Automated Driving Roadmap

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ERTRAC Working Group
"Connectivity and Automated Driving"

Note to the reader:

This document is a draft for public consultation: its objective is to collect opinions from industry, research providers and public authorities on the new proposed roadmap. The first “Automated Driving Roadmap” of ERTRAC was issued in July 2015 and requested a complete update to cope with the many developments that happened since then. The present draft document focuses on the development paths, which are the most critical aspects of the roadmap, on which ERTRAC looks for a large consensus among stakeholders. The final roadmap will include other chapters to offer a complete state of the art of Automated Driving in Europe.

Comments shall be sent to info@ertrac.org before the 8 May 2017.

The final roadmap will be published in June and distributed at the European ITS Congress in Strasbourg.

The following European projects provide support for this work:

FUTURE-RADAR
SCOUT
CARTRE

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1. Scope and Objectives

The main objective of the ERTRAC Roadmap is to provide a joint stakeholders view on the development of Automated Driving in Europe. The Roadmap starts from common definitions and a listing of available technologies, and then identifies the challenges for the implementation of higher levels of automated driving functions. Development paths are provided for the different categories of vehicles.

The Key Challenges identified should lead to efforts of Research and Development: ERTRAC calls for pre-competitive collaboration among European industry and research providers. The key role of public authorities is also highlighted: for policy and regulatory needs, with the objective of European harmonisation.

Note about Connectivity: the scope of this roadmap is by purpose limited to not cover all aspects of connectivity in Transport. Connectivity will be addressed only when it is used to support the automation of driving functions.

Why Automated Driving?

Automated Driving is seen as one of the key technologies and major technological advancements influencing and shaping our future mobility and quality of life. The main drivers for higher levels of Automated Driving are:

- **Safety:** Reduce **accidents** caused by human errors.
- **Efficiency and environmental objectives:** Increase **transport system efficiency** and reduce time in congested traffic by new urban mobility solutions. Also, smoother traffic will help to decrease the energy consumption and emissions of the vehicles.
- **Comfort:** Enable user's **freedom** for other activities when automated systems are active.
- **Social inclusion:** Ensure **mobility** for all, including elderly and impaired users.
- **Accessibility:** Facilitate access to city centres.

Automated Driving must therefore take a key role in the European Transport policy, since it can support several of its objectives and societal challenges, such as road safety, congestion, decarbonisation, social inclusiveness, etc. **The overall efficiency of the transport system can be much increased thanks to automation.**

Moreover, automated driving should be understood as a process taking place in parallel and possibly in integration with other important evolution of road transport: the electrification of the powertrains, and the multiplication of mobility offers, especially shared mobility concepts. This roadmap for Automated Driving therefore contributes to the long-term vision of ERTRAC for the transport system. **In one sentence: in 2050, vehicles should be electrified, automated and shared.**

2. Common Definitions

2.1 Levels of Automation

ERTRAC acknowledges the definitions of SAE J3016 defining the Levels of Automated Driving:

SAE level	Name	Narrative Definition	Sustained lateral and longitudinal vehicle motion control	Object and event detection and response (OEDR)	Dynamic driving task fallback (DDT fallback)	Operational design domain (ODD)
***Human driver* monitors the driving environment**						
0	**No Automation**	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	**Driver Assistance**	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Limited
2	**Partial Automation**	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Limited
***Automated driving system* ("system") monitors the driving environment**						
3	**Conditional Automation**	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Fallback- ready user (becomes the driver during fallback)	Limited
4	**High Automation**	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Limited
5	**Full Automation**	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**Unlimited**

Figure 1: SAE Levels of Driving Automation for On-Road Vehicles (September 2016)

2.2 Road definitions

Some roads and areas are more suitable to introduce systems involving high level of automation, before they can be deployed to open roads.

- **Confined areas** with restricted access control, such as terminal areas and ports.
- **Dedicated road/lane** where vehicles with specific automation level(s) are allowed but the area is not confined, such as parking areas and dedicated lanes.
- **Open road** with mixed traffic in single or multiple lane operation on local, regional, and highway operation, for use by vehicles with any automation level. Local, regional, national and European and cross border regulation needs to be taken into consideration when targeting automation level.

2.3 Current systems – Levels 0 and 1

Similar than in the 2015 Roadmap. This chapter will be available as an *Annex*.

2.4 Systems for Automated Passenger Cars

2.4.1 Automated Parking Assistance

2.4.1.1 Park Assistance (Level 2)

Partial Automated Parking into and out of a parking space, working on public parking area or in private garage. Via smartphone or key parking process is started, vehicle accomplishes parking manoeuver by itself. The driver can be located outside of the vehicle, but has to constantly monitor the system, and stops the parking manoeuver if required.

2.4.1.2 Parking Garage Pilot (Level 4)

Highly Automated parking including manoeuvring to and from parking place. In parking garage the driver does not have to monitor the system constantly and may leave once the system is active. E.g. via smartphone or key, parking manoeuvre and return of the vehicle is initiated. The parking garage may take over part of the functionality, so that early introduction is supported.

2.4.1.3 Automated Valet Parking (Level 4)

Highly Automated parking including manoeuvring to and from any parking space. The driver can leave the vehicle and initiates the manoeuvring to the parking space and the parking itself by e.g. smartphone or key. He does not have to monitor the system constantly and may initiate the parking out manoeuvre the same way when coming back.

2.4.2 Highway Pilot

2.4.2.1 Traffic Jam Assist (Level 2)

The function controls the vehicle longitudinal and lateral to follow the traffic flow in low speeds (<60km/h). The system can be seen as an extension of the ACC with Stop&Go functionality. (i.e. no lane change support).

2.4.2.2 Lane Guiding / Changing Assist (Level 2)

The function controls the vehicle longitudinal and lateral to follow the traffic flow at all speeds on all roads. The system cannot cope with all traffic situation, so the system needs the hands on the steering wheel, with some short interrupts, depending from the individual system capabilities.

2.4.2.3 Traffic Jam Chauffeur (Level 3)

Conditional automated driving in traffic jam up to 60 km/h on motorways and motorway similar roads. The system can be activated in case of a traffic jam scenario. It detects slow driving vehicle in front and then handles the vehicle both longitudinal and lateral. Later version of this functionality might include lane change functionality. The driver must deliberately activate the system, but does not have to monitor the system constantly. The driver can at all times override or switch off the system. In case of a takeover request to the driver from the system, the driver has sufficient time reserve to orientate himself and take over the driving task. In case the driver does not take over, the system will go to a reduced risk condition, i.e. bring the vehicle to a safe stop.

2.4.2.4 Highway Chauffeur (Level 3)

Conditional Automated Driving up to 130 km/h on motorways or motorway similar roads. From entrance to exit, on all lanes, including overtaking. The driver must deliberately activate the system, but does not have to monitor the system constantly. The driver can at all times override or switch off the system. In case of a takeover request to the driver from the system, the driver has sufficient time reserve to orientate himself and take over the driving task. In case the driver does not take over, the system will go to a reduced risk condition, i.e. bring the vehicle to a safe stop.

