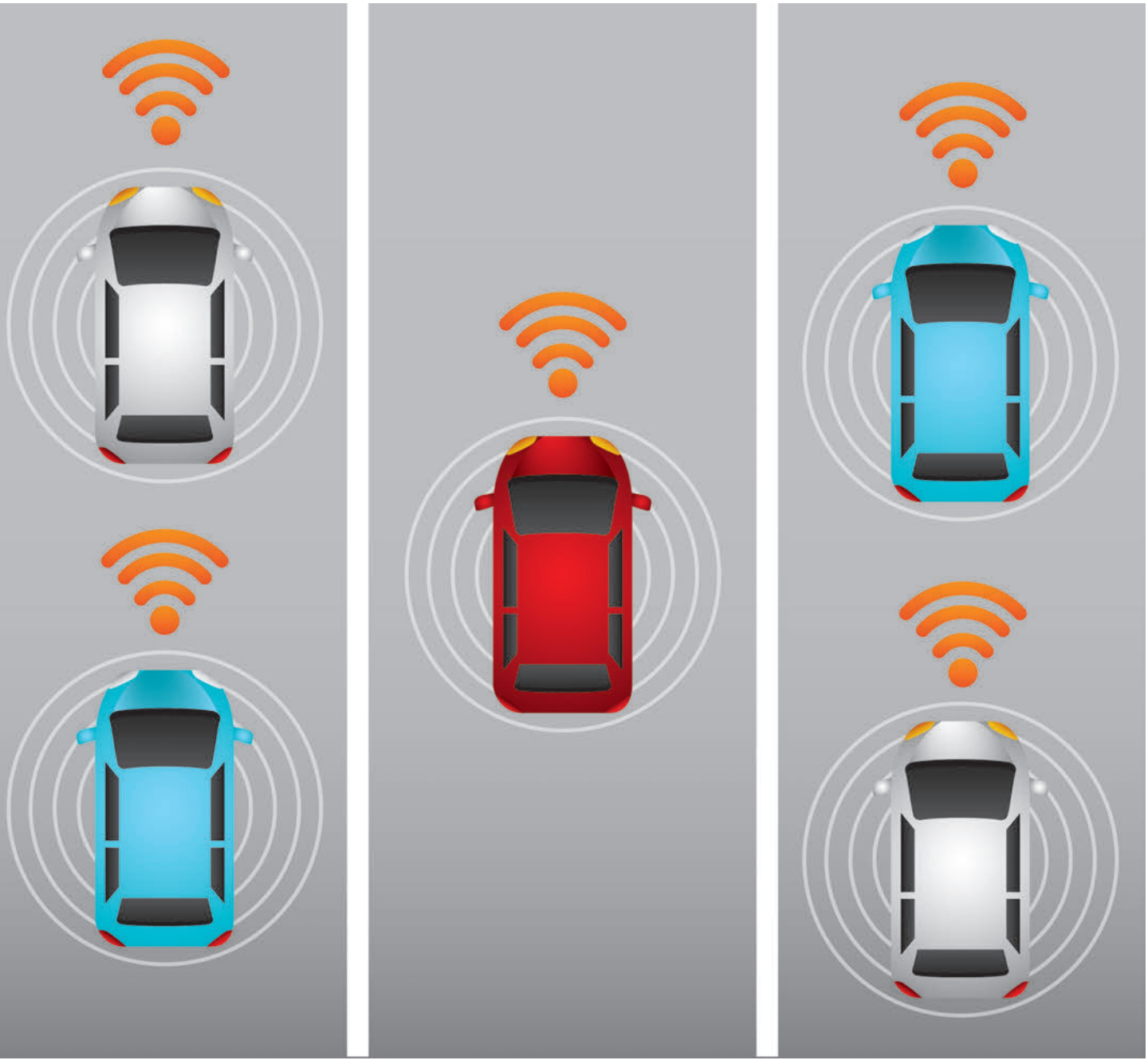
UNECE

All you need to know about Automated Vehicles

Technical progress and regulatory activities



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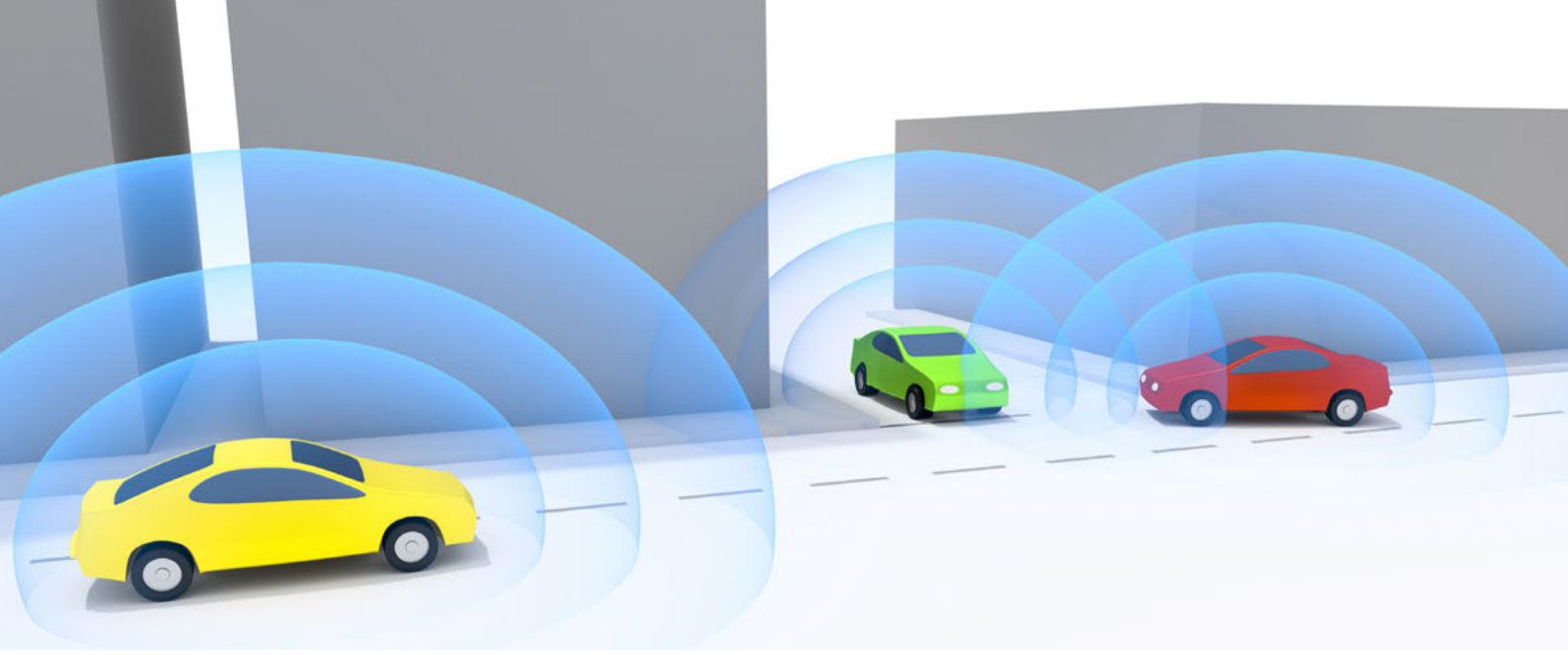

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1. Overview

The motor industry's 125-year history is an impressive succession of innovation. Today, the industry faces the challenging task to massively electrify vehicles over the next 5 to 10 years, at least in developed markets.

At the same time, with the rise and promises associated to automated driving, we are standing before what will be the biggest quantum leap forward in automotive technology in history.

Automated vehicles have the potential to change the life of billions of people and fundamentally change how road transportation works. This will be made possible by the global automotive industry, which employs some 50 million people and represents a turnover of almost $2 trillion per year.

