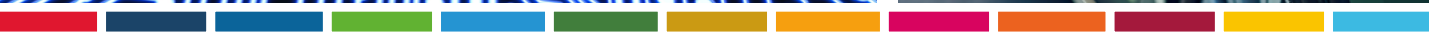
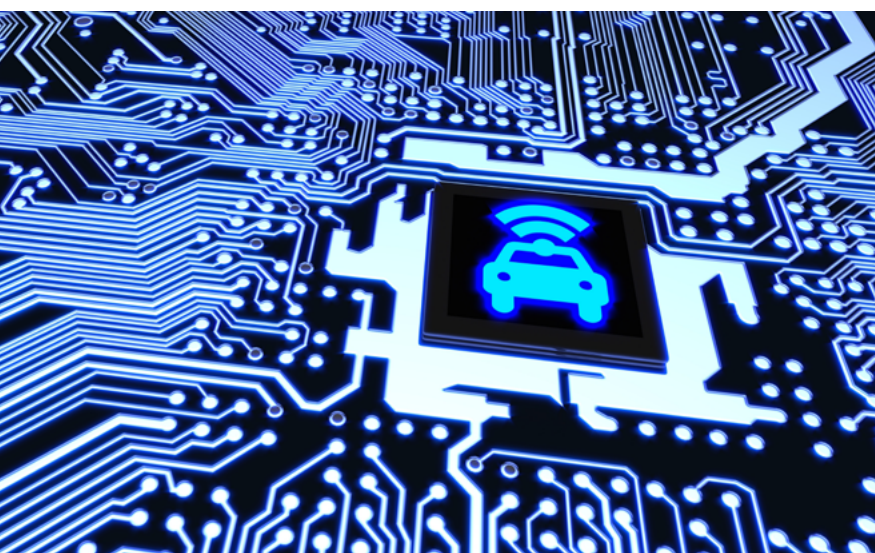


UNECE

Intelligent Transport Systems (ITS) for Sustainable Mobility, Second Edition

Part of the WP.29 “How it works – How to join it” series



UNITED NATIONS

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Geneva, 2023

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Foreword

In our contemporary world, where concerns over road safety and sustainable transportation have assumed paramount importance, the imperative for action cannot be overstated. The sobering statistics underscore the urgency of our mission: annually, road traffic accidents claim over 1.35 million lives and inflict approximately 50 million injuries on a global scale. The transport sector is also a contributor to climate change, accounting for about 23 percent of global energy-related carbon dioxide (CO₂) emissions. These stark figures underscore the pressing need for effective solutions that cohesively address both the safety and environmental concerns of transportation.

However, there is a widely shared consensus that advanced technologies, such as intelligent transport systems (ITS), can help improve this situation. Over the past decade, we have witnessed a concerted effort to harness the transformative potential of ITS, with a particular emphasis on the unfolding narrative of automated and connected vehicles. One of the key upcoming developments is the completion of the “Guidelines for Regulatory Requirements and Verifiable Criteria for Automated Driving System (ADS) Safety Validation” by the Working Party on Automated/Autonomous and Connected Vehicles (GRVA). This accomplishment signifies a pivotal milestone, the culmination of international collaborative endeavours uniting diverse global stakeholders, including Contracting Parties, subject-matter experts, and dedicated industry players, all ardently committed to advancing the goals of vehicle safety and sustainable transportation.

Yet, in our journey towards realizing the full potential of ITS, the path ahead demands further sustained and coordinated efforts across countries. Our focus should expand to encompass connectivity in its entirety, alongside the complex field of data collection, analysis, and accessibility. It is imperative that we extend intelligence beyond the confines of the vehicle, harmoniously integrating it into the broader transport infrastructure. It is through this holistic and integrated approach that we stand to fully leverage ITS, steering us toward the optimization of traffic flow, the curbing of accidents, the reduction of emissions, and the ultimate creation of a safer, more sustainable future.

This publication stands as a testament to the unwavering commitment of those who have paved the way for progress. It builds upon the firm foundations laid by its predecessor in 2012, offering an encompassing view of the remarkable developments and achievements that have unfolded over the past decade in the realm of Intelligent Transport Systems. It encompasses a synthesis of the progress that was made and provides insights and recommendations for the path ahead.

Tatiana Molcean
United Nations Undersecretary-General
Executive Secretary of the
United Nations Economic Commission for Europe

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Introduction

United Nations Economic Commission for Europe



The United Nations Economic Commission for Europe (ECE) 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, ECE 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, ECE acquired not only many new member States, but also new functions. Since the early 1990s the organization has focused on assisting the countries of Central and Eastern Europe, Caucasus and Central Asia with their transition process and their integration into the global economy. Today, ECE supports its 56 member States in Europe, Central Asia and North America in the implementation of the 2030 Agenda for Sustainable Development with its Sustainable Development Goals (SDGs). ECE provides a multilateral platform for policy dialogue, the development of international legal instruments, norms and standards, the exchange of best practices and economic and technical expertise, as well as technical cooperation for countries with economies in transition. Offering practical tools to improve people's everyday lives in the areas of environment, transport, trade, statistics, energy, forestry, housing, and land management, many of the norms, standards and conventions developed in ECE are used worldwide, and a number of countries from outside the region participate in ECE's work. ECE's multisectoral approach helps countries to tackle the interconnected challenges of sustainable development in an integrated manner, with a transboundary focus that helps devise solutions to shared challenges. With its unique convening power, ECE fosters cooperation among all stakeholders at the country and regional levels.

Transport in the Economic Commission for Europe

All over the globe affordable, efficient and sustainable transport systems will make a huge difference in the way we live our lives. Transportation is expected to be the major driving force behind a growing world demand for energy and it will play a key role in many areas, like emerging economies, where the improvement of transport networks will lead to improved access to markets, improved employment and educational opportunities as well as the establishment of basic services critical to poverty reduction, among other things.

Within the United Nations, the platform for inland transport is the Inland Transport Committee (ITC) of ECE. It was formally established in July 1947, four months after the founding of ECE. It took over the roles of the European Central Inland Transport Organization (ECITO) which was established to restore international transport and support the reconstruction of Europe. One of the primary objectives of ITC was to stimulate international cooperation and promote agreements on long term inland transport policy in Europe.

Over the past 75 years, the ITC programme of work has been dynamically evolving in response to emerging demands. At the same time, it has remained a centre for inland transport. In essence, the main outcome of the work of ITC is a set of constantly renewed and updated international agreements, conventions, and other international legal instruments, as well as recommendations on key inland transport issues.

Today, ITC services 59 United Nations inland transport conventions. Several of the Conventions are global either by design or because their success has caused them to grow beyond the ECE region. In addition to negotiating the amendments to existing legal instruments, ITC has been active in facilitating new legal instruments. Its normative activities are enhanced with developing methodologies, guidelines, and definitions on subjects such as transport planning, data collection and the collection of transport statistics.

ITC functions with the support of the work of its 20 Working Parties which are in turn supported by more than 40 formal and informal expert groups and in cooperation with 11 Treaty bodies (Administrative Committees).

Annual sessions of ITC are the crown moments of this comprehensive intergovernmental work, when results from all subsidiary bodies, as well as the ECE Sustainable Transport Division, are presented to ITC members and contracting parties.

The Sustainable Transport Division provides the secretariat to ITC and its subsidiary bodies, and services other intergovernmental bodies including the ECOSOC Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals, as well as 11 treaty bodies of United Nations legal instruments and the Transports Internationaux Routiers (TIR) Executive Board.

In cooperation with ESCAP, ECE's Sustainable Transport Division supports the United Nations Special Programme for the Economies of Central Asia. It also annually alternates with ESCAP as the secretariat to the SPECA Thematic Working Group on Sustainable Transport, Transit and Connectivity.

In cooperation with the ECE Environment Division and World Health Organization (WHO) Europe, the Division services the Transport, Health and Environment Pan-European Programme (THE PEP). It ensures the management and oversight of the Trans European North-South Motorway (TEM) and the Trans-European Railway (TER) projects.

Finally, since 2015, ECE hosts the secretariat of the United Nations Secretary General's Special Envoy for Road Safety and since 2018 the secretariat of the United Nations Road Safety Fund (UNRSF). Additionally, as part of the United Nations, the secretariat has been responsible for supporting the accession and implementation of the legal instruments through policy dialogues, technical assistance, and analytical activities with the priority of promoting regional and subregional cooperation and capacity-building.

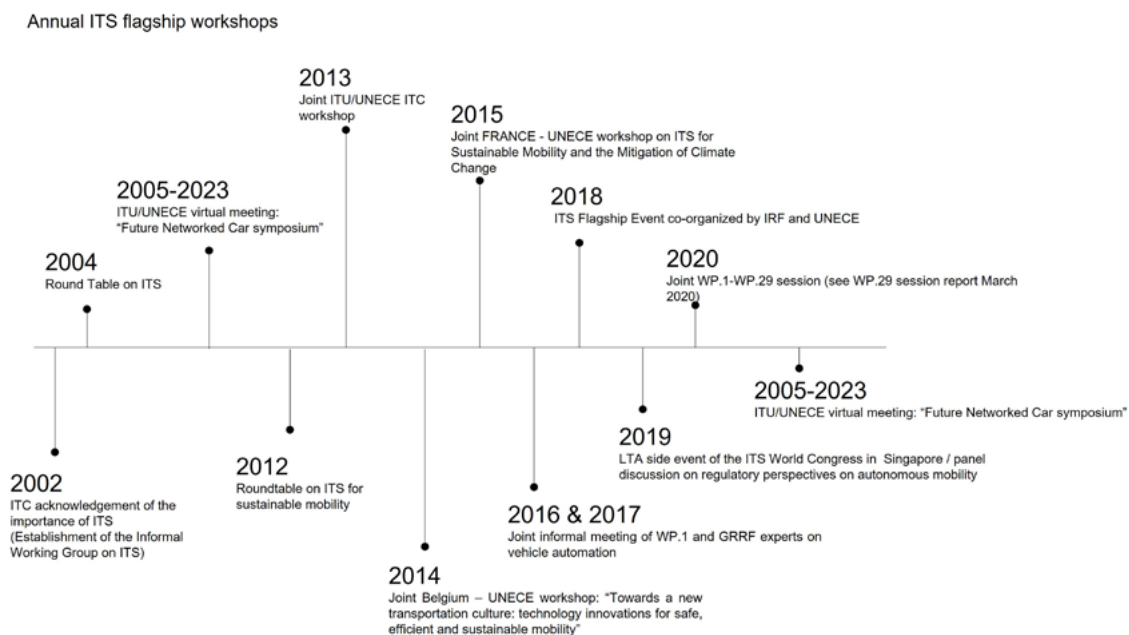
All these different bodies work in symbiosis, which is facilitated by the services ensured by the common vision and goals. The intra-Committee and cross sectoral coordination activities ensure a high level of synergy and results that facilitate progress by its Working Parties in several areas, and especially in promoting multi-modal thinking, Intelligent Transport Systems and innovative technologies. Thus, ITC results are much more than its constituent parts.

Intelligent Transport Systems in the Economic Commission for Europe

Intelligent Transport Systems (ITS; also called Intelligent Transportation Systems in the United States and several other nations) are considered a part of the solution to current and future transport challenges. They are widely recognized as an efficient instrument towards achieving safe, smart and sustainable mobility. The majority of potentials and benefits, however, can only be reaped if ITS solutions are put in place across multiple nations regardless of borders, internationally harmonized as much as possible and if technical and policy challenges can be overcome.

In 2002, ITC identified the use of telematics and ITS as an issue that could become a major challenge for the future, or possibly change direction of its work. This conclusion led to the organization of a Round Table on Intelligent Transport Systems under the auspices of the World Forum for Harmonization of Vehicle Regulations, WP.29, back in 2004, another building block in developing the UNECE strategy on development of legislative and practical implementation of ITS.

Figure 1 Annual ITS flagship workshops



Source: UNECE

ECE and ITC launched activities for the formulation of a common strategy for the future implementation of ITS solutions. This initiative resulted in the elaboration of the 2012–2020 Road Map on ITS – "20 global actions to promote the use of ITS".

The Road Map on ITS outlined areas and listed activities that ECE could embark upon in addressing impediments to the broader and faster dissemination of ITS applications. At its 2020 session the ITC noted with satisfaction that the 2012–2020 Road Map on ITS encouraged ITS activities linked to infrastructure and all transport modes, and contributed to addressing ITS issues in an integrated approach. As the 2012–2020 Road Map on ITS had come to its conclusion, the ITC at its eighty-second session (ECE/TRANS/294, para. 32) decided that an updated Road Map on ITS would be warranted. Therefore ITC requested the secretariat in close cooperation with relevant Working Parties and subsidiary bodies, to prepare it for consideration in the framework of relevant Working Parties and the ITC Bureau and possible endorsement at its eighty-third session.

Following this decision, the ECE secretariat initiated activities to prepare a revision of the ECE Roadmap on ITS. The secretariat consulted the Co-Chairs of the Informal Working Group on ITS on the basis of the existing 2012–2020 Road Map and sought guidance on necessary amendments. The secretariat launched consultations of the Working Parties and subsidiary bodies and requested inputs from the stakeholders. The draft received numerous comments, despite disruptions created by the COVID-19 pandemic, that were all incorporated. The latest version of the Road Map on ITS for the period 2021–2025 is reproduced ([ECE/TRANS/2021/15](#)) is reproduced in the annex of this publication.¹

¹ 83rd session of ITC, "Draft revision of the UNECE Road Map on Intelligent Transport Systems", ECE/TRANS/2021/15

I. Overview of Intelligent Transport Systems

Intelligent transport systems have the potential to enhance safety and to revolutionize mobility, to improve the way we move and communicate. The foundation to enable improvements in the mobility of people and transportation of passengers and goods, and to develop and deploy ITS is Information and Communication Technologies (ICT), which include a wide range of technology-based systems. Some of these systems as well as some of the relevant definitions related to ITS will be detailed in the following. The publication does not cover digitalization of custom related cross border proceedings and the carriage contracts under civil law.



A. Definitions, developments and mobility services related to ITS

1. Intelligent Transport Systems

Intelligent transport systems are defined in different ways in various jurisdictions:

- United States Code of Federal Regulations Title 23, Chapter 1, Subchapter K, Part 940.3:

“Intelligent Transportation System (ITS) means electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system.”

Or, as defined by the U.S. DOT Intelligent Transportation Systems Joint Program Office (ITS JPO) in the *ITS JPO Strategic Plan, 2020 – 2025* (FHWA-JPO-18-746, May 2020²):

“ITS improves transportation by integrating advanced information and communications-based technologies (ICT) into transportation infrastructure and vehicles. ITS refers to a system of technologies and operational advancements that, when combined and managed, improve the capabilities of the overall transportation system.”

- European Union (Directive 2010/40/EU, June 2010):

“Intelligent Transport Systems (ITS) are advanced applications which without embodying intelligence as such aim to provide innovative services relating to different modes of transport and traffic management and enable various

² Accessible at: https://www.its.dot.gov/stratplan2020/ITSJPO_StrategicPlan_2020-2025.pdf

users to be better informed and make safer, more coordinated and ‘smarter’ use of transport networks. ITS integrate telecommunications, electronics and information technologies with transport engineering in order to plan, design, operate, maintain and manage transport systems. The application of information and communication technologies to the road transport sector and its interfaces with other modes of transport will make a significant contribution to improving environmental performance, efficiency, including energy efficiency, safety and security of road transport, including the transport of dangerous goods, public security and passenger and freight mobility, whilst at the same time ensuring the functioning of the internal market as well as increased levels of competitiveness and employment.”

- European Telecommunications Standards Institute (ETSI³):

“Intelligent Transportation Systems (ITS) aim to provide services relating to different modes of transport and traffic management, enable users to be better informed and make safer, more coordinated and ‘smarter’ use of transport networks. They include advanced telematics and hybrid communications including IP based communications as well as Ad-Hoc direct communication between vehicles and between vehicles and infrastructure.”

- SAE (SAE J2725, November 2022):

“Systems that apply information technology to transportation challenges. ITS will often integrate components and users from many domains, both public and private. ITS improves transportation safety and mobility and enhances productivity through the integration of advanced communications technologies into the transportation infrastructure and in vehicles. Intelligent transportation systems (ITS) encompass a broad range of wireless and wire line communications-based information and electronics technologies.”

- Society of Automotive Engineers of Japan, Inc. (“ITS Standardization Activities of ISO/TC 204”, Publication October 2021):

“ITS (Intelligent Transport Systems) is designed to rapidly improve road traffic safety, transport efficiency and comfort and to significantly contribute to energy and environmental conservation through traffic flow facilitation, such as elimination of traffic jams, by using communication technologies to link between people, infrastructure and vehicles. Due to its wide variety of related technologies and its ability to drastically change social and economic structures, ITS has the potential to create new industries and markets.”

- PIARC (World Road Association):

“Intelligent Transport Systems are the control and information systems that use integrated communications and data processing technologies for the purposes of:

- improving the mobility of people and goods
- increasing safety, reducing traffic congestion and managing incidents effectively
- meeting transport policy goals and objectives –such as demand management or public transport priority measures”

Although there is no common view on what ITS means for transport, there are a lot of commonalities between the existing definitions.

³ Accessible at: <https://www.etsi.org/technologies/automotive-intelligent-transport>

Figure 2 Word Cloud Showing the Commonalities of Different ITS Definitions



Source: UNECE

2. Developments related to ITS

More recent developments in the area of ITS are focusing on the communication between ITS solutions, vehicles, infrastructure and/or users. These technologies are named differently, for example **Intelligent and Connected Vehicles (ICV)** in the People’s Republic of China, **Cooperative-ITS (C-ITS)** in the European region and **Connected Vehicles (CV)**, **Vehicle-to-Everything (V2X)** or **Cellular Vehicle-to-Everything (C-V2X)** in the United States of America. Various definitions exist, some of them are mentioned below:

- People’s Republic of China, Guidelines of Construction of National Intelligent and Connected Vehicle (ICV) Industry Standard System (2018 edition), please see more details in box 1.

Box 1 Progress of China’s ICV Standard System

“This comprehensive plan systematically laid out the development and deployment of the Chinese ICV standard system in stages. The first phase of the Chinese ICV standard system construction has been successfully completed, establishing a foundation that supports advanced driver assistance and low-level automated driving. This achievement effectively met the industry’s developmental and management requirements.

To adapt to the new trends, characteristics, and demands in the evolving landscape of Chinese ICVs, China revised and produced the “2023 Edition Guidelines.” This new edition adopts a phased planning approach, summarising the progress in the current standard system while presenting a specific plan for two phases, targeting the years 2025 and 2030. The planned standard system encompasses three major categories: basics and general specifications, and product and technology applications, with more than 100 standards envisaged.

Compared to the previous version, the new edition introduces technical standards in areas of current interest such as intelligent cockpits and data protection. Overall, this new standard system is more aligned with the practical needs of China’s intelligent and connected vehicle industry development.”

Source: China Automotive Technology and Research Center (CATARC), October 2023

- EU directive 2010/40/EU, review proposal 14 December 2021 and Communication from the Commission to the European Parliament regarding a European strategy on Cooperative Intelligent Transport Systems is defining C-ITS as follows:

“Cooperative intelligent transport systems mean intelligent transport systems that enable ITS users to cooperate by exchanging secured and trusted messages.”

- “[...] Cooperative Intelligent Transport Systems (C-ITS), [...] will allow road users and traffic managers to share and use information previously not available and to coordinate their actions. This cooperative element – enabled by digital connectivity – is expected to significantly improve road safety, traffic efficiency and comfort of driving, by helping the driver to take the right decisions and adapt to the traffic situation.”
- ETSI's definition of C-ITS⁴:

“Cooperative-ITS and its evolution to increasingly improve road safety and pave the way towards the realization of full autonomous driving based on the exchange of information via direct wireless short range communications dedicated to C-ITS and Road Transport and Traffic Telematics (RTTT).

- C-ITS data exchange, data formats and dictionaries
- C-ITS connectivity: This includes Ad-Hoc communication protocols for direct communication among road participants and between road participants and infrastructure.
- C-ITS Security: This includes trust and privacy management and certificate formats”

- U.S. Department of Transportation (USDOT):

“Vehicle-to-everything (V2X) technology enables vehicles to communicate with each other, with other road users such as pedestrians and cyclists, and with roadside infrastructure. Deployments utilizing V2X technologies have demonstrated the safety benefits on a smaller scale. However, to realize the full lifesaving potential of V2X technology will require vehicles and infrastructure to communicate safely, securely and without harmful interference across a variety of devices and platforms.

Integrating technology and connectivity into a vision zero approach requires that technology operates with many other devices, users, vehicles, and infrastructure. We call this ‘interoperable connectivity,’ where a diverse range of mobile, in-vehicle, and roadside technologies must be able to communicate everywhere, efficiently, securely and protect personal information. Connected V2X technology must be reliable and seamless to allow communities and users to effectively move across boundaries, meeting their needs and destinations every day.

V2X communication enables the Safe System approach adopted by the USDOT National Roadway Safety Strategy (NRSS). The Safe System approach is a holistic and comprehensive approach that provides a guiding framework to make places safer for people. It works by building and reinforcing multiple layers of protection to both prevent crashes from happening in the first place and minimize the harm caused to those involved when crashes do occur.

The National Roadway Safety Strategy directs the USDOT to advance the use and deployment of V2X and other technologies to advance safer roadways. The National Transportation Safety Board has likewise identified V2X connectivity as a safety-critical “most wanted” technology. Technology advancements in vehicles and infrastructure have enabled incremental improvements in roadway safety over the last decade, but roadway fatalities and injuries have taken a turn in the wrong direction. For example, NHTSA estimates 42,795 motor vehicle fatalities occurred in 2022, up 18 per cent from 36,355 fatalities in 2019. A broader, transformational approach, defined by the Safe Systems approach in the NRSS, includes leveraging advanced technologies that can prevent or mitigate crashes. Bold leadership is needed to ensure connected V2X technologies are integrated into the surface transportation system. Not only does V2X technology save lives, but it also enhances mobility, bolsters efficiency, and reduces negative environmental impacts. Accelerating V2X deployment now is a crucial step to save lives.”⁵ Other Countries work on ITS such as Japan, as detailed in Box 2.

⁴ Accessible at: <https://www.etsi.org/technologies/automotive-intelligent-transport>, accessed on 10.11.2023

⁵ Text provided by USDOT, 1.11.2023

Box 2 ITS in Japan

“In the development of ITS in Japan, we have established a roadmap for public-private cooperation, continuously revised it to share major directions among stakeholders, set up Strategic Innovation Program (SIP) activities to lead the development of innovative technologies, and established high-precision 3D map technology as a key technology indispensable for automated driving. We have expanded our services through communication technology. The process of investigating V2X/V2N issues related to these achievements is to define what the target applications are, develop use cases according to definitions, formulate communication requirements based on use cases, examine technologies using existing communication methods, and extract issues through demonstration experiments. In recent years, Japan initiatives have gone through this process to identify specific issues for introduction, such as the need for new communication methods with negotiation functions, new communication methods according to the degree of penetration, securing new wireless bands, standardization of communication methods, ensuring security and privacy protection, and planning for generational change. The necessity of new communication technologies for solving problems and a roadmap for their realization were proposed. Based on these results, an appropriate process for the realization of cooperative automated driving is currently underway, but prior to the implementation of autonomous driving, we are continuously considering its application and dissemination in safe driving support.”

Source: Japan Automobile Standards Internationalization Center (JASIC), October 2023

3. Mobility services powered by ITS



(a) Mobility as a Service

Mobility as a Service (MaaS) is a mobility concept gaining pace in many cities around the world. Its value proposition concerns integration of mobility options and services which is realized by providing trip planning and one-stop fare purchase for the user through a single platform, regardless of service provider(s) and mode(s). There is a growing amount of literature which documents that MaaS is a promising mobility concept and it is expected to deliver several economic, societal, transport-related and environmental benefits.