2.4.2.5 Urban and Suburban Pilot (Level 4)

Highly Automated Driving up to limitation speed, in urban and suburban areas. The system can be activated by the driver on defined road segments, in all traffic conditions, without lane change in the first phase. The driver can at all time override or switch off the system.

2.4.2.6 Highway Pilot (Level 4)

Automated Driving up to 130 km/h on motorways or motorway similar roads from entrance to exit, on all lanes, including overtaking and lane change. The driver must deliberately activate the system, but does not have to monitor the system constantly. The driver can at all times override or switch off the system. There are no request from the system to the driver to take over when the system is in normal operation area (i.e. on the motorway). Depending on the deployment of cooperative systems, ad-hoc convoys could also be created if V2V communication is available.

2.4.3 Fully automated private vehicle (Level 5)

The fully automated vehicle should be able to handle all driving from point A to B, without any input from the passenger. The driver can at all-time override or switch off the system. Note: only a rough time estimation can be given for this system at the moment.

2.5 Systems for Automated Freight Vehicles

This path focuses on automation of commercial vehicles primarily for long-distance freight transport. Automated commercial vehicles operate mainly on open roads but also in restricted roads/lanes and confined areas should be considered where the automation level can be applied.

2.5.1 Platooning

2.5.1.1 C-ACC Platooning

Partially automated truck platooning, in which trucks are coupled by cooperative ACC (C-ACC), through speed control keeping a short but safe distance to the lead vehicle, while the drivers remain responsible for all other driving functions.

2.5.1.2 Automated Truck Platooning

This function enables platooning in both dedicated lane/road and on open roads in mixed traffic. The vehicle should be able to keep its position in the platoon with a safe distance between the vehicles. The driving behaviour of the leading vehicle is transmitted by V2V communication to the following vehicle taking vehicle characteristics into consideration, such as braking capacity, load. The function will also handle platooning management of forming, merging and dissolving platoons together with interaction with other road users and road infrastructure requirements.

Platooning will be deployed in steps balancing capabilities and needs from fleets, drivers and authorities;

- In scenarios where there are strong combined incentives through fuel savings, safety, traffic flow and road utilization improvements
- From short mono-fleet platoons in high density truck on selected roads to multi-brand/multi-fleet ad-hoc platoons on open roads in mixed traffic
- From platoons low level platoons with driver involvement to high-level platoons without driver involvement, in line with safety and traffic regulation
- From platooning services for dedicated fleets to pan-European platooning services provided by independent platooning services providers

2.5.2 Highway Pilot

2.5.2.1 Traffic Jam Assist (Level 2)

The function controls the vehicle longitudinal and lateral to follow the traffic flow in low speeds (<30km/h). The system can be seen as an extension of the ACC with Stop&Go functionality without lane change support.

2.5.2.2 Traffic Jam Chauffeur (Level 3)

Conditional automated driving in traffic jam up to 60 km/h on motorways and highways. The system can be activated in case of a traffic jam scenario exists. It detects slow driving vehicles in front and then handles the vehicle both longitudinal and lateral. Later versions of this functionality could include lane change functionality. Driver must deliberately activate the system, but does not have to monitor the system constantly. Driver can at all times override of switch off the system. Note: There is no take over request to the driver from the system.

2.5.2.3 Highway Chauffeur (Level 3)

Conditional Automated Driving up to 90 km/h on motorways or motorway similar roads from entrance to exit, on all lanes, including overtaking. The driver must deliberately activate the system, but does not have to monitor the system constantly. The driver can at all times override or switch off the system. The system can request the driver to take over within a specific time, if automation gets to its system limits. Later versions of this functionality might include lane change and overtaking functionality.

2.5.2.4 Highway Pilot with ad-hoc platooning (Level 4)

Automated Driving on motorways or highways from entrance to exit, on all lanes, incl. overtaking and lane change. The driver must deliberately activate the system, but does not have to monitor the system constantly. The driver can at all times override or switch off the system. There is no request from the system to the driver to take over when the system is in normal operation area (i.e. on the motorway).

Combined with cooperative systems (V2X communication) this will enable higher level platooning as described in 2.5.1.

2.5.2.5 Highly Automated Trucks on public roads (Level 4)

High automated trucks for automated operation on public roads in mixed traffic handling all typical scenarios without driver intervention on planned freight transport operations hub-to-hub on approved roads according to planned routes. Remote fleet and transport management and monitoring is required.

2.5.3 Autonomous freight vehicles (Level 5)

Autonomous freight transport to handle all driving from hub-to-hub where vehicles are operating in full autonomy. Vehicles could be designed without cab or room for drivers.

2.5.3.1 Autonomous vehicles in confined areas (Level 5)

Autonomous freight transport carriers in confined areas (e.g. harbour, mining and work-site) for un-manned freight transport. Vehicles can be designed without cab for driver.

2.5.3.2 Autonomous vehicles in dedicated lanes/roads/areas (Level 5)

Autonomous freight transport carriers on dedicated and controlled lanes/roads/areas and for un-manned freight transport. Vehicles can be designed without cab for driver. Operation could be done during night in lower speed to safe fuel.

2.5.3.3 Autonomous hub-to-hub transport on public roads (Level 5)

Autonomous freight transport carriers on public roads and for un-manned freight transport. Vehicles can be designed without cab for driver. Operation could be done during night in lower speed to safe fuel.

2.6 Urban Mobility Vehicles

This path covers ‘Low Speed High Automation’ for the urban environment. In specific areas in Europe today high automation in transit areas exist with specific solutions requiring low vehicle speed and/or dedicated infrastructure:

- **Cybercars**: These are small automated vehicles for individual or collective transportation of people or goods, with the following characteristics: a) fully automated on demand transport systems that under normal operating conditions do not require human interaction; b) they can be fully autonomous or make use of information from a traffic control centre, information from the infrastructure or information from other road users; c) they are small vehicles, either for individual transport (1-4 people) or for transport of small groups (up to 20 people); d) they can either use a separated infrastructure or a shared space.

- **Automated buses**: These are buses with the following characteristics: a) they are vehicles for mass transport (more than 20 people); b) they use an infrastructure, which can be either exclusive (e.g. BRT, Bus Rapid Transit) for the buses or shared with other road users; c) they can use various types of automated functionality like; guidance, driver assistance, collaborative automation, bus-stop automation, bus-platooning, queue assist; d) they always have a driver allowing the vehicles to use open roads.

- **Personal Rapid Transit (PRT)**: This is a transport system featuring small fully automatic vehicles for the transport of people, with the following characteristics: a) PRT operates on its own exclusive infrastructure (there is no interaction with other traffic); b) they are fully automated systems that under normal operating conditions do not require human interaction; c) they are small with a capacity usually limited to 4 to 6 persons per vehicle; d) PRT offers an on-demand service, where people are transported directly from the origin station to the destination station without stopping at inter-mediate stations, without changing vehicles and ideally without waiting time.