Since it is widely acknowledged that up to 90 per cent of road crashes are at least partially due to human error, assisted and automated driving systems could reduce the human factor from the road safety equation, leading to a significant decrease in road crashes, and therefore could significantly reduce deaths and injuries on roads.

Automated driving could also support existing policies that otherwise would have no clear path to implementation, such as intelligent transport systems and mobility as a service.

Yet, all these benefits will not come at once and will not come by themselves. Conditions in some developing countries will be such that it will be difficult to accommodate autonomous driving for decades. In addition, automated vehicles raise as many questions as they offer potential benefits. These include: responsibility, safety standards, software reliability, environmental performance and cybersecurity, to name just a few.

Providing an appropriate and balanced regulatory answer to these questions is a prerequisite to the mass introduction of these vehicles on the road.

UNECE, through the World Forum for Harmonization of Vehicle Regulations (WP.29) and the UN Road Safety Instruments, is the platform where countries from all around the world gather to develop jointly the regulatory frameworks governing these vehicles. It has therefore embarked since 2014 in adapting existing legal instruments and developing new ones to facilitate the gradual introduction of automated driving functionalities.

In an effort to focus its activities on automation, UNECE established the Working Party on Automated/Autonomous and Connected Vehicles (GRVA) in 2018.

Since the establishment of GRVA, the Working Party has created a global scheme to develop requirements and guidelines for automated and connected vehicles, namely the Framework on Automated/Autonomous and Connected Vehicles (FDAV), which largely guides GRVA's work. This Framework was drafted by China, the European Union, Japan, and the United States of America and endorsed by the World Forum for Harmonization of Vehicle Regulations and the UNECE Inland Transport Committee. The document defines a safety vision, key safety elements, guidance to the Working Parties of WP.29 as well as a programme of activities. These activities, at the intergovernmental level, form a novel initiative aimed at harmonizing globally automated driving regulations and creating a more productive environment for innovation.

GRVA achieved some initial results under the 1958 Agreement, with the adoption of amendments to UN Regulation No. 79 (Steering) 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 brochure focuses on the automotive sector developments and governmental responses, as well as provides insights on the activities' development performed by intergovernmental bodies of UNECE to enable assisted and automated driving as of September 2021. It further includes a short section aimed at providing clarity about various 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. At the time of drafting this brochure, a German vehicle manufacturer was also equipping its flagship vehicle with an automated driving system.

A ride hailing system using vehicles equipped with automated driving systems is currently providing hundreds of trips per week to the public in East Valley of Phoenix, Arizona. These vehicles are not operated by human drivers, but are supervised by a remote operator monitoring the rides. In addition, Automated Shuttle manufacturers are experimenting with automated shuttles in many locations around the globe.

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

Since 2014, further developments in the field of assisted driving have occurred thanks to technical progress and industrial competition. For instance, an announcement by a search engine company as well as market pressure created by an electric vehicles manufacturer, offered a Level 2 assistance system for sale.

In Europe alone, a considerable number of vehicles were equipped with assisted driving features of Level 2 already in 2018. A year later, this amount increased significantly, reaching 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 (OEDR). Light Detection and Ranging systems (LIDARs), radars and cameras as well as Deep Learning related technologies provide opportunities for developing the highest levels of automation. These sensing and automation technologies can also be utilized for “simpler” use cases, such as safety features that provide assistance to drivers when a potential crash is detected. These “simpler” technologies include AEBS and steering assistance at low speed, Emergency Steering Function (ESF) and Risk Mitigation Functions (RMF).

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, in 2002, the Informal Working Group on Intelligent Transport Systems (IWG on ITS).

From 2002-2013, the ITS group focused on 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 (ADAS). These developments coincided with ESC's and AEBS' market entry for trucks and coaches. As these technologies and systems advanced, the ITS group shifted its attention toward automated driving systems.

