provisions and technical requirements that road vehicles, separate technical units and components need to comply with, in order to be placed in the market. In addition to that, such regulation establishes also the provisions for other procedures that guarantee a life-cycle compliance, like conformity of production and market surveillance.

On a second level, we can find a series of regulatory tools which support the framework regulation, by means of amending, supplementing or implementing it.

One of the most important regulatory tools is Regulation (EU) 2019/2144, 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.

This regulation, also known as General Safety Regulation 2 or GSR2 introduces a series of mandatory systems that the vehicles will need to equip from July 2022 onwards. But most important, for the purposes of this paper, it defines a series of requirements that will need to be met by automated and fully automated vehicles.

As an initial step towards allowing the type approval of automated driving technologies, GSR2 does not define the technical specifications in detail, but creates a structure to kick-off the work for the creation of such technical requirements.

3.2. UNECE-WP29

One of the principles of Regulation (EU) 2019/2144 is that, for those requirements where there exists an UN Regulation, such Regulation shall be adopted by the European Commission with no need to duplicate efforts.

UN Regulations are developed in the framework of UNECE-WP29, the World Forum for Harmonization of Vehicle Regulations of the UNECE, headquartered in Geneva.

A series of Groups of Experts (GR-) subsidiaries of UNECE-WP29 deal with the different topics which are included within the regulatory framework, as indicated in figure 2.

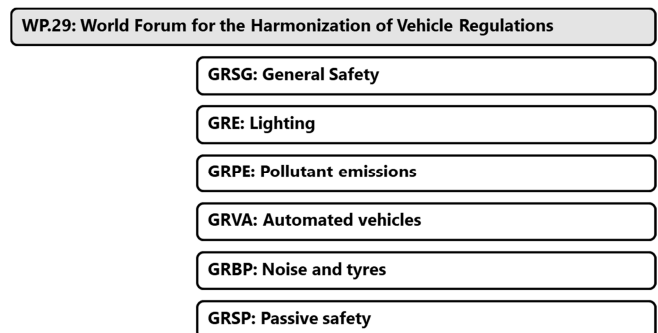


Figure 2 WP29 GR structure

GRVA was newly created in June 2019 to replace the previously existing GRRF (Group of experts on brakes and running gear), as a consequence of the publication of the Framework Document on Automated/autonomous Vehicles by UNECE-WP29 [1].

The framework document primary purpose is to provide guidance to WP.29 subsidiary Working Parties (GRs) by identifying key principles for the safety and security of automated/autonomous vehicles of levels 3 and higher. The framework document also defines the work priorities for WP.29 and indicates the deliverables, timelines and working arrangements for those certain work products related to those priorities.

One of the tasks of the framework document was the definition of a “safety vision”, which included a list of topics which should be taken into account to ensure safety:

- a) System Safety: When in the automated mode, the automated/autonomous vehicle should be free of unreasonable safety risks to the driver and other road users and ensure compliance with road traffic regulations;
- b) Failsafe Response: The automated/autonomous vehicles should be able to detect its failures or when the conditions for the [ODD/OD] are not met anymore. In such a case the vehicle should be able to transition automatically (minimum risk manoeuvre) to a minimal risk condition
- c) Human Machine Interface (HMI) /Operator information: Automated/autonomous vehicle should include driver engagement monitoring in cases where drivers could be involved (e.g. take over requests) in the driving task to assess driver awareness and readiness to perform the full driving task. The vehicle should request the driver to hand over the driving tasks in case that the driver needs to regain a proper control of the vehicle. In addition, automated vehicle should allow interaction with other road users (e.g. by means of external HMI on operational status of the vehicle, etc.)
- d) Object Event Detection and Response (OEDR): The automated/autonomous vehicles shall be able to detect and respond to object/events that may be reasonably expected in the [ODD/OD];
- e) Operational Design Domain (ODD/OD) (automated mode): For the assessment of the vehicle safety, the vehicle manufacturers should document the OD available on their vehicles and the functionality of the vehicle within the prescribed OD. The OD should describe the specific conditions under which the automated vehicle is intended to drive in the automated mode. The OD should include the following information at a minimum: roadway types; geographic area; speed range; environmental conditions (weather as well as day/night time); and other domain constraints
- f) Validation for System Safety: Vehicle manufacturers should demonstrate a robust design and validation process based on a systems-engineering approach with the goal of designing automated driving systems free of unreasonable safety risks and ensuring compliance with road traffic regulations and the principles listed in this document. Design and validation methods should include a hazard analysis and safety risk assessment for Automated Driving System (ADS), for the OEDR, but also for the overall vehicle design into which it is being integrated and when applicable, for the broader transportation ecosystem. Design and validation methods should demonstrate the behavioural competencies an Automated/autonomous vehicle would be expected to perform during a normal operation, the performance during crash avoidance situations and the performance of fall back strategies. Test approaches may include a combination of simulation, test track and on road testing.
- g) Cybersecurity: The automated/autonomous vehicle should be protected against cyber-attacks in accordance with established best practices for cyber vehicle physical systems. Vehicles manufacturers shall demonstrate how they incorporated vehicle cybersecurity considerations into ADSs, including all actions, changes, design choices, analyses and associated testing, and ensure that data is traceable within a robust document version control environment
- h) Software Updates: Vehicle manufacturers should ensure system updates occur as needed in a safe and secured way and provide for after-market repairs and modifications as needed
- i) Event data recorder (EDR) and Data Storage System for Automated Driving vehicles (DSSAD): The automated/autonomous vehicles should have the function that collects and records the necessary data related to the system status, occurrence of malfunctions, degradations or failures in a way that can be used to establish the cause of any crash and to identify the status of the automated/autonomous driving system and the status of the driver. The identification of differences between EDR and DSSAD to be determined;