- **Advanced City Cars,** new city vehicles integrating zero or ultra-low emission mode and driver assistance such as ISA (Intelligent Speed Adaptation), parking assistance, collision avoidance, queue assist, etc. These vehicles should also incorporate access control coupled with advanced communications in order to integrate them easily into car-sharing services.
- **Dual-mode vehicles,** developed from traditional cars but able to support both fully automatic and manual driving. The first applications of automatic driving will be for relocation of shared cars using platooning techniques but these vehicles could become full cybercars in specific areas or infrastructures. Dual-mode vehicles represent the migration path from traditional cars to automatic driving.

These solutions will go towards higher and higher vehicles speeds combined with less specific requirements on the infrastructure.

2.6.1 Last mile solutions

2.6.1.1 Cybercars (Level 4)

The last mile solution is fully automated in its area of operations. In a Gen1 it operates in a specific area with dedicated infrastructure with a maximum speed of 40 km/h. In a Gen 2, it operates in a specific area with adapted infrastructure.

2.6.1.2 Automated Cyber Solutions (Level 5)

Fully automated driving that can in principle takes the passenger to all places. Note: only a rough time estimation can be given for this system at the moment.

2.6.2 Automated bus or Personal Rapid Transit (PRT)

2.6.2.1 Automated bus or PRT in designated lanes, Gen 1 (Level 4)

The automated bus drives in designated bus-lanes and dedicated infrastructure, with a maximum speed of 40km/h. This may be combined with automated functions for enhanced safety, traffic flow and network utilization.

2.6.2.2 Automated bus or PRT in dedicated lane, Gen 2 (Level 4)

The automated bus operation in dedicated bus lanes and supporting infrastructure with normal city vehicle speeds, e.g. bus-trains and bus-stop automation, for enhanced safety, traffic flow and network utilization. Additional functionality such as adaptive urban traffic control system that controls the traffic lights and gives speed advices and priority can be introduced when these systems reach the market.

2.6.2.3 Automated bus (Level 4)

The automated bus drives in mixed traffic on designated roads and in restricted areas.

3. Development paths

Systems of level 0 to 2 on the market today are the basis for developing the deployment paths for both passenger and freight vehicles with a stepwise approach to higher levels of automation. Another path is possible for urban mobility vehicles: high automation is already being tested in some areas in Europe but with low speed and/or dedicated infrastructure. In all cases, the evolution is similar: a progressive increase of automation level during the upcoming decade. These main deployment paths are shown in Figure 2.

