



Automated Driving Roadmap

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ERTRAC Task Force
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2. SCOPE AND OBJECTIVES

This document provides an overview on the current status for Automated Driving technologies with regard to implementation in Europe. The ERTRAC roadmap is based on available documents for automated driving. The overall objective is to identify challenges for implementation of higher levels of automated driving functions. A lot of work has been done on this topic by various stakeholders and multi-stakeholders platforms (e.g. iMobility Forum, EUCAR, CLEPA, ERTICO, EPoSS) and in European research projects. Therefore, it is essential to avoid any duplication of activities and concentrate on the missing items, concerns and topics for future implementation.

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. 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 be considered as a key aspect for the European Transport policy, able to support several objectives and societal challenges, such as road safety, decarbonisation, smart cities, social inclusiveness, etc. In technological terms, the advancement towards highly Automated Driving is seen as an evolutionary process to ensure that all involved stakeholders can develop and evolve with the adequate pace. This process already started with the development of ABS, ESP and Advanced Driver Assistant Systems (ADAS) and will progressively apply to more functions and environments. In parallel, driverless automated systems can be deployed to provide transport solutions in restricted areas with dedicated infrastructure or at specific locations e.g. airports. The European community is nevertheless facing important challenges to enable or implement higher levels of Automated Driving in all environments. It is utmost important that these challenges and existing gaps (technology, legislation, regulatory, policy, etc.) are early recognized and appropriate measures are taken.

Europe has a very strong industrial basis on automotive technologies and systems. The automotive industry is the largest private investor of R&D in Europe: four out of the TOP5 companies investing most in R&D in Europe are automotive companies. Various studies revealed the outstanding economic impact projected for automated driving for the years to come ranging up to €71bn in 2030^{1,2}. The estimated global market for automated vehicles is 44 million vehicles by 2030³. The economic impact is realised through economic growth, new jobs across the automotive value chain, and wider economic impacts such as increased productivity, reduced time in congestion, reduced number of severe accidents (reduced number of fatalities), efficiency gains in the transport system (i.e. increased capacity and reduced fuel consumption), etc. The whole industrial sector needs to evolve and adapt in a fast pace to stay ahead in global competitiveness while including all stakeholders and addressing societal needs.

¹ KPMG, Connected and Autonomous Vehicles – The UK Economic Opportunity

² Boston Consulting Group (2015) Revolution in the Driver's Seat: The Road to Autonomous Vehicles

³ Autonomous Vehicles, Navigant Research, Aug/13



Some challenges are beyond the scope of a research roadmap, but their clearance is key to a future exploitation of the R&D results, and to reach the objective to establish a European lead market and technology leadership. To name just the most obvious one, legislation and regulatory framework must be adapted according to the technological advancement. Further, industrialisation is key for implementation of automated driving and to realise the positive economic impact. In order to avoid another 'developed in Europe but produced outside' scenario, a pan-European effort with high visibility and recognition is required.

ERTRAC, the European Road Transport Research Advisory Council, acknowledges its important role to ensure a harmonised approach towards implementation of higher levels of Automated Driving functionalities. In 2014, ERTRAC established a task force with stakeholders and experts from its member associations and individual members to define a joint roadmap for Automated Driving.

The document is structured in **Scope and Objectives**, **Common Definitions** and Deployment Paths, **State of the Art** including an overview on the current EU and international situation, the **Key Challenges** and the ERTRAC **Roadmap** for Automated Driving.

3. COMMON DEFINITIONS

ERTRAC acknowledges the definitions of SAE J3016 for Automated Driving (see Figure 1). This section contains common definitions of the different automation functions used in this document and different deployment paths. The focus lies on automated driving level 2-5. No estimation on the likelihood and impact of the different paths will be included in this version of the document but will come in later versions.

Summary of Levels of Driving Automation for On-Road Vehicles

This table summarizes SAE International's levels of *driving* automation for on-road vehicles. Information Report J3016 provides full definitions for these levels and for the italicized terms used therein. The levels are descriptive rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. "System" refers to the driver assistance system, combination of driver assistance systems, or *automated driving system*, as appropriate.

The table also shows how SAE's levels definitively correspond to those developed by the Germany Federal Highway Research Institute (BAST) and approximately correspond to those described by the US National Highway Traffic Safety Administration (NHTSA) in its "Preliminary Statement of Policy Concerning Automated Vehicles" of May 30, 2013.