Three groups of stakeholders are expected to benefit from it, namely: end users (travellers), businesses and the public sector. Travellers may benefit from seamless, easy-accessed, high-quality and value-for-money mobility. In addition, if both public and private transport operators/providers join a MaaS scheme, then there is potential to provide customised mobility options and better accessibility to people with disabilities or reduced mobility. Businesses identify new markets and new business opportunities, while active transport operators may ensure cost reduction in individual operations. The public sector, with the implementation of MaaS may expect the creation of new jobs, resource allocation efficiency and improvement in transport system reliability. Also, environmental and societal benefits are feasible, should MaaS be designed so as to promote low energy consumption and environmentally friendly mobility solutions. Finally, reduced dependence on private vehicles has been documented as a potential benefit of MaaS.

MaaS has been widely debated by researchers but a unique definition for MaaS is still pending. Most consider as key feature the potential to deliver integrated mobility to enable end-to-end trips by offering services combining different transport modes provided by different transport service providers under a single platform and a single service provider for trip planning, scheduling, ticketing and payment.

This reflects the first comprehensive definition of MaaS “a mobility distribution model in which a customer’s major transportation needs are met over one interface and are offered by a service provider”. Later MaaS was described as “a user-centric, intelligent mobility management and distribution system, in which an integrator brings together offerings of multiple mobility service providers and provides end-users access to them through a digital interface, allowing them to seamlessly plan and pay for mobility”. Depending on the feature of MaaS considered most important, researchers focus on customization and user-centric features of MaaS, or envision MaaS as an opportunity to deliver a more sustainable transport system by the reduction of private car usage and increasing the use of electric vehicles.⁶

Hence, as promoted in the definition of MaaS, there are four key objectives of the development of MaaS as transportation system:

- Seamless and efficient flow of information, goods, and people both locally and on long distances;
- Globally scalable door-to-door mobility services without using a private car;
- A better level of service than the private car; and
- An open ecosystem for information and services in intelligent transportation. MaaS can be established for specific target groups.

MaaS can thus respond to different mobility demands providing different mobility solutions. Among them:

1. Business-to-customer (B2C) solution – MaaS is designed for travellers being commuters and residents of cities and region, as well as tourists, to meet their mobility needs, such as seamless travel from A to B, easy booking and payment for all integrated services and saving of either money or time while travelling on the modes recommended through the MaaS platform.
2. Business-to-employee (B2E) solution – MaaS is designed to serve employees of an enterprise taking their expectations and preferences into account while reducing the costs of employee’s mobility.
3. Business-to-business (B2B) solution – MaaS is designed to combine various mobility service operators/providers with various MaaS providers to create a networking platform aimed at fostering MaaS in general.⁷

(b) Intelligent Transport Systems in Car-Sharing and Car Pooling

The concept of car-sharing, which provides consumers with access to vehicles for short-term rental, emerged in the 1940s. These systems used key boxes, reservations were made by phone call, with paper recording of usage. These low-tech systems meant that they were difficult to scale, and therefore it did not emerge as a common service. The evolution and usage of IT systems in recent years has changed this situation. The launch of smartphones (in 2007) and development of applications allowed digital services like ride-hailing, which recently made it possible to go through the whole rental process, including searching, booking, billing, (un)locking of cars only by using an app and reducing the effort, as visiting a rental desk is not needed anymore. This made car sharing commercially efficient and improved the consumer experience.⁸

Following this development, car-sharing has been increasing over recent years, as can be represented by the following figures:

- The revenue is expected to show an annual growth rate (CAGR 2023-2027) of 5.64 per cent, resulting in a projected market volume of US\$16.04bn by 2027.
- In the Car-sharing segment, the number of users is expected to amount to 62.11m users by 2027.
- User penetration is 0.7 per cent in 2023 and is expected to hit 0.8 per cent by 2027.

⁶ ECE/TRANS/285

⁷ UNECE, “Transport Trends and Economics 2018-2019 - Mobility as a Service”, ECE/TRANS/285

⁸ ECE/TRANS/285 and ECE/TRANS/302

- The average revenue per user (ARPU) is expected to amount to US\$241.10.
- In the Car-sharing segment, 96 per cent of total revenue will be generated through online sales by 2027.
- In global comparison, most revenue will be generated in the United States (US\$2,888.00m in 2023)⁹

Car pooling, where drivers can share empty seats on their vehicles for pre-defined journeys, has also benefited from digitalization of this kind of services, easing the way to find suitable persons to share their journey.

Car-sharing and car pooling provide alternative means of access to a vehicle for consumers, reducing the need for individual vehicle ownership. Offering the flexible access and use of a vehicle can aid integration with the wider mobility system, where shared cars can be used to provide links to other modes.¹⁰ The UNECE publication “Strengthening the capacity of Central Asian countries to develop sustainable urban mobility policy on car sharing and carpooling initiatives” shows how these mobility services can be part of an urban multimodal transport system, having the potential to contribute to a more efficient use of available resources.¹¹



(c) Intelligent Transport Systems in Bike-Sharing and other forms of shared micro mobility

Bike-sharing is one form of fast-growing, sustainable transport. It represents an important option in the repertoire of traveller choice, which has been shaped by the introduction of ICT with regard to – for instance – urban analytics and digital integration in multimodal transport networks.

The first generation of bike-sharing started in the mid-1960s in Amsterdam, where 10,000 bicycles were distributed throughout the city so that anyone could use them for free. The second generation, introducing docking stations, started in the late 1990s. With the third generation from the late 1990's, digital technologies entered the “value chain” of bike-sharing to complement a business and operations model that could then focus on upgrading the complex interaction between bicycles, infrastructure and logistics.

One of the first cities that used IT solutions to improve bike sharing was Rennes. In 1998, the city decided to incorporate IT solutions to create a technologically sophisticated system that worked with fixed docks and magnetic smartcards for the check-out and return of the bicycles. The racks contained a controller, which consisted of a Global System for Mobile Communications (GSM) modem, a Central Processing Unit (CPU), a card reader and a power supply. The bicycles were equipped with microchips, and a central computer downloaded information stored in each docking station. From a logistical point of view, this made it easier to transport bicycles from full docks to empty ones (or to a repair centre). This example has been followed by many other cities all over the world.¹²

⁹ Accessible at: <https://www.statista.com/outlook/mmo/shared-mobility/shared-rides/car-sharing/worldwide>

¹⁰ ECE/TRANS/285

¹¹ ECE/TRANS/302

¹² ECE/TRANS/285

In the United States, Washington D.C was the first US city to launch a bikeshare system: Capitol Bikes in 2010. It continues to be one of the most popular systems in the nation and has attracted several other scooter and e-bike players. Bike share and scooter systems have expanded exponentially since then. The total number of these systems has reached almost 300, serving more than 200 U.S. cities.¹³

Nowadays technology has improved further. Thanks to ICT and the enabled mobility solutions, users can access via an app or a website the status of the service, inquire about the availability of bicycles in a specific docking station, or manage their user accounts and interact with the operating company.¹⁴



The increasing importance and growth of the Bike-Sharing segment can also be seen in numbers:

- Expected annual growth rate (CAGR 2022-2026): 11.48 per cent, resulting in a projected market volume of US\$12.29bn by 2026.
- Expected number of users: up to 930.3m users by 2026.
- User penetration: 10.0 per cent in 2022; expected to hit 11.8 per cent by 2026.
- The average revenue per user is expected to amount to US\$10.46.
- In the Bike-sharing segment, 92 per cent of total revenue will be generated through online sales by 2026.¹⁵

B. Technical overview of ITS technologies

Before the 1980s, ITS research focused on in-vehicle navigation and route guidance systems. The first ITS technologies, e.g. Traffic Control Centres/ Traffic Management Centres, aimed at monitoring traffic, improving traffic safety, and reducing congestion. In the early to mid-1990s, one of the streams of ITS evolution was moving from passive information sharing to more effective and active solutions through advances in sensing and computing technologies.¹⁶ It was envisaged to increase information sharing to the driver for reducing the perception-reaction time, e.g. in case of emergencies or accidents and thereby increasing safety. The technologies for enabling this first stage of ITS included mainly radio channels and data systems, variable message signs, blinking roadside markers, etc.

During the first decade of the 21st century, substantial expansion in communication technology capabilities led to the development of automated and connected technologies, among others.¹⁷ This shifted the ITS focus on technologies that

¹³ U.S. DOT/Bureau of Transportation Statistics: Bikeshare and E-scooter Systems in the U.S. (last updated 10.07.23), accessible at: <https://data.bts.gov/stories/s/fwcs-jprj>

¹⁴ ECE/TRANS/285

¹⁵ Bike-sharing worldwide, statista, accessible at: <https://www.statista.com/outlook/mmo/shared-mobility/shared-rides/bike-sharing/worldwide>, accessed on 22.09.22

¹⁶ USDOT, "History of Intelligent Transportation Systems - 2023 Update", Publication number: FHWA-JPO-16-329

¹⁷ USDOT, "History of Intelligent Transportation Systems - 2023 Update", Publication number: FHWA-JPO-16-329, page 23

enable vehicles to perceive its environment and react based on the data they receive, mostly relying on its own hardware rather than on information received from control centres outside.

ITS involves a wide range of technological systems and services focused on land-based transport and mobility. This chapter aims at providing a general overview of ITS technologies, including some examples.

1. ITS in Road Transport – automated, connected and cooperative transport technologies

(a) Automated transport technologies

ITS include technologies that support vehicle automation which have the potential to fundamentally change the lives of billions of people and to change how road transportation works. It is widely acknowledged that some 90 per cent of motor vehicle crashes are caused at least in part by human error.¹⁸ Assisted and automated driving systems can contribute to reducing the human factor from the road safety equation, which could lead to a decrease in road crashes, and therefore deaths and injuries on roads.



Automated driving technologies rely on on-board hardware, software, and sensors that enable the vehicle to perceive its surroundings and perform the Dynamic Driving Task (DDT).¹⁹ The degree of automation can vary from just supporting the driver in the driving task up to the vehicle being fully autonomously driven by the system.

Currently extensively deployed functions belong to the group of Advanced Driver Assistance Systems (ADAS). They represent a wide range of systems, which can be divided into two main groups:

- (a) Systems designed to continuously provide assistance on a sustained basis while driving, to improve efficiency and provide comfort; and
- (b) Safety systems.

Some examples are listed below:

- *Electronic Stability Control (ESC)*: ESC controls the braking of individual wheels to help the driver maintain control of the vehicle during extreme manoeuvres. Using this system, it helps to keep the vehicle headed in the direction in which the driver is steering even when the vehicle reaches the limits of its road traction abilities. The stability control system maintains “yaw” (or heading) control by comparing the driver’s intended heading with the vehicle’s actual response, and automatically turning the vehicle if its response does not match the driver’s intention. However, with a stability control system, turning is accomplished by applying counter torques from the braking system rather than from steering input. Speed and steering angle are used to determine the driver’s intended heading.²⁰

¹⁸ NHTSA, National Motor Vehicle Crash Causation Survey, December 2008, DOT HS 811 052

¹⁹ UNECE, “All you need to know about automated vehicles - technical progress and regulatory activities”, December 2021

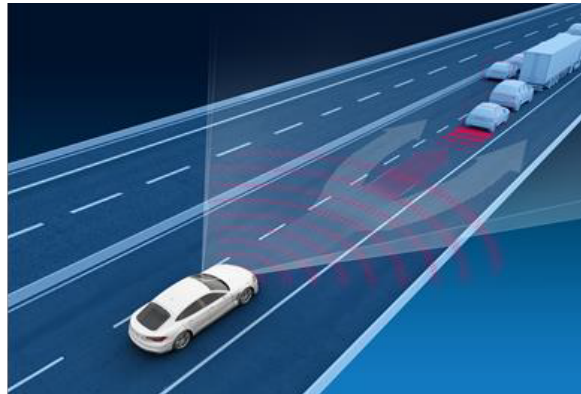
²⁰ UNECE, “Intelligent Transport Systems for Sustainable Mobility”, 2012, page 44

- *Advanced Emergency Braking System (AEBS)*: this system employs sensors to monitor the proximity of the vehicle or pedestrian in front and detects situations where the relative speed and distance between the two vehicles or between the vehicle and pedestrian suggest that a collision is imminent. In such a situation, if the driver does not react to the system's warning alerts, emergency braking will be automatically applied to avoid the collision or at least to mitigate its effects.
- *Advanced Driver Assistance Steering System (ADASS)*, as defined in UN Regulation No. 79, being part of the 1958 Agreement (*full title: Agreement concerning the Adoption of Harmonized Technical United Nations Regulations 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 United Nations Regulations*): ADASS describes a system, additional to the main steering system, that provides assistance to the driver in steering the vehicle but in which the driver remains at all times in primary control of the vehicle. It comprises various categories, which are also defined in the 1958 Agreement, for example:
 - *"Automatically commanded steering function (ACSF)"*, which means a function within an electronic control system where actuation of the steering system can result from automatic evaluation of signals initiated on-board the vehicle, possibly in conjunction with passive infrastructure features, to generate control action in order to assist the driver in keeping the vehicle on an ideal path (Lane Guidance, Lane Keeping), to assist the driver in manoeuvring the vehicle at low speed in confined spaces or to assist the driver in coming to rest at a pre-defined point (Bus Stop Guidance).
 - *"ACSF of Category A"* means a function that operates at a speed no greater than 10 km/h to assist the driver, on demand, in low speed or parking manoeuvring.
 - *"ACSF of Category B1"*, also known as Lane Keeping ADAS, means a function which assists the driver in keeping the vehicle within the chosen lane, by influencing the lateral movement of the vehicle, corrects the steering angle to prevent departure from the chosen lane (Lane Departure Avoidance) or corrects the steering angle of one or more wheels to improve the vehicle's dynamic behaviour or stability.
 - *"ACSF of Category C"*, a function which is initiated/activated by the driver and which can perform a single lateral manoeuvre (e.g. lane change) when commanded by the driver.
- *"Driver Control Assistance Systems (DCAS)"* are a subset of ADAS. DCAS are driver-operated vehicle systems assisting a human driver in performing vehicle dynamic control via sustained lateral and longitudinal motion-control support within the system boundaries. DCAS, while active, provide support to the driving tasks, and increase comfort and reduce the drivers' workload by actively stabilising or manoeuvring the vehicle. The responsibility remains with the driver.²¹
- Other examples for passive systems are lane departure warning systems, collision avoidance system (pre-crash system), driver monitoring e.g. for driver drowsiness detection and warning, pedestrian protection systems, automatic parking etc.

Systems that perform the driving task and do not require the driver to monitor the driving task are called Automated Driving Systems (ADS). The current technological developments assume that an ADS performs the DDT based on its own perception of the environment. These developments are in contrast with some of the originally envisaged systems, which were aiming at managing traffic and individual vehicles by providing signals, emitted by the infrastructure (as noted in the preamble of UN Regulation No. 79 (steering equipment) and the authority potentially managing the transport systems.

²¹ 17th session of GRVA, September 2023, working document ECE/TRANS/WP.29/GRVA/2023/20

Figure 3 Sensor and Sensor Fusion Technology in Autonomous Vehicles



Source: SAE International/ZF Group (or ZF Friedrichshafen AG), November 2023

To perform the DDT, a vehicle needs to perceive and analyse its environment by receiving and processing data to classify objects, the current traffic situation and driving conditions using different sensors and performing sensor fusion. This process is called “Object and Event Detection and Response” (OEDR). Commonly used or considered sensor solutions at the time this publication was drafted, are:

- Lidar (determining variable distances using a laser)
- Radar (Far Range Radar, Medium Range Radar, Short Range Radar – determines the distance using radio waves)
- Ultrasonic Sensor (determining the distance by emitting and receiving sound waves at a frequency that is not audible for humans)
- Wheel speed sensor
- Moisture sensor
- Cameras (surround view camera, rear view camera, front view camera, interior camera)
- Inertial Measurement Unit (IMU) contains an accelerometer and gyroscope, among others, and is necessary for Automated Vehicles (AVs) to achieve accurate localization.
- Global Navigation Satellite Systems (GNSS) is a general term including existing and future satellite systems like BeiDou from China, Galileo from the European Union, Global Navigation Satellite System (GLONASS) from the Russian Federation and Global Positioning System (GPS) from the United States of America.
- At the time this publication was drafted, the following ADS were already available:
- *Automated Lane Keeping System (ALKS)*: ALKS controls the lateral and longitudinal movement of the vehicle for extended periods without further driver command, can perform lane changes and is operational up to a speed of 130 km/h within an ODD specified by the manufacturer. It could be activated under certain conditions on roads where pedestrians and cyclists are prohibited and which by design are equipped with a physical separation that divides the traffic moving in opposite directions.²²
- Autonomous shuttles, as well as any other form of vehicle automation including but not limited to robo-taxis, lorries, autonomous vehicles operating in closed areas like mines and ports, partially still as prototypes involved in trial phases.
- Automated Driving Systems (ADS) is the term used by GRVA to cover all automated vehicles technologies for the different possible use cases and vehicle categories. ADS were subject to a pre-regulatory activity performed by the Informal Working Groups on Functional Requirements for Vehicles Driving and Validation Method for Automated Driving. This work is expected to be completed in June 2024, followed by the development of a fully global regulation at GRVA.

²² UNECE press release on ALKS, accessible at: <https://unece.org/media/press/368227>

In order to improve the functionalities of an ADS the next envisaged step is to extend the system with accessible information by using connected technologies. They have the potential to enhance the perception of the vehicle and to make ADS behaviour more predictable to other road users by sharing information with other vehicles and infrastructure of the surrounding in real-time. This would allow the automated vehicle to react faster and thereby improve safety (see for example the activities in Beijing, in box 3).

Box 3 Beijing High-level Autonomous Driving (BJHAD) Demonstration Zone

“Because of security risks, impact on traffic efficiency and high costs, autonomous driving cannot achieve high-scale operation in a short term. Based on the practical experience, China proposed the path of vehicle infrastructure cooperated autonomous driving (VICAD). In September 2020, to coordinate the resources of the whole city, Beijing decided to build the Beijing High-level Autonomous Driving (BJHAD) Demonstration Zone, integrating “Smart Vehicle, Intelligent Road, Real-time Cloud, Reliable Network, Precise Map” to build an engineering test platform on city level.

- “Smart Vehicle”: BJHAD supports research and development of key technologies and installed three mode on-board units to collect 36 types of data from vehicles in real time.
- “Intelligent Road”: BJHAD defined the intelligent connection standard intersection scheme to reuse functional roadside sensing facilities and fully cover the 160 square kilometers of intelligent roads, equipped with various intelligent devices like cameras, millimeter-wave radars and edge computing units.
- “Reliable Network”, BJHAD promoted the construction of Enhanced Ultra High Throughput (EUHT), V2X and 4G/5G networks synchronously to build low latency, high reliability and extremely stable network support.
- “Real-time Cloud”, BJHAD built a cloud platform with a unified data base, providing data base services and cooperation with vehicles.
- “Precise Map”, as China’s first basic map application pilot, BJHAD established the high-precision dynamic basic map platform.

To create a business environment that is policy-friendly and conducive for industrial development, BJHAD established a “2 + 5 + N” VICAD Management Policy System and launched first domestic operation of unmanned delivery vehicles, highway testing, and unmanned testing in Beijing. BJHAD launched eight types of scenarios, such as robotaxis, autonomous retail and delivery vehicles, autonomous shuttles, autonomous patrol cars, autonomous sanitation vehicles, robobuses, trunk logistics and citizen services.”

Source: China Automotive Technology and Research Center (CATARC), October 2023

These recent advances in automated transport technologies (including, among others, machine learning, perception, sensor fusion, V2X), offer potential solutions to improve roadway safety, e.g. at intersections, for all road users, including both vehicles and vulnerable road users (VRUs), such as pedestrians, bicyclists, and micro-mobility device users. Repurposing these technologies can provide real-time alerts to approaching vehicles and VRUs at roadway intersections, pedestrian crossings, and railroad crossings, significantly reducing the risk of accidents.²³

In line with this evolving technology, pilot runs are being carried out to deploy truck platooning (see box 4), which wirelessly links multiple trucks in a convoy. When connected, the trucks maintain a predefined distance from each other, responding automatically to changes in the movement of the lead truck. Platooning can reduce CO₂ emissions as the trucks following the lead truck experience less air resistance and can also improve safety (It may also be possible to deploy fully automated vehicles as part of such convoys). The benefits in terms of CO₂ emission reduction depends on the distance between trucks in the platoon and on the frequency of opening the platoon, which is directly depending on the distance between motorway exits. An expert guess of this benefit is that a few per cent fuel economy reduction can be achieved in the best case.^{24, 25}

²³ Notice by USDOT, “Enhancing the Safety of Vulnerable Road Users at Intersections; Request for Information”, 16.09.2022, accessible at: <https://www.federalregister.gov/documents/2022/09/16/2022-20188/enhancing-the-safety-of-vulnerable-road-users-at-intersections-request-for-information>

²⁴ United Nations. Sustainable transport, sustainable development. Interagency report for second Global Sustainable Transport Conference, 2021, accessible at: <https://sdgs.un.org/publications/interagency-report-second-global-sustainable-transport-conference>

²⁵ 76th session of GRRF, “Cooperative dynamic formation of platoons for safe and energy-optimized goods transportation”, Informal document GRRF-76-43, February 2014, accessible at: <https://unece.org/DAM/trans/doc/2014/wp29grf/GRRF-76-43e.pdf>

Box 4 Truck platooning system in Singapore

With the vehicle population in Singapore approaching one million, the government is seeking to address the increasing travel demand and land constraints: 12 per cent of the country's total land is used for road and land transport infrastructure. Singapore is also faced with a shortage of local drivers. This situation has led the authorities to consider new operational methods that will increase productivity, improve road safety, optimize road capacity, and enable new mobility concepts. Singapore has tested autonomous cars, taxis, utility vehicles, and buses. Truck platooning trials took place in two phases over a three-year period, from January 2017 to December 2019. The Ministry of Transport and the PSA (Singapore's container port terminal operator) have partnered with two automotive companies to design, develop and test an autonomous truck platooning system for use in transporting containers from one port terminal to another. Truck platooning can help alleviate labour shortages, and allow more freight movements to be carried out at night to ease traffic congestion. Truck platoons have also shown the potential to achieve major fuel savings and contribute to increased road safety.

Source: Vehicle Technology and Standards Division, Vehicle Services Group Land Transport Authority (LTA), Singapore, October 2023

There are also automated transport technologies that are deployed outside of the vehicle. One example is toll collection or speeding systems through Automatic Number Plate Recognition (ANPR). ANPR has emerged as vital tool for road safety and traffic management, being also a key component for the establishment and management of car free zones and as such they can contribute to climate change mitigation actions. ANPR usually uses either a colour, black and white or infrared camera, being able to take images under different environmental conditions. The image is then processed using advanced Optical Character Recognition (OCR) algorithms.²⁶

(b) Connected and cooperative transport technologies



The term *connected transportation* is used (for example in the United States) to refer to transportation system elements that include wireless communications that support the exchange of data between vehicles, between vehicles and infrastructure elements and between vehicles and backend data systems (traffic management centers or third parties). The term *cooperative transportation* is used to refer to transportation system elements that include wireless communications that support collectively acting between the participants communicating (This would include, e.g., infrastructure sensors that share vulnerable road user data with vehicles to avoid collisions and vehicles communicating between each other to coordinate movements/speeds in a platoon).²⁷ Existing technologies that enable this data exchange include **among others**:

- **Mobile technologies**, like the fourth generation of mobile technologies (4G) and the fifth generation of mobile technologies (5G).
- **Wi-Fi**, a wireless networking technology that uses radio waves to provide wireless high-speed internet access.