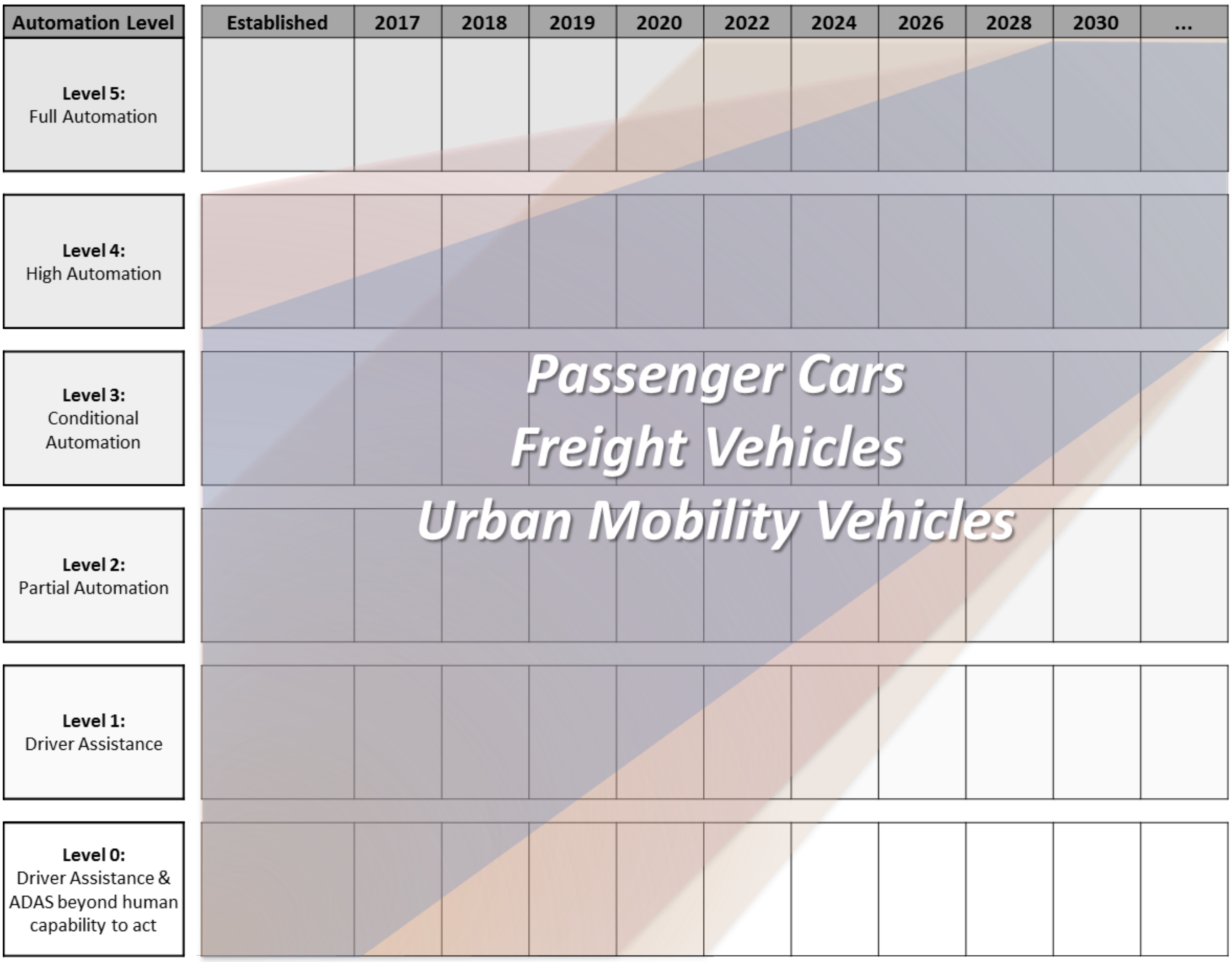

Figure 2: The main automation deployment paths

3.1 Automated Passenger Cars Path

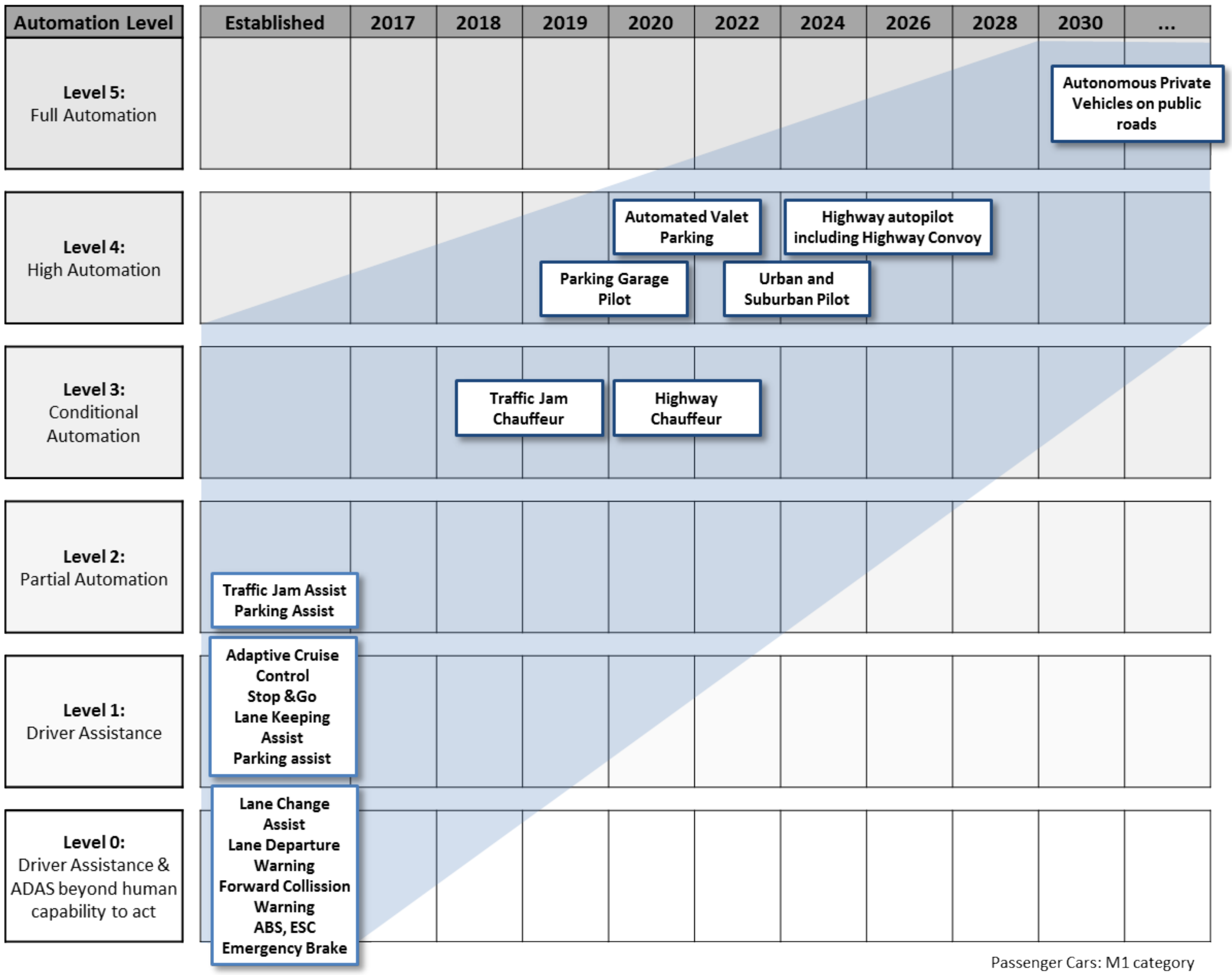

Figure 3: The Automated Driving deployment path for passenger cars

3.2 Automated Freight Vehicles Path

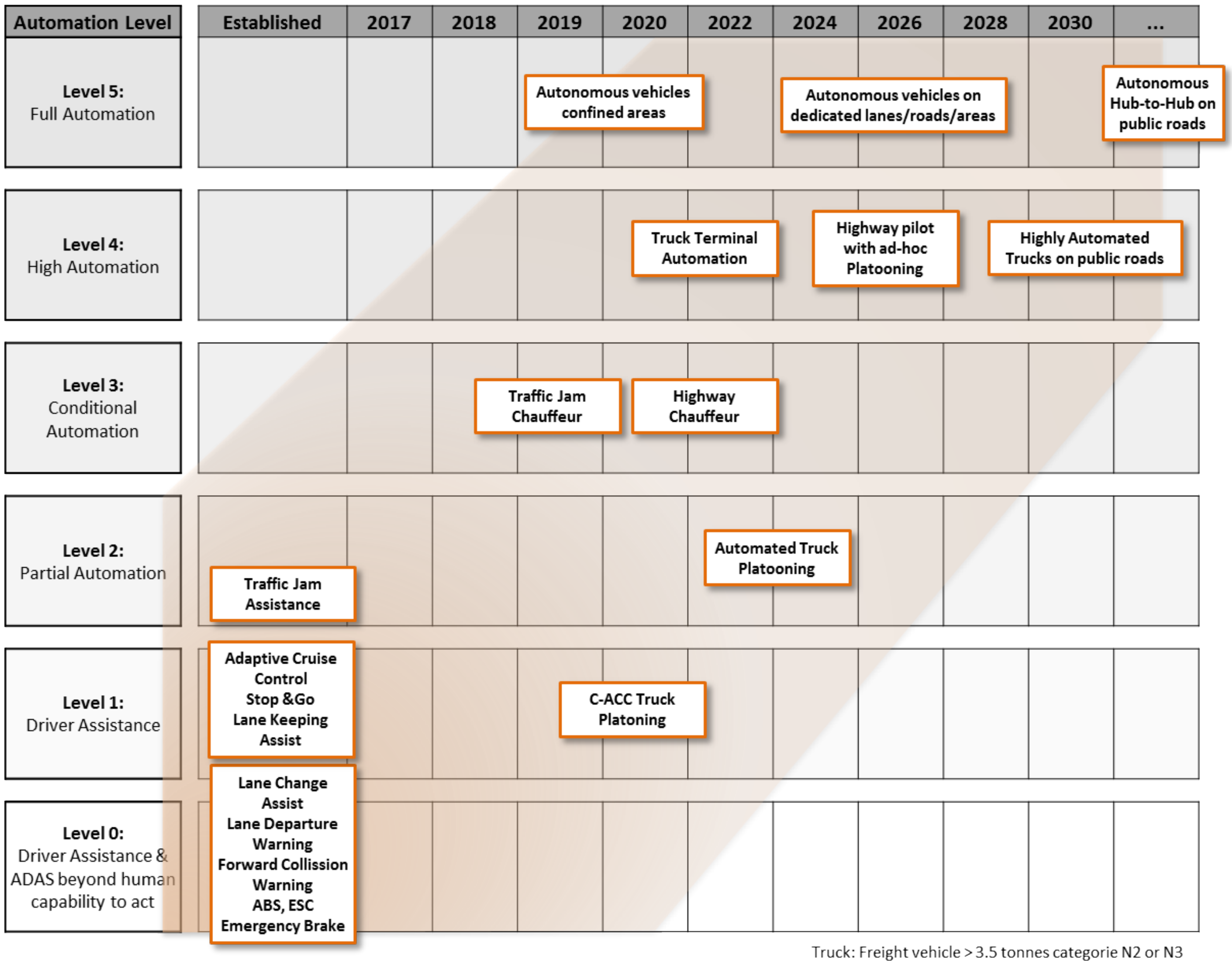

Figure 3: The Automated Driving deployment path for freight vehicles

3.3 Urban Mobility Vehicles

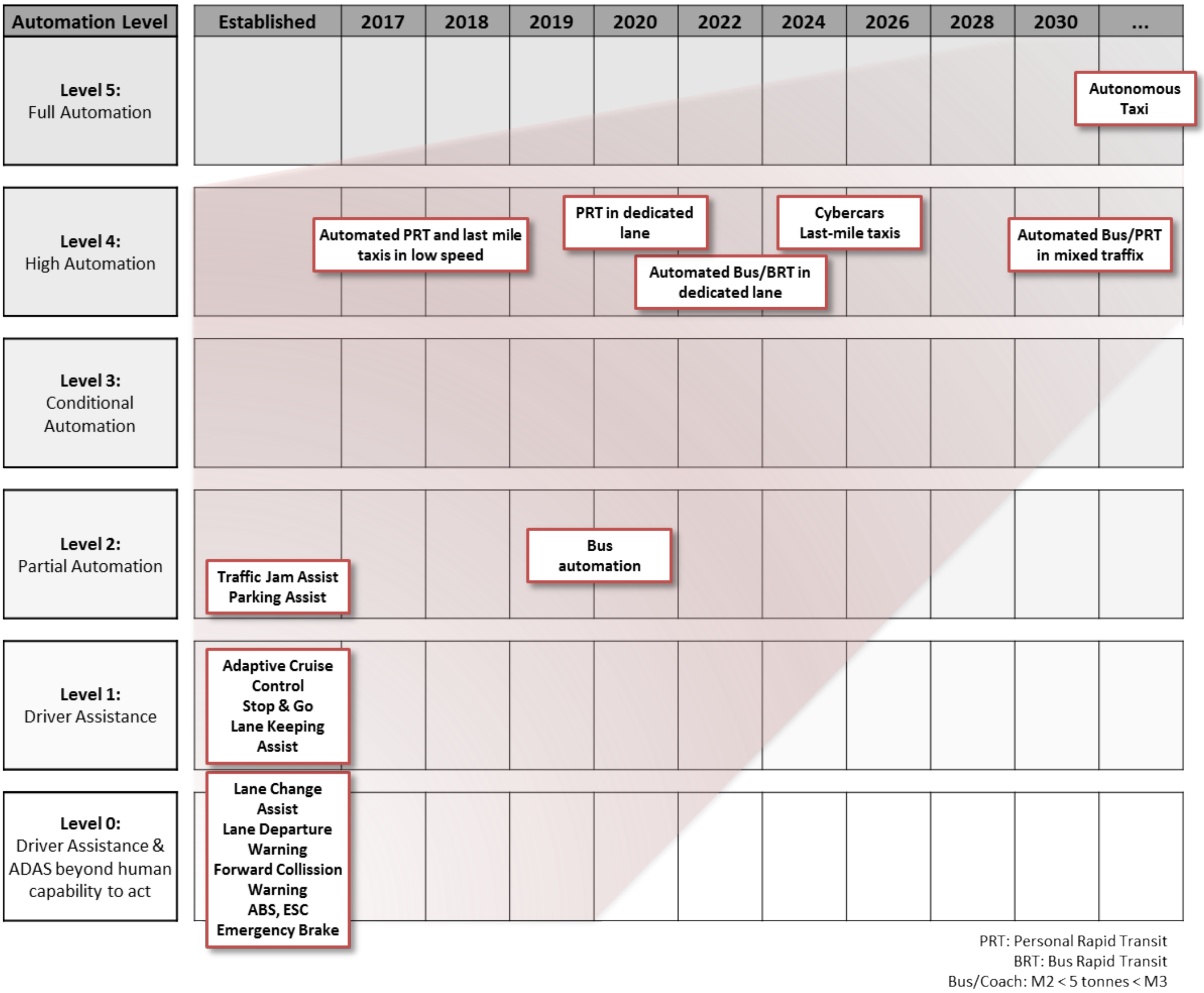

Figure 5: The Automated Driving deployment path for urban mobility vehicles

4. EU and international initiatives

This chapter is not included in this public consultation draft. It will be released in the final version to be published in June.

If you wish to review or contribute to a subchapter, please contact info@ertrac.org

4.1 European research projects

Will include an overview picture of the recent and current European funded projects on AD.

4.2 European initiatives

4.2.1 CARTRE and SCOUT support actions

4.2.2 High-level Roundtable and Alliance of Automotive and Telecom Industries

4.2.3 GEAR 2030

4.2.4 C-ITS Platform

4.2.5 Related PPPs: ECSEL, 5G, Cyber-Security

4.3 EU Member States initiatives

4.3.1 France

4.3.2 Germany

4.3.3 United Kingdom

4.3.4 Sweden

4.3.5 The Netherlands

4.3.6 Spain

4.3.7 Austria

4.4 Initiatives around de world

4.4.1 USA

4.4.2 Japan

4.4.3 South Korea

4.4.4 China

4.4.5 Singapore

4.4.6 Australia

4.4.7 United Arab Emirates

5. Key Challenges and Objectives

Automated driving is the opportunity to address several important societal challenges of road transport: **safety, energy efficiency, congestion, urban accessibility and social inclusion.** These societal needs match with the Vision and the Strategic Research Agenda of ERTRAC for the long-term evolution of the Transport System. Impacts should be assessed in the wide sense: not only from the introduction of new vehicle technologies but also considering new services enabled by automation and their likely societal impacts. So a System approach is necessary to have a good overview of what the deployment of Automated Driving can bring. Mobility offers could extend to more users including elderly and people with disabilities. And new solutions for shared mobility and public transport could be developed, which could have important impacts on our future urban and inter-urban environments. And these benefits can be brought to both passenger and freight transport.

The following chapters list the main challenges and objectives on the path to higher levels of automation. Various types of actions are necessary, sometimes at local level, sometimes at European level, and sometimes also at the international level with other world regions. In addition to technologies and vehicle aspects, there are important challenges of system integration for the deployment of new services. New business models need to clarify their data management and their integration with digital and physical infrastructures. But firstly, policy and societal aspects must be addressed, to ensure a proper user information and acceptance and make the necessary regulatory adaptations.