From 2014-2018, the group, renamed IWG on Intelligent Transport Systems/ Automated Driving, considered the intersection between automated driving and traffic rules. It developed definitions, terms and concepts, as well as proposed recommendations on cyber security and software integrity. It received presentations on the classification of automated driving technologies from Germany (BASt), United States of America (NHTSA) at about the time the standard SAE J3016, defining automated driving levels, was drafted.

Advanced Driver Assistance Systems

During the Inland Transport Committee session in 2014, a search engine company announced the availability of their self-driving system in four years and a major automotive systems supplier presented the strategy to launch automated driving systems 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), established under the 1958 Agreement, contained the provisions for the approval of Automatically Commanded Steering Functions (ACSF) limited to 10 km/h and Corrective Steering Functions (CSF) for two decades. This speed limit prevented the type approval of driver assistance systems to achieve higher velocity. Some manufacturers developed lane keeping functions that were using the Electronic Stability Control (ESC) in order to cope with this limitation.

In 2014, activity began to develop the regulatory provisions under which the 10 km/h limitation could be exceeded. This produced the regulatory basis under which vehicle manufacturers could enter the market with ADAS, namely Levels 1 and 2 technologies.

Automated Driving Systems

The Word Forum felt that regulatory activities on assisted and automated vehicles would require more of its resources and 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) Ministers of Transport 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 profoundly transformed the way it addresses cyber security as well as further generalised ADAS systems performing lane keeping or changes on highways. These impressive developments were also supported by the first UN Regulation for approval of

Level 3 systems that perform automated lane keeping at low speed on motorways, a use case covering, for instance, congested traffic situations. The first series vehicle equipped with an Automated Lane Keeping System in conformity with UN Regulation No. 157 under the 1958 Agreement were put on the market in 2021.

Many other technologies are also in development and under trial in various regions of the world.

While some countries (mostly those applying the type approval system) are in favour of developing technical regulations (with minimum performance requirements, potentially applicable during the life cycle of a vehicle type) to accompany the development and facilitate the emergences of those technologies, other countries (most of them applying the self-certification regime) believe that guidance and recommendations are currently sufficient under a self-certification regime to provide the greatest flexibility for innovation and 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, and guidance to the Working Parties of WP.29, as well as a 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 the intergovernmental level, form a novel initiative aimed at harmonizing globally automated driving regulations and creating a more productive environment for innovation.

The World Forum WP.29 unanimously endorsed 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 Over-The-Air issues and Data Storage System for Automated Driving / Event Data Recorder (DSSAD/EDR), 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 documents for contracting parties to the 1958 and 1998 Agreements, for global harmonization:

(a) Recommendations for Automotive Cyber Security and Software Update (draft).

(b) Guidance on Event Data Recorder - Performance Elements Appropriate for Adoption under the 1958 and 1998 Agreements (draft).

(c) First iteration of the New Assessment/Test Method for Automated Driving (NATM) - Master Document.

(d) Second iteration of the New Assessment/Test Method for Automated Driving (NATM) - Master Document (draft).

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 No. 160 (Event Data Recorder).

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 an interesting question from an academical point of view.

However, it is currently expected, given the current technological state of the art, 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 of stop whenever circumstances so require […]. From the safety point of view, if this rule is imposed on 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 in cases when avoidance is impossible, instead of computing highly complex and subjective parameters related to potential victims.

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

This myth implies that self-driving (automated driving system) primarily relies on wireless communication (Wi-Fi, LTE, 5G etc.). However, no automated driving technology rely on off-board information to drive. Automated driving systems consist of onboard hardware, software, and sensors that together perform the entire dynamic driving task. On the contrary, remote driving (also known as teleoperation) and vehicle-to-vehicle communications do rely on off-board information, but neither of those technologies constitute automated driving, nor are under mass production. Before telecommunications can safely perform a driving task, matters related to network coverage, latency and interference would need to be addressed for all locations and conditions.