Level	Name	Narrative definition	Execution of steering and acceleration/deceleration	Monitoring of driving environment	Fallback performance of dynamic driving task	System capability (driving modes)	BAST level	NHTSA level
<i>Human driver monitors the driving environment</i>								
0	No Automation	the full-time performance by the <i>human driver</i> of all aspects of the <i>dynamic driving task</i> , even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a	Driver only	0
1	Driver Assistance	the <i>driving mode</i> -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 <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	Human driver and system	Human driver	Human driver	Some driving modes	Assisted	1
2	Partial Automation	the <i>driving mode</i> -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 <i>human driver</i> perform all remaining aspects of the <i>dynamic driving task</i>	System	Human driver	Human driver	Some driving modes	Partially automated	2
<i>Automated driving system ("system") monitors the driving environment</i>								
3	Conditional Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> with the expectation that the <i>human driver</i> will respond appropriately to a <i>request to intervene</i>	System	System	Human driver	Some driving modes	Highly automated	3
4	High Automation	the <i>driving mode</i> -specific performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> , even if a <i>human driver</i> does not respond appropriately to a <i>request to intervene</i>	System	System	System	Some driving modes	Fully automated	3/4
5	Full Automation	the full-time performance by an <i>automated driving system</i> of all aspects of the <i>dynamic driving task</i> under all roadway and environmental conditions that can be managed by a <i>human driver</i>	System	System	System	All driving modes		

Figure 1: Levels of Driving Automation for On-Road Vehicles

3.1. Deployment paths

There are several systems for Automated Driving level 0 and level 1 on the market today. These systems will be the basis for developing the deployment path for both passenger and commercial vehicles with a stepwise approach to higher level of automation. These systems will in the years to come, with increasing deployment, have a significant impact on driving efficiency and safety both when driving in automatic and manual mode. In manual mode, the systems will work as advanced active safety systems. Another alternative path is the urban environment systems path. In specific areas in Europe today high automation in transit areas exist but with low speed and/or dedicated infrastructure. These main deployment paths are shown in Figure 2.