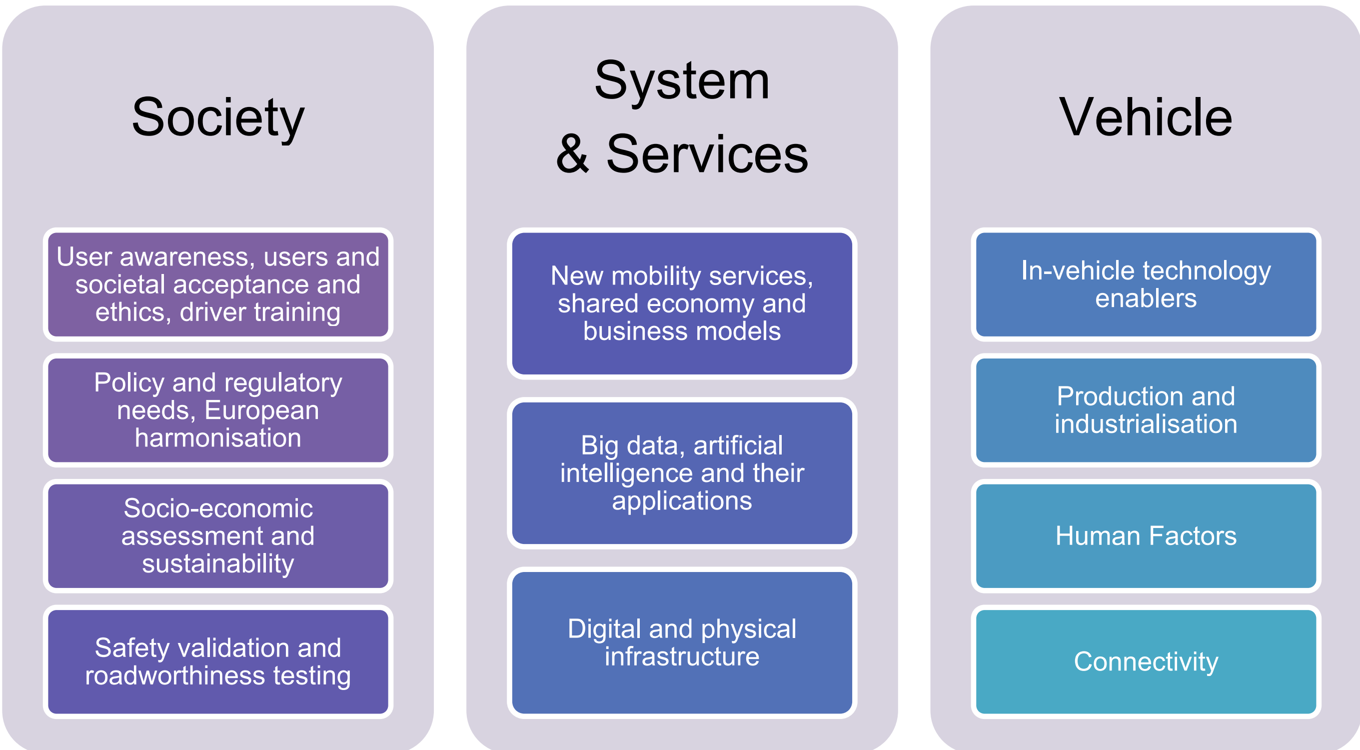

Figure 6: Thematic challenge areas

5.1 User awareness, users and societal acceptance and ethics, driver training

Will AD take control from the users? Will it be accepted? How will this personality be reflected with automated vehicles? How to handle socio-economic and age group differentiation?

How will AD challenge the desire for the driver to stay in control?

How will automation change our mobility habits? Will automated mobility be more or less expensive?

Should an automated car decide for the driver on ethical questions of life and death?

How will driver training and the driver licence handle the differences between the functionalities with which semi-automated cars are equipped and in which environments and conditions they operate?

5.2 Policy and regulatory needs, European harmonisation

Today, the discussions concentrate on research, testing and type approval. First activities on traffic rules are started in some countries. Which areas of policy and regulation are affected in total?

On research and testing, how to bundle and coordinate all research activities to speed up and not loose competition?

On type approval regulation, Level 2 is still under strong discussion, Level 3 has not really started yet, on Level 4 and 5 there is no clear view how to proceed. How to set up regulation quick enough to be in place when technology will be ready?

How and to which extend to harmonize traffic rules for a quick introduction of higher automation levels?

5.3 Socio-economic assessment and sustainability

How to come to a realistic und harmonized evaluation of socio-economic and sustainability impact?

5.4 Safety validation and roadworthiness testing

How to handle initial release validation and real world awareness and functional validation?

How to handle development completeness including validation testing operational safety and functional safety as part of the development of a new function and/or a whole automation level?

How to include/adapt/improve existing development methodologies?

How to validate human interaction for automated driving?

How to ensure granularity to cover different levels of the whole system: component level, vehicle level, system level (including interaction with other road users and infrastructure) taking into account its specific characteristics, commonalities and differences (i.e. scenarios and/or raw data)?

How to handle vehicle updates, infrastructure functional updates and vehicle lifecycle?

5.5 New mobility services, shared economy and business models

How will the area of shared vehicle services evolve?

How to handle and stimulate mobility services innovation?

How to handle management of professional driver services management such as driving/working/resting time operation?

What are the new business models for private, commercial and public users?

5.6 Big data, artificial intelligence and their applications

How to build a framework across Europe to speed up and harmonize technological approaches as well as research guidelines?

How to organise cross-industrial cooperation to maximize competitiveness?

5.7 Digital and physical infrastructure

What are the roles and responsibilities of the different stakeholders for physical and especially digital infrastructures for connected and automated vehicles?

Should the vehicle cope with any road infrastructure, and if not, what demands can be set to adapt the existing physical infrastructure – including planning, building, operation, maintenance while also considering the differences in operating environments ranging from rural roads in remote areas to busy interurban motorways and from residential areas to central business districts?

In which conditions should dedicated lanes/roads/areas be allocated to automated vehicles especially in the transition phase towards full automation?

Where is digital infrastructure needed for different levels of automation?

What are the terms, conditions and roles for service provision, collection of, and access to data from especially automated vehicles?

How to ensure the security of the infrastructures?

How to manage and verify the changes made to the physical infrastructure, and guarantee the level of quality of the information?

5.8 In-vehicle technology enablers

How to establish a consensus for societal expectations for safety margin, ethic and mobility issues? (These expectations are very much related to the in-vehicle technologies, as these determine the system requirements. On the other hand, the current and future state of technology will also determine what will be possible from the technology side. A societal consensus concerning a certain safety margin enables investments of industry towards technology development.)

How to reduce costs down to an optimum balance to the benefits and master complexity for the strongly divergent solution space of functional and technological combinations and the fusion of the digital/telecommunication-world and the automotive world?

5.9 Production and industrialisation

How to speed up “Time to market” to enable early market deployment of new solutions?

How will the automotive industry handle the transformation into software driven industry handle complex functional growth, continuous software online updates and cyber-security?

5.10 Human Factors

How to understand the interaction between humans and automated vehicles (in-vehicle and outside vehicle) at different levels of automation?

How to understand effects of vehicle automation on humans such as misuse, skill degradation, trust and acceptance, and motion sickness?

How to adapt the vehicle automation to human needs and states?

How to derive interaction design concepts for the automated vehicles so that both the human driver and other humans in the surrounding sufficiently understand the capabilities and limitations of the vehicle?

5.11 Connectivity

Interoperability of V2X equipment especially when driving between countries

V2X communication protocols where updates are needed for automated driving

Ubiquitous connectivity / seamless use of different communication technologies

Reliable and resilient communication considering harsh environments (e.g. truck platooning in tunnels) to ensure functional safety and a minimum quality of service

Cyber-security to make automobiles tamper-proof in attacks from hackers

Data privacy and data ownership (use of enormous amount of data respecting privacy concerns and at the same time ensuring a minimum quality of service)

Mass market adoption of V2X communication in accordance with spectrum availability (study the effects at different penetration levels incl. extremely high and extremely low penetration level of V2X equipment)

Rapid evolution of communication systems especially cellular technologies (3G → 4G → 5G)

6. Recommendations for Horizon 2020 Work Programme 2018-2020

Recommendations have been prepared by the ERTRAC Working Group on "Connectivity and Automated Driving" and delivered to the European Commission services in December 2016. They call for activities at European level in the coming years, addressing the Transport Programme of the European Research and Innovation Programme "Horizon 2020".