The second consequence of the framework document was a redefinition of the structure of informal working groups, task forces and special interest groups, subsidiary of GRVA. Those groups are created under certain terms of reference, as a mandate from GRVA, in order to reach a target within a defined timeframe.

Those working groups develop their activities under the coordination of a chairperson or several chairpersons, with the support of a secretariat and report their results to GRVA.

The frequency of meetings of those working groups is, compared to GRVA, much more frequent, as the technical discussions are held within such forums, while the discussions at GRVA are kept at a higher level, and are focused mainly on decision making rather than the discussion of the details.

The current structure of GRVA and subsidiary working groups can be seen in figure 3, and the direct relationship between the topics described in the safety vision of the framework document and the different working groups is evident.

4. VMAD AND THE NEW ASSESSMENT AND TESTING METHODOLOGIES

As stated in the previous section of this paper, one of the topics of the safety vision of the framework document is the validation for system safety. As it was earlier introduced, the automated and autonomous technologies require a new approach to the validation methodology, different from the classical tests for a prototype under repeatable conditions.

The seed for this new technology is the “three pillar approach”, firstly introduced in the GRVA discussions upon initiative from OICA.

GRVA	FRAV: Functional Requirements for Automated and Autonomous Vehicles
	VMAD: Validation Method for Automated Driving
	CS/OTA: Cybersecurity and (OTA) Software Updates
	DSSAD/EDR: Data Storage System for Automated Driving
	AEBS/LDWS: Advanced Emergency Braking and Lane Departure Warning
	SIG ALKS: Special Interest Group on Advanced Lane Keeping System
ADAS	

Figure 3 Current structure of GRVA working groups, February 2022

The seed for this new technology is the “multi-pillar approach”, firstly introduced in the GRVA discussions upon initiative from OICA in 2019 [2]. According to this approach, the use of different tools is required in order to guarantee the safe market introduction of automated and autonomous vehicles:

a) Audit / assessment:

- Understand the system to be certified
- Assess that the applied processes and design/test methods for the overall system development (HW and SW) are effective, complete and consistent
- Assess system’s strategies/test performance to address (multiple) fault-conditions and disturbances due to deteriorating external influences; vehicle behavior in variations of critical scenarios
- Simulation: Test parameter variations (e.g. distances, speeds) of scenarios and edge-cases that are difficult to test entirely on a test track

b) Physical Certification Tests:

- Assess critical scenarios that are technically difficult for the system to cope with, have a high injury severity (in case the system would not cope with such a scenario) and are representative for real traffic
- Compare with critical test cases derived from simulation and validate simulation tools

c) Real World Test Drive:

- Assess the overall system capabilities and behavior in non-simulated traffic on public roads and show that the system has not

been optimized on specific test scenarios

-Assess system safety requirements like e.g. HMI and ODD

-Assess that the system achieves a performance comparable to an experienced driver

The multi-pillar approach has been further developed under the workframe of VMAD, being renamed as NATM: New Assessment and Testing Methods. For such purpose, and additional level of subgroups, dealing with different specific topics was also created (figure 4):

Figure 4 VMAD subgroups

During the 12th Session of GRVA (January 2022), VMAD presented a proposal for a second iteration of the Master Document on NATM [3], which defines the principles of such methodology on the basis of five pillars:

1. Simulation/virtual Testing

It uses different types of simulation toolchains to assess the compliance of an ADS with the safety requirements on a wide range of virtual scenarios including some which would be extremely difficult if not impossible to test in real-world settings. The aspect of credibility of simulation/virtual testing is included in this topic.

2. Track testing

It uses a closed-access testing ground with various scenario elements to test the capabilities and functioning of an ADS.

3. Real world testing

It uses public roads to test and evaluate the performance of ADS related to its capacity to drive in real traffic conditions.