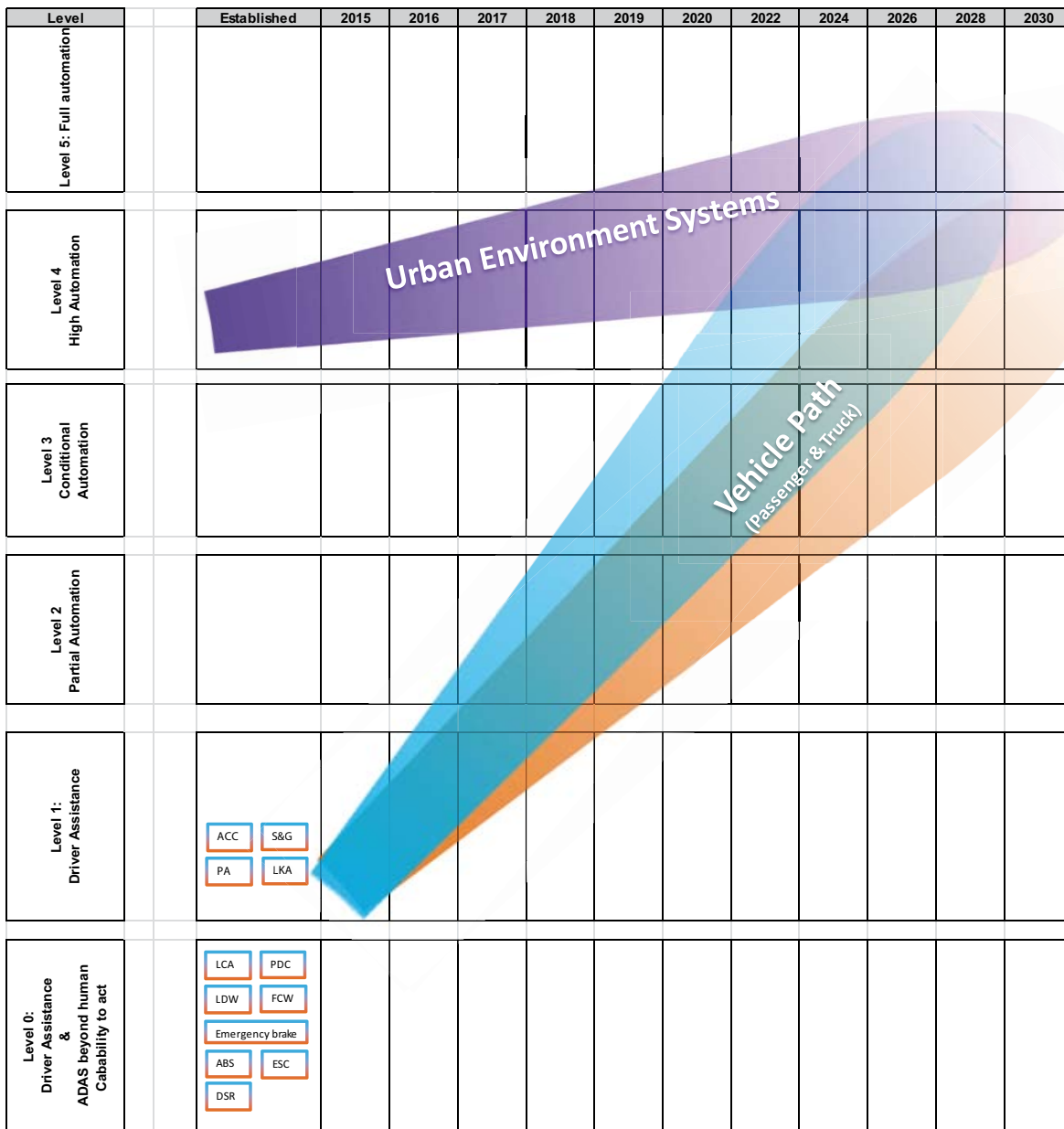


Figure 2: The main automation deployment paths

3.2. Systems beyond human capability to act

There are several systems on the market today that intervene when it is beyond the human capability to act, like ABS (Anti-Lock System), ESC (Electronic Stability Control) and emergency braking. These systems are only mentioned and not covered in detail here, but they are active safety systems that will be building blocks for high levels of automation and will facilitate deployment.

Future version of these systems will include emergency evasion and emergency stopping.

3.3. Current and future vehicle Systems – Level 0

Currently on the market (both for trucks and passenger vehicles) there is several assist system:

3.3.1. LCA – Lane Change Assist

The system monitors the areas to the left and right of the car, including the blind spot detection, and up to 50 metres behind it and warns you of a potentially hazardous situation by means of flashing warning lights in the exterior mirrors.

3.3.2. PDC – Park Distance Control

The Park Distance Control supports the driver to manoeuvre into tight spaces and reduce stress by informing him of the distance from obstacles by means of acoustic or, depending on vehicle, optical signals.

3.3.3. LDW – Lane Departure Warning

Lane Departure Warning helps to prevent accidents caused by unintentionally wandering out of lane, and represents a major safety gain on motorways and major trunk roads. If there is an indication that the vehicle is about to leave the lane unintentionally, the system alerts the driver visually and in some cases by means of a signal on the steering wheel.

3.3.4. FCW – Front Collision Warning

The Front Collision Warning monitoring system uses a radar sensor to detect situations where the distance to the vehicle in front is critical and helps to reduce the vehicle's stopping distance. In dangerous situations, the system alerts the driver by means of visual and acoustic signals and/or with a warning jolt of the brakes. Front Collision Warning operates independently of the ACC automatic distance control.

●● 3.4. Current Systems – Level 1

3.4.1. ACC – Adaptive Cruise Control

The cruise control system with “automatic distance control ACC” uses a distance sensor to measure the distance and speed relative to vehicles driving ahead.

The driver sets the speed and the required time gap with buttons on the multifunction steering wheel or with the steering column stalk (depending on model). The target and actual distance from following traffic can be shown as a comparison in the multifunction display.

3.4.2. PA – Park Assist

Park Assist automatically steers the car into parallel and bay parking spaces, and also out of parallel parking spaces. The system assists the driver by automatically carrying out the optimum steering movements in order to reverse-park on the ideal line. The measurement of the parking space, the allocation of the starting position and the steering movements are automatically undertaken by the Park Assist: all the driver has to do is to operate the accelerator and the brake. This means that the driver retains control of the car at all times.

3.4.3. ACC including Stop & Go

Adaptive cruise control with stop & go function includes automatic distance control (control range 0–250 km/h) and, within the limits of the system, detects a preceding vehicle. It maintains a safe distance by automatically applying the brakes and accelerating. In slow-moving traffic and congestion, it governs braking and acceleration.

3.4.4. LKA – Lane Keeping Assist

Lane Assist automatically becomes active from a specific speed (normally from 50 km/h) and upwards. The system detects the lane markings and works out the position of the vehicle. If the car starts to drift off lane, the LKA takes corrective action. If the maximum action it can take is not enough to stay in lane, or the speed falls below 50 km/h, the LKA function warns the driver (e.g. with a vibration of the steering wheel). Then it is up to the driver to take correcting action.