²⁶ S. Du, M. Ibrahim, M. Shehata and W. Badawy, "Automatic License Plate Recognition (ALPR): A State-of-the-Art Review," in IEEE Transactions on Circuits and Systems for Video Technology, vol. 23, no. 2, pp. 311-325, Feb. 2013, accessible at: <https://ieeexplore.ieee.org/document/6213519>

²⁷ Definition provided by an expert from the USDOT, 10.11.2023

- There are two main radio access technologies enabling V2X communication to date using the 5.9GHz spectrum (These technologies are further detailed below; they do not come enabled in all devices by default)²⁸:

- **Cellular-V2X (C-V2X)**

The connectivity standard C-V2X relies on LTE-V2X (and its evolution: New Radio-V2X (NR-V2X)). It is an aspect of cellular standards, but in contrast to them they don't require a base station connection to function. C-V2X combines two complementary communication modes in one module, namely *direct communication* and *network communication*. C-V2X *direct communication* connects the vehicle with its local and close surroundings including other vehicles (V2V), pedestrians (V2P) and connected infrastructure (V2I), independent of the cellular network.²⁹ C-V2X *network communication*, also referred as Vehicle-to-Network (V2N), employs the cellular network to extend the transmission radius for telematics. This could provide various services, e.g. crash notification, software over the air updates, expanded infotainment services, traffic and road condition updates, and remote control.^{30, 31, 32} It is currently the preferred connected technology in China and the United States of America, where the standard is specified by the U.S. Federal Communications Commission (FCC).

- **Dedicated Short Range Communication (DSRC)**

(Also referred to as ITS-G5 in the European region)³³.

DSRC relies on IEEE 802.11p (and its evolution: IEEE 802.11bd), also known as WAVE (Wireless Access in Vehicular Environments), which is a derivative of the Wi-Fi standard.³⁴ DSRC is optimised for the communication between moving senders and receivers without the need for having a base station or any other kind of external infrastructure to coordinate the messages and allows low latency functionality in areas with low coverage.³⁵ This was de facto the preferred standard in the European region in the beginning³⁶ (see more details on the current situation in box 5 and an example in box 6).

Box 5 European Council adopts new framework to boost the roll-out of intelligent transport systems

In October 2023, the European Council adopted a new Directive amending the Directive 2010/40/EU on the framework for the deployment of ITS in the field of road transport and for interfaces with other modes of transport. The amendment aims at taking into account technological developments, such as connected and automated mobility, on-demand mobility applications, and multimodal transport. It also aims to accelerate the availability and enhance the interoperability of digital data that feed services, such as multimodal journey planners and navigation services to allow vehicles and road infrastructure to communicate with one another, for example to warn about unexpected events, such as a traffic jam ahead. The Directive also addresses C-ITS and includes provisions to ensure that requirements for ITS systems neither impose nor discriminate in favour of the use of a particular type of technology in line with the principle of technological neutrality as laid down in Directive (EU) 2018/1972.

Source: Council of the European Union, press release of 23.10.2023

²⁸ G. Naik, B. Choudhury and J. -M. Park, "IEEE 802.11bd & 5G NR V2X: Evolution of Radio Access Technologies for V2X Communications," in IEEE Access, vol. 7, pp. 70169-70184, 2019, doi: 10.1109/ACCESS.2019.2919489, accessible at: <https://ieeexplore.ieee.org/document/8723326>

²⁹ 5GAA presentation on ITS, ECE webinars on ITS, 2022, accessible at: <https://unece.org/info/events/event/369438>

³⁰ 5G Americas, "Vehicular Connectivity: C-V2X & 5G – A 5G Americas White Paper", September 2021, accessible at: <https://www.5gamericas.org/wp-content/uploads/2021/09/Vehicular-Connectivity-C-V2X-and-5G-InDesign-1.pdf>

³¹ Accessible at: <https://www.techtarget.com/iotagenda/definition/Cellular-Vehicle-to-Everything-C-V2X>

³² Accessible at: <https://www.audi-mediacycenter.com/en/press-releases/why-we-are-now-equipping-our-vehicles-with-the-new-5g-mobile-communications-standard-14189>

³³ 5G Americas White Paper, "Vehicular Connectivity: C-V2X & 5G", September 2021, Accessible at: <https://www.5gamericas.org/wp-content/uploads/2021/09/Vehicular-Connectivity-C-V2X-and-5G-InDesign-1.pdf>

³⁴ Ma, X., Chen, X. & Refai, H.H. Performance and Reliability of DSRC Vehicular Safety Communication: A Formal Analysis. J Wireless Com Network 2009, 969164 (2009). <https://doi.org/10.1155/2009/969164>, Accessible at: <https://jwcn-urasipjournals.springeropen.com/articles/10.1155/2009/969164>

³⁵ Kenney, John. (2011). Dedicated Short-Range Communications (DSRC) Standards in the United States. Proceedings of the IEEE. 99. 1162 - 1182. 10.1109/JPROC.2011.2132790.

³⁶ 5GAA, "Coexistence of C-V2X and ITS-G5 at 5.9GHz", Position Paper, April 2018

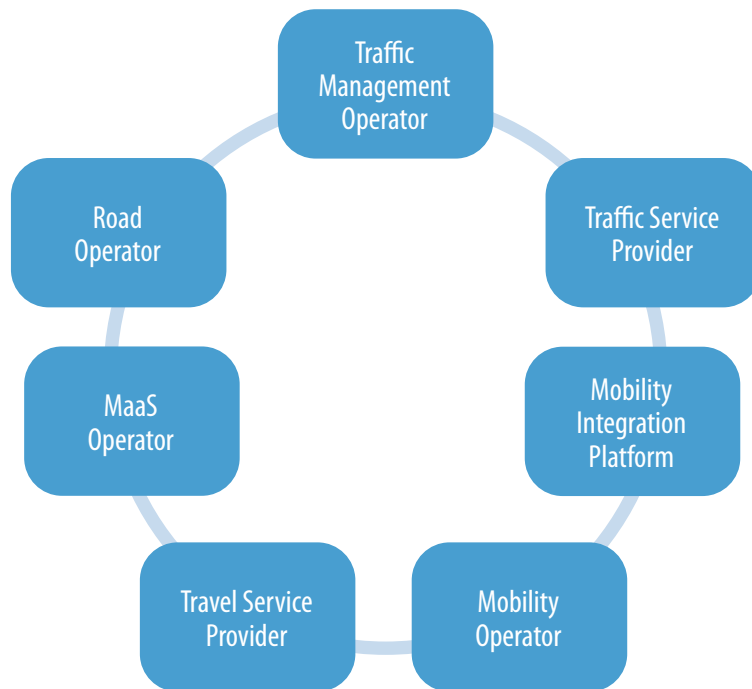
Box 6 ASFINAG connects roads with vehicles on a large scale in Europe.

Commencing in November 2020, Austrian highways will undergo the installation of dedicated short-range communication equipment, facilitating a seamless exchange of safety-critical information between vehicles and the road infrastructure. ASFINAG will initiate the implementation on specific segments, with plans to progressively extend coverage to the entire Austrian motorway network within the next few years.

Source: ASFINAG, press release: 28.10.2020

Traffic Control Centres (TCC)/ Traffic Management Centers (TMC)³⁷ and Traffic Information Centers (TIC) belong to one field where data exchange technologies are used. TICs are charged with providing information about traffic, among others, by collecting real-time information and checking, validating, and diffusing it to the general public through all possible media outlets (radio, TV, call centres, internet etc.). The collection and coordination of information is particularly important because information can arrive from various sources (although usually from road police and road operators) and involves many different partners at regional or national level. The efficiency of TCCs assures the correct flow of information to and from different stakeholders (traffic police, authorities, public etc.), which contributes to timely and appropriate actions during the operational phase.³⁸

Figure 4 ITS technologies can enable the cooperation between various entities like traffic management operators, road and mobility operators, etc.



Source: UNECE

³⁷ Different terms are used in different regions of the world. E.g. the term TMCs is used in the United States of America

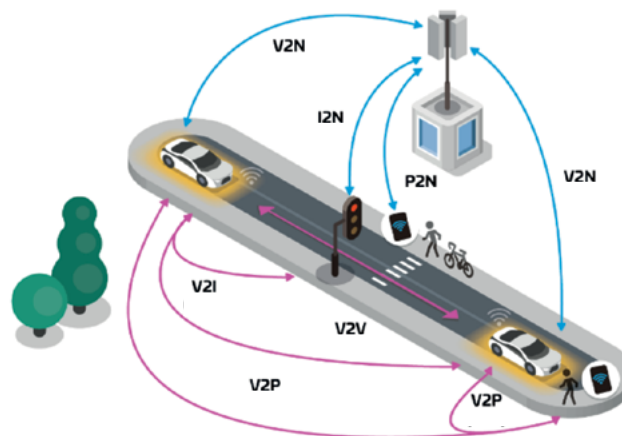
³⁸ UNECE, Publication on Intelligent Transport Systems for Sustainable Mobility, 2012

Other developments of data exchange technologies are focusing on on-board ITS solutions and offer the possibility to improve safety and efficiency amongst others. Some examples, also showing various levels of complexity, are listed below:

- *Accident Emergency Call System (AECS)*: every second counts in a road traffic emergency. Reducing the time it takes for medical services, firefighters, and rescuers to arrive on the scene can save lives and can limit the severity of the consequences of road accidents for survivors. The system informs emergency services of the vehicle's precise location, along with information on time of accident and direction of travel, regardless of whether the driver is conscious or able to make a phone call. The system may also be activated manually in the case of emergency needs, such as if the driver witnesses a serious accident. AECS aligns the "ERA-GLONASS" emergency call system in use in the Russian Federation with the European Union's "eCall", which is set to become compulsory for all new cars sold in the EU from April 2018.³⁹
- *Smart Tachographs* are devices that automatically record the start and end location of the daily journey to control the driving and resting times of drivers, using GNSS. It provides the service of remote data transmission to road and control authorities using Dedicated Short-Range Communication (DSRC), and allows communication with other ITS services, such as smart parking.⁴⁰

Moreover, data exchange technologies (and especially the introduced radio access technologies introduced earlier in this chapter) are enabling the communication between a vehicle and devices/systems in its surrounding, which is referred to as Vehicle-to-Everything (V2X). This includes, but is not limited to, Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I), Vehicle-to-Pedestrian (V2P) and Vehicle-to-Network (V2N). Vehicle-to-Grid (V2G) in the context of electric vehicle charging is a specific case, and more information is provided in box 7.

Figure 5 Examples of Vehicle-to-Everything connections



Source: 5GAA⁴¹

³⁹ Accessible at: <https://unece.org/media/press/1578>

⁴⁰ Accessible at: https://dtc.jrc.ec.europa.eu/dtc_smart_tachograph.php.html#:~:text=Smart%20Tachograph%20activities&text=It%20will%20allow%20automatic%20recording,data%20transmission%20to%20control%20authorities.&text=All%20documents%20useful%20for%20the,are%20added%20on%20this%20page

⁴¹ 5GAA presentation on ITS, ECE webinar on ITS, 2022, accessible at: <https://unece.org/info/events/event/369438>

V2X could bring many advantages, e.g. facilitate information exchange between vehicles and various road users (see box 8) in the surrounding area including, but not limited to information on velocity, acceleration, location, speed or/and to warn against problems or potentially dangerous situations (e.g. emergency braking, accidents, traffic jams or bottlenecks). It can also facilitate communication between vehicles and the road infrastructure (e.g. traffic lights for optimal speed advice, construction works, weather conditions), communication between electric vehicles and the next available charging infrastructure and communication between vehicles and vulnerable road users, among others.⁴² This has the potential to positively impact the coordination of actions and to improve traffic safety, flow and efficiency, and fuel efficiency.

Box 7 V2X energy for electric vehicle (dis)charging:

“V2X, or Vehicle-to-Everything, is a terminology also used in the context of electric vehicle charging, where it is also referred to as “V2X energy”. V2X energy relates to the bi-directional charging and discharging of an electric vehicle’s battery, which is currently facilitated using a wired connection with both power and communications requirements, although wireless solutions are in development. Bi-directional charging allows for the vehicle to not only import energy into its battery, but also facilitates the export of energy held within the battery for a variety of use cases. These include the following:

- Vehicle-to-Grid (V2G): the export of energy back to the electricity grid.
- Vehicle-to-Home (V2H): the export of energy back to a domestic property.
- Vehicle-to-Building (V2B): the export of energy to a building including commercial and industrial sites.
- Vehicle-to-Load (V2L): the vehicle directly supplying energy to a load such as electrical devices, e.g. coffee machines / portable heaters.
- Vehicle-to-Vehicle (V2V): energy export from one vehicle’s battery to another vehicle’s battery.

V2X energy carries a variety of benefits. It supports electricity grids through shifting demand and providing energy flexibility; it allows for maximum use of renewable energy generation; and it can generate savings or revenues for electric vehicle owners.

Effective communication is essential between all electric vehicles, bi-directional chargers and consumers via a host of aggregators, utility providers and energy management systems so common standards are key to V2X deployment.”

Source: Innovate UK, Innovation Lead - ZEV Infrastructure, United Kingdom of Great Britain and Northern Ireland

⁴² European strategy on Cooperative Intelligent Transport Systems, COM(2016) 766 final, Brussels, 30.11.2016

Box 8 SAE International's work on V2X

"SAE International members have been writing Intelligent Transportation Systems standards for over twenty years. One category of these is the set SAE's collection of connected vehicle standards, starting with the J2735 V2X (Vehicle to Everything) Communications Message Set Dictionary. Using that dictionary, several additional standards have been developed to support safety such as J2945/1 and J2945/1B which address Vehicle to Vehicle (V2V) safety communications using the basic safety message (BSM).

The motivation for developing a specific or set of standards can come from many different sources. One such is the need to minimize or eliminate a safety problem. The United States National Transportation Safety Board (NTSB) conducts crash investigations and conducts research to make recommendations to improve all modes of transportation safety. One such mode is the transport of children to and from school and while among the safety modes of transport, there are still tragic crashes which sadly harm children. NTSB investigates school bus crashes to determine ways to prevent these. One recent investigation was of a horrific crash where a vehicle hit children, three sisters, an older and her two younger twin sisters that were crossing a road to board their bus (<https://youtu.be/m-4w8mueKuA>).

The three little girls were struck by a vehicle whose driver did not heed the school bus's warnings which included flashing red lights and a red octagon stop sign arm extended from the front of the bus.

Figure 6 School bus stop sign



Source: SAE International

Figure 7 School bus and crossing children



Source: SAE International

SAE recognized that connected vehicle technology when deployed, may have prevented this and began developing another safety standard to address school bus safety.

As a result of NTSB's investigation and analysis, SAE, supported by the US Department of Transportation, prioritized the development of school bus safety performance standards for connected vehicle technologies. Given their special operating features, school buses must be uniquely treated. The J2945/1C standard specifies the interface and Basic Safety Message extensions that support school buses sharing information with other vehicles (V2V) such as slowing, stopping, the loading and unloading of children, and when they are crossing the street. This initial standard just completed its first ballot and is expected to be published in the first quarter of 2024 and will be available without cost from sae.org/publications."

2. ITS in Inland Waterways

In inland navigation, safety and efficiency of transport operations rely to a large extent on smart and intelligent transport solutions. One of them is River Information Services (RIS) that support traffic and transport management, including, wherever technically feasible, the interfaces with other transport modes. They cover a wide range of operational and technical services related to the fairway, traffic, transport logistics, statistics and other relevant information, and are based on the following key technologies:

- Inland Electronic Chart Display and Information System (Inland ECDIS)
- Notices to Skippers (NtS)
- Vessel Tracking and Tracing (VTT)

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- Electronic Reporting International (ERI), mainly based on UN/CEFACT standards
- Automatic Identification System (AIS) technology; Inland AIS in Europe applies the same parameters and message structure as AIS Class A mobile stations according to IMO requirements, however, it extends the information content according to the inland navigation requirements.

RIS are increasingly integrated for use in the inland water transport sector. RIS is a harmonized and interconnected information system that provides real time data to users and authorities about the traffic and fairway conditions on a waterway, and about vessel positions and directions. Streamlined planning of vessel movements are, in this way, facilitated on the waterways. RIS not only increases safety on the waterways, but also increases the efficiency of transport across rivers and canals by adding functions such as RIS corridor management.

Vessel Traffic Services (VTS) on inland waterways are considered an element of the Vessel Traffic Management service provided by RIS. Inland VTS aims at enhancing navigation safety in estuaries, lakes and other cross-border areas where inland waterways connect with the sea and vessels cross the boundaries of responsibility of maritime and river administrations.

A rapid development of automated navigation and smart shipping implies a fundamental change for inland navigation. Automation in inland navigation has been included in the work programme of the European Committee for drawing up Standards in the field of Inland Navigation (CESNI), the Central Commission for the Navigation of the Rhine (CCNR), the World Association for Waterborne Transport Infrastructure (PIANC) and other international organizations. Since 2018, automated shipping has been introduced in the agenda of the Working Party on Inland Water Transport (SC.3).

Research work and pilot projects are underway,⁴³ in particular, in Flanders (De Vlaamse Waterweg NV, Belgium), France, Germany, Netherlands, in the North Sea region. They include such projects as AUTOSHIP (Autonomous Shipping Initiative for European Waters), NOVIMAR, AURIS (Autonomous Remotely Monitored Innovative Ship), AVATAR (Autonomous Vessels, cost-effective transshipment, waste return), autonomous vessels Marine Litter Hunter, Zulu 3 and Zulu 4 and testing of automated and unmanned vessels by Seafar (Belgium). (Noticeably, ITS is also deployed in ports, see box 9.) However, a lack of the international legislative framework is one of the major obstacles for enabling testing and commercial use of automated vessels. International coordination and agreement are particularly important for transboundary rivers and international waterways.

Box 9 Deployment of ITS at ports

ITS also provides the possibility to increase cargo capacity and the reliability of freight moving through ports, e.g. by integrating automated driving into ports.

Initiatives exist for example in the United States of America, where the Maritime Administration (MARAD) in partnership with Federal Highway Administration (FHWA), Federal Motor Carrier Safety Administration (FMCSA), ITS JPO, and Volpe National Transportation Systems Center, is using open source software of the CARMASM Program to test the integration of Cooperative Driving Automation (CDA) technology in U.S. ports. The Port Cooperative Driving Automation Drayage Truck Development and Testing initiative aims to demonstrate automated driving systems in a port environment. The project is developing proof-of-concept applications with a fleet of four cooperative automated driving system (C-ADS)-equipped heavy vehicles to demonstrate how CDA concepts can increase cargo capacity and the reliability of freight moving through ports. The fleet will perform tasks such as loading and unloading of chassis and containers, U.S. Customs and Border Protection inspection point passage, gate passage, and short-haul drayage. The project will also recommend cybersecurity research areas and expand the Federal Motor Carrier Safety Administration's (FMCSA) freight research framework. This research will draw on experience gained through academic and other partner communities.

Source: USDOT⁴⁴

⁴³ List of pilot and research projects in the field of automated navigation is maintained by CCNR at <https://automation.ccr-zkr.org>

⁴⁴ Accessible at: <https://www.its.dot.gov/resources/marad.htm>

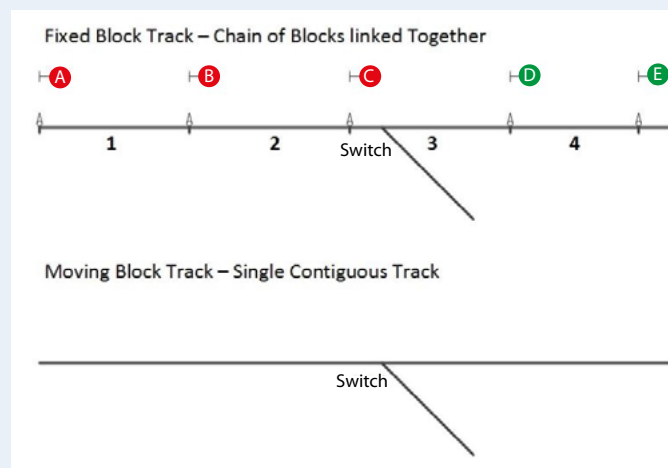
3. ITS in Rail Transport

ITS solutions in Rail Transport have been helping the development of the rail sector for decades with a focus on making operations both safer and more efficient. One of the most significant advancements in this area come in relation to traffic management where ITS has been extensively introduced in railway signalling over the past 30 years across the world. Much of this innovation has been driven by European countries and the standards that have been developed within the region are now used as a basis for signalling around the world. ITS in signalling has allowed for safety and capacity information to be transferred more quickly leading to fewer accidents while at the same time increasing the number of trains on a specific section. More recent advancements have further improved traffic management by introducing mobile telephony into the traffic management processes allowing trains to be managed using a “moving block” removing the need for fixed signalling (please find additional information in box 10).

Box 10 Moving block vs. fixed block signalling

Fixed block signalling is a traditional method where the railway track is divided into fixed segments, called “blocks”. The block length can be vary, depending on e.g., location and geographical conditions. Each block is isolated from adjacent blocks to accommodate only one train at a time. The position of the trains is determined by physical signals located at the boundaries of each block. Trains can only enter a block once it’s confirmed to be empty and safe. This system provides a structured and clear approach to train management but may result in underutilization of track capacity.

Figure 8 Moving block vs. fixed block signalling



Source: CBTC Solutions

On the other hand, moving block signalling is a more advanced and dynamic system. Instead of fixed blocks, the track is virtually divided into flexible and adjustable segments, length and location being consistent with the train, allowing for real-time monitoring and control of train positions. Trains communicate their exact positions, speeds, and braking capabilities to a centralized control system, which calculates safe separation distances and optimizes train movements accordingly. This system enhances track capacity, increases flexibility, and enables trains to run at closer intervals while maintaining safety.

Source: Moving Block vs Fixed Block Signalling - Which is Better?, 2015

Source: ⁴⁵; Picture source: ⁴⁶

⁴⁵ Baran Alikoc, Ilhan Mutlu, Ali Fuat Ergenc, Stability Analysis of Train Following Model with Multiple Communication Delays, IFAC Proceedings Volumes, Volume 46, Issue 25, 2013, Pages 13-18

⁴⁶ Graphic accessible at: <https://www.linkedin.com/pulse/moving-block-vs-fixed-signalling-which-better-naeem-ali#:~:text=Since%20the%20separation%20is%20kept,efficient%20manner%20while%20ensuring%20safety>, accessed on 17.10.2023

ITS has also increased the efficiency of rolling stock by allowing systems to be optimised to reduce fossil fuel consumption while at the same time providing for the return of energy of electric traction vehicles to the network. Currently solutions are being developed, with the help of ITS, to implement digital automated coupling of coaches and wagons with the aim of reducing the risk to staff during the coupling process and increasing the speed at which it can take place.

There are already many autonomous metro trains running in many cities around the world, but most recently, automation of rolling stock has also moved beyond the city environment. The most well-known example is in Australia where autonomous locomotives have been introduced to haul raw materials on a dedicated line. This is an important step in railway operations and something that is likely to grow in the coming years with greater testing and piloting.^{47,48} Automation has also been introduced within the freight terminals mentioned above where the vehicles and cranes used to move goods (mainly in containers) are automated and controlled from an office rather than directly on the vehicle or crane.

Another very important contribution that ITS has made to the railways has been through railway asset management systems where the use of modern technologies has made the management, maintenance and renewal of all railway assets more predictable and accurate. This is supported by sophisticated measuring of railway infrastructure undertaken by measuring trains running on the network with the support of drones that inspect the infrastructure from on high.

ITS has also had a strong impact on the ultimate users of the service with passengers and freight companies now able to track their journeys online thanks to the use of GNSS and similar systems. Logistics chains have been developed with the integration offered by ITS systems in particular in the intermodal movement of freight. ITS in this case is used to efficiently move more containers around a freight terminal, to automatically control access to the terminals, to digitalise key transport documentation and to manage their movement within the terminal. Finally, passengers have been able to acquire their tickets electronically through dedicated and integrated ticketing systems thanks to ITS solutions.