This public consultation does not target these recommendations, which have been finalised in 2016. The European Commission is now solely responsible for the preparation and publication of the H2020 Work Programme.

Efficient and safe Connected and Automated heavy-duty vehicles in real logistics operations

Specific Challenge: Implementing connected and automated driving in multi-brand/multi-fleet heavy-duty trucks freight transport operation has great potential to improve freight efficiency, safety and fuel efficiency in real logistics operation on roads in mixed traffic and in confined areas. There are a number of specific challenges that needs to be addressed: enhanced vehicle technologies for improved perception, control, connectivity, resilience and cost; harmonization and acceptance with other road users, infrastructure and logistics in mixed traffic on public roads; enhanced harmonized operation in port and terminals to optimize the complete logistic chain.

Scope and Content: The focus of this topic is to: investigate needs and opportunities; develop, test and demonstrate innovative, safe, efficient and resilient hub-to-hub long-distance connected and automated enhanced freight logistics operation on public roads in mixed traffic and at terminal logistics sites.

Expected Impacts: Improvement of overall freight transport efficiency, energy efficiency and safety.

RIA/IA, WP2020

Automated concepts for safe and efficient last-mile urban logistics

Specific Challenge: Connected and automation technologies open up for new possibilities to improve freight transport vehicles utilization, operation, loading and distribution. The challenges for urban freight transport are to handle the increased demands for urban freight transport in balance with the need to improve efficiency, safety, emissions and resource utilization of the overall urban logistics system.

Scope and Content: Research and innovation of end-to-end automated urban logistics solutions, waste collection, last-mile delivery, goods-on-vehicle consolidation and consolidation centres. This topic will address how automated low-speed solutions will complement the existing high-speed transport networks for goods. Modular building blocks (mechanical and electrical) for autonomous transportation units designed for scalability enabling maximum availability. Multi-stakeholder pilots in order to address the operational needs and opportunities to increase efficiency, flexibility and reduce travel time and costs. Investigate the potential of combining automated urban delivery and people transportation.

Expected Impact: Improvement of overall urban freight transport efficiency, operation efficiency, emission reductions and safety.

RIA

Automated Public Transport – from Today and into the Future!

Specific Challenges: The bus public transport system needs to evolve to meet and balance the increasing demands from the users, the operators and from the society of improved efficiency, safety and environmental impact. Improved utilization of existing urban road infrastructure, reduced travel time, increased accessibility for all users, convenience, safety, reduced time at bus stops and charging stations, operation at bus-depots are challenges that needs to be addressed. Implementation of connected and automated technologies in enhancing driver operated full size buses, highly automated public solutions. Introduction of innovative solutions for connected travellers and fleet operators of tomorrow.

Scope and Content: To speed up the introduction of CAD technologies this action will demonstrate how to implement automated solutions in the public transport system for increased mobility efficiency and safety. Urban bus-trains/BRT-evolution, bus depot automation, bus-stop automation, charging station automation and automated accessibility solutions for impaired and elderly users should be addressed. Multi-stakeholder involvement, research, concept development and demonstration and impact assessments in typical European urban and rural contexts.

Expected Impact: Transport efficiency, driver and operator aspects, enhance existing system, BRT, electrification.

RIA, WP2019

Short and long-term impact and socio economic assessment of connected and automated driving

Specific Challenge: We need to assess the short, medium and long term impacts, benefits and costs of the deployment of automated vehicles in order to make decisions related to investments on connected and automated driving. Higher levels of automated driving present a rupture in evolution of driver support and the whole driving task making the assessment of impacts of automated driving difficult and challenging as the changes in mobility itself (vehicle ownership and use, choice of residence, use of mobility services, use of travel time for different purposes, etc.) are likely substantial but hard to estimate ex-ante, and will affect all other impacts. The behavioural impacts will also be challenging due to need to get also sufficient empirical data on actual behaviour of automated vehicles in open traffic as results from simulators and models need empirical support for their transferability.

Scope and Content: A large research and innovation project comparing the impacts, benefits and costs of different scenarios of road vehicle automation deployment would enable European and national decision-makers to assess and promote the most promising scenarios. The scenarios assessed should contain all major location, road, condition and different user types as well as the related varieties of vehicle automation. Impacts on both mobility behaviour as well as driver behaviour, and thereby on safety, traffic efficiency, CO2 and other environment should be included. Specific attention should also be paid to the transition phase towards higher levels of automation, where human- and machine operated vehicles are both present in varying penetration degrees, as well as the impacts on urban mobility.

Expected Impacts: Good knowledge basis for European and national decision makers to decide on which deployment scenarios to support and which to deploy, resulting in accelerated measures to facilitate large-scale deployment. Information on gaps related to assessment methods and their further development.

WP2018-19

Connected automated driving for the mobility of all

Specific Challenge: With higher levels of automation being deployed, development of easy access and use of automated vehicles, as a driver/rider also for the elderly, the children, and those with disabilities (movement, sight, hearing, cognitive, mental), will give many new possibilities of mobility to their lives and need to be understood and included in the development of the future road transport system.

Scope and Content: A large research and innovation project assessing the requirements of the afore-mentioned user groups to better understand which new possibilities in work, leisure and travel have their priority, and developing use cases, services and designs corresponding to the needs of these users. With these use cases, connected and automated vehicles and infrastructure work hand in hand with these new mobility solutions. In the assessment and development, also some more general well-being criteria and indicators such as participating in transport, access to new ICT solutions, access to physical and mental health services, personal safety, equality, cost of travel will be applied. The development can address possibilities to adapt the basic parameters for automation (headways, control takeover, safety margins, etc.), access (entry, exit) to automated vehicles, automated driving in adverse road and weather conditions, mobility of both people and goods, and use of public and shared transport. The different user needs in different regions and operating environments including both rural and urban conditions should be addressed, aiming at compatibility across EU member states.

Expected Impacts: Completely new solutions for the mobility of all will have impact on all stakeholders of the road transport system across Europe and give new opportunities to the elderly, children and persons with disabilities.

WP2020

Automated vehicle driver behaviour modelling and demands

Specific Challenge: The role of the driver will change dramatically when higher levels of automation are introduced into road transport. This is the start of a very long transition phase with coexistence of manually driven vehicles and automated vehicles. Drivers/operators must have a very clear understanding about the automation grade available in each situation.

Scope and Content: Research for upgrading the driver behaviour, monitoring and readiness models and impact and especially safety assessment methods based on these models is necessary due to new relationship between driver and vehicle (mutual cooperation or even handover rather than continuous control) as well as the use cases where an operator controls the vehicle remotely. This leads to virtual human modelling for driver/operator behaviour and readiness as well as impact evaluations considering also driver control handover, driver/operator state and impairment. Solutions for keeping the driver/operator in the loop and for ensuring a secure function (re-)allocation with reduced resources. A support action is needed to explore the impact on the new driver/operator roles and skill needs on regulations, driving tests, advanced driving courses, general public information, and safe driver education programmes, including both current and new drivers, and use of both automated and manually driven vehicles. [The focus is on levels 4-5 while building on ART4 for level 3].

Expected Impacts: A better common understanding and evaluation of driver/operator behaviour gives the framework for the deployment of higher automation levels. So behavioural risks in road traffic caused by drivers/operators being not aware of the performance and limits of the automation grade of their vehicle can be avoided.

WP2018-19

Testing and Validation

Specific Challenge: Driver assistance functions require significant effort of testing and validation to be achieved by automotive industry already today. In highly automated and autonomous driving modes, the driver will be out the loop: this means a huge increase of scenarios, which have to be validated. This will not be feasible - not to mention affordable by individual approaches. So there is need to assess testing and validation processes for highly automated and autonomous driving. On such a basis, also completely new liability questions need to be addressed before products are on the market, to create a robust framework for business cases of all partner industries (transport, IT, telecom, insurance). Also, enforcement can be crucial to Member States when new approaches are necessary to be in place together with automated vehicles coming to the market.

Scope and Content: What should be covered by this project is the development of testing and validation processes of future systems. Detection of driver or user misbehaviour, misuse or abuse by utilizing data available through communication (in- vehicle or backend), and the interaction of automated vehicles with law enforcement officials or any other person in charge of regulating traffic should be considered. Specific focus should be on differences across the EU member states. The scope should imply to elaborate common criteria for model-based validation and simulation on vehicle and component sensor level as well. Both, on- and off-board validation should be considered. Target is to support harmonization and standardization of homologation processes.

Expected Impacts: In preparation of the deployment of higher levels of automation, transport, it, telecom and insurance industries work on common standards across Europe concerning testing, validation and so liability criteria. Impact is expected on new vehicles and on existing vehicles as well. Member States can harmonize requirements on interaction with enforcement of connected and automated road transport.

Physical and digital infrastructures for higher-level automation

Specific Challenge: Higher levels of road vehicle automation will set specific requirements and have specific consequences for both the digital and physical road and road-side infrastructure. Many of the physical infrastructure elements will have a life-span of several decades and thereby the infrastructures set up and deployed during the next ten years should already be adapted where and when possible, according to the requirements of higher levels of road vehicle automation. Higher level automation also needs in addition to on-board sensors, off-board data in order to operate in complex environments and specific traffic scenarios. There is so far no general agreement on the roles and responsibilities of different stakeholders in implementing, maintaining, operating and financing infrastructures for automated driving, threatening to delay investments in these.

Scope and Content: Research and Innovation and/or large scale FOT on especially the physical (road and roadside) infrastructure needs for and consequences of higher level automation. This relates to use and adaptation of exiting physical infrastructure (consequences to pavements, bearing capacity, utilisation of hard shoulders, roundabouts, new road monitoring/maintenance tools, allocation of special use lanes, forms of visual guidance, traffic management, connectivity solutions, electrification, need of standardized road infrastructures for automated driving) and for building up new physical infrastructure (city planning, road/street planning and design). The transition phase needs to be specifically addressed. The interaction between road infrastructure and connected automated vehicles needs to facilitate functional safety in distributed functions for automated road transport.

With regard to digital and data-oriented infrastructure and especially off-board sensors, in urban environments new infrastructural sensing methods could overcome blind spots in vehicle surround sensing by aggregating data from multiple sources to cope with critical situations. Another approach could be to use large-scale heterogeneous vehicle fleet data for a backend-based collective perception resulting in a near-real-time map. In this case, the needs and the conditions for the use, reuse and sharing of data generated by connected and automated vehicles need to be assessed. To set up a suitable backend solution, integrated, efficient and dependable computing platforms and control strategies are required. Altogether, a scalable consolidation of large amounts of floating car data is needed while data reliability must be assured. New standards for the applied data interfaces are to be established.

Expected Impacts: City and road authorities/operators know what is expected from them and what is feasible for them to deliver with regard to the physical and digital backend infrastructure. The infrastructure operators and service providers will be able to commence actions to adapt their planning, building, maintenance and operation guidelines accordingly.

Development of security methods to protect automated driving

Specific Challenge: Already today, cyber-security and vehicle safety are strongly linked due to continuously increasing connectivity. Higher levels of vehicle automation even increase the need for secure electronics architectures significantly for two reasons. On one hand, vehicle control will be automated: the human driver will not be enabled to intervene immediately in case of a cyber-attack. On the other, in many automation use cases, off-board data will be used for immediate driving decisions. The used data channels are potential entrance gates for attacks. There is need for a holistic approach to protect the electronics architecture with specific reference to automation. To ensure accessibility and integrity of automated driving related data, these have to be constantly and reliably accessible and its integrity must be guaranteed.

Scope and Content: Examine a potential extension and combination of Functional Safety Standards with already existing security standards (Common Criteria). We need to identify and analyse large-scale cyber-security challenges and current weaknesses. To reach this goal, risks and threads of the whole chain of effects from infrastructure to the vehicle control have to be assessed and validated, and assets need to be identified. Suitable high automation use cases should be considered. (Remark: Privacy topics are not considered under this topic as long as there is no direct impact to safety).

Expected Impacts: A holistic approach to protect automated vehicles is described. Authorities know what to expect. Automotive knows what is expected. Deployment of connected automated driving is promoted.

Data architectures for automated driving enabling safe off-board and on-board inter-operability

Specific Challenge: Safety in backend and cloud computing, the connectivity technologies as well as on-board computing applied to automated road transport services need to be assessed across industries to fit to the requirements of a safe vehicle control functionality. To reach this goal, we need common cross-industries safety and security standards.

Scope and Content: Safe cooperative digital High Definition map corrections need to be developed and standardized. One major issue for that is the validity of live data, which can be reached e.g. by adding confidence in terms of trust values and digital signatures. The remote diagnosis interface is a critical asset to ensure the operation of the autonomous vehicle (e.g. cloud computation, navigation data updates, remote diagnosis) and to protect the safety of the operator. A standardized and protected “over the air” (remote) diagnosis interface will be required to protect the interface and to comply with legitimate needs of the aftermarket (3rd party service providers, insurance companies, free garages, automotive clubs etc.).

Along with the increase of number and complexity of use cases there is need to develop and assess data architectures for autonomous driving. One aspect is that sensor data need to be stored in a standardized way. We need to examine how these data can be “securely” stored in the vehicle and end-to-end protected transferred to a backend server (e.g. OEM or to public authorities). Technologies, methods and standards to handle the challenges to enable safe, secure and dependable V2X data communication for Automated Driving critical functions in all driving environments need to be developed.

Expected Impacts: Common standards across automotive, IT and telecom industries for a safe and secure input (from road infrastructure and vehicle sensors), connection (for v2i, i2v, v2v), algorithms and software systems (both offboard and onboard for operating systems like AUTOSAR, LINUX, middleware as well as application software).