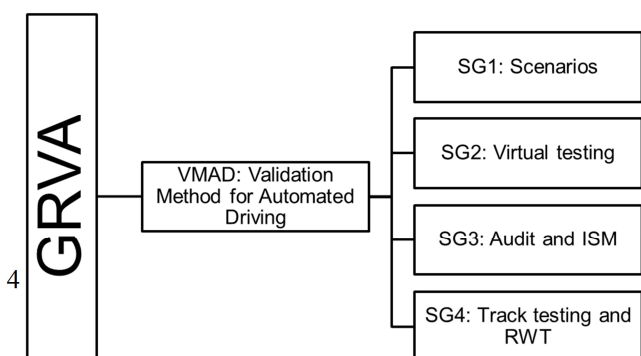
4. Audit/assessment procedures

They establish how manufacturers will be required to demonstrate to safety authorities using documentation, their simulation, test-track, and/or real-world testing of the capabilities of an ADS. The audit will validate that hazards and risks relevant for the system have been identified and that a consistent safety-by-design concept has been put in place. The audit will also verify that robust processes/mechanisms/strategies (i.e., safety management system) that are in place to ensure the ADS meets the relevant safety requirements throughout the vehicle lifecycle. It shall also assess the complementarity between the different pillars of the assessment and the overall scenario coverage.

5. In-service monitoring and reporting

It addresses the in-service safety of the ADS after its placing on the market. It relies on the collection of fleet data in the field to assess whether the ADS continues to be safe when operated on the road. This data collection can also be used to fuel the common scenario database with new scenarios from the field and to allow the whole ADS community to learn from major ADS accidents/incidents.

In order to guarantee the efficiency of those pillars, they need to be supported by a scenario catalogue, descriptions of real-world



driving situations that may occur during a given trip, will be a tool used by the NATM-pillars to validate the safety of an ADS.

This new approach leads consequently to a change in the interaction between Technical Services and vehicle manufacturers. As per the traditional approach (figure 1), it was limited to very late stages of the process, once the vehicle or system had already been validated by the manufacture. However, the new approach requires the type-approval process to be started way in advance, so that the development methodology can be evaluated before the vehicle is ready to be assessed. (figure 5).

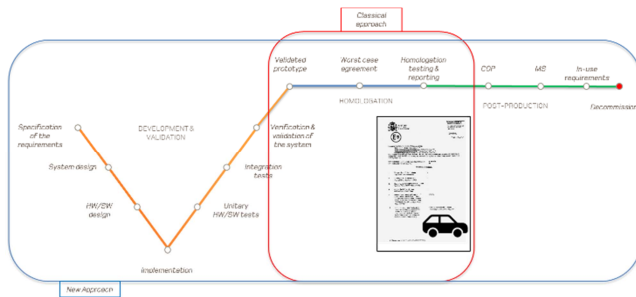


Figure 5 description of the application of NATM within the vehicle life-cycle

5. NATM VS OTHER METHODOLOGIES

Type-approval of vehicles and systems is normally the latest step in the life-cycle of the vehicle development. Previously, the manufacturer may have performed its internal validation tests, in order to guarantee the safety of the vehicle, but also some aspects which are not part of the areas of interest of type-approval, such as the feeling or the comfort of the vehicle.

This may have led to different approaches to the testing and assessment methods, depending on the stage of development of the vehicle. However, there is a trend for the harmonization of such methods, and it is becoming frequent for manufacturers to use a similar approach for the validation of their vehicles. Additionally, other evaluation frameworks, like EuroNCAP are introducing similar methodologies.

Efforts for harmonization of these methodologies can also be found in EU-funded projects like HEADSTART, which aimed to define testing and validation procedures of Connected and Automated Driving functions including key technologies such as communications, cyber-security and positioning. The tests will be in both simulation and real-world fields to validate safety and security performance according to the key users' needs. Those key users included:

- a) Type-approval rulemakers

- New CAV type-approval regulation
- CAV safe market introduction
- Digital driving license

- b) EuroNCAP

- New official assessment protocols
- User acceptance

- Safety-aware sales growth

- c) Vehicle manufacturers

- New development strategies

- New CAV functions enabler

- Cost and time-to-market reduction

6. CONCLUSION

The introduction of automated vehicle technologies introduces a series of challenges to vehicle industry stakeholders, and type-approval is an important one. Guaranteeing that a vehicle is safe to be placed in the market is essential, but it shall be balanced with a certain flexibility to allow the market introduction in a pragmatic and cost effective manner.

The use of innovative methodologies is thus required, as the traditional methods have proven not to be valid for vehicles able to perform dynamic driving tasks on their own.

Rulemaking forums have already stepped forward and developed an innovative methodology that will allow the type-approval of those vehicles, but as a side-effect, all the involved stakeholders will need to adapt themselves to the new tools, time-span and methods introduced by NATM.

Finally, there is also a clear trend for harmonization of the validation methodology along the automotive industry, which reflects the effort to optimize resources and time.

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