Another example how ITS can contribute to safety in Rail Transport is using these technologies for intelligent grade rail crossings. In the United States of America, the USDOT is working on a national architecture that addresses all ITS user services and defines the subsystems and data flows. Two of these user services deal directly with grade crossing, being No. 30 for highway rail intersection and No. 31 for archived data. The ITS architecture integrates railroad operating systems with traffic management systems, enabling advance train warnings for approaching trains to the motorists and allows for warning the locomotive engineer of obstacles or trapped vehicles at grade crossings. As the next step in the ITS Program, the USDOT Federal Railroad Administration and the ITS Joint Program Office have collaborated with Standards Development Organizations to create standards for implementing ITS at grade crossings nationwide which will also be turned into regulations by the USDOT Federal Highway Administration.⁴⁹

All these steps are in continual evolution and further research and development through such initiatives as Europe's Rail Joint Undertaking will mean that ITS can further contribute to improving efficiency and safety on the railways.

4. Cross-sectoral aspects of ITS technologies

There are several aspects that are relevant for any ITS solution, independent of the (transport) area in which it is applied. Some of these aspects are mentioned in the following.

(a) Cyber Security

UNECE member states already acknowledged the importance of cyber security with adopting the Roadmap on ITS in 2012, addressing this item with action 5 on protection of privacy and data security. Since then, especially the automotive sector is undergoing a profound transformation with the digitalization of in-car systems that are necessary to deliver vehicle automation, connectivity and shared mobility. Today, cars contain up to 150 electronic control units and about 100 million lines of software

⁴⁷ An example is provided here: <https://www.riotinto.com/news/stories/how-did-worlds-biggest-robot>

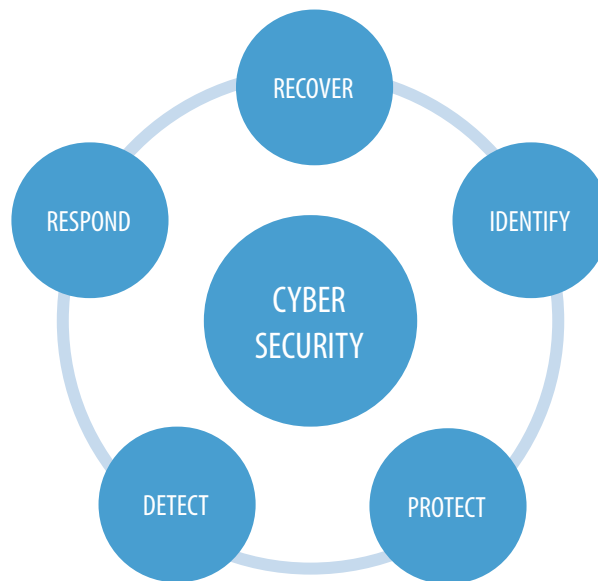
⁴⁸ Accessible at: <https://miningdigital.com/technology/rio-tinto-world-first-autonomous-trains-network-now-fully-operational>

⁴⁹ USDOT, "Intelligent Grade Crossings", 25.10.2019, accessible at: <https://railroads.dot.gov/program-areas/train-control/intelligent-grade-crossings>

code – four times more than a fighter jet, projected to rise to 300 million lines of code by 2030.^{50,51} These enable computers or mobile applications to remotely control and monitor almost all systems in a vehicle including the steering, brakes, locking and unlocking, and the engine itself.

This comes with significant cybersecurity risks, as hackers seek to access electronic systems and data, threatening vehicle safety and consumer privacy, if the system is not adequately protected. This is making cybersecurity a grave concern for both customers and the automakers and is essential for the safe deployment and development of ITS services as well as their maintenance. Cyber security measures protect the system by detecting and identifying potential risks, responding to attacks, and recovering a safe status. Several actions were taken to foster the application of good practices in the field of vehicles, see boxes 11 and 12.

Figure 9 Essential aspects of Cyber Security



Source: UNECE

Box 11 USDOT and NIST Cybersecurity Framework

The United States of America Department of Transportation (USDOT) has been working with the National Institute of Standards and Technology (NIST) to develop a tailored version of their cybersecurity framework. The NIST Cybersecurity Framework (CSF) is voluntary guidance, based on existing standards, guidelines, and practices for organizations to better manage and reduce cybersecurity risk. The framework provides a common language for understanding, managing, and expressing cybersecurity risk to internal and external stakeholders. It can be used to identify and prioritize actions for reducing cybersecurity risk, and it is a tool for aligning policy, business, and technological approaches to managing that risk. The framework core provides a set of activities to achieve specific cybersecurity outcomes, and references examples of guidance to achieve those outcomes. Building on the 2021 release of the Connected Vehicle CSF Profile, the USDOT is sponsoring expansion of this profile to include ITS infrastructure. This research is focused on developing approaches, strategies, and examples for state, local, and tribal DOTs and transportation operating agencies on how to incorporate cybersecurity into their decision making, and options for how to address cybersecurity issues for the ITS ecosystem. When complete, the resulting ITS CSF profile will be posted on a USDOT website and available for anyone to use.

Source: USDOT, November 2023⁵²

⁵⁰ Accessible at: <https://unece.org/sustainable-development/press/un-regulations-cybersecurity-and-software-updates-pave-way-mass-roll>, accessed 19.09.2023

⁵¹ Accessible at: <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/the-race-for-cybersecurity-protecting-the-connected-car-in-the-era-of-new-regulation>, accessed 19.09.2023

⁵² Text provided by USDOT, November 2023

Considering the increasing numbers of automated and assisted vehicles but also other ITS solutions for transport on the market and the associated cyber risk, ITC kept the item about data security on its Roadmap on ITS for the period of 2021-2025. ITC is focusing to find gaps, provide solutions and to achieve data protection and cyber security with the help of standards and regulations.

Box 12 UN Regulation No. 155 – Cyber Security and Cyber Security Management System

The risk of cyber-attacks is increasing significantly with the growing deployment of connected vehicles. To address these risks UNECE's WP.29 adopted UN Regulation No. 155 in June 2020. It provides a framework for approval of the vehicle manufacturers Cyber Security Management System. Further details can be found in chapter V., B., 3. on ECE's vision and approach to ITS, and specifically the work of GRVA.

Source: UNECE

(b) Data



Information sharing via connected technologies is based on data, therefore being the foundation and key for future developments.⁵³ Data builds the basis for the digital economy, analysing and testing performance to ensure safety, improving statistics as well as forecasting and predictive management.

Through ITS technologies, the amount of collected data is continuously increasing and depending on its quality, also the knowledge that can be extracted by analytics. Despite these potential advantages that can lead to safer, more comfortable, and efficient transport, data sharing and access is still controversial, and rules and regulations are different in different regions of the world. Challenges of maximising benefits on the one hand and mitigating risks for privacy, right of intellectual property, ownership, and confidentiality of data of individuals and organisations, among others, on the other hand need to be solved. Some other challenging aspects are missing trust and insights, how data is processed and forwarded, as well as missing rules and frameworks for cross border data traffic flow.

One example showing the enormous potential for improving efficiency, safety and economy by creating new markets, among others, is the transport of London. Over ten years, the Transport for London (TfL) has been releasing a significant amount of data (including timetables, service status and disruption information) in an open format for anyone to use. The provision of this free, accurate and real-time open data by TfL is helping London's economy by up to £130 million a year. More than 650 apps are being powered specifically using TfL's open data feeds, used by 42 per cent of Londoners. In addition to its own data sources, TfL also receives crowdsourced anonymous traffic data to get an even better understanding of journeys in London to improve its operations. Citymapper, one of the first journey-planning apps in London, was enabled by TfL open data. Other businesses, which use TfL data to improve customer information include Apple, Google, BusChecker, BusTimes, and Moovit.^{54,55}

Another example can be found in the United States of America, where the USDOT supports the generation and sharing of open ITS data. Through the ITS JPO, the USDOT publishes open data sets through the ITS DataHub (<https://www.its.dot.gov/data/>) to demonstrate the benefits of the ITS data. Currently featured data sets within the ITS DataHub include Connected Vehicle data collected by the CV Pilot projects, work zone data feeds from the Work Zone Data Exchange (WZDx) program and Next Generation Simulation (NGSIM) Open Data which used high-quality traffic datasets that were used to create microscopic behavioural algorithms for modelling and simulation.⁵⁶

⁵³ Ertico-ITS Europe, Annual Review 2022-2023, accessible at: <https://ertico.com/wp-content/uploads/2023/09/ERTICO-Annual-Review-2022-2023.pdf>

⁵⁴ ECE/TRANS/285

⁵⁵ Accessible at: <https://www.oecd-ilibrary.org/sites/15c62f9c-en/index.html?itemId=/content/component/15c62f9c-en>

⁵⁶ Text provided by USDOT, 1.11.2023



In the context of data, digital infrastructure is an important aspect and critical to ensure interoperability. Hereby, digital infrastructure refers to the foundational components and systems that enable the seamless exchange, access, and utilisation of data across various platforms, systems, and organisations. It plays a pivotal role in ensuring that data can be shared and integrated effectively, breaking down data silos. Some key aspects of digital infrastructure related to data interoperability are, among others, data standards and protocols, data storage and management, data security and privacy, data access controls, data interoperability frameworks that establish rules and guidelines for sharing and using data across different systems and organisations.

(c) Artificial Intelligence

Data is the basis for training, validation and testing of Artificial Intelligence (AI) and machine learning algorithms which can be used to support many types of complex tasks, including automation. Therefore, the availability and quality of data is one of the main aspects that influences the quality and performance of an AI model. Discussions on AI already emerged in the 1950s, but it was picked up again in recent years, also impacted by further developments and improvements of devices, computing capacities and ICT. It is predicted that the global spending on AI-based technologies will reach \$204 billion by 2025⁵⁷.

AI has an essential impact on the development of all transport sectors. It can enable autonomous functioning of vehicles, trains, ships etc., which could reduce human error, being a reason for many accidents, and can make transport safer and more efficient.

There is no globally shared view on what AI means for transport. One possible way to describe it, is a set of methods or automated entities that together build, optimize and apply a model so that the system can, for a given set of predefined tasks, compute predictions, recommendations, or decisions.⁵⁸

(i) Artificial Intelligence in the automotive sector

Especially in recent years, AI represents a major aspect in the automotive sector, having the potential to progress the levels of vehicle automation enormously. By using AI, data generated by the vehicle's sensors can be quickly processed and interpreted, which brings the potential to improve autonomous activities that require real-time information, as well as its perception of the environment. AI can impact certain driving functions, e.g. detection and categorization of road users, perception and planning as well as non-driving functions. For the moment, the automotive industry could use machine-learning algorithms to deploy frozen software versions in vehicles and/or to support automated test processes (see box 13).⁵⁹

⁵⁷ Accessible at: <https://www.idc.com/getdoc.jsp?containerId=prUS48191221>

⁵⁸ UNECE, 191st WP.29 session, informal document WP.29-191-06, accessible at: <https://unece.org/transport/documents/2023/11/informal-documents/grva-proposal-draft-resolution-guidance-artificial>

⁵⁹ 16th GRVA meeting, informal document GRVA-16-04, May 2023, accessible at: <https://unece.org/transport/documents/2023/05/informal-documents/clepa-oica-industry-position-usage-ai-machine>

Box 13 Code / feature freeze vs. Online learning

There are different terms related to a freeze in software engineering, of which some are explained in the following. “Code freeze” is a period during which non-critical changes to the code are not allowed. “Feature freeze” is a period during which no new features are added to a specific branch, which allows the branch to stabilize for a release.

“Online learning” describes incremental training of a new version of the AI-based system during operation onboard production vehicles to achieve defined goals.

Source: ISO and UNECE ^{60, 61}

At the second workshop of ECE's Working Party on Automated/ Autonomous and Connected Vehicles (GRVA) on AI in May 2022, the aspects mentioned above were discussed as shown in the table below. It contains some of the different types of algorithms belonging to AI and examples, for which purpose they are currently used in vehicles.

⁶⁰ ISO/IEC/IEEE 24765:2010(en), “Systems and software engineering - vocabulary”, accessible at: <https://www.iso.org/obp/ui/#iso:std:iso-iec-ieee:24765:ed-1:v1:en>

⁶¹ UNECE, 16th GRVA meeting, informal document GRVA-16-05, May 2023, accessible at: <https://unece.org/transport/documents/2023/05/informal-documents/clepa-oica-initial-points-and-terms-support>

Table 1 AI in automotive applications⁶²

	AI Application	Safety functions			
		Driving Function		Non Driving Functions	
		Perception	Planning	Actuation	
Conventional Software	Artificial Intelligence is a set of methods or automated entities that together build, optimize and apply a model so that the system can, for a given set of predefined tasks, compute predictions, recommendations, or decisions	Out of Scope [Non-AI] Detection of other road users for AEBS, ACC Detection of road infrastructure for LDW, LKAS	Out of Scope Activation of FCW and AEBS based on ego vehicle position and other road users	Not Applicable	Out of Scope Detection of driver's face for ID (under conditions ensuring privacy)
	Supervised learning is a type of machine learning that makes use of labelled data during training	Detection of other road users for AEBS, ACC Detection of passive road infrastructure for LDW, LKAS	Trajectory prediction using drivable path prediction from labelled data (e.g. HD maps)	Not Applicable	Detection of drivers eye gaze / state for DMS Fault detection, Predictive Maintenance
	Unsupervised learning is a type of machine learning that makes use of unlabelled data during training	Streamlining data labelling process for less safety critical systems like ISA. Extracting scenarios from real world data to support validation Generation of synthetic data for supervised learning / distortion of real world data	Trajectory prediction using Kalman filters, KalmanNet or Gaussian Process architectures, or other architectures	Not Applicable	[?]
Artificial Intelligence	Semi supervised learning is a technique that "learns" from a mix of labelled data and data that is both un-labelled and unstructured. They build on a small set of known exemplars and then use this information to guide unsupervised learning.	Streamlining data labelling process for less safety critical systems like ISA	Shadow mode' used in development for training control algorithms	Not Applicable	[?]
	Reinforcement learning is a type of machine learning utilizing a reward function to optimize a machine learning model by sequential interaction with an environment	Some manufacturers are starting to use RL for perception, could potentially be used in cooperative perception in the future	Lane Centering or ACC systems may use RL due to the reduction in cost / data required to train the system	Not Applicable	Predictive Maintenance

Source: UNECE

⁶² UNECE, 2nd Workshop on AI and Vehicle Regulations, 9 May 2022, accessible at: <https://unece.org/sites/default/files/2022-05/AI%20Automotive%20applications.pdf>

Next to the vehicle itself, AI can also be used for road traffic management systems, e.g. for the analysis of traffic patterns and providing information about the best route. By adapting traffic signals to the current demands and capacity utilisation, it could help to reduce congestion, therefore reduce the negative environmental impact of transport, and improve traffic flow.

To respect the type-approval regime that is applied in some countries, the automotive industry cannot issue software updates which may significantly affect type-approval relevant functions without re-engaging with the type-approval process.

(ii) Artificial Intelligence in Inland Water Transport

The management of inland water transport typically requires decision making based on many parameters. These are evaluated based on the amount of data generated by more advanced navigation systems (performance and navigation) and received from the various sensors and navigation charts, among others. The increasing number of ships and container traffic leads to the need for the optimization of logistics, surveillance of safety and more efficient usage of ports. Tools like AI could support the decision making by providing insights and enable the path to fully autonomous navigation, where research is ongoing.⁶³

(iii) Artificial Intelligence in Railway Transport

The usage of AI can have a positive impact on railway transport and can be a natural evolution of the ITS innovations mentioned previously, however significant testing needs to be undertaken on its use and potential effects and so is likely to remain, for the moment, limited to non-safety critical aspects of the system such as in journey planning for passengers.

(d) Intelligent management of infrastructure and public safety

The management of infrastructure is essential, independent of the type of transport. One aspect is the maintenance of physical characteristics of infrastructure to enable maximum efficiency, but also providing a safe basis for the operation of vehicles. Proper management of transport infrastructure is first and foremost about ensuring that maintenance is carried out properly. ITS is fundamental to this process, allowing maintenance schedules to be adapted to the real needs of the infrastructure.

As mentioned previously, this is very common in railways with the use of railway asset management systems that efficiently plan the maintenance of the infrastructure according to the actual condition of the network rather than historical approaches where interventions were carried out on a regular basis without a connection to the actual condition of the infrastructure. This is supported by extremely sophisticated measuring machines that traverse the railway network and measure everything from the state of the track to the quality of the overhead wires.

In addition to appropriate maintenance, the condition of infrastructure depends on appropriate use, e.g. in terms of the number and weight of vehicles, which is particularly important for the safe use of bridges and tunnels. In recent years, tragic incidents occurred where bridges have collapsed either because of the lack of maintenance as in the province of Genoa, Italy in 2018⁶⁴, or due to excessive load, as in Mirepoix-sur-Tarn, France in 2019⁶⁵, where a 45t truck used a bridge with a permissible payload of 19t. In addition to the systems mentioned earlier in this chapter, ITS devices could be used to actively identify potential critical situations (such as the overweight truck mentioned above) and implement mechanisms to avoid them. For instance, the data which is recorded by ITS devices like cameras of automated vehicles, could be shared with public entities responsible for infrastructure maintenance as it is already done in the railway sector of many countries of the region. The analysis of this data allows for an immediate reaction on potential infrastructure risks and leads to improved maintenance. ITS can also be used for the maintenance of roadway safety (e.g., work zone management, road weather management, including snow and ice removal, warnings for poor visibility)⁶⁶, and public safety (i.e., crash reduction and crash avoidance).

Another aspect of infrastructure management concerns multimodal transport. This includes intelligent management of parking lots, charging or refuelling infrastructure, online and multimodal transport ticketing systems as well as information systems, e.g. for drivers indicating nearby availability. This contributes to more efficiency and sustainability, as users receive information about the most appropriate route, which could lead to reduced energy consumption and a reduction of the negative impact on the environment.

⁶³ Accessible at: [https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/635609/EPRS_BRI\(2019\)635609_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/BRIE/2019/635609/EPRS_BRI(2019)635609_EN.pdf)

⁶⁴ New York Times, "Italy Bridge Collapse Leave 37 Dead", accessible at: <https://www.nytimes.com/2018/08/14/world/europe/italy-genoa-bridge-collapse.html>

⁶⁵ BBC, "France bridge collapse: 50-tonne lorry 'probably caused accident'", accessible at: <https://www.bbc.com/news/world-europe-50479476>

⁶⁶ USDOT FHWA, Road Weather Management Program, accessible at: <https://ops.fhwa.dot.gov/weather/>

II. Transport challenges that can directly be addressed by ITS

Transport provides the possibility to improve access to work, health, education, markets and supply chains for business, but the sector also faces challenges. The following chapter focuses on some of the challenges.

A. Roadway and Railway Safety

Safety is of particular concern in all transport sectors. One of them is road transport where road traffic crashes cause over 1.3 million preventable deaths and an estimated 50 million injuries globally each year – making it the leading killer of children and young people worldwide aged 5-29. More than half of all road traffic death and injuries involve vulnerable road users, such as pedestrians, cyclists, and motorcyclists and their passengers⁶⁷. In addition, between 20 and 50 million non-fatal injuries yearly are caused by road traffic crashes. The death rate was over 3.5 times higher in low-income countries than in high-income countries, despite lower rates of vehicle ownership in developing countries.^{68,69}

As things stand, roadway crashes are set to cause a further estimated 13 million deaths and 500 million injuries during the next decade, again - particularly in low- and middle-income countries. These are unacceptable numbers, both in absolute and relative terms. Road traffic crashes have remained a major cause of death globally, even though many of those deaths and injuries are preventable.⁷⁰

Safety also concerns the railway sector, for another example. ITS developments in railways, in particular through the development of modern signalling, has contributed significantly to reducing safety risks. However, more needs to be done here as rail fatalities have not fallen to zero with large incidents still occurring within and outside the ECE region.

B. Accessibility and affordability issues

In many parts of the world, transportation infrastructure is insufficiently developed, leading to limited access to reliable transportation options. Rural areas, remote regions and underserved areas in particular, often lack reliable and affordable public transit networks, making it challenging for residents to connect to essential services, employment opportunities, and education and disproportionately harms the poor, older persons, persons with disabilities and children.⁷¹ These limitations do also exist in urban areas, where transportation costs, tolls, maintenance of personal vehicles, and parking expenses can quickly add up and can become a substantial burden, especially for many low-income individuals and families. Due to the divergences between rural and urban areas, it is challenging to find the strategy for improving accessibility and life quality holistically for all areas and people of all ages.

Transport is especially costly for many of the world's least developed countries, particularly those that are landlocked, and small island developing countries. Customs and border-crossing procedures, as well as long and often circuitous transit routes, mean that, from order to delivery, it takes landlocked-least developed countries nearly twice as long to import and export goods than others and have a higher average cost of export - \$3,444 per container, than transit countries. In addition, landlocked least developed countries would need to construct almost 200,000 km of paved roads and 46,000 km of railway, at a cost of about \$500 billion,

⁶⁷ https://www.who.int/health-topics/road-safety#tab=tab_1, accessed on 1.11.2023

⁶⁸ Accessible at: <https://unece.org/general-unece/press/unece-and-partners-release-global-plan-decade-action-road-safety-2021-2030>, accessed on 1.11.2023

⁶⁹ Accessible at: <https://www.un.org/en/desa/transport-transformation-critical-address-climate-change-and-universal-access-safe-affordable>, accessed on 1.11.2023

⁷⁰ Accessible at: <https://www.un.org/en/desa/transport-transformation-critical-address-climate-change-and-universal-access-safe-affordable>

⁷¹ UN, "Transport transformation critical to address climate change and universal access to safe, affordable, resilient mobility: UN Report", Accessible at: <https://www.un.org/en/desa/transport-transformation-critical-address-climate-change-and-universal-access-safe-affordable>

equivalent to an average of around 2 per cent of Gross Domestic Product (GDP) over a period of 20 years to catch up with transport accessibility in the rest of the world.⁷²

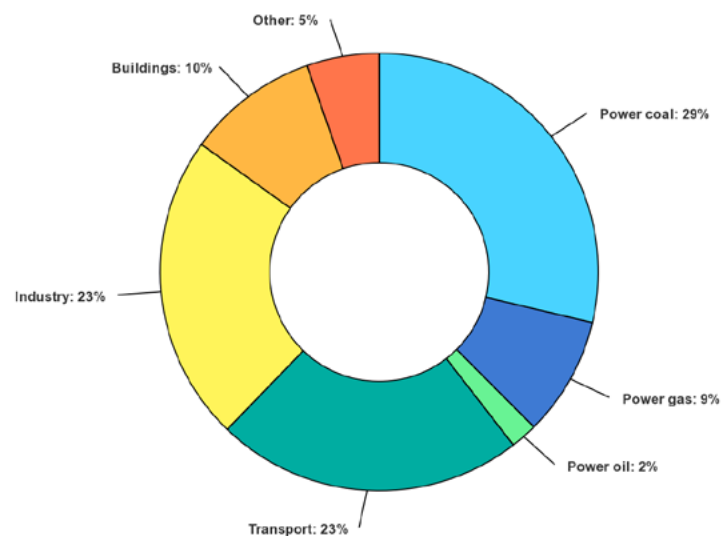
Affordability and accessibility are two fundamental pillars of a well-functioning transportation system. Ensuring that transportation options are both affordable and accessible to all members of society is not only a matter of convenience but also a critical element in promoting economic growth, social equity, and environmental sustainability.