Relying on external information could create a dilemma. For example, at a road crossing, does the absence of a signal (supposed to inform on the presence of a vehicle) really mean the absence of a vehicle? It could be that a vehicle has a technical defect and is not properly emitting, or that interference disturb the communication.

Progress of vehicle-to-vehicle communications and vehicle to infrastructure communications are going on. Such telecommunication technologies will in the future create added values and could potentially enhance automated driving system, supporting a "natural driving" vehicle behaviour and more comfort for vehicle occupants and off board information could contribute to "anticipation".

For the time being, UN Regulation No. 79 defines autonomous steering systems 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 enables self-driving cars for sale to the public

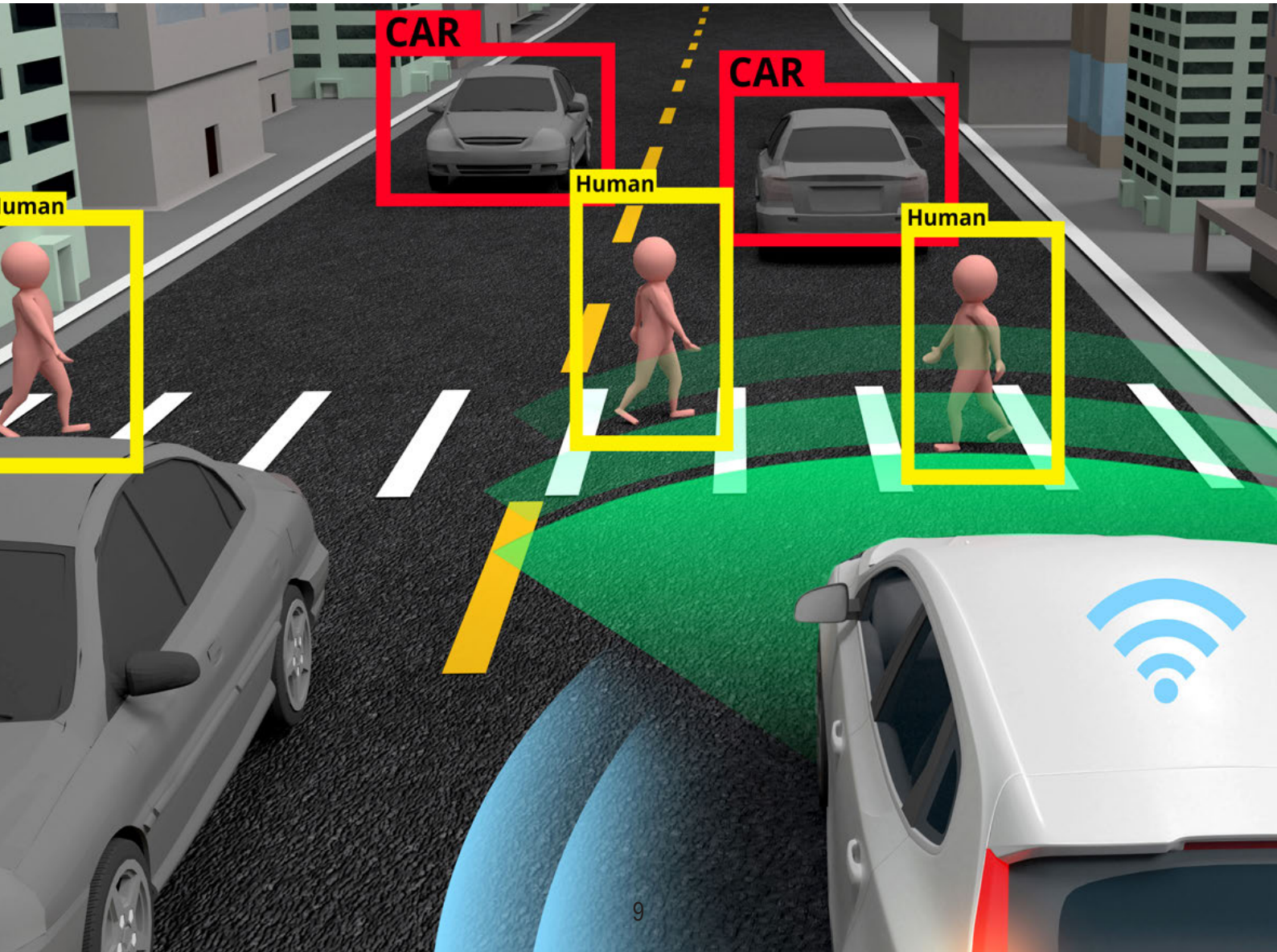
There is no product for sale to the public that is technically self-driving on public roads. Even the most advanced technology under trial remains under the control or supervision of an operator that can take over the control of the "ego vehicle" in case of an issue. Automated driving exists currently 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 in vehicles for sale to the public do not enable automated driving systems without any supervision that could allow a driver to sleep. In fact, UNECE observes a different trend: manufacturers have started implementing driver monitoring functions in vehicles that require the vehicle to verify the availability of the fall-back user in case the individual should resume the driving task. Level 4 ride-hailing applications that do not have a human driver nor a fall-back user will allow for passengers to take naps throughout a trip, as these trials are performed under remote supervision.

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 Sustainable Development Goal (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 such systems. It is expected that vehicles equipped with automated driving systems (Level 3 through 5) will not commit the same errors (e.g. impaired driving or distraction) that cause the vast majority of vehicle crashes today.

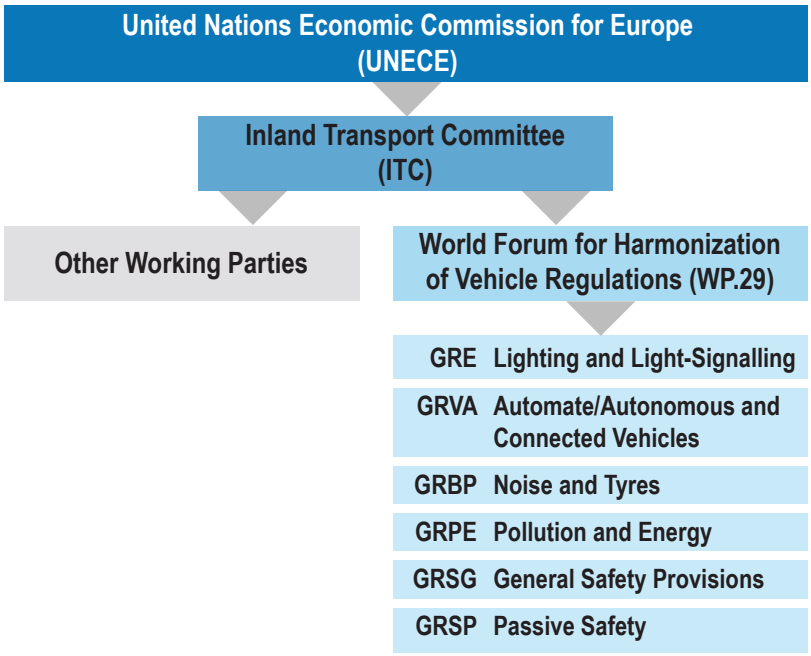


Glossary

"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) worldwide 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: https://unece.org/transport/vehicle-regulations.

"UN 1998 Agreement" is the Agreement Concerning the Establishing of Global Technical Regulations (GTRs) 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 the Agreement had 38 Contracting Parties. To date, 22 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 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.29/2019/34/Rev.2
- **Reference document (levels of autonomy): ECE/TRANS/WP.29/1140**
- **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. 3.
- **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 Control)** 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.
- **ISO/SAE PAS 22736:2021 / SAE: J3016**
  Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles
  https://www.sae.org/binaries/content/assets/cm/content/blog/sae-j3016-visual-chart_5.3.21.pdf

For further reading:

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

Documents with "official symbols" (e.g. ECE/TRANS/WP.29/1140) can be accessed via
https://undocs.org/ + symbol = document.

(e.g. https://undocs.org/ECE/TRANS/WP.29/1140)

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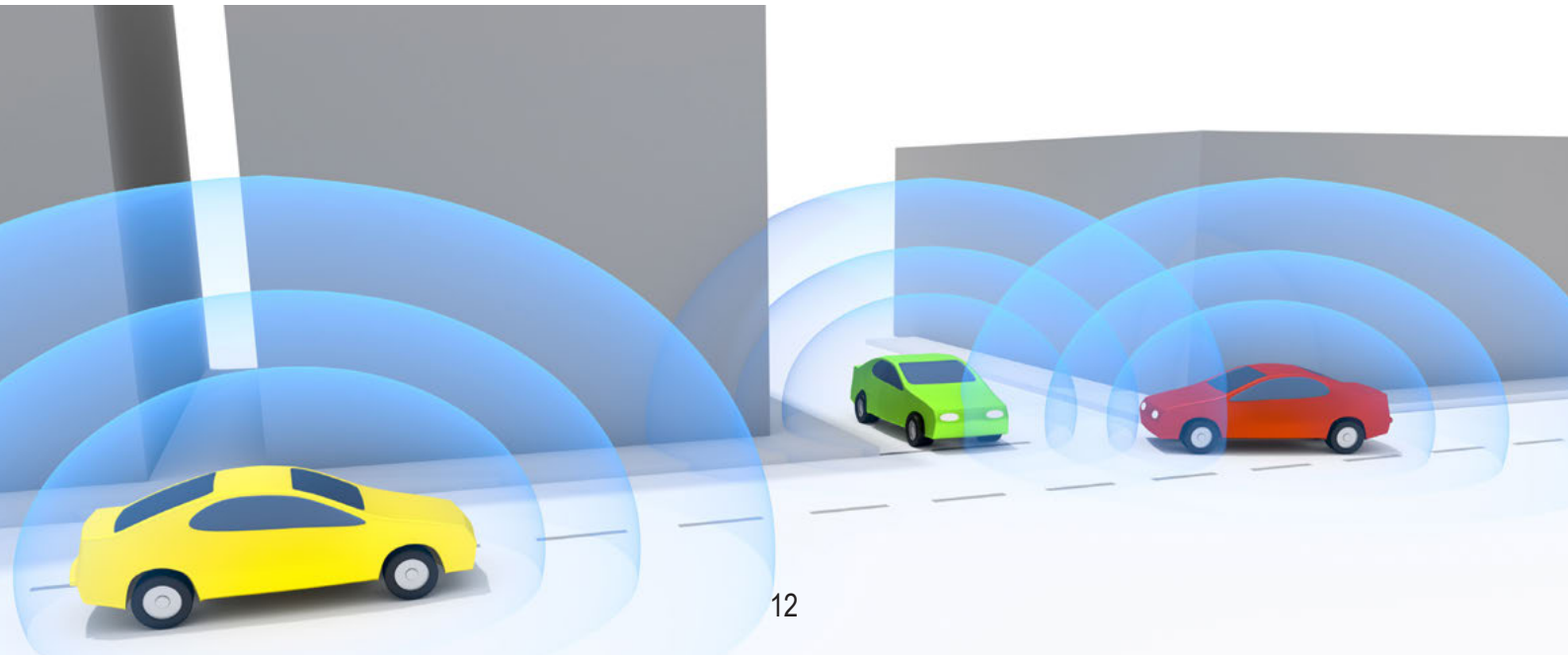

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Information Service
United Nations Economic Commission for Europe

Palais des Nations
CH - 1211 Geneva 10, Switzerland
Telephone: +41(0)22 917 12 34
E-mail: unece_info@un.org
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