

Note by the secretariat

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UNITED NATIONS ECONOMIC COMMISSION FOR EUROPE

All you need to know about Automated Vehicles

Technical progress and regulatory activities



UNECE

United Nations Economic Commission for Europe

The United Nations Economic Commission for Europe (UNECE) is one of the five United Nations regional commissions, administered by the Economic and Social Council (ECOSOC). It was established in 1947 with the mandate to help rebuild post-war Europe, develop economic activity and strengthen economic relations among European countries, and between Europe and the rest of the world. During the cold war, UNECE served as a unique forum for economic dialogue and cooperation between East and West. Despite the complexity of this period, significant achievements were made, with consensus reached on numerous harmonization and standardization agreements.

In the post-cold-war era, UNECE acquired not only many new member States, but also new functions. Since the early 1990s the organization has focused on analyzing the transition process, using its harmonization experience to facilitate the integration of Central and Eastern European countries into the global markets.

UNECE is the forum where the countries of Western, Central and Eastern Europe, Central Asia and North America – 56 countries in all – come together to forge the tools of their economic cooperation. That cooperation concerns economics, statistics, environment, transport, trade, sustainable energy, timber housing and land management. UNECE offers a regional framework for the elaboration and harmonization of conventions, norms and standards. The experts of UNECE provide technical assistance to the countries of South-East Europe and the Commonwealth of Independent States. This assistance takes the form of advisory services, training seminars and workshops where countries can share their experiences and best practices.

Transport in UNECE

The UNECE Sustainable Transport Division is the secretariat of the Inland Transport Committee (ITC) and the ECOSOC Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals. The ITC and its 17 working parties, as well as the ECOSOC Committee and its sub-committees are intergovernmental decision-making bodies that work to improve the daily lives of people and businesses around the world, in measurable ways and with concrete actions, to enhance traffic safety, environmental performance, energy efficiency and the competitiveness of the transport sector.

The ECOSOC Committee was set up in 1953 by the Secretary-General of the United Nations at the request of the Economic and Social Council to elaborate recommendations on the transport of dangerous goods. Its mandate was extended to the global (multi-sectoral) harmonization of systems of classification and labelling of chemicals in 1999. It is composed of experts from countries which possess the relevant expertise and experience in the international trade and transport of dangerous goods and chemicals. Its membership is restricted in order to reflect a proper geographical balance between all regions of the world and to ensure adequate participation of developing countries. Although the Committee is a subsidiary body of ECOSOC, the Secretary-General decided in 1963 that the secretariat services would be provided by the UNECE Transport Division.

ITC is a unique intergovernmental forum that was set up in 1947 to support the reconstruction of transport connections in post-war Europe. Over the years, it has specialized in facilitating the harmonized and sustainable development of inland modes of transport. The main results of this persevering and ongoing work are reflected, in among other things, (i) 58 United Nations conventions and many more technical regulations, which are updated on a regular basis and provide an international legal framework for the sustainable development of national and international road, rail, inland water and intermodal transport, including the transport of dangerous goods, as well as the construction and inspection of road motor vehicles; (ii) the Trans-European North-south Motorway, Trans-European Railway and the Euro-Asia Transport Links projects, that facilitate multi-country coordination of transport infrastructure investment programmes; (iii) the TIR system, which is a global customs transit facilitation solution; (iv) the tool called For Future Inland Transport Systems (ForFITS), which can assist national and local

governments to monitor carbon dioxide (CO₂) emissions coming from inland transport modes and to select and design climate change mitigation policies, based on their impact and adapted to local conditions; (v) transport statistics – methods and data – that are internationally agreed on; (vi) studies and reports that help transport policy development by addressing timely issues, based on cutting-edge research and analysis. ITC also devotes special attention to Intelligent Transport Services (ITS), sustainable urban mobility and city logistics, as well as to increasing the resilience of transport networks and services in response to climate change adaptation and security challenges.