3.5. Automated Passenger Cars Path

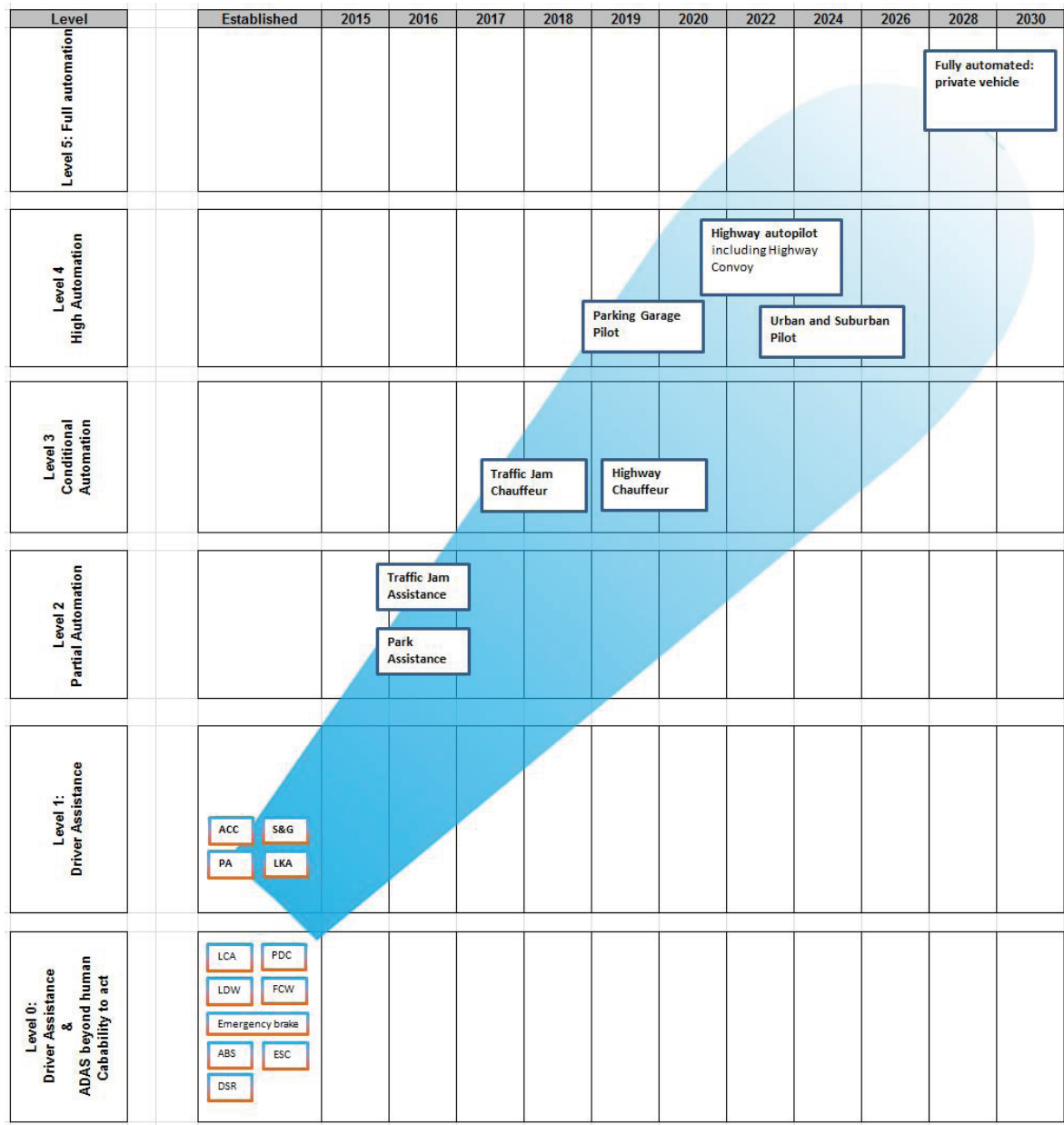


Figure 3: The Automated Driving deployment path for passenger cars

3.5.1. Automated Parking Assistance

3.5.1.1. 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 manoeuvre by itself. The driver can be located outside of the vehicle, but has to constantly monitor the system, and stops the parking manoeuvre if required.

3.5.1.2. Parking Garage Pilot (Level 4)

Highly Automated parking including manoeuvring to and from parking place (driverless valet parking). In parking garage the driver does not have to monitor the system constantly and may leave once the system is active. Via smartphone or key, parking manoeuvre and return of the vehicle is initiated.

3.5.2. Highway Pilot

3.5.2.1. 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. (i.e. no lane change support).