C. Climate Change

The world is well off course to reach the ambitions of the Paris Agreement to the United Nations Framework Convention on Climate Change (UNFCCC) “to limit the temperature increase to 1.5°C above pre-industrial levels.”⁷³ The UN Secretary General Mr. António Guterres stated in his remarks to the High-Level opening of COP27 in November 2022: “We are in the fight of our lives. And we are losing. Greenhouse gas emissions keep growing. Global temperatures keep rising. And our planet is fast approaching tipping points that will make climate chaos irreversible. We are on a highway to climate hell with our foot still on the accelerator. [...]”⁷⁴

In 2020, the transport sector produced around 23 per cent of global energy-related carbon dioxide (CO₂) emissions, as shown in figure 1 (with more details for the different areas of the transport sector in figure 2). Currently, the sector accounts for about 30 per cent of global CO₂ emissions in OECD (Organization for Economic Cooperation and Development) countries and about 15 per cent in non-OECD countries. It accounts for 29 per cent of the European Union’s CO₂ emissions from fuel combustion, about 35 per cent in the United States, and is often the main cause for air pollution in cities.⁷⁵

Figure 10 Global energy-related CO₂ emissions by sector (2020)



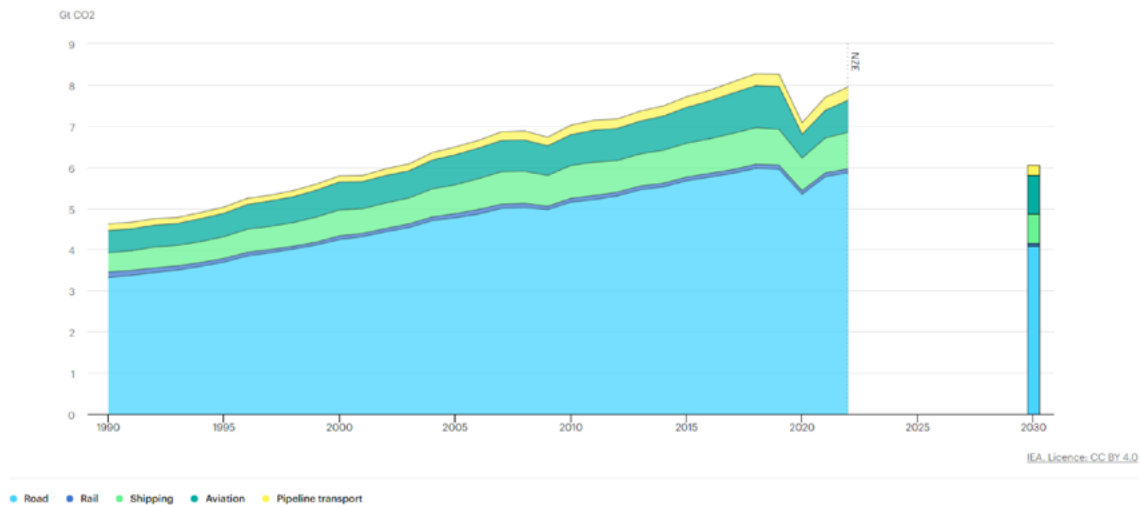
Source: IEA, Global energy-related CO₂ emissions by sector, IEA, Paris, accessible at: <https://www.iea.org/data-and-statistics/charts/global-energy-related-co2-emissions-by-sector>, IEA. Licence: CC BY 4.0

⁷² UN, “Transport transformation critical to address climate change and universal access to safe, affordable, resilient mobility: UN Report”, Accessible at: <https://www.un.org/en/desa/transport-transformation-critical-address-climate-change-and-universal-access-safe-affordable>

⁷³ Accessible at: <https://unfccc.int/process-and-meetings/the-paris-agreement>, accessed 10.10.2023

⁷⁴ UN, “Transport transformation critical to address climate change and universal access to safe, affordable, resilient mobility: UN Report”, Accessible at: <https://www.un.org/sg/en/content/sg/statement/2022-11-07/secretary-generals-remarks-high-level-opening-of-cop27-delivered-scroll-down-for-all-english-version>

⁷⁵ IEA World Energy Balances and IEA Greenhouse Gas Emissions from Energy, 2020

Figure 11 Global CO₂ emissions from transport by sub-sector in the Net Zero Scenario, 2000-2030

Source: IEA, Global CO₂ emissions from transport by sub-sector in the Net Zero Scenario, 2000-2030, IEA, Paris, accessible at: <https://www.iea.org/data-and-statistics/charts/global-co2-emissions-from-transport-by-sub-sector-in-the-net-zero-scenario-2000-2030-2>, IEA. Licence: CC BY 4.0

Intelligent Transport Systems (ITS) is the transport part of the information age; it provides the framework to design, deploy and coordinate the efficient solutions that people need, by optimising the transport system in a way that contribute to the greenhouse gas emission reduction objectives. There are three aspects of ITS technologies that need to be closely considered when looking at the climate impact of ITS (Note: there is no consensus about the intrinsic benefits of ITS for climate change mitigation):

- 1) Some traffic management experts consider that ITS technologies in transport can induce the so-called rebound effect

ITS technologies can ease the use of mobility, allow for other, non-driving, tasks when travelling, decrease average trip duration, which can all lead to higher transport activity and demand, driving up energy and emissions. Measures to ensure a balanced approach to mobility might be considered together with ITS to avoid adverse effects of ITS technologies on transport activity and its associated energy demand and emissions.

- 2) Embedded carbon

Improvement and deployment of infrastructure needs to be considered cautiously. Construction and maintenance work on infrastructure generate CO₂ emissions, e.g., due to tree felling, land preparation, emission of construction vehicles and used materials embodying carbon like concrete and asphalt.⁷⁶

- 3) Energy use of ITS technologies

The production, energy consumption and usage of ICT equipment as well as data storage and transfer leads to CO₂ emissions, which currently accounts for about 1.8 – 3.9 per cent (depending on the assumptions made).⁷⁷ Predictions vary, but the technology industry is expected to produce around 14 per cent of global emissions by 2040.⁷⁸

⁷⁶ Accessible at: <https://www.ice.org.uk/news-insight/news-and-blogs/ice-blogs/the-infrastructure-blog/how-roadbuilding-projects-create-co2-emissions-and-what-can-be-done-to-reduce-them/#:~:text=Road%20building%20generates%20carbon%20emissions,and%20emissions%20from%20construction%20vehicles>

⁷⁷ Accessible at: <https://reader.elsevier.com/reader/sd/pii/S2666389921001884?token=A789B298F4699106B2F18DDDECB893462E8BC51D1940F5C727EFE9B841DF7B941EBBF4F7A508E7657C033DBDDDE3D4BA&originRegion=eu-west-1&originCreation=20221110143752>

⁷⁸ Accessible at: <https://www.sciencedirect.com/science/article/abs/pii/S095965261733233X?via%3Dihub>

Transport is one of the sectors targeted where effective public interventions are being called for to reduce CO₂ emissions. There is the widespread agreement to reduce CO₂ emissions from transport by a minimum of 50 per cent at the latest by 2050, with a reduction of 96 per cent needed in road transport, comparing the numbers of total CO₂ emissions in 2022 with the 2050 target.⁷⁹

Box 14 The U.S. National Blueprint for Transportation Decarbonization

In the United States of America, the U.S. National Blueprint for Transportation Decarbonization is a landmark strategy for cutting all greenhouse gas (GHG) emissions from the transportation sector by 2050. It exemplifies a whole-of-government approach to addressing the climate crisis and will help reach net-zero carbon emissions by 2050. The Blueprint provides a comprehensive, system-level perspective of the entire transportation system across all passenger and freight travel modes and fuels, and lays out three key strategies to achieve decarbonization:

Increase convenience by supporting community design and land-use planning at the local and regional levels that ensure that job centers, shopping, schools, entertainment, and essential services are strategically located near where people live to reduce commute burdens, improve walkability and bikeability, and improve quality of life.

Improve efficiency by expanding affordable, accessible, efficient, and reliable options like public transportation and rail, and improving the efficiency of all vehicles.

Transition to clean options by deploying zero-emission vehicles and fuels for cars, commercial trucks, transit, boats, airplanes, and more.

Source: USEPA⁸⁰

⁷⁹ IEA, "Net Zero Roadmap - a Global Pathway to Keep the 1.5°C Goal in Reach - 2023 Update", page 198, accessible at: https://iea.blob.core.windows.net/assets/13dab083-08c3-4dfd-a887-42a3e533bc/NetZeroRoadmap_AGlobalPathwaytoKeepthe1.5CGoalinReach-2023Update.pdf

⁸⁰ Accessible at: <https://www.epa.gov/greenvehicles/us-national-blueprint-transportation-decarbonization>, accessed on 1.11.2023

III. The role of ITS to make transport safer, more efficient and more sustainable

New innovative technologies, when appropriately applied, are key to solving many of the challenges to achieving sustainable transport, stated by the UN Interagency report for the second Global Sustainable Transport Conference from 2021.⁸¹ It is important that challenges of different areas are faced, holistically taking into account the other ones, so that work does not remain in silos and does not lead to solutions being harmful for other areas.

One example of a silo solution, having the potential to reduce the negative impact of transport on the environment, could be lighter vehicles. However, levels of safety may be negatively impacted. Another solution could be to reduce the number of vehicle journeys, e.g. by increasing e-commerce and teleworking, but this could lead to more trips, e.g. due to increased demand for delivery services, so there would be again a need for alternatives etc.⁸²

These examples can be classified into one of the pillars of the ASI-approach, which entails “Avoid”, “Shift” and “Improve”. The approach of “avoid” is aiming at the efficient development of cities in order to closely connect districts, reduce trip length and therefore the need for motorized travels. “Shifting” promotes alternative modes of transport, like active transport (cycling and walking) and public transport. The “improve” method is aiming at improving efficiency of vehicles, in terms of fuel and energy consumption, and of public transport, including its attractiveness.⁸³

ITS has the potential to address these different pillars in a holistic way. Governments and international bodies need to provide regulations, policies and incentives to accelerate the development and deployment of new transport technologies, including digital applications, while ensuring that no one is left behind.

A. Safer transport

In September 2020, the UN General Assembly adopted resolution A/RES/74/299 “Improving global road safety”. It launched the Decade of Action for Road Safety 2021-2030, setting the ambitious target of preventing at least 50 per cent of road traffic deaths and injuries by 2030. To realize this vision, ECE partnered with WHO and its sister UN Regional Commissions and developed a Global Plan for the Decade of Action, which was released in October 2021.⁸⁴



⁸¹ UN Interagency report for the second Global Sustainable Transport Conference, 2021, Accessible at: <https://sdgs.un.org/publications/inter-agency-report-second-global-sustainable-transport-conference>

⁸² Jaramillo, P., S. Kahn Ribeiro, P. Newman, S. Dhar, O.E. Diemuodeke, T. Kajino, D.S. Lee, S.B. Nugroho, X. Ou, A. Hammer Strømman, J. Whitehead, 2022: Transport. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA

⁸³ Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Sustainable Urban Transport: Avoid-Shift-Improve (A-S-I) Integrate". Accessible at: https://www.transformative-mobility.org/assets/publications/ASI_TUMI_SUTP_iNUA_No-9_April-2019.pdf

⁸⁴ Accessible at: <https://unece.org/general-unece/press/unece-and-partners-release-global-plan-decade-action-road-safety-2021-2030>

A way to improve safety and efficiency in the transport of people and goods could be the enabling, promotion and accessibility of ITS technologies like automated, autonomous, and connected vehicles as well as optimised MaaS. They could contribute to more safety by reducing the human error, and by exchanging safety related traffic information like local hazard warnings, dangerous weather conditions, emergency vehicle notifications, providing and using traffic light information services and real time traffic information, proposing fastest routes with mixed modes of transport, etc.

Box 15 National Roadway Safety Strategy in the United States of America

The United States Department of Transportation National Roadway Safety Strategy (NRSS) outlines the Department's comprehensive approach to significantly reducing serious injuries and deaths on U.S. highways, roads, and streets. This is the first step in working toward an ambitious long-term goal of reaching zero roadway fatalities.

The strategy includes advancing the use and deployment of technologies (e.g., ITS, interoperable V2X capabilities, an Intersection Safety Challenge, etc.), to increase roadway safety through training, knowledge transfer, and grant funding. These technologies should adhere to cybersecurity practices, and enhance safety for all users. (FHWA, OST-R)

Source: USEPA ⁸⁵

To address the global road traffic safety crisis, many more stakeholders are committed to take actions than ever before in history. To successfully combat the road safety crisis, it is imperative to put all resources to their maximum use, including the mainstreaming of ITS solutions.

B. New mobility solutions

ITS can leverage technology, data, and smart systems to make transportation more cost-effective and accessible. These innovations have the potential to optimize transportation services, encourage sustainable practices, and provide real-time information that provides the opportunity to users to make more efficient and economical choices when it comes to their transportation needs. This, in turn, can help to create a more inclusive and affordable transportation ecosystem for all.

1) Real time data for cost savings

- ITS can use real-time data from sensors, cameras, and GNSS to optimize traffic flow and reduce congestion. This can reduce fuel consumption, travel time and ultimately lower transportation costs for individuals and businesses.
- Fuel Efficiency: ITS can provide drivers with real-time information about optimal routes, traffic conditions, and fuel prices. This allows them to make more informed choices, can reduce fuel consumption and their environmental footprint.

2) Public transit efficiency

- Smart Scheduling and real time information: ITS provides the possibility to public transit agencies to improve the efficiency of their services through real-time tracking and scheduling. Buses and trains could adjust their routes and schedules based on demand, reducing wait times and increasing ridership. Providing real time information also benefits individuals with disabilities, as they can plan their trips with confidence, knowing that they will have access to appropriate facilities and services.

3) Fare Integration: Integrated fare systems and mobile apps could offer passengers the convenience of using multiple modes of public transportation with a single ticket or payment method.

4) Dynamic ride sharing, carpooling and last-mile solutions

- Dynamic carpooling and ride-sharing using ITS services has the potential to reduce the cost of individual travel while promoting vehicle sharing.
- ITS platforms often include information about micro-mobility options like electric scooters and bike-sharing, which can bridge the "last-mile" gap between public transportation and final destinations.

⁸⁵ Accessible at: <https://www.epa.gov/greenvehicles/us-national-blueprint-transportation-decarbonization>, accessed on 1.11.2023

5) *Autonomous (public) transport and self-driving taxi services*

Autonomous transport, e.g. autonomous public shuttles or self-driving taxi services, are enhancing accessibility by offering 24/7 availability, benefiting individuals with disabilities and diverse schedules. They are also contributing to Vizion Zero goals for safety and providing new options for access to electric mobility. Two examples of the current progress in China and the United States of America are provided in boxes 15 and 16.

Box 16 Apollo's progress in Autonomous Driving Vehicles

"In 2013, Baidu began to layout autonomous driving, and in 2017, it launched the world's first autonomous driving open platform "Apollo". In 2019, Baidu and FAW jointly produced China's first series of mass-production L4 autonomous driving vehicle, Hongqi EV. On June 17 2021, Baidu Apollo and BAIC released the new generation of robotaxis for ride-hailing, Apollo Moon. On July 21 2022, Baidu released the sixth generation of mass-production autonomous driving vehicle, Apollo RT6.

Baidu Apollo autonomous driving has been put into commercial trial operation in several cities, including Beijing, Shanghai, Guangzhou, Shenzhen, Chongqing, Changsha, and Yangquan, etc. The driverless, autonomous driving fleet has entered five cities including Beijing, Shenzhen, Wuhan, Chongqing, and Shanghai. As of September 30 2023, the overall ride-hailing orders of Apollo robotaxi have reached a total of 4 million."

Source: China Automotive Technology and Research Center (CATARC), October 2023

Box 17 WAYMO's progress with self-driving vehicles

In October 2015 a small self-driving vehicle developed by Waymo made its pioneering journey, marking a significant milestone in autonomous technology. In 2017, Waymo initiated a programme for an exclusive group of users in the Metro Phoenix area, employing the more advanced Waymo Driver technology integrated into a full-size Chrysler Pacifica hybrid. In 2019, this new technology has pioneered fully driverless, paid rides on high-speed roads across a service area larger than the city of San Francisco.

Figure 12 Self-Driving Car



Source: Waymo.

In 2020, Waymo reached 5-10 per cent of its rides being fully driverless for the exclusive group of users under non-disclosure agreements, yielding valuable insights to enhance the service. Since then, Waymo progressively expanded access to the public Waymo service, with rides being monitored by a vehicle operator. Effective October 8 2020, Waymo opened its fully driverless service to the general public in Phoenix.

Source: Waymo. ⁸⁶

⁸⁶ Accessible at: <https://waymo.com/blog/2020/10/waymo-is-opening-its-fully-driverless.html>, accessed on 18.09.2023

6) Leapfrogging

Underdeveloped countries often face challenges such as inadequate road infrastructure, traffic congestion, and road safety issues. ITS presents a significant opportunity to overcome these hurdles. By bypassing traditional, costly, and resource-intensive transport development stages, these countries can implement state-of-the-art ITS solutions to improve their transportation systems.⁸⁷

In summary, ITS can make transport more accessible and affordable by offering new mobility solutions and expanding and connecting current capabilities, especially for persons with reduced mobility and elderly people. ITS and extended mobility offers are the basis to establish new markets and create access to employment and improve living conditions. Investment in (ITS) infrastructure can introduce high returns as it increases people's choices: where to live and work, what to consume, what sort of economic activities to carry out, and which other people to communicate with.

C. Sustainable transport as an effort to limit climate change

Combined efforts can help making transport more sustainable as it accounts for around 23 per cent of global energy-related CO₂ emissions (in 2020), as mentioned in chapter II. C. Many countries are aware of this, as shown during the COP27 that recently took place in Egypt, where governments representing over half of global GDP set out a twelve-month action plan to help make clean technologies cheaper and more accessible everywhere.^{88 89}



The announcement from the Breakthrough Agenda, a commitment launched at COP26 by 45 countries to make clean technologies as financially attractive as fossil fuels by 2030, set out 25 collaborative actions they would deliver by COP28 to speed up the decarbonisation of power, road transport, steel, hydrogen and agriculture sectors. One of the private sector contributions to this is the "First Movers Coalition", using their purchasing power to create early markets for innovative clean technologies across eight hard to abate sectors. These in-scope sectors were responsible for 30 per cent of global emissions - a proportion expected to rise to over 50 per cent by mid-century without urgent progress on clean technology innovation. Commitments for the first four sectors (aviation, shipping, steel and trucking) were launched in November 2021, at COP26.⁹⁰ At the time this publication was drafted, it was made up of 65 companies with a collective market value of \$8 trillion. Another coalition of 40 countries and 14 vehicle manufacturers, called "Accelerating to Zero", came together at COP27, committing to make all new car sales zero emission by 2035. This could include electrification of passenger cars and light duty vehicles.⁹¹

⁸⁷ UNECE, "Intelligent Transport Systems (ITS) for sustainable mobility", 2012, ISBN 9788897212034

⁸⁸ Accessible at: <https://climatechampions.unfccc.int/breakthrough-agenda/#:~:text=The%20Priority%20Actions%20include%20agreements,to%20ensure%20credibility%20and%20transparency>, accessed on 09.01.2023

⁸⁹ Accessible at: <https://www.un.org/en/climatechange/cop27/photos>

⁹⁰ Accessible at: <https://www.weforum.org/first-movers-coalition/about>

⁹¹ Accessible at: <https://www.reuters.com/business/sustainable-business/after-disappointing-cop27-calls-grow-new-approach-fighting-climate-change-2022-11-28/>

However, electrification comes with challenges such as range anxiety where ITS could play a decisive role and provide information about charging infrastructure and smart grid. Another possibility how ITS and information sharing can contribute to reducing CO₂ emission, is making transport more efficient, e.g. through sharing information of traffic signals allowing vehicles to know when to coast to a traffic signal, by directly broadcasting the number of vehicles at a traffic signal to reduce wait time, by sending road conditions from smart vehicles to authorities to improve road maintenance, etc. As deploying ITS has the potential to reduce accidents, it could also reduce CO₂ emissions by reducing accident-related congestion, reducing emergency vehicle trips, reducing the production of replacement vehicles, etc.

Another possibility where ITS can be applied to optimise passenger transport is integrated land-use and transport planning, and by shifting to more sustainable modes. Modal shift can be achieved with urban (re)development and investments in new, digital infrastructure, linked with integrated urban planning, multimodal logistics hubs, transit-oriented development, and more compact urban forms that support public transport, cycling and walking, as well as more efficient urban logistics (see an example for autonomous delivery services in box 18).⁹²

Box 18 Autonomous Delivery of Wuling in China

“Since 2019, the automobile company SAIC-GM-Wuling has achieved unmanned logistics delivery in closed areas based on the battery electric city car Baojun E100. In 2021, it iterated the second-generation unmanned logistics product and deployed it on factory premises. As of now, the unmanned delivery miles have exceeded 2 million kilometers, and the number of vehicles in operation has exceeded 400.

In June 2021, by combining 5G + C-V2X technology and integrating cloud computing and roadside perception technology, the company realized the public road unmanned logistics operation in Liuzhou National-level Internet of Vehicles Pilot Zone, put 10 vehicles into test operation, and exceeded the accumulated mileage of 16,000 kilometers.”

Source: China Automotive Technology and Research Center (CATARC), October 2023



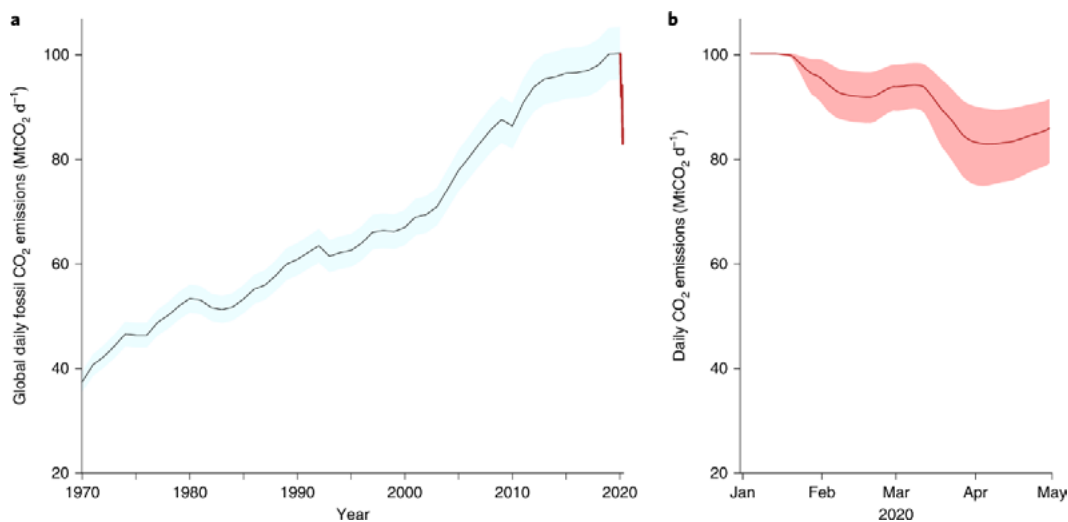
⁹² Jaramillo, P., S. Kahn Ribeiro, P. Newman, S. Dhar, O.E. Diemuodeke, T. Kajino, D.S. Lee, S.B. Nugroho, X. Ou, A. Hammer Strømman, J. Whitehead, 2022: Transport. In IPCC, 2022: Climate Change 2022: Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [P.R. Shukla, J. Skea, R. Slade, A. Al Khourdajie, R. van Diemen, D. McCollum, M. Pathak, S. Some, P. Vyas, R. Fradera, M. Belkacemi, A. Hasija, G. Lisboa, S. Luz, J. Malley, (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA

As mentioned previously, modal shift to rail and inland waterways remains a high priority to reduce the climate impacts of the transport sector. Therefore, an efficient use of the entire logistics chain, with the optimal use of ITS solutions in the process, building on current advancements, will have a positive effect on climate change.⁹³ This was also demonstrated during COP27 with a progress report on an initiative launched at COP26 to establish at least six green shipping corridors, zero-emission maritime routes between two or more ports, by 2025. It identified more than 20 initiatives, including between Shanghai and Los Angeles, a route that carries 40 per cent of all the goods that go between China and the U.S.⁹⁴

Moreover, the expansion and improvements of digital infrastructure for freight and logistics could improve economical aspects and reduce the environmental impact of transport through less congestion and paperless work. These multimodal transport possibilities are part of the ITS solutions that have the potential to provide the framework to design, deploy and coordinate the efficient solutions that people need.

The effort that is needed to efficiently tackle climate change can be estimated when looking at the drop of emissions during the time of Covid-19 (figure 3) especially in early 2020 when many regions were under some level of confinement, and its impact on the atmospheric CO₂ concentration.⁹⁵

Figure 13 Global daily fossil CO₂ emissions



Source : Le Quéré, C., Jackson, R.B., Jones, M.W. et al. Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement. Nat. Clim. Chang. 10, 647–653 (2020). <https://doi.org/10.1038/s41558-020-0797-x>, accessible at : <https://www.nature.com/articles/s41558-020-0797-x>

- a) Annual mean daily emissions in the period 1970–2019 (black line) with uncertainty of $\pm 5\%$ ($\pm 1\sigma$; grey shading). The red line shows the daily emissions up to end of April 2020 estimated here.
- b) Daily CO₂ emissions in 2020 (red line, as in a) and the uncertainty (red shading).

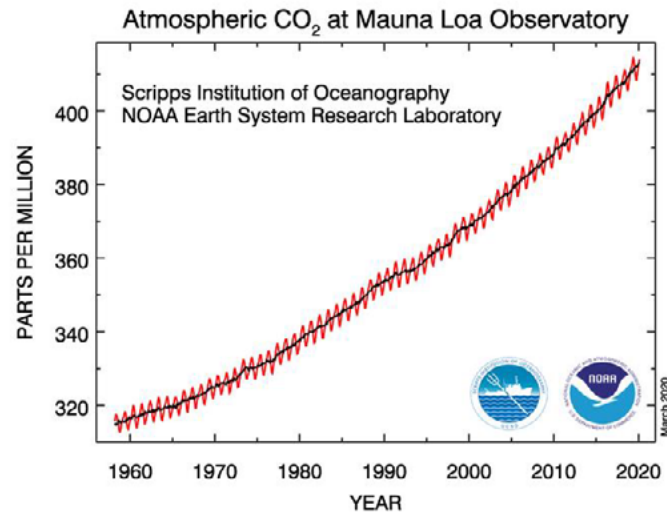
⁹³ Accessible at: <https://unfccc.int/climate-action/marrakech-partnership/reporting-tracking/pathways/transport-climate-action-pathway#Climate-Action-Pathway-2021>

⁹⁴ Accessible at: <https://www.reuters.com/business/sustainable-business/after-disappointing-cop27-calls-grow-new-approach-fighting-climate-change-2022-11-28/>

⁹⁵ Le Quéré, C., Jackson, R.B., Jones, M.W. et al. Temporary reduction in daily global CO₂ emissions during the COVID-19 forced confinement. Nat. Clim. Chang. 10, 647–653 (2020). <https://doi.org/10.1038/s41558-020-0797-x>, accessible at : <https://www.nature.com/articles/s41558-020-0797-x>

This drop in emissions did not have any detectable impact on the atmospheric CO₂ nor the climate change, as shown in figure 14 below, because CO₂ remains in the atmosphere and oceans for centuries.^{96,97} Therefore, efforts to tackle climate change need to increase, where the deployment of ITS solutions could play an important role.

Figure 14 Atmospheric CO₂ at Mauna Loa Observatory, being a benchmark station of the Global Atmosphere Watch Network



Source: WMO, Accessible at: <https://public.wmo.int/en/media/news/economic-slowdown-result-of-covid-no-substitute-climate-action>

Acknowledging the importance and impact of ITS on the environment, the ITS community gathered in Bordeaux 5-9 October 2015, reaffirming its awareness of the challenges and its readiness to cooperate at the relevant scale (city, region, nation, international) to make contributions to addressing them, which are efficient and sustainable. Internationally, nationally and regionally there is a need to develop awareness and exchange experience about the scope of ITS, its achievements and its potential. In particular, local best practices need to be shared and promoted and costs and benefits need to be documented and publicised. The participants to the minister's roundtable:

- Expressed their appreciation for the support given by the previous Round Tables of Vienna, Tokyo and Detroit that has fostered the coherent deployment of ITS to face transport challenges;
- Committed to promoting the deployment of ITS systems to reduce CO₂ and greenhouse gas emissions linked to transport through stepping up investments into these instruments;
- Invited the experts, national decision makers, relevant international organisations and legal bodies to provide guidelines and capacity building actions to support the deployment of appropriate solutions based on ITS;
- Invited both public and private sector stakeholders to come forward with 'best practice' examples of ITS deployment that contributes to the reduction of CO₂ and associated greenhouse gas emissions so that governments can be helped to reach the ambitious objectives.

⁹⁶ Accessible at: https://unfccc.int/sites/default/files/resource/1.GCP_.pdf and <https://www.nature.com/articles/s41558-020-0797-x>

⁹⁷ Accessible at: <https://public.wmo.int/en/media/news/economic-slowdown-result-of-covid-no-substitute-climate-action>

IV. Gaps and stumbling blocks in ITS deployment

Achieving appropriate governance of ITS is a major factor for its wide-scale deployment and is vital for securing the full benefits of ITS. While good governance is essential, there are also several distinctive and very specific obstacles, some of which are explained in more detail below.

A. Interoperability and continuity across borders

Despite the large number of existing ITS applications, many of them remain incompatible and fragmented across national borders and different parts of the world.

Some interoperability issues can be found in the automotive area. The coexistence of different standards for implementing V2X services as well as the lack of an internationally agreed common message set has been hampering the development of new features and reaching a critical mass for deployment. Not using V2X is limiting the domain where a vehicle equipped with ADS could work, for example to merge on a high-speed road, the AV needs to communicate with any kind of other road user, including non-automated vehicles too. Another interoperability issue is non-harmonized traffic rules across borders, for which the creation of a digital repository, as proposed by ITU in 2023, could be a potential solution so that ADS have at least a reliable source for them. There are divergent views on the responsibilities of the driver/ user of an AV. This could hamper cross-border deployment of automated, autonomous and connected vehicles.

The threat posed by a lack of interoperability and compatibility of ITS is similar to that which already exists in the railways, where more than a century of diverging technical standards have been developed which will require at least another 50 years of efforts to harmonise. Even though the application of ITS solutions is not mandatory, it could lead to a better service for transport users, including better information services and seamless transport, among others. The fact that these ITS solutions are not mandatory is leading to a widening digital divide in some sectors, increasing the lack of interoperability and the pursuit of non-compatible systems. A parallel running and disconnected management of regulations and standards would undermine the desired benefits of ITS and could result in being an obstacle to further developments. The development of harmonized standards, regulations and agreements between neighbouring countries is difficult and time-consuming, but the exchange of experiences and best practices is essential.

B. Infrastructure

To make road management more efficient and smarter, and to extend the possibilities of automated, autonomous and connected vehicles, infrastructure needs to be upgraded to deliver information that can enable new services. For example, ICT equipped infrastructure could extend the functionalities of TCCs and automated vehicles by providing more information about the vehicle's surroundings, on the current traffic and weather conditions, and could allow communication, e.g., between a vehicle and parking lots, traffic lights etc. It would provide the basis for agile traffic management and achieving effective traffic flow.

Insufficient quality and poorly maintained infrastructure remain a significant problem also for the railway sector. This is a concern for the introduction of ITS solutions, particularly in signalling and traffic management.⁹⁸

C. Data management and access to data

ITS services are based on data and can also create a huge amount of data. It comes with the challenge of data management, data privacy and security, data quality and finding a solution to the question of who owns it and who should be allowed to access and/or share it. In some jurisdictions the access is regulated in a horizontal manner, for example via the General Data Protection Regulation (GDPR) in the European Union, the Personal Information Protection Law (PIPL) in China and the California Consumer Privacy Act (CCPA) in California, United States of America.

⁹⁸ UNECE, "Trans-European Railway High-Speed Master Plan Study – A general background to support further required studies", accessible at: https://unece.org/sites/default/files/2021-07/2017852_E_web_light.pdf

Within the automotive, vehicle sensors collect a huge amount of data about the geo-localization, driving environment, driving style e.g. engine speed or temperature peaks, how the system reacted, when it was switched on, etc. So far, only the European Union developed specific guidelines “1/2020 on processing personal data in the context of connected vehicles and mobility related applications”⁹⁹. However, the idea to harmonize the access to in-vehicle data still encounters resistance. There are diverging views on how to proceed and not everyone is in favour of conducting an evaluation covering the wide range of the different possible models to create knowledge regarding necessities and challenges of harmonization.

Another challenge regarding access to data is the request of making data publicly available. On the one hand it can enable the development of new markets and to exploit the potential knowledge provided through data analytics. On the other hand, it is important to respect privacy, the right of intellectual property as well as the ownership and confidentiality of data of individuals and organisations.

D. High complexity and vulnerability

Managing ITS transport systems is a highly complex task, especially in dense, urban areas where huge amounts of data are sent and received from different sources and need to be processed in real-time. Developments in the field of ICT could provide the capacity and infrastructure to deal with big data.

However, this brings the challenge to establish a secure process, ensuring secure communication between recognizable relevant parties, making it resilient against cyberattacks during the whole lifecycle and at the same time being fast enough to allow real-time operation.¹⁰⁰ Moreover, it is important to ensure that technology devices do not become obsolete after a short period of use, and that maintenance and updates can be carried out without having to replace the device.

E. Question of liability

With an increasing level of automation in vehicles, there is an increased potential for more efficient and safer transport, but it also raises new questions. One of the biggest questions might be who is liable, if any accident happens. In many countries, the law clearly states that the liability of driving remains exclusively with the driver. However, the first systems are already on the market, where the driver is allowed to do any other activity than driving and only needs to be able to react within a time delay on a transition demand issued by the system to take over the driving task. Looking at the next levels of automation, the driver will not be needed as a fallback option anymore. Therefore, further research and work needs to be done to build the foundation for the deployment of autonomous driving, also regarding international law.

F. Awareness raising for ITS and its application

The world has demonstrated an extremely high pace for innovation. To build their acceptance by the public and foster deployment, the public needs to be informed and educated on these new technologies, their capabilities and correct application, to plant understanding. People need to be educated on the way AVs work, regardless of whether they are pedestrians, drivers in mixed traffic situations where non-automated and automated vehicles share the road, passengers of an autonomous shuttle or users of vehicles equipped with ADS. As ADS are developed by different manufacturers, they might behave differently in the same situation, that is why it is important that users are aware of the functionalities of their vehicle.

Another field of ITS, where public awareness is needed, is bidirectional charging of electric vehicles. The technology could provide more energy flexibility to the network, among other benefits, like an increased usage of renewable energy but would require the vehicle owners to allow this functionality, if available in the vehicle.

Additionally, workforce development efforts must be undertaken to ensure that enough training is provided for ITS installation, operations, and maintenance.

⁹⁹ Accessible at: https://edpb.europa.eu/our-work-tools/documents/public-consultations/2020/guidelines-12020-processing-personal-data_en

¹⁰⁰ Joanna Kolodziej, Matteo Repetto, Armend Duzha: “Cybersecurity of Digital Service Chains”, Springer, 2022

V. ECE's vision and approach to ITS

ECE and its bodies promote ITS through facilitating coordinated activities for legal instruments aimed at the application and deployment of ITS. Nowadays, the transport division's main challenge is to listen, understand and respond to new transport issues and in parallel continue its task of promoting the implementation of existing conventions and agreements by all its member countries to reach the SDGs.



A. Inland Transport Committee Strategy until 2030¹⁰¹

1. Inland Transport Committee Vision 2030:

The Inland Transport Committee is the United Nations platform for inland transport to help efficiently address global and regional needs in inland transport

The 2017 Ministerial Resolution contains the policy directions for the future work of ITC,¹⁰² as articulated in Decision 1, in principle “enabling the Committee to efficiently address the needs of global inland transport, with special attention to global regulatory governance through the UN transport Conventions and other means, (...) while leaving the organizational structure of the ECE secretariat, as well as the programme-budgeting function and oversight unchanged”.

The outcome of the ECE reform review and specifically decision A(65) of the Commission in 2013,¹⁰³ acknowledged that “9. The [Transport] subprogramme is a unique United Nations centre providing a comprehensive regional and global platform for consideration of all aspects of inland transport development and cooperation. The ECE Transport subprogramme, the Inland Transport Committee (ITC) and its related subsidiary bodies work within current mandates in an efficient way, producing concrete results in a regular and ongoing way that have clear value added for the region and beyond.”¹⁰⁴

United Nations General Assembly Resolutions stress the global role of the legal instruments under the purview of the ITC and encourage all member States to accede to, including: Resolution 72/271 adopted in April 2018 and other biennial road safety resolutions; Resolution A/RES /72/212 on intermodality; and Resolution A/70/197 on connectivity and corridors.

¹⁰¹ UNECE, Report of the ITC on its eighty-first session, Addendum 2, ECE/TRANS/288/Add.2

¹⁰² For the full 2017 Ministerial Resolution, see ECE/TRANS/288/Add.2, Annex II. For more comprehensive background information, see ECE/TRANS/288/Add.2, Annex X.

¹⁰³ For a more complete reference to relevant parts of A(65), see ECE/TRANS/288/Add.2, Annex IV.

¹⁰⁴ ECE/TRANS/288/Add.2, Annex V provides the current Terms of Reference of the ITC. ECE/TRANS/288/Add.2, Annex VI contains the structure of the ITC and the transport subprogramme.

The above can be summarised as **“Vision: ITC is the UN platform for inland transport to help efficiently address global and regional needs in inland transport”**.

The ITC as the UN platform for inland transport will continue to provide a comprehensive regulatory framework for inland transport including road, rail, inland waterway and intermodal transport, comparable to the role of the International Maritime Organization (IMO) and International Civil Aviation Organization (ICAO).

The ITC as the UN platform for inland transport should perform the following key functions:

- Leading change in inland transport
- Developing and administering transport legal instruments
- Increasing accessions and equitable participation, including by non-ECE Member States.

2. Inland Transport Committee Mission

The **mission** for ITC is that **it contributes to sustainable inland transport and mobility for achieving the sustainable development goals in the ECE and UN member States through policy dialogue, harmonizing regulatory frameworks, as appropriate, promoting new technologies, assisting in enhancing connectivity and supporting the implementation of legal instruments.**

In performing its mission, the Committee will enhance its role as:

- (a) **The UN Platform for regional and global inland transport conventions.** By strengthening its role as the UN platform of inland transport conventions to all UN Member States and by remaining at the forefront of global efforts to curb the road safety crisis, through its 360° approach to road safety, cut emissions by setting and promoting its vehicle standards, and reduce cross-border barriers with its large set of facilitation conventions.
- (b) **The UN Platform for supporting new technologies and innovations in inland transport.** By ensuring that (i) its regulatory functions are keeping pace with cutting-edge technologies driving transport innovation - especially in the areas of Intelligent Transport Systems, autonomous vehicles and digitalization - thus improving traffic safety, environmental performance, energy efficiency, inland transport security and efficient service provision in the transport sector, (ii) the different amendment processes for the different conventions do not cause fragmentation, and (iii) the dangers of stifling progress due to too early regulation are avoided.
- (c) **The UN Platform for regional, interregional and global inland transport policy dialogues.** By providing a platform for policy dialogue to review emerging challenges in inland transport, as well as proposals for improving infrastructure and operation at its annual session.
- (d) **The UN Platform for promoting sustainable regional and interregional inland transport connectivity and mobility.** By providing a comprehensive, harmonized regulatory framework, as appropriate, and institutional reference point supporting international connectivity, developing new or building on existing initiatives, agreements, or corridors, as needed.

3. Inland Transport Committee Strategic Objectives

(a) Strategic Objective

Increased governance – ITC is truly the UN platform with equal participation of all contracting parties to UN legal instruments under its purview to lead the future development of inland transport; - UN transport conventions under its purview are universally accepted and implemented, open for accession/ratification by all UN Member States if feasible, and inclusive of regional good practices; - ITC keeps pace with technological developments in a timely manner; - ITC's work enhances regional and inter-regional connectivity.

(b) Horizontal Objective

Increased support to the implementation of all Sustainable Development Goals (SDGs), in particular through: (a) improved traffic safety and urban mobility (SDGs 3 and 11); (b) reduced pollutant and GHG emissions (SDGs 3 and 13); (c) improved industry innovation and infrastructure efficiency and connectivity (SDG 9); (d) Affordable and clean energy (SDG 7); (e) decent work and economic growth (SDG 8); (f) gender equality (SDG 5) and (g) contributions to global monitoring of progress towards sustainable transport as much as feasible (all relevant SDGs).

4. Action Plan for Achieving the Inland Transport Committee Vision

Incorporating the vision, mission, objectives, regional and global challenges and mandates, and views and suggestions expressed on the strategy at the eightieth session of ITC in February 2018, an action plan is drawn below as part of its strategy for 2030.

(a) Enhance the role of ITC as the United Nations Platform for inland transport conventions

- (a) Strengthen promotion of accession by non-ECE member States to the United Nations legal instruments on inland transport administered by ECE
 - (i) Facilitate participation of non-ECE member States in the legal instruments
 - Amend the terms of reference (TORs) of ITC to provide full membership of ITC for non-ECE Contracting Parties to the United Nations legal instrument(s) and relevant subsidiaries, and observer status for other UN Member States that are not Contracting Parties.
 - Amend the legal instruments with geographical and procedural barriers to allow accession by non-ECE member States, where necessary.
 - (ii) Exploit full benefits of all the legal instruments
 - Review the existing legal instruments to identify their relationship and complementarity in practical applications and recommend to non- ECE member States
 - Identify the needs for additional necessary legal instruments to support the implementation of the existing legal instruments in non-ECE member States
- (b) Formulate new binding and/or non-binding legal instruments to address emerging challenges under the Sustainable Development Agenda
- (c) In cooperation with other organizations and institutions, develop new or adjust/update existing training manuals, guidelines, standards and competency criteria to assist in enhancing capacity in the accession and implementation of the legal instruments and organize training courses
- (d) Develop indicators for Contracting Parties to evaluate status and progress in the implementation of the legal instruments

(b) Enhance the role of ITC as the United Nations Platform for supporting new technologies and innovations in inland transport

- (a) Strengthen the platforms for digitalization, automated driving and intelligent transport systems of inland transport
- (b) Improve regulatory environment to promote automated/autonomous and connected vehicles

(c) Enhance the role of ITC as the United Nations Platform for regional, interregional and global inland transport policy dialogues

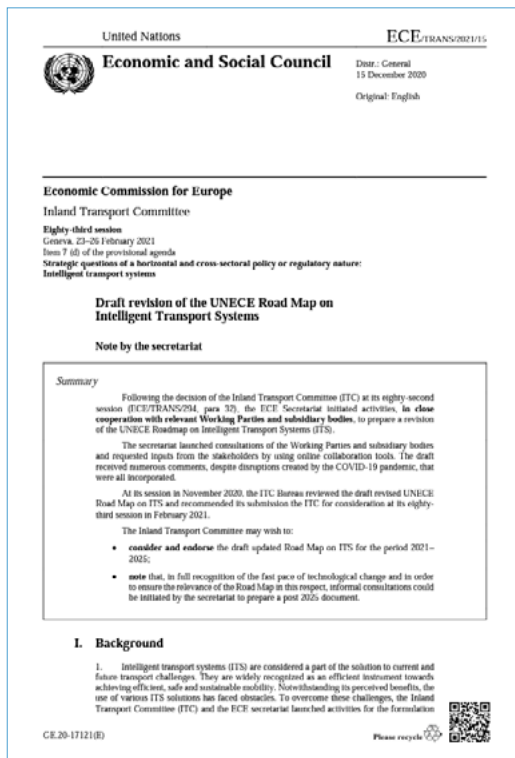
- (a) Organize regional, interregional and global thematic segments on sustainable inland transport during ITC sessions
- (b) Include ITC agenda items on challenges facing inland transport in different regions

(d) Enhance the role of ITC as the United Nations Platform for promoting sustainable regional and interregional inland transport connectivity and mobility

- (a) Continue to work for sustainable regional integrated intermodal infrastructural connectivity and mobility
- (b) Cooperate with other regional commissions and organizations to improve sustainable interregional connectivity including through various corridors
- (c) Promote green transport connectivity and mobility

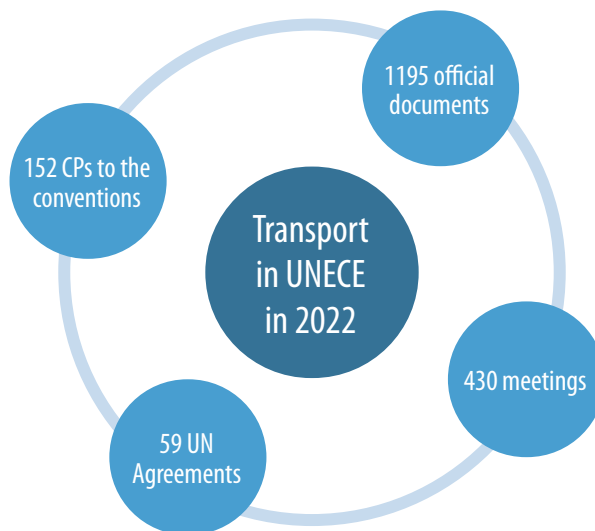
Cross-cutting areas, such as climate change statistics and gender issue, will be embedded in the relevant actions.

B. Inland Transport Committee and the Road Map on ITS



ECE is determined to be a frontrunner for innovative policies to ensure road safety and sustainability in all aspects. In the context of offering best practices and solutions for a safe and seamless mobility, ECE Working Parties are mandated to seek multiple synergies to maximize the benefits of legal instruments. Their work is guided by the Road Map on Intelligent Transport Systems (current period: 2021-2025, symbol ECE/TRANS/2021/15), which includes 18 Actions. In order to achieve these actions, each of the Working Parties organizes several sessions a year, well attended by members from all around the world see the figures from 2022 below¹⁰⁵. The Working Parties as well as their specific approach to enable and support ITS deployment are introduced in the following.

Figure 15 Transport in UNECE in numbers



Source: UNECE

¹⁰⁵ Information provided by ITC secretariat, "performance indicators", 85th session of the ITC, February 2023

1. World Forum for the Harmonization of Vehicle Regulations

The World Forum for Harmonization of Vehicle Regulations (WP.29) is a unique worldwide regulatory forum within the ITC, being the only global forum for harmonizing vehicle regulations and rules on vehicle performance and on vehicle parts and equipment, vehicle safety, environmental pollution, energy efficiency, anti-theft and security.

The terms of reference and rules of procedure of WP.29 allow for the smooth administration of the three major international United Nations Agreements on motor vehicles, providing the legal basis and allowing Contracting Parties attending the WP.29 sessions to establish regulatory instruments concerning motor vehicles and motor vehicle equipment:

1. The 1958 Agreement concerning the Adoption of Harmonized Technical United Nations Regulations 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 United Nations Regulations (Revision 3). The 1958 Agreement includes roughly 170 UN Regulations annexed to the Agreement at the time this publication was drafted as well as the complete status information of the Agreement, listing the Contracting Parties applying ECE regulations.
2. The 1997 Agreement concerning the adoption of uniform conditions for periodical technical inspections of wheeled vehicles and the reciprocal recognition of such inspections.



3. The 1998 Agreement concerning the establishment of the global technical regulations for wheeled vehicles, equipment and parts which can be fitted and/or be used on wheeled vehicles. The 1998 agreement includes the Global Registry, which is the repository of 24 Global Technical Regulations (GTR) at the time this publication was drafted, the compendium of candidates for participation in the harmonization or adoption of global technical regulations as well as the complete status information of the agreement.

The three UN Agreements provide a legal framework allowing contracting parties to establish internationally harmonized regulatory instruments concerning the certification of motor vehicles, their equipment and parts, and rules for technical inspections of vehicles in use. The regulatory framework developed by the World Forum allows the mass market introduction of innovative vehicle technologies, while continuously improving global vehicle safety, energy efficiency and environmental performance. Countries joining the World Forum benefit from a global platform where state-of-the-art technical regulations are discussed and adopted, reducing the administrative burden for contracting parties, and offering harmonized technical specifications for faster deployment of vehicle technologies aiming at achieving sustainable mobility.

Box 19 Vehicle Type Approval vs. Self-certification

“Vehicle Type Approval”

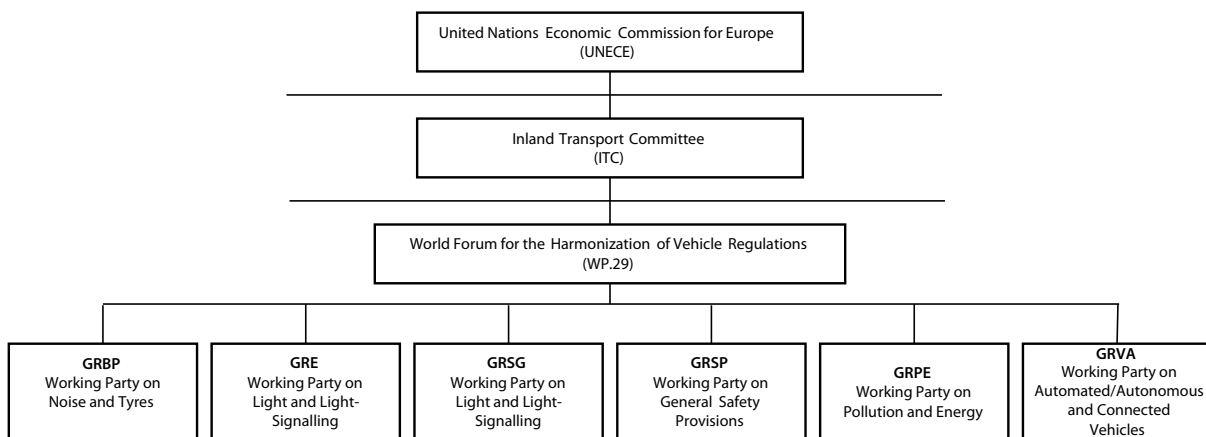
The 1958 Agreement and its UN Regulations are based on the type approval process. An independent test institution produces a report with the aim of confirming the validation of ECE requirements. A public authority then issues the type approval on this basis. The type approval is the confirmation that production samples of a type of vehicle, vehicle system, component or separate technical unit will meet specified performance standards. It can be demonstrated through type approval markings ('e' or 'E' marks) applied to products by the manufacturer, and in the case of vehicles approved under the GB, UK(NI) or EU Whole Vehicle Type Approval (WVTA) schemes, by a Certificate of Conformity (CoC) issued by the manufacturer.

“Self-certification”

The 1998 Agreement and its UN GTRs are compatible with the self-certification scheme. Self-certification is the process by which a manufacturer internally validates that a vehicle meets the applicable regulatory requirements of a specific market. It is not necessary that witnessed testing be conducted by a government authority.

In order to be able to address all the different aspects of vehicle regulation in detail, WP.29 established six permanent working parties (Groupe de Rapporteur - GR), which are involved in activities relating to safety and other matters that are potentially ITS-related: the Working Party on Noise and Tyres (GRBP), the Working Party on Lighting and Light-Signalling (GRE), the Working Party on General Safety Provisions (GRSG), the Working Party on Passive Safety (GRSP), the Working Party on Pollution and Energy (GRPE) and the Working Party on Automated/Autonomous and Connected Vehicles (GRVA). These subsidiary bodies consist of participants with relevant expertise, consider specialized tasks and are responsible for updating the existing requirements or developing new ones. The structure of WP.29 is shown in figure 16 below.

Figure 16 Structure of WP.29 and its subsidiary GRs



Source: UNECE

WP.29 continues its work on ITS and specifically automated driving systems by guiding relevant Working Parties on their activities through the Framework Document on Automated Vehicles (FNAV). This document was established by WP.29 and endorsed by ITC at its eighty-second session (Feb 2020). It was originally 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

¹⁰⁶ Accessible at: <https://www.vehicle-certification-agency.gov.uk/vehicle-type-approval/what-is-vehicle-type-approval/>

¹⁰⁷ Resaffa Nogueira Martins, Henrique (2010). Overview of Type Approval Homologation and Self-Certification

¹⁰⁸ Accessible at: <https://www.vda.de/en/topics/automotive-industry/Standardization-and-technical-standards/harmonisierung-von-zulas-sungsvoraussetzungen>

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.¹⁰⁹

Some of the WP.29 main achievements in 2022 related to automated driving, were the endorsement of the second iteration of the "Master Document on the New Assessment / Test Method for Automated Driving", the guidelines derived from the master document, and the initial draft of the recommendations concerning the safety of ADS. The Administrative Committee to the 1958 Agreement adopted amendments to UN Regulation No. 157 on Automated Lane Keeping System, extending the scope of this regulation to heavier trucks and allowing lane changes as well as a maximum speed up to 130 km/h.



2. Informal Working Group on Intelligent Transport Systems

In 2002, in response to the rapid progress of advanced technologies regarding road vehicles, the Informal Working Group (IWG) on Intelligent Transport Systems was established under WP.29 as a forum to discuss the impact of these technologies on vehicle regulation.

During 2002-2013, the ITS informal group focused on the driver-assistance technologies entering the market and human-machine interaction issues, resulting in guidelines for high-priority/safety-critical warnings, and on ADAS.

As these technologies and systems advanced, the informal group shifted its attention towards ADS. In response, the IWG on ITS was reorganized as the IWG on ITS/ Automated Driving (AD) to assist WP.29 with its work on related issues. In this second phase from 2014 to 2018, the group established security guidelines, defined the main concepts of automated driving and established the Task Force on Cyber Security and Software. In 2018, following the agreement of WP.29 concerning the transition and the establishment of GRVA, the IWG on ITS/AD was dissolved.

Recognizing that ITS extends beyond the scope of WP.29's focus on the regulation of vehicles, a third phase of work under the IWG on ITS has started. It was to act as a platform for exchange on cross sectoral developments relevant to the regulation of ITS and to ensure exchange with organizations and institutions having responsibilities in these important areas.¹¹⁰

In the beginning of 2022, the Co-Chairs of IWG on ITS and the secretariat hosted three well-attended webinars on actions of the revised ECE Road Map on ITS, as agreed by WP.29. The webinars specifically addressed Actions 5, 6 and 7 concerning the questions "What is ITS and where does it belong?", "Ensuring data security in the ITS context" and "Exploring the technological developments related to V2V and V2I" (for more details, please see chapter VI., A., 2. "Intelligent Transport Talks").

¹⁰⁹ Accessible at: <https://unece.org/transport/publications/framework-document-automatedautonomous-vehicles-updated>; https://unece.org/sites/default/files/2022-02/FDAV_Brochure%20-%20Update%20Clean%20Version.pdf

¹¹⁰ UNECE, report of the 178th session of WP.29, June 2019, ECE/TRANS/WP.29/1147, Annex VIII, accessible at: <https://unece.org/fileadmin/DAM/trans/doc/2019/wp29/ECE-TRANS-WP.29-1147e.pdf>

Also in the beginning of 2022, a roundtable on “the future of electrification and automation of vehicles” was organized by the leadership of IWG on ITS during the 75th anniversary of ITC, addressing questions related to automation, connectivity, and e-mobility (for more details, please see chapter VI., A., 3. “75th Anniversary of the Inland Transport Committee”).

Moreover, the IWG on ITS discusses its involvement in the organization (together with the International Telecommunication Union) of the annual symposium on the Future Networked Car (FNC).

In March 2023, WP.29 established a Task Force on Vehicular Communications under the IWG on ITS to further analyse the potential role of WP.29 in vehicular communications. Until the time this publication was drafted, the Task Force met several times, exchanging views, defining its scope of work, deliverables and a timeline and organising a workshop on V2X and electric vehicle charging, communication and infrastructure.



3. Working Party on Automated/Autonomous and Connected Vehicles

At its February 2018 session, ITC acknowledged the importance of WP.29 activities related to automated, autonomous and connected vehicles and requested WP.29 to consider establishing a dedicated subsidiary Working Party¹¹¹. Following this request, WP.29 decided at its June 2018 session to convert the Working Party on Brakes and Running Gear (GRRF) into a new Working Party on Automated/Autonomous and Connected Vehicles (GRVA). The GRRF activities on tyres and couplings were passed to GRB which became GRBP.

WP.29’s work on ADS is mainly addressed by GRVA, whose activities are guided by FDAV. In order to be able to address all the innovations that are likely and realistic to enter the market, GRVA has established several informal working groups, being the IWG on Functional Requirements for Automated Vehicles (FRAV), Validation Method for Automated Driving (VMAD), Event Data Recorder/Data Storage Systems for Automated Driving (EDR/DSSAD) and Cyber Security and Over-The-Air (CS/OTA) issues. Some of the actions as well as some of the results, that have been achieved so far, are mentioned in the following (more details can be found on the dedicated website: <https://unece.org/reference-documents-0>):

- “Functional Requirements for automated/ autonomous vehicles”, being one of WP.29’s work priorities and mandated to the IWG on FRAV, who produced draft Guidelines for Regulatory Requirements and Verifiable Criteria for Automated Driving System Safety Validation that were endorsed by WP.29 in June 2023. The IWG on FRAV is preparing a set of functional requirements for system safety, failsafe response, Human Machine Interface (HMI) / operator information, object and event detection and response (Functional Requirements) and the Operational Design Domain (ODD).
- “New Assessment/Test Method for automated driving” (NATM), mandated to the IWG on VMAD. Since then, the IWG on VMAD is working on this mandate and is developing assessment methods, including scenarios, to validate the safety of automated systems based on a multi-pillar approach including audit, simulation/virtual testing, test track, and real-world testing. The second version of the NATM – the Master Document, was endorsed as a reference document for the validation of ADS during the 187th session of WP.29 in June 2022.

¹¹¹ UNECE, report of the eightieth ITC session, February 2018, ECE/TRANS/274, para. 52

- A “proposal for recommendations on uniform provisions concerning cyber security and software updates” was adopted by GRVA as guidance for Contracting Parties of the 1998 Agreement in January 2022 and endorsed by WP.29 in June 2022. The document provides guidance when formulating regulation or legislation on cyber security for automotive vehicles and/or regulation or legislation on software updates and the processes for updating a vehicle's software. It includes technical requirements for the vehicle and for the management system.

GRVA also continued to work on activities which were initiated before the adoption of FDAV. The work has resulted in a first set of UN Global Technical Regulations (GTRs) and UN Regulations governing automated vehicle certification, including elements related to cyber-security, software update management and a first UN Regulation for the approval of automated driving functionality (among others):

- *UN GTR No. 8*, concerning electronic stability control systems (ESC). The purpose of this GTR is to reduce the number of deaths and injuries that result from crashes in which the driver loses directional control of the vehicle, including those resulting in vehicle rollover (for more details about the system, please see in chapter II; “Technical overview of Intelligent Transport System technologies”).
- *UN Regulation No. 79*, concerning the approval of vehicles with regard to steering equipment and being instrumental for the approval of several ADAS. This Regulation addresses systems whereby the driver remains in primary control of the vehicle but may be helped by the steering system being influenced by signals initiated on-board the vehicle and which are defined as ADASS (for more details about the system, please see chapter “Technical overview of Intelligent Transport System technologies”).

GRVA also initiated a task force on ADAS that reviewed UN Regulation No. 79. This task force is working on the drafting of a horizontal regulation for the type approval of ADAS.

- *UN Regulations Nos. 131 on AEBS for trucks and busses, and 152 on AEBS for cars and vans*. UN Regulation No. 152 imposes strict and internationally harmonized requirements for the use of AEBS at low speeds, even in complex and unpredictable situations such as traffic in urban areas. The Regulation includes requirements for testing AEBS in a range of different speeds, from 0-60 km/h. In addition to cars, the Regulation is applicable to all light commercial vehicles (vans and minibuses with less than 9 passengers).



This image displays two crashed cars at the Palais des Nations. After a frontal impact test at 64 km/h, one car scores zero stars, the lowest level of occupants' safety, while the other achieves five stars, the highest level. The two cars illustrate the importance that crash tests play in ensuring road safety and the different levels of safety between cars sold in emerging markets and in advanced economies.¹¹²

¹¹² Accessible at: <https://www.flickr.com/photos/98046700@N04/17144577995/in/album-72157651890173686/>, accessed on 31.10.2023

- *UN Regulation No. 155 on Cyber Security and Cyber Security Management Systems (CSMS)* provides a framework for approval of the vehicle manufacturers CSMS, which requires processes for, among others, the management of risks including risks assessments (TARA) and testing, assessments regarding the valid efficiency of cyber security risks mitigation measures, the ability to identify and respond to attacks and the support of the analysis of successful or attempted attacks. In order to obtain the approval for a vehicle type, the manufacturer is required to provide evidence that the CSMS applies to the vehicle type, risk assessments for the vehicle type, evidence that mitigations to reduce identified risks are effective, measures to detect and prevent cyber-attacks, measures to support data forensic and for reporting of the outcome of monitoring activities for a vehicle type to the relevant type approval authority. Since it has been adopted, Japan and the secretariat have organized several workshops on the implementation of UN Regulation No. 155 for all the Contracting Parties.

Box 20 Cybersecurity Regulations' Impact on OEMs and Their Suppliers

"In recent years the automotive industry has undergone a significant shift toward the adoption of connected technologies: electrification, autonomy, and software-defined vehicles.

These advancements have changed the industry and customer experience, but they have also created cybersecurity risks, which are being addressed by recent regulatory requirements.

The framework for cyber secure certified vehicles starts with the adoption of UN Regulations Nos. 155 and 156, which define the scopes and work products that OEMs must ensure throughout their development lifecycle. The ISO/SAE 21434 standard built upon the UN regulations further tightens cybersecurity requirements towards all vehicle type approvals, and the most recent Chinese national GB regulation provides an even more stringent structured approach that will be ratified in 2024.

These regulatory requirements are impacting OEMs and their entire supply-chain suppliers to incorporate cybersecurity culture and posture throughout the lifecycle of all products from concept to decommissioning, including continuous monitoring and remediating vulnerabilities while vehicles are on the road.

Including cybersecurity verification, remediation and embedded controls in the vehicles' software lifecycle, risks vehicles' time to market and may delay business return. OEMs and suppliers are seeking automated tools that expedite cybersecurity verification, offer automated security for critical Electronic Control Units (ECUs), and enable continuous - yet efficient - monitoring of newly reported vulnerabilities and incidents.

Such automation is part of the industry's evolution to software-defined vehicles, which are based on frequent software releases, feature-on-demand, and alike. The main promise of automated tools is to ensure a high security posture, compliance with cybersecurity regulations, for minor and major releases, without causing costly product delays. As industry we must comply with these stringent standards and regulations to ensure our customers safe and cyber-secure vehicles, with rich and dynamically changing customer experience."

Source: Karamba Security, October 2023

- *UN Regulation No. 156 on Software Update and Software Update Management Systems (SUMS)*. This Regulation requires vehicle manufacturers to establish specific processes, including to record the hardware and software version, verifying the compatibility of target vehicles/ updates, informing vehicle owners about updates and ensuring the cyber security of software updates before sending them to the vehicle. In order to obtain the approval for a vehicle type, the manufacturer is required to provide evidence that SUMS applies to the vehicle type, and that the software update delivery mechanism and process ensures authenticity and integrity of the software update. This Regulation also addresses over-the-air-updates and provides requirements for vehicle types, like the ability of the vehicle to restore systems in case an update fails, ensuring that vehicles are capable of conducting the update, executing them safely and only if sufficient power is available, the ability to inform users about the execution status of an update and/or when a mechanic is needed.

Box 21 Workshops on Cyber Security

GRVA organized several technical workshops on the implementation of UN Regulations Nos. 155 and 156 on cyber security as well as on software update provisions under the 1958 and 1998 Agreements. Various type approval authorities participated in these workshops for information sharing and to discuss potential issues.

Source: UNECE

- *UN Regulation No. 157 on ALKS*. This Regulation is the first international regulation for the type approval of an ADS, with a limited use case and a simple definition of the dynamic driving task given the limited ODD. The last amendments of UN Regulation No. 157 included the scope extension of the Regulation, to increase the maximum allowed speed to 130 km/h, to allow lane changes and the type approval for these systems for heavier vehicles (trucks, coaches and buses).

Moreover, GRVA explored Artificial Intelligence in the context of automotive products and worked on definitions relevant for automated, autonomous and connected driving. The group also discussed the impact of AI on validation methods for automated driving, the effect of online learning and self-learning on the vehicle's behaviour and put narrow AI (including machine learning, deep learning, etc.) under scrutiny. GRVA held two technical workshops on AI in 2022 to check among others whether narrow AI, Machine Learning, Deep Learning etc. requires specific regulatory response or whether technology neutral requirements are sufficient.

4. Global Forum for Road Traffic Safety

The Global Forum for Road Traffic Safety (WP.1) is the only permanent body in the United Nations system dedicated to road traffic safety. Its primary function is to serve as guardian of the United Nations legal instruments aimed at harmonizing traffic rules. WP.1 administers, among other ECE legal instruments, two conventions on Road Traffic, namely the 1949 Geneva Convention and the 1968 Vienna Convention with its amendments, as well as the 1968 Vienna Convention on Road Signs and Signals, which provide the legal framework for traffic rules in contracting states. They address the main factors of road accidents and are therefore tangible contributors to improved road safety. Consequently, many countries across the world have become contracting parties to these legal instruments and thus benefit from their implementation. These contracting parties are also the key driving forces keeping these international road safety conventions up to date by participating in WP.1 sessions. Given this background, the Global Forum has continued playing an important role in facilitating and forging international cooperation to improve road safety.

In addition, WP.1 adopted a resolution on safety considerations for activities other than driving undertaken by drivers when ADS issuing transition demands exercise dynamic control, and intends to continue considering policy challenges of remote driving.

Finally, WP.1 explores the definition and role of the driver, driver education and training, and the possibility of contributing to developing a glossary of terminology for automated vehicles. Developing a framework of key principles for automated vehicle safety and human centred needs may become an important element of the WP.1 work plan in the months following the issuance of this publication. Also in the context of ITS, the exchange of views will be continued with expected contributions from eminent academics and experts on many pertinent issues.

Drivers' representatives consistently insist that human centred needs shall be implemented in the technical design of a vehicle by applying the principles of "Data Privacy by Design".



5. Working Party on Inland Water Transport

The activities of the Working Party on Inland Water Transport (SC.3) focus on developing inland water transport as a sustainable, resilient, intelligent, safe and efficient mode of transport, which is an integral part of inland transport networks. Increasing navigation safety is an element of high focus in the development of advanced information and communication technologies which include River Information Services (RIS). Since 2001, SC.3 has developed and maintained a set of resolutions on RIS that are harmonized with the relevant regulations and guidelines of the European Union, Central Commission for the Navigation of the Rhine (CCNR), World Association for Waterborne Transport Infrastructure (PIANC), International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and other international organizations.

The role of RIS for inland navigation as one of the priorities for the forthcoming period was emphasized in the Wroclaw Ministerial Declaration “Inland Navigation in a Global Setting” of 18 April 2018, signed by eighteen Member States of the United Nations and supported by resolution No. 265 “Facilitating the Development of Inland Water Transport”, adopted by the Inland Transport Committee (ITC) on 22 February 2019.

The ECE White Paper on the Progress, Accomplishments and Future of Sustainable Inland Water Transport, endorsed by ITC in 2020, has set out policy recommendation No. 5 “Promote the development and pan-European application of RIS and other information technologies”. The recommendation provides for cooperation with other international institutions on the implementation of RIS and other information technologies, and for the regular updating of ECE resolutions on RIS. It also encourages other uses of information technologies to facilitate inland water transport operations and inspections of inland vessels, and the development and promotion of the harmonized rules and criteria in this area.

From 2019 to 2023, SC.3 revised and updated five of the six resolutions related to RIS:

- *Resolution No. 48: “Recommendation on electronic chart display and information system for inland navigation”*
- *Resolution No. 57: “Guidelines and Recommendations for River Information Services”*
- *Resolution No. 58: “Guidelines and Criteria for Vessel Traffic Services on Inland Waterways”*
- *Resolution No. 63: “International Standard for Tracking and Tracing on Inland Waterways”*
- *Resolution No. 79: “International Standard for Electronic Ship Reporting in Inland Navigation”*
- *Resolution No. 80: “International Standard for Notices to Skippers”*

The revised version of *resolution No. 58* is based on the IALA Guideline G1166 "Vessel Traffic Services in Inland Waters", it establishes a concept of Inland Vessel Traffic Services, taking into account the existing practice on European inland waterways.

Since 2022, SC.3 and its subsidiary body, the Working Party on the Standardization of Technical and Safety Requirements in Inland Navigation (SC.3/WP.3) have been discussing possibilities how to keep resolutions of relevance to RIS as live instruments and, in particular, keep them aligned with the European Standard on River Information Services of the European Committee for Drawing up Standards in the Field of Inland Navigation.

The corridor management will be the next step in the deployment of RIS to support inland navigation as an important transport mode in the international multimodal logistic chain. It will enable the use of RIS not only as a safety management tool, but as an integrated system that serves as a facilitator in the whole logistics chain, by enabling harmonized services across borders. SC.3 and SC.3/WP.3 are discussing the opportunities provided by RIS and the RIS enabled corridor management for improving the traffic management, introducing the smart infrastructure and fostering the digital transition of inland waterways, based on the outcome of the recent and ongoing projects, such as the integrated web application ELIAS¹¹³ developed under the project EMMA¹¹⁴, projects RIS COMEX¹¹⁵, DIWA (Masterplan Digitalization of Inland Waterways)¹¹⁶ and the European RIS platform EuRIS¹¹⁷ [5]. SC.3 has stressed that the availability of data, in particular related to the voyage planning, and the availability of data on the inland waterway, road and rail network were of a key importance for the development of inland water transport and its integration into multimodal transport and logistics chains.

In the field of automated navigation, SC.3 adopted resolution No. 95 "Enhancing international cooperation to support the development of automation in inland navigation" at its sixty-third session. The resolution and the road map contained in the annex are aimed to strengthen international cooperation towards harmonizing approaches and policies and creating a framework for the deployment of automation in inland navigation at the pan-European level as a part of the activities of ITC as the UN Platform for supporting new technologies and innovations in inland transport, the coordination of work and reaching synergy with other ITC working parties.

Following resolution No. 95, SC.3 and SC.3/WP.3 regularly address automated navigation at their sessions through the ongoing discussion on the definitions of automation levels based on the international definitions developed by CCNR, the harmonization of the legal framework and policy areas for fostering innovations in inland navigation aimed to evaluate international conventions and ECE resolutions for identifying gaps, challenges and bottlenecks that hamper the development of automated navigation and at various workshops on automation, digitalization, cybersecurity and related topics. In particular, SC.3/WP.3 at its sixty-first session in June 2022 addressed the various aspects of automation in the context of the development of the inland waterways infrastructure. The participants considered the development of automated and smart navigation concept and innovative types of automated and autonomous vessels as one of the most important developments in the field of digitalization for the upcoming decade and stressed the importance of developing standards for automated navigation, safe and secure operation of autonomous ships for fostering digital transition in the sector.

At its sixty-sixth session in November 2022, SC.3 noted with satisfaction progress by member States in the field of automation and smart shipping as a part of the strategic actions set forth in the Wroclaw Ministerial declaration "Inland Navigation in a Global Setting", reported by member States. SC.3 decided to begin working on provisions on automated and autonomous shipping in 2023 with a view to developing recommendations for the European Code for Inland Waterways (CEVNI). At its sixty-third session in July 2023, SC.3/WP.3 considered policy areas for automated navigations and provided guidance for further work on CEVNI.

The next step will be determining the most appropriate way of addressing the operation of automated vessels, which may include temporary derogations, interpretations or amendments to the existing documents or developing new documents. Furthermore, provisions for testing of automated vessels and their commercial use may be treated in a different way and may include the transition period needed for the sector.

¹¹³ Accessible at: <https://elias.isl.org>

¹¹⁴ Accessible at: Enhancing freight mobility and logistics in the Baltic Sea Region by strengthening inland waterway and river sea transport and promoting new international shipping services, see www.project-emma.eu

¹¹⁵ Accessible at: River Information Services Corridor Management Execution, see www.riscomex.eu

¹¹⁶ Accessible at: www.masterplandiwa.eu

¹¹⁷ Accessible at: www.eurisportal.eu

6. Working Party on the Transport of Dangerous Goods

Dangerous goods are subject to transport, workplace, storage, consumer and environment protection regulations, to prevent accidents to persons, property or the environment, to other goods or to the means of transport employed. To ensure consistency between all these regulatory systems, the United Nations has developed mechanisms for the harmonization of hazard classification criteria and communication tools, and for transport conditions for all modes for transport. ECE also administers, in close collaboration with the International Organization for International Carriage by Rail (OTIF) and the Central Commission for the Navigation of the Rhine (CCNR), regional agreements for effective implementation of these mechanisms for road, rail and inland waterways transport of dangerous goods.

The Joint Meeting of the Committee of experts on the Regulations concerning the International Carriage of Dangerous Goods by Rail (RID) and the Working Party on the Transport of Dangerous Goods (WP.15) continues its work on telematics related to the Regulation 2020/1056 of the European Parliament and of the Council of 15 July 2020, on the use of the data model in the context of the electronic freight transport information (eFTI) regulation. eFTI is a set of data elements processed electronically for the purpose of exchanging regulatory information among economic operators (mainly companies involved in freight transport and logistics) and between operators and competent authorities¹¹⁸. In September 2022, the Joint Meeting was informed on the progress of work in the Digital Transport Logistics Forum (DTLF) of the European Union and potential issues related to some developments of the current data model that do not take account of the specificities for the transports of dangerous goods in RID, in ADR (Agreement concerning the International Carriage of Dangerous Goods by Road) and ADN (European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways).

At its Spring 2023 session, the Joint Meeting adopted an amendment to clarify the documentation requirements in RID/ADR/ADN to make sure all the required information is taken over in automated applications for electronic information exchanges.

7. Working Party on Intermodal Transport and Logistics

The Working Party on Intermodal Transport and Logistics (WP.24) carries out activities in support of the objective of the ECE transport subprogramme to facilitate the international movement of persons and goods by inland transport modes and improve safety, environmental protection, energy efficiency and security in the transport sector to levels that contribute effectively to sustainable transport. In this context, WP.24 leads activities aimed at making freight transport more sustainable and climate neutral, in particular by increasing the share of intermodal freight transport in freight transport, whereby freight is moved in one and the same loading unit or road vehicle using successively two or more modes of transport without handling the freight in changing modes.

Within this context, WP.24 is elaborating a handbook on automation of freight transport and logistics sector. This handbook will shed some light on when there is a business case for digitalisation and automation of freight transport and logistics. It will discuss the benefits from automation as well as challenges to realise those benefits. It will describe the role that governments have in accompanying the digitalization and automation in the sector. Among them, the provision of legal framework and interoperability standards, the assurance of human-centre approach to automation, the assurance of inclusion of SMEs in automation, the responsibility for cybersecurity. It will also describe examples of various automation technologies. Last but not least, it will provide recommendations for terminal operators, transport carriers, governments and training centres on how to manage automation.

This handbook, once developed before the end of 2024, is expected to serve as a high-level guide and a source of information for managing automation in freight transport and logistics sector at different levels.

¹¹⁸ Accessible at: [https://eur-lex.europa.eu/EN/legal-content/summary/electronic-freight-transport-information.html#:~:text=Electronic%20freight%20transport%20information%20\(eFTI\)%20is%20a%20set%20of%20data.between%20operators%20and%20competent%20authorities](https://eur-lex.europa.eu/EN/legal-content/summary/electronic-freight-transport-information.html#:~:text=Electronic%20freight%20transport%20information%20(eFTI)%20is%20a%20set%20of%20data.between%20operators%20and%20competent%20authorities).

8. Working Party on Rail Transport

The Working Party on Rail Transport (SC.2) is an intergovernmental body which manages two rail related legal agreements and provides a pan-European forum for exchange of technical, legal and policy information and best practices in international rail transport. The objective is to promote rail transport in ECE member countries and to ensure its economic efficiency and environmental sustainability.

Since 1951, the Working Party and its predecessors have been involved in preparation of evidence-based policy advice and now administers two UN legal instruments: one pertaining to minimum rail infrastructure standards in the pan-European region (the European Agreement on Main International Railway Lines -AGC) and the Model Rules for the Permanent Identification of Railway Rolling Stock. The Working Party provides assistance to rail industry and transport policy makers in areas such as¹¹⁹:

- Pan-European rail infrastructure standards (AGC)
- Financing for the railways (Model Rules)
- Development of a trans-European railway network (TER project, more details in chapter VI., A., 1)
- Facilitation of border crossing in international rail transport
- Operational aspects of international rail transport (infrastructure capacity, productivity, interoperability, new transport technologies, etc.)
- Facilitation of container train traffic on Euro-Asian routes
- Rail safety
- Rail security
- Passenger accessibility of rail transport
- Innovation in the railways
- Environmental questions related to railways

SC.2 continues its work on ITS activities through the regular updating of the rail security observatory and through the creation of a new innovation platform identifying key areas where ITS could increase the competitiveness of the rail sector following the successful workshop on the issue at its seventy-second session. As part of this work, the Working Party also continued its activities related to the digitalization of documents in collaboration with the activities of WP.24 as identified above. The newly created Revisions Committee for the Model Rules may proceed to discuss possible electronic tagging of rolling stock in addition to the permanent identification already foreseen in the legal instrument. The Working Party is also working on identifying new solutions to reduce the energy consumption of the railways going forward, also through the use of ITS solutions.

Finally, as part of its activities to modernize and digitalize infrastructure agreements the Working Party noted the finalization of the AGC-AGTC (European Agreement on Important International Combined Transport Lines and Related Installations) online tool. The tool introduces a new innovative way to rail activities, further facilitates the modernization of AGC and is aimed at assisting operators in identifying optimum routes for rail flows across the region and facilitating shift to rail.

¹¹⁹ Accessible at: <https://unece.org/about-us-14>

VI. Networking and partner events

Besides the activities that are ongoing within the bodies of UNECE, UNECE is also reaching out to and collaborating with other organizations and performing projects in order to promote ITS, achieve the SDGs and improve road safety.

A. ITS projects and events at ECE

1. Trans-European Railway and Trans-European Motorway projects

To ensure seamless connections throughout Europe, including access to markets, ECE coordinates work on the Trans-European network for motorways (TEM) and rail (TER) in Central, Eastern and South-Eastern Europe.

The ECE **TEM project** was established in 1997. It is a sub-regional cooperation between the member countries Armenia, Austria (associate member), Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Georgia, Italy, Lithuania, Poland, Romania, Slovakia, Slovenia and Türkiye. The TEM Project constitutes a forum for cooperation between the governments of the TEM Member States, which creates standards, good practices and guidelines for systemic and strategic issues related to road infrastructure management. In its activities the TEM Project takes the perspective of national government administrations and focuses on the issue of sustainable development. The objectives of this project are:

- To facilitate road traffic in Europe;
- To improve the quality and efficiency of transport operations;
- To balance gaps and disparities between motorway networks; and
- To assist the integration process of transport infrastructure.

The TEM Project fosters governmental partnerships in developing and maintaining the road network and is a valuable platform for the exchange of knowledge and experience. It assists in designing, building, maintaining, operating and administering the TEM motorway network on the territories of participating states as part of an integrated European international road infrastructure, thus filling the gaps in the existing motorway network between Western, Eastern, Central and South-Eastern Europe.

In order to realize its activities, TEM publishes reports in each thematic domain with expertise, best practices and implementation process, and organises thematic workshops with invited external experts as well as seminars with other involved parties, like the Highway Engineering Exchange Program (iHEEP) USA, within three main areas:

- Network and funding;
- Operational proficiency; and
- Trends.

The TEM Strategic Plan constitutes a roadmap for the implementation of the TEM Project for 2017-2021 and takes into account that cooperation between countries in the TEM Project can involve a wide range of substantive topics on planning, designing, constructing or maintaining of road and motorway networks. The Strategic Plan focuses on the identified challenges and on issues that will be essential for the TEM region in the near future. The challenges identified in the Strategic Plan were classified into the following Strategic Areas:

1. Environmental protection
2. Organisation and financing of the roads and motorways
3. Information systems for the management of the road infrastructure
4. Innovations in road infrastructure management
5. Road safety

The project's vision was to obtain the role of a substantive partner for ECE and the Inland Transport Committee on road infrastructure management, thus supporting the UN and TEM Member States in achieving the sustainable development goals by implementing the project strategic initiatives.¹²⁰

The ECE **TER project** was established in 1990 with initial financial support provided by the United Nations Development Programme (UNDP). It is a sub-regional cooperation among 17 member countries: Armenia, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Georgia, Greece, Italy, Lithuania, Poland, Romania, Russian Federation, Serbia, Slovak Republic, Slovenia and Türkiye (Azerbaijani membership is pending, awaiting signature for accession). In addition, a number of observer countries participate in certain activities of the project: Belarus, Latvia, Moldova, Montenegro, The former Yugoslav Republic of Macedonia and Ukraine. The main objectives of the TER project are as follows:

- Improving the quality and efficiency of transport operations;
- Assisting the integration process of European transport infrastructure systems;
- Developing a coherent and efficient international railway and combined transport system in accordance with ECE Pan-European infrastructure agreements: European Agreement on Main International Railway Lines (AGC - May 1985) and European Agreement on Important International Combined Transport Lines and Related Installation (AGTC - Feb. 1991).

The TER project is organized around three pillars:

1. The active participation and support of member countries through the Trust Fund Agreement, deposited with ECE, which nominates the Project's Steering Committee as its highest administrative and political body, formed by national delegates from each participating country.
2. The Project Central Office in Belgrade, hosted by the Government of Serbia, with Project office personnel coordinating activities.
3. National Project Offices set up or designated in each participating country to liaise between national activities and those under the Project. These national offices operate under the responsibility of a nominated National Coordinator from every member.

The annual and long-term action plans are set by the Steering Committee and the work is done by the Project's personnel, Working Groups, Ad hoc Expert Groups, and when required by external consultants in close co-operation with member countries.¹²¹

2. Intelligent Transport Talks

In 2022, the Co-Chairs of the IWG on ITS along with the secretariat hosted three webinars as mandated by WP.29, titled "Intelligent Transport Talks". The virtual nature of the webinars allowed for worldwide participation and gave the participants an opportunity to pose questions to experts on matters related to the ITS Roadmap. The purpose of these webinars was to discuss the following actions of the ITS roadmap (as annexed to this publication):

- Action 1 – Reaching a common definition for ITS
- Action 5 – Ensuring Data Security
- Action 6 – Promoting Vehicle to vehicle infrastructure communication
- Action 7 – Vehicle to Vehicle communications

(a) Webinar 1

Webinar 1 focused on Action 1 of the road map, reaching a common definition for ITS. The speakers at this session explored and explained to the group how ITS was viewed within their organisations. The representative of ERTICO (ITS Europe) presented their activities on data and mobility, and traffic management within the context of ITS. He highlighted how defining the scope of ITS sets a clear direction for the development of ITS technologies and infrastructure. Utilising the European Union directive of 2010 as

¹²⁰ Accessible at: https://unece.org/DAM/trans/main/tem/temdocs/Brochure_on_Trans-European_Motorways_TEM_Project.PDF

¹²¹ Accessible at: <https://unece.org/about-1>

their guiding definition for ITS, he presented areas where further work needs to be done. These include affordability, investments in infrastructure and availability, and accessibility of data among others. The representative of motoring organisations and motor car users highlighted that end users' expectations would be better managed, providing clarity about benefits and optimising modes (Mobility as a Service). She mentioned that the data and analysis collected by her organisation illustrated the value harmonised definitions have to real world users. The representative of the Joint Programme Office on ITS of the United States of America provided their working definition of ITS including the connection to other systems as a part of a smart community. Utilising the current definitions of ITS, he shared with the participants their current strategic plan for ITS (2020-2025). The priority areas included, among others, available, reliable versatile ITS data, advancing mobility and accessibility for all and cultivating the next generation of ITS. The representative of the automotive industry presented what ITS would look like for the future from their perspective, highlighting the scope of ITS with a detailed look into ITS and AI. He also underlined how the different stakeholders of the ITS ecosystem can work together with a harmonised definition to bring ITS systems to the end users effectively.

(ii) Webinar 2

Webinar 2 addressed Action 5 of the ITS Road map on Data Security. The representative of the automotive industry highlighted the work done so far in cybersecurity, the positive impact of harmonisation of data regulations and their benefits to the end user. These benefits included ensuring that the vehicle is protected from cybersecurity attacks and that software updates on a vehicle stays compliant with the vehicle homologation. UN Regulations Nos. 155 and 156 covered these aspects, however, the representative stated the importance of supporting efforts for a uniform application of regulations within the countries signed on to the 1958 Agreement. The representative of Germany from the Ministry for Digital and Transport, also presented UN Regulations Nos. 155 and 156, and focused on how they can be integrated into the type approval framework in order to enhance the IT security of the vehicle. This can be done at the Original Equipment Manufacturer level through cyber security management system, at the vehicle level through risk assessment and mitigation measures and at the fleet level through market surveillance. He also illustrated the links between data security and safe applications in road traffic of autonomous vehicles, secure V2V communication and trustworthy vehicle data.

(iii) Webinar 3

Webinar 3 explored the road map actions 6 and 7, "Promoting V2I" and "V2V" respectively. ITS America provided case studies and examples of V2V and V2I currently in various phases of development and establishment in the United States of America. These case studies highlighted how V2V, V2I and V2X can be leveraged to reduce emissions and fuel economy and how data exchange platforms designated to V2X data can assist with predictions as well as actual data for vehicle manufactures, traffic operators and evaluators to name a few. The representative of the automotive industry provided insights into the work of the Alliance for Automotive Innovation (one of their members in the United States of America), providing details on the work being done in the United States of America over the last 20 years. He also presented a case for how regulation can positively address development risks by highlighting the example of how the assignment of bandwidth and then subsequent reassignment has negatively impacted the development of V2V, V2X and V2I. The representative of Japan provided highlights from the project of the Strategic Innovation Promotion Program (SIP) and gave examples of the work that has been done in V2I, specifically related to the development of signal information. Through the dedicated frequencies in regional areas, the study confirmed that there was a safe and smooth implementation of AVs. He also highlighted that there is current work on using V2N systems putting into practical use the expansion of traffic environment management. In the long term, there is work on the development of a road map for communication technology. The representative of the fifth-generation technology for broadband cellular networks automotive association highlighted the current V2X use cases in countries around the world, with use case examples of C-V2X enabled vehicles, a road safety initiative to create a Safety Related Traffic Information (SRTI) ecosystem and intelligent traffic with smart phone apps. He also presented a future view with an expected timeline for C-V2X use cases.

This series of webinars provided IWG on ITS with the positive impacts of ITS through the real-world examples. The diversity of presenters allowed the group to identify the similarities across countries both in the barriers faced in ITS advancement as well as the demonstrated positive impact ITS has on vehicle safety and traffic efficiency among other things. A common thread that arose from the webinars was the significant role that ECE could contribute by creating space for mutual discussions and harmonization.¹²²

¹²² ECE/TRANS/2023/19

3. 75th Anniversary of the Inland Transport Committee

The 84th plenary session of the Inland Transport Committee marked its 75th anniversary in February 2022. During the course of the past 75 years, together with its subsidiary bodies, ITC has provided a unique intergovernmental forum where countries come together to forge tools for economic cooperation and adopt international legal instruments on inland transport.

Within the framework of the session, ITC in cooperation with some member countries organised several activities, like the high-level side event titled “Automation, Connectivity and E-Mobility”. This event intended to raise the profile of the work within ECE on the new frameworks and regulations for automated/autonomous vehicles and their safe use in traffic.

The side event illustrated the fundamental change to road transport that was now underway in how vehicles were used since their introduction in the late 19th century. From then, vehicles had required drivers, and most had used an internal combustion engine for propulsion, which was now going to change rapidly. The event showed changes for the E-mobility sector, like behavioural changes by consumers and road users as well as the need for the outcomes of WP.29’s work, e.g. on battery health requirements as a means to reassure purchasers. Various presenters highlighted that WP.29 had the role to develop and facilitate solutions for society, for industry and for Governments and make these changes happen. They also recognised the legal issues for drivers and the work of WP.1 (for detailed information, please see the addendum to the corresponding ITC report: ECE/TRANS/316/Add.1).

B. Collaborations and joint projects

As mentioned earlier, ITC (in cooperation with the ECE Environment Division and WHO Europe) services the Transport, Health and Environment Pan-European Programme (THE PEP). Moreover, it ensures the management and oversight of joint projects like the Future Networked Car Symposium (FNC) with ITU, which are further detailed below.

1. Transport, Health and Environment Pan-European Programme – ECE (Transport and Environment) / WHO

Transport is an essential part of life, but it also has harmful effects on the environment and on our health, through congestion, accidents, pollution and greenhouse gas emissions.

In order to increase awareness of the Transport, Health and Environment (THE) link and also to address the key challenges, ECE and WHO Europe established the Pan-European Programme on Transport, Health and Environment (THE PEP). Since then, it encourages governments, at national and local levels to pursue an integrated approach to policymaking and to put sustainable mobility at the top of the international agenda. Furthermore, through THE PEP, transport, health and environment sectors can work together to find innovative solutions to make our environment and cities more healthy, liveable and prosperous in the coming years.

THE PEP comprises, inter alia, active mobility and activities related to sustainable urban transport, health impacts of transport, cycling and walking as feasible non-motorised transport modes the Clearing House project, green economy and consideration of institutional arrangements for policy integration.¹²³

At the high-level meetings in 2009, 2014 and 2021, THE PEP adopted the Declarations of Amsterdam, Paris and Vienna:

- (a) The Amsterdam Declaration on Transport Choices for Health, Environment and Prosperity set the priority goals of reducing the emission of transport-related greenhouse gases, air pollutants and noise to improve the quality of life in urban areas.
- (b) The Paris Declaration on “City in Motion - People First!” enhanced the priority goals adopted in Amsterdam with a new strategic direction by including a new goal, “to integrate transport, health and environmental objectives into urban and spatial planning policies”. Furthermore, a new implementation mechanism “THE PEP Academy” was established in addition to the existing mechanisms – namely, THE PEP Relay Race, National Transport, Health and Environment Action Plans and THE PEP Partnerships.

¹²³ Accessible at: <https://unece.org/transport-health-environment-pep-0>

- (c) The Vienna Declaration “Building forward better by transforming to new, clean, safe, healthy and inclusive mobility and transport” includes the adoption of the Pan-European Master Plan for Cycling Promotion, a first for the region, and also calls on countries to develop a comprehensive pan-European strategy to further policy goals in transport, health and the environment. In recognition of the COVID-19 situation and the impact it has had and continues to have on transport, the Vienna Declaration also includes recommendations for green and healthy sustainable transport to address concerns raised throughout the COVID-19 pandemic.

2. Future Networked Car Symposium – ECE / ITU

Since 2012, ECE and the International Telecommunication Union (ITU) have collaboratively been organising a yearly symposium on Future Networked Cars (FNC), which has brought together representatives of the automotive, information and communications technology industries, along with government leaders and regulators, to discuss the status and future of vehicle communications and automated driving from both, technical and regulatory, viewpoints.¹²⁴ This annual symposium was used to be organised during the Geneva Motor Show, but due to Covid-19, it has been conducted virtually as a one week meeting from 2020 to 2023, covering four different sessions.

The FNC symposium in March 2023 was held online, with the first session highlighting the work of ECE and aimed at addressing the question “if AI controlled automated vehicles would be safe for road users”. The second session focused on “using automotive AI to improve vehicle safety, services and transport management, the third session on “ADS for consumer and other vehicles” and the fourth session gave an update and insights on “wireless communications applied to vehicle safety, services and transport management – current status and future directions”.

In October 2023, the FNC symposium could take place again in conjunction with the Geneva International Motor Show, which was organised as a spin off in Doha, Qatar to foster a deeper engagement with the automotive and telecommunication experts of the Gulf Cooperation Council (GCC) region. The main areas of focus were 5G and V2X communications, autonomous driving, cybersecurity, and software developed using AI technology aimed at improving road safety.¹²⁵

3. ECE and the International Organization for Standardization

The International Organization for Standardization (ISO) is an independent, non-governmental international organisation, established in 1946. ECE and ISO are working together closely in various fields, in which they also signed Memorandum of Understandings (a nonbinding agreement that states each party’s intentions to take action and form a new partnership).

4. ECE and SAE International

The Society of Automotive Engineers (SAE International) is a global association of engineers and technical experts in aerospace, automotive and commercial vehicle industries. They are intensively collaborating with ECE and especially WP.29, where they are contributing with their wide experience and standards in the field of automated driving, and also provided the secretary to one of the informal working groups under GRVA. A very known and widely used taxonomy, developed by SAE International, are the five SAE levels of driving automation.

¹²⁴ Accessible at: <https://fnc.itu.int/>

¹²⁵ Accessible at: <https://fnc.itu.int/fnc-regional-spin-off-in-qatar/>, accessed on 19.09.2023

VII. Conclusion

During the past decade there was significant progress in the development of intelligent transport systems in all areas of transport, marking a paradigm shift in focus from smart infrastructure as a mandatory basis to the integration of intelligent systems in every vehicle and device. This shift has paved the way for several evolutions, e.g. ADAS and the steady advancement towards ADS. The achievements to date in the various modes of transport are indicative of the potential for future advancements in the field of automated technologies.

These improvements have also brought new challenges, e.g. artificial intelligence, data management and cybersecurity. These topics are now crucial components of ITS development, requiring ongoing research and innovation to ensure the security, reliability and robustness of intelligent transport systems.

While ITS has made substantial progress, there are still gaps that need to be addressed. Interoperability remains a key obstacle as ITS applications are often localised, using specific technologies which are limited to certain areas. The lack of harmonisation hampers the widespread adoption of ITS for services, like MaaS and connected driving, across borders.

Nevertheless, ITS remains an overarching tool with enormous potential to improve road safety, enhance accessibility, and reduce the negative impact of transportation on the climate. It is essential that the journey forward be guided by a harmonised approach to fully unlock the benefits of ITS. Collaboration among governments, industries, academia and other relevant stakeholders is essential to achieve a seamless, interconnected ITS ecosystem that transcends borders and fosters a sustainable and efficient future of transportation.

Addressing the existing challenges while embracing the new technological progress will be critical to shaping the future of ITS. Only through continued cooperation and harmonisation can we unlock the full potential of ITS and its role in building a smarter and more sustainable transportation future.

Intelligent Transport Systems (ITS) for Sustainable Mobility, Second Edition

Part of the WP.29 “How it works – How to join it” series

The United Nations Economic Commission for Europe (UNECE) has been at the forefront of shaping the future of transport through its Roadmap on Intelligent Transport Systems (ITS). This roadmap, initially adopted in 2012 and recently revised in 2021, lays out a strategic vision for harnessing cutting-edge technologies to significantly improve transportation across the globe.

Since 2012, a comprehensive set of regulations, rules, and norms has been established to support the development of Intelligent Transport Systems across the different inland transport modes. These regulations span diverse domains, including safety, automation, and connectivity.

The year 2021 marked a pivotal moment for the UNECE. Alongside the adoption of the updated ITS Roadmap, significant milestones were reached. For example, provisions addressing cybersecurity and robust cybersecurity management systems were established by the Working Party on Automated/Autonomous and Connected Vehicles. As the digital landscape evolves, safeguarding transport networks against cyber threats remains paramount.

This publication serves as a snapshot of recent advancements in the field of Intelligent Transport Systems, relating them to the activities of the UNECE Inland Transport Committee and its working parties.

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