In addition, the UNECE Sustainable Transport and Environment Divisions, together with the World Health Organization (WHO) – Europe, co-service the Transport Health and Environment Pan-European Programme (THE PEP).

Finally, as of 2015, UNECE is providing the secretariat services for the Secretary General's Special Envoy for Road Safety, Mr. Jean Todt.

Inland Transport Committee (ITC) – Centre of United Nations Transport Conventions

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1. Executive summary

Policy makers observe impressive technical developments in the field of assisted and automated driving. The current and potential benefits of these systems are such that they aroused a great deal of interest, including from governments, industries, administrations and academia.

This paper focuses on the automotive sector developments and the regulatory response.

It is often said that 90 per cent of road crashes are due, at least partially, to human errors and that, therefore, assisted and automated driving systems can help reduce human errors leading to crashes.

Automated driving is also promising as a means to support and, in some cases enable, existing policies aimed to transform the transport systems that are otherwise less obvious to implement, such as intelligent transport systems, mobility as a service etc.

UNECE is managing a number of legal instruments that organize international (and therefore also national) road transport. These legal instruments include the Road Traffic Conventions from 1949 and from 1968 and the vehicle related Agreements from 1958, 1997 and 1998 aimed at harmonizing requirements applicable to vehicles. Some stakeholders found that these legal instruments should be amended to support the implementation of frontier technologies.

This led to the adoption of amendments to the 1968 Vienna Convention on Road Traffic Safety and amendments to UN Regulation No. 79 under the 1958 Agreement.

Beyond these initial steps, UNECE established the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) in 2019.

Since 2019, GRVA worked primarily under two frameworks.

It worked under the guidance provided by the Framework on Automated/Autonomous and Connected Vehicles (FDAV). This Document was drafted by China, the European Union, Japan and the United States of America and was endorsed by the World Forum for Harmonization of Vehicle Regulations. The document defines a safety vision, key safety elements, guidance to the Working Parties of WP.29 as well as programme of activities. These activities, at intergovernmental level, form a novel initiative aimed at harmonizing globally automated vehicles regulations and creating a more productive environment for innovation.

GRVA also achieved results under the framework provided by the 1958 Agreement, with the adoption of amendments to UN Regulation No. 79 (Steering equipment) as well as of new UN Regulations Nos.: 157 (Automated Lane Keeping System), 155 (Cyber Security and Cyber Security Management System) and 156 (Software Update and Software Update Management System).

This leaflet provides some insights on the development of the activities performed by intergovernmental bodies of UNECE to enable assisted and automated driving as of September 2021. It also includes a short section aimed at providing some clarity about some myths.

2. Technical developments in the field of assisted and automated driving systems

The technical progress in the field of assisted and automated driving, for the last seven years, is impressive. A Japanese Vehicle Manufacturer launched a model in March 2021, which is the first series vehicle equipped with a Level 3 technology. A German vehicle manufacturer is equipping its flagship vehicle with a similar system.

An Automated Driving System based hailing system is currently available in the East Valley of Phoenix Arizona. Automated Shuttle manufacturers are experimenting automated shuttles in many locations around the globe.

These industrial achievements find their origin in the early developments related to warning and assistance systems, which were closely linked to safety systems. Anti-lock braking, already in the seventies, and Electronic Stability Systems, in 1995, were the first systems that interfered in the driving task and were sold across the series vehicle model ranges. Later came Adaptive Cruise Control (ACC), Lane Departure Warnings Systems (LDWS) and Advanced Emergency Braking Systems (AEBS) for trucks and coaches, which were the first systems using sensors to monitor the road and other vehicles ahead of the subject vehicle.

Since 2014, further developments in the field of assisted driving occurred, due to technical progress and also due to competition mechanisms, with the announcements by a search engine company as well as the market pressure created by an electric vehicles manufacturer, with the offering for sale of a Level 2 assistance system.

Alone in Europe, already in 2018, a non-neglectable amount of vehicles were equipped with assisted driving features of Level 2. A year later, this amount increased significantly to reach about 10 per cent of the cars sold.

Technological progress in the field of Artificial Intelligence, especially with the growing use of Machine Learning and Deep Learning, increased possibilities in the field of Object and Event Detection and Response. LIDARs, radars and cameras as well as Deep Learning related technologies, provide opportunities not only for developing the highest levels of automation. These sensing and automation technologies can also be used for “simpler” use cases, e.g. safety features, that provide

assistance to drivers when a potential crash is detected. These “simpler” technologies include Advanced Emergency Braking Systems (AEBS) as well as steering assistance at low speed, Emergency Steering Function and Risk Mitigation Functions.

3. The role of the World Forum for Harmonization of Vehicle Regulations (WP.29) on assisted and automated driving

Early responses

The emergence of safety features in the automotive sector led WP.29 to establish the Informal Working Group on Intelligent Transport Systems (IWG on ITS).

During 2002-2013, the ITS group focused on the driver-assistance technologies entering the market and human-machine interaction issues resulting in guidelines for high-priority/safety-critical warning and on Advanced Driver Assistance Systems. These developments coincided with the entry on the market of Electronic Stability Control and Advanced Emergency Braking Systems (AEBS) for trucks. As these technologies and systems advanced, the ITS group shifted its attention toward automated driving systems.

During 2014-2018, the group, rename IWG on ITS/AD, considered the intersection of automated driving and traffic rules. It developed definitions, terms and concepts, it proposed recommendations incl. on cyber security and software integrity. It received presentations on the classification of automated driving technologies from Germany, United States of America (NHTSA) before the standard SAE J3016 J3016, defining automated driving levels, was established.

Advance Driver Assistance Systems

During the Inland Transport Committee session in 2014, Google announced that their self-driving system would be ready in four years and Continental presented their strategy based on a step-by-step approach.

At the same time, the former Working Party on Brakes and Running Gear (GRRF) received inputs concerning Truck Platooning and interrelations with technical regulations under the purview of the working party.

UN Regulation No. 79 (Steering equipment), established under the 1958 Agreement, contained, for two decades, provisions for the approval of Automatically Commanded Steering Functions (limited until 10 km/h) and Corrective Steering Functions. This speed limit prevented the type approval of assisted driving of level 2 that could achieve higher speeds. Some manufacturers developed lane keeping functions that were using the Electronic Stability Control in order to cope with this limitation.

Activities started in 2014 to develop the regulatory provisions under which the 10 km/h limitation could be exceeded. These activities produced the regulatory basis under which vehicle manufacturers could place on the market so called Level 2 technologies (Advanced Driver Assistance System).

Automated Driving Systems

The Word Forum felt that regulatory activities on assisted and automated vehicles would require more of its resources and therefore it established the Working Party on Automated/autonomous and Connected Vehicles (GRVA – French abbreviation for the group). At the same time, the Group of Seven (G7) agreed to cooperate within this group to tackle the harmonization of related regulatory matters.

The activities of the Working Party are performed under the framework provided by the United Nations vehicle Agreements from 1958, 1997 and 1998 as well as the Framework Document on Automated/Autonomous Vehicles.

Since the inception of GRVA, the automotive sector performed a profound transformation in the way it addresses Cyber Security matters. It also generalised ADAS systems performing lane keeping and lane changes on highways. The sector also developed the first Level 3 systems performing automated lane keeping at low speed on motorway, a use case covering for example congested traffic situations. The first series vehicle equipped with an Automated Lane keeping System in conformity with UN Regulation No. 157 entered the market in 2021.

Many other technologies are in development and under trial in various regions of the world, including regions that don't apply the type approval regime facilitated by the 1958 Agreement.

While some countries (mostly those applying the type approval system) are in favour of developing technical regulations (with minimum performance requirements) to accompany the development of technologies and facilitating the emergences of those technologies, other countries (most of them applying the self-certification regime) feel that guidance and recommendations are sufficient under a self-certification regime for the time being, given the pace of technological development.

Framework Document on Automated/Autonomous and Connected Vehicles

The Framework on Automated/Autonomous and Connected Vehicles (FDAV) was drafted by China, the European Union, Japan and the United States of America. It defines a safety vision, key safety elements, guidance to the Working Parties of WP.29 as well as programme of activities suitable for the countries under the regime of type approval and the countries under the regime of self-certification. These activities, at intergovernmental level, form a novel initiative aimed at harmonizing globally automated vehicles regulations and creating a more productive environment for innovation.

The World Forum WP.29 endorsed unanimously this document. WP.29 continues to use it as a programme management tool, clustering activities on Functional Requirements for Automated Vehicles, Validation Method for Automated Driving, Cyber Security and OTA issues and Data Storage System for Automated Driving / Event Data Recorder, to be dealt with by specific working groups.

Under this environment, several activities are still ongoing, but some outcomes were already delivered such as:

Guidance document for contracting parties to the 1958 and 1998 Agreements:

(a) Recommendation for Automotive Cyber Security and Software Update.

- (b) Guidance on Event Data Recorder - Performance Elements Appropriate for Adoption under the 1958 and 1998 Agreements - draft
- (c) Master Document on the New Assessment / Test Method

UN Regulations under the 1958 Agreement:

- (a) UN Regulation No. 155 (Cyber Security and Cyber Security Management System) and the corresponding interpretation document.
- (b) UN Regulation No. 156 (Software Update and Software Update Management System) and the corresponding interpretation document.
- (c) DSSAD requirements in UN Regulation No. 157 (ALKS) in chapter 8.
- (d) UN Regulation on EDR.

4. Myths and realities

Myth 1 – Vehicles will decide who to kill in case of a dilemma

This myth is related to the famous trolley dilemma, which is a very interesting question especially from an academical point of view.

But it is currently expected that an automated driving system will have to comply with the same rules as conventional vehicles driven by drivers. Existing traffic rules stipulate that the driver shall at all time have its speed under control [...], and slowdown or stop whenever circumstances so require [...]. From the safety point of view, if this rule is imposed to drivers, why should the rules be more lenient for Automated vehicles? It is also noted that complex situations don't provide much time for computation. From the safety point of view, it is argued that this time should be used for optimizing trajectories, decelerations, and interactions with road users to avoid or at least mitigate a crash instead of computing highly complex and subjective ethical parameters.

Myth 2 – Self-driving cars are driving thanks to the 5G.

No automated driving technology rely on off-board information to operate. Matters related to network coverage, latency and interference still need to be addressed as a starting point before the telecommunication can safely perform a driving task. Relying on external information may create dilemma: at a road crossing, does the absence of signal (supposed to inform on the presence of a vehicle) really means the absence of vehicle? It can be that a vehicle has a technical defect and is not properly emitting, or that interference disturb the communication.

Progress of car-to-car communications and vehicle to infrastructure communications are going on. Such telecommunication technologies will create added values and could potentially enhance Automated Driving System, supporting a "natural driving" vehicle behavior and more comfort for vehicle

occupants and off board information could contribute to “anticipation”.

For the time being, UN Regulation No. 79 defines autonomous vehicles as follow:

"Autonomous Steering System" means a system that incorporates a function within a complex electronic control system that causes the vehicle to follow a defined path or to alter its path in response to signals initiated and transmitted from off-board the vehicle. The driver will not necessarily be in primary control of the vehicle."

It stipulates in the introduction:

"It is anticipated that future technology will also allow steering to be influenced or controlled by sensors and signals generated either on or off-board the vehicle. This has led to several concerns regarding responsibility for the primary control of the vehicle and the absence of any internationally agreed data transmission protocols with respect to off-board or external control of steering. Therefore, the Regulation does not permit the general approval of systems that incorporate functions by which the steering can be controlled by external signals, for example, transmitted from roadside beacons or active features embedded into the road surface. Such systems, which do not require the presence of a driver, have been defined as "Autonomous Steering Systems"."

Myth 3 – Current state of the art technology enable self-driving cars

There is no product on the market that is technically self-driving on public roads. Even the most advanced technology under trial remains under the control or supervision of an operator that can take over the control of the ego vehicle in case of an issue. Automated driving exists currently within the boundaries and limitations of the Operational Design Domain defined by the manufacturer.

Myth 4 – Drivers can have a nap while an automated driving system is engaged.

The current technologies do not enable automated driving systems without any supervision that could allow a driver to sleep. In fact, UNECE observes a different trend: manufacturers implement driver monitoring functions to verify the availability of the driver in case a driver should resume the driving task.

Myth 5 – Automated driving is pointless if it requires a human supervision.

The advancements in lower levels of automation, including assisted driving are expected to serve the purpose of SDG 3.6 and road safety in general. ADAS may assist the human driver for several activities while driving and therefore ease the basic driving tasks. Thus drivers are in the position to use their capacities for better observing the traffic situations and are supported during emergency manoeuvres by the systems.

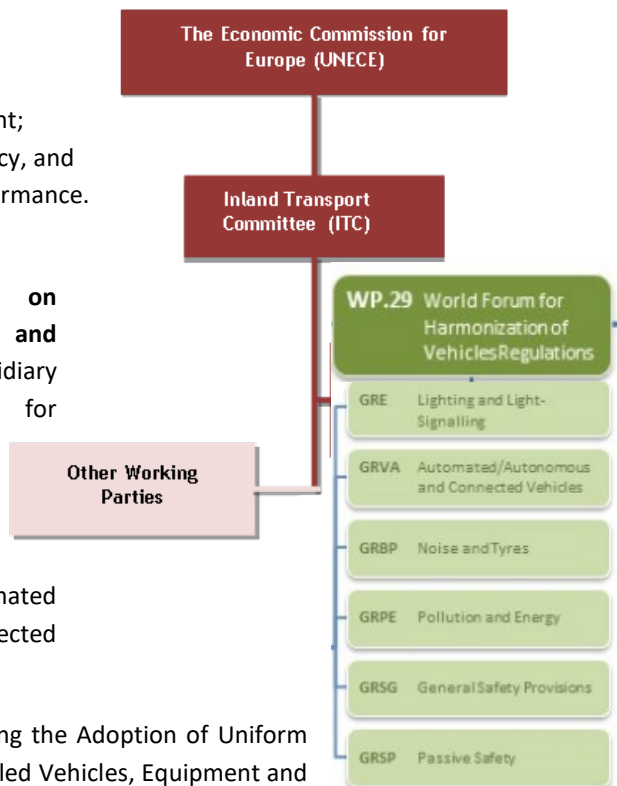
Glossary

"**World Forum for Harmonization of Vehicle Regulations (WP.29)**" was established on 6 June 1952 as the Working Party on the Construction of Vehicles, a subsidiary body of the Inland Transport Committee (ITC) of the United Nations Economic Commission for Europe (UNECE). In March 2000, WP.29 became the "World Forum for Harmonization of Vehicle Regulations (WP.29)". The objective of the WP.29 is to initiate and pursue actions aimed at the worldwide harmonization or development of technical regulations for vehicles. Providing uniform conditions for periodical technical inspections and strengthening economic relations worldwide, these regulations are aimed at:

- Improving vehicle safety;
- Protecting the environment;
- Promoting energy efficiency, and
- Increasing anti-theft performance.

"**Working Party on Automated/Autonomous and Connected Vehicles**" is a subsidiary body of the World Forum for Harmonization of Vehicle Regulations (WP.29) that prepares regulatory proposals on active safety, Advanced Driver Assistance Systems, Automated Driving Systems and Connected Vehicles.

"**UN 1958 Agreement**" concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of these Prescriptions; the Agreement counts 56 Contracting Parties (UN Countries) world wide and around 160 annexed **UN Regulations** (by end of 2021). Whenever a company designs a prototype of an automotive component, accessory or vehicle they must prove that it meets the



performance requirements of the 1958 Agreement's Regulations. Once that is done, the manufacturer can follow the motto "certified once, sold everywhere". That company engraves the E on their parts, and a car maker in any country can buy it with the confidence that it meets the Regulations. Companies can trade across borders and to different regions without a costly re-verification process which would be passed on to the consumer. UN Regulations, can be consulted on-line at or downloaded free of charge from the following website: <http://www.unece.org/trans/main/welcwp29.html>

“UN 1998 Agreement is the Agreement Concerning the Establishing of Global Technical Regulations for Wheeled Vehicles, Equipment and Parts Which Can Be Fitted and/or Be Used on Wheeled Vehicles. The 1998 Agreement was negotiated and concluded under the auspices of ECE and opened for signature on 25 June 1998. The United States of America became the first signatory. The Agreement entered into force on 25 August 2000 for eight Contracting Parties. In 2018 2020 the Agreement had 38 Contracting Parties. To date, 20 UN GTRs have been established under this Agreement. The goal of the 1998 Agreement is to continuously improve global road safety, decrease environmental pollution and consumption of energy and improve anti-theft performance of vehicles and related components and equipment through globally uniform technical regulations.

The 1998 Agreement establishes a process by which countries from all regions of the world can jointly develop UN GTRs jointly on safety, environmental protection systems, energy sources and theft prevention of wheeled vehicles, equipment and parts and to implement these regulations in line with the uniform provisions of UN Regulations. The equipment and parts cover, but are not limited to, vehicle construction, exhaust systems, tyres, engines, acoustic shields, anti-theft alarms, warning devices and child restraint systems

List of reference documents and regulations mentioned in this document:

- **Framework Document on Automated/Autonomous and Connected vehicles** was adopted by WP.29 in 2019. See ECE/TRANS/WP.29/2019/24/Rev.2
- **UN GTR No. 3 (Motorcycle braking)** was established in 2006. It includes performance requirements for e.g. Combined Braking System (CBS) and Anti-lock Braking System (ABS).
- **UN GTR No. 8 (Electronic Stability Control)** was established in 2008. It defines the performance requirements applicable to ESC, still in use in 2021.

- **UN Regulation No. 13 (Heavy vehicle braking)** established in 1970 and **13-H (Light vehicle braking)**, established in 1998, defined the minimum performance requirements for braking systems, including ABS and ESC.
- **UN Regulation No. 78 (Braking of category L vehicles)** was established in 1988. It is harmonized with UN GTR No. 78
- **UN Regulation No. 79 (Steering equipment)** was established in 1995.
- **UN Regulation No. 130 (Lane Departure Warning System)** was established in 2013.
- **UN Regulation No. 131 (Advanced Emergency Braking System)** was established in 2013.
- **UN Regulation No. 140 (Electronic Stability function)** was established in 2017 based on UN Regulation No. 13-H. it is harmonized with UN GTR No. 8 (ESC).
- **UN Regulation No. 155 (Cyber Security and Cyber Security Management System)** was established in 2021.
- **UN Regulation No. 156 (Software update and software update management system)** was established in 2021.
- **UN Regulation No. 157 (Automated Lane Keeping System)** was established in 2021.

UN Regulations can be consulted on the UNECE website here:

<https://unece.org/un-regulations-addenda-1958-agreement>

UN GTRs can be consulted on the UNECE website here:

<https://unece.org/transport/standards/transport/vehicle-regulations-wp29/global-technical-regulations-gtrs>