3.5.2.2. 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. Note: There is no take over request to the driver from the system.

3.5.2.3. 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. The system can request the driver to take over within a specific time, if automation gets to its system limits.

3.5.2.4. 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.

3.5.3. 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.

3.6. Automated Commercial Vehicle Paths

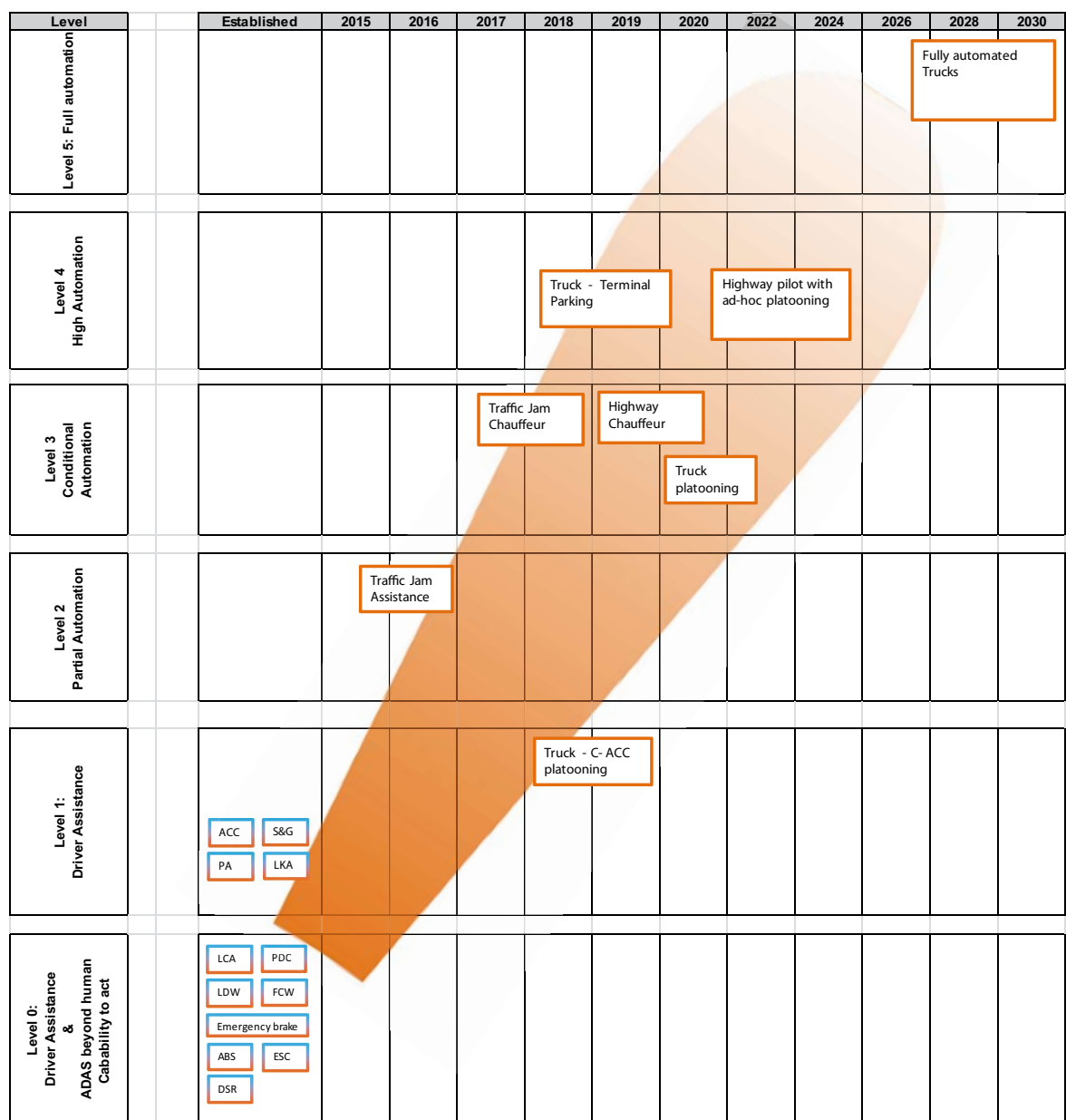


Figure 4: The Automated Driving deployment path for commercial vehicle

3.6.1. Platooning

3.6.1.1. C-ACC Platooning

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

3.6.1.2. Truck platooning

This function enables platooning in specific lane. The vehicle should be able to keep its position in the platoon with a fixed distance or fixed time difference from the front vehicle. The behaviour of the first vehicle (e.g. braking and steering) should be transmitted by V2V communication. The function should also handle vehicles that wants to leave the platoon.

Up scaling and deployment can be reached as follows:

- 1. Start with trucks as there is a strong financial incentive due to 10% to 15% fuel savings.
- 2. Start with small platoons of only 2 trucks and co-operation with fleet-owners in high density truck area.
- 3. Start with a system where drivers are still in the following truck, for legal reasons.
- 4. Setup an (open) fleet management system for trip matching between equipped trucks of different fleet owners.

3.6.2. Highway Pilot

3.6.2.1. 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 (i.e. no lane change support).

3.6.2.2. 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 exists. It detects slow driving vehicles in front and then handles the vehicle both longitudinal and lateral. Later versions of this functionality might 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 or switch off the system. Note: There is no take over request to the driver from the system.

3.6.2.3. 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.

3.6.2.4. Highway Pilot with ad-hoc platooning (level 4)

Automated Driving up to 110 km/h on motorways or motorway similar roads 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). Depending on the deployment of cooperative systems, ad-hoc convoys could also be created if V2V communication is available (see 3.6.1).

3.6.3. Fully automated truck (level 5)

The fully automated truck should be able to handle all driving from point A to B. No driver need to be in the vehicle. Note: only a rough time estimation can be given for this system at the moment.

3.7. Urban Environment Systems⁴

The path is 'Low Speed High Automation'. 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.
- **High-Tech Buses.** These are buses on rubber wheels, operating more like trams than like traditional 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 for the buses or shared with other road users; **c)** they can use various types of automated systems, either for guidance or for driver assistance; **d)** they always have a driver, who can take over control of the vehicle at any time, allowing the vehicles to use the public road.
- **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.

⁴ Based on result from CityMobil2

- **Advanced City Cars (ACC):** new city vehicles integrating zero or ultra-low pollution mode and driver assistance such as ISA (Intelligent Speed Adaptation), parking assistance, collision avoidance, stop&go, 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.

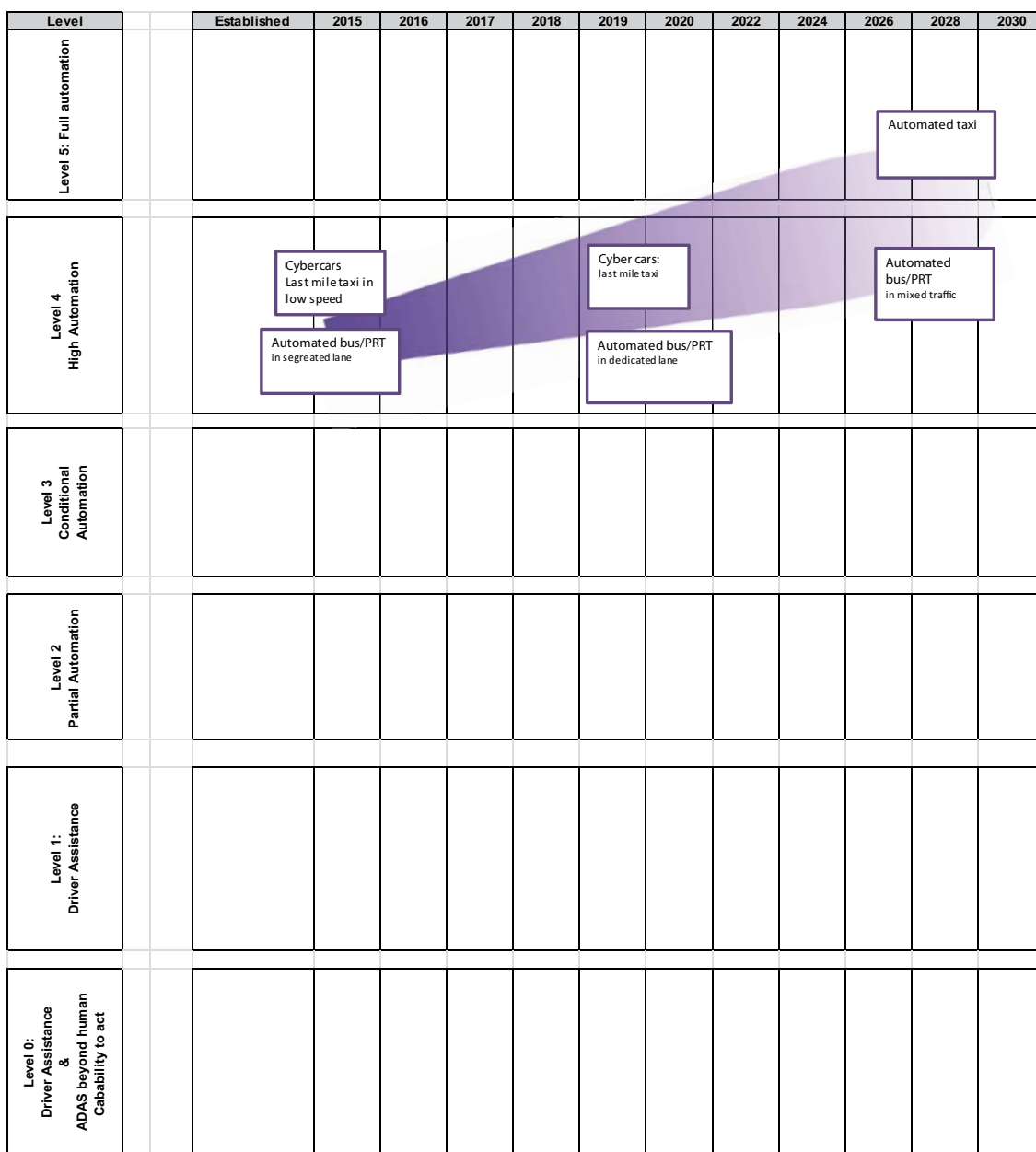


Figure 5: The Automated Driving deployment path for urban environment systems

3.7.1. Last mile solutions

3.7.1.1. Cybercars, Gen 1 (level 4)

The last mile solution is fully automated in its area of operations with a maximum speed of 40 km/h. It operates in a specific area with dedicated infrastructure.

3.7.1.2. Cybercars, Gen 2 (level 4)

The last mile solution is fully automated in its area of operations. It operates in a specific area with adapted infrastructure.

3.7.1.3. Automated Cyber Solutions (level 5)

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

3.7.2. Automated bus or PRT

Automated bus or Personal Rapid Transit.

3.7.2.1. Automated bus or PRT in segregated lane, Gen 1 (level 4)

The automated bus drives in segregated bus lanes and dedicated infrastructure, with a maximum speed of 40km/h.

3.7.2.2. Automated bus or PRT in dedicated lane, Gen 2 (level 4)

The automated bus drives in dedicated bus lanes and supporting infrastructure with normal city vehicle speeds.

Additional functionality such as adaptive urban traffic control system that controls the traffic lights and gives speed advice and priority can be introduced when these systems reach the market.

3.7.2.3. Automated bus (level 4)

The automated bus drives in mixed traffic in the defined area of operation.

4. STATE OF THE ART

European projects:

The European Union has a long history of funding collaborative research projects contributing to the development of automated driving. The following graph is giving an overview of projects, which are being funded partially or fully by the EU. The projects are illustrated for the period of last ten years of research and sorted in four different categories: **a) Networking and Challenges**, **b) Connectivity and Communication**, **c) Driver Assistance Systems** and **d) highly automated urban transport systems**. A complete overview of these projects is listed in the Annex containing also additional information on duration, significant results and the focus of realised research.

A number of EC-funded projects gave remarkable results in the field of vehicle automation contributing to an overall traffic safety and security. One of the pioneer projects was the EUREKA PROMETHEUS project that contributed enormously to the development of radar technology. In recent years, SARTRE demonstrated advantages of platooning, HAVEit delivered a temporary auto pilot and interactive designed and developed intelligent vehicle systems (IVS). Furthermore, CATS and CityMobil demonstrated successfully the application of robotic vehicles for shuttle services in protected environments.

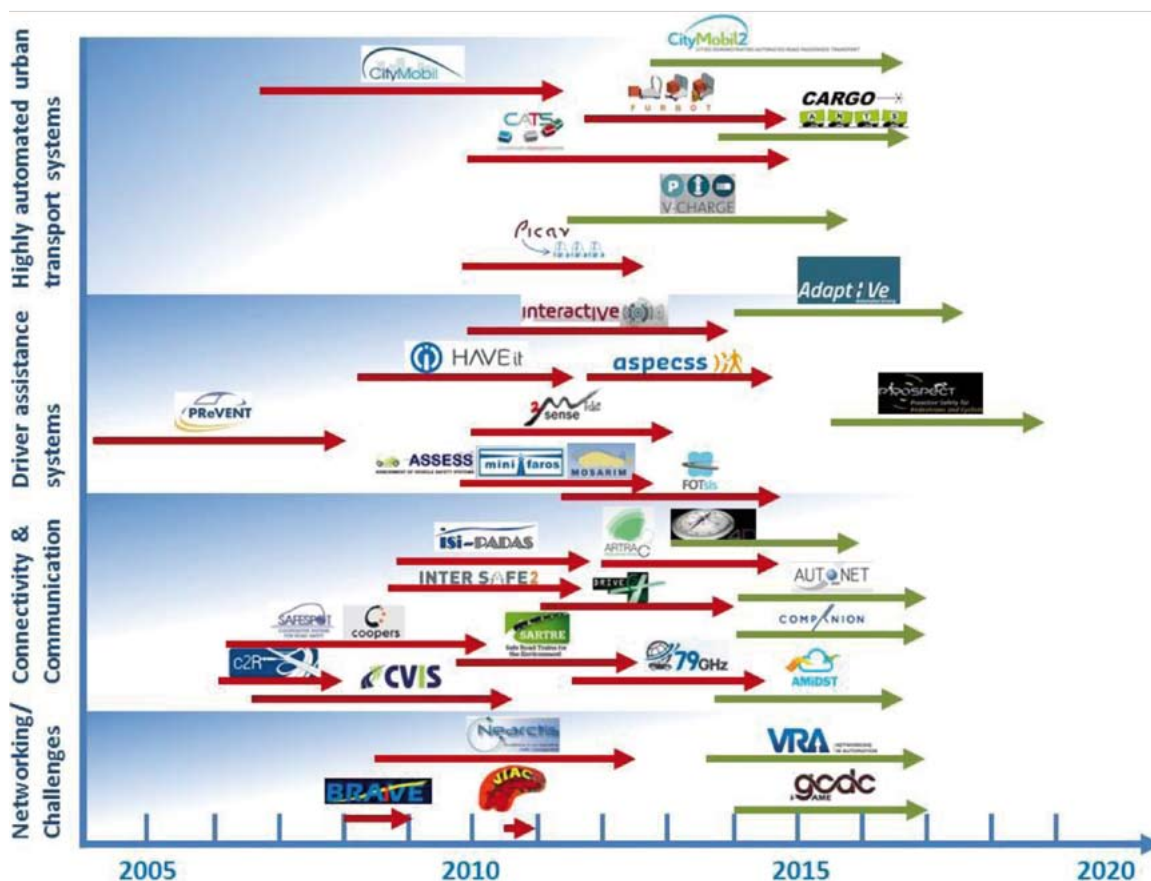


Figure 6: An overview of the EC funded projects that support development of automated driving. The analysis has been done for the period of last ten years. Red arrows, completed projects are shown and with green ones, the projects that are still running. See Annex for detailed list of all projects.

5. EU AND INTERNATIONAL SITUATION

5.1. Actions beyond EU

Public authorities around the world recently presented action plans to facilitate the development and introduction of automated vehicles. At the same time many announcements and demonstrations from automotive companies and research groups showed that the industry is globally moving closer to a scenario where the driving task will be gradually transferred from the human to the computer. Beyond Europe, recent developments in the U.S. and in Japan are of particular importance. Also South Korea and China are present with their national programmes and initiatives on a vehicle automation landscape.

5.1.1. USA:

The U.S. Department of Transportation (DoT) has announced a national program on vehicle automation⁵, with an ambitious goal to “position industry and public agencies for the wide-scale deployment of partially automated vehicle systems that improve safety, mobility and reduce environmental impacts by the end of the decade”. Thus, the 5-years automation programme framework should cover research and development in all levels of automation as defined by NHTSA: **a)** Level 1, development and testing of Human-in-the-loop (HITL) Connected Driving Assistance, **b)** Level 2/3, Conditional Automation Safety Assurance, and **c)** Level 4, Limited Driverless Vehicle Operations (see Figure 1). Besides, from the perspective of the DoT, the potentials of automation can only be achieved if vehicles are seamlessly connected to infrastructure.

A regulatory framework for the testing and operation of autonomous vehicles on public roads has already been established in California, in September 2014. “Senate Bill No.1298” states that the Department of Motor Vehicles should also adopt novel regulations on autonomous vehicles by January 1st, 2015 at the latest⁶. This follows from the fact that solutions for the early stages of automation, according to the SAE definition, are already available on the market. At the same time, solutions for Level 3 are now on trial, whereas solutions for Level 4 are already being developed. These regulations will thus enable manufacturers to test autonomous vehicles on public roads. Similar legislations are being passed in Nevada, Florida, the District of Columbia and Michigan, and further states will follow⁷. The inherent differences between the self-certification procedure (US, Canada) and the type approval process (UN ECE WP29) as well as the Vienna Convention play a decisive role in this respect. Interestingly, the mentioned regulatory framework in the US allows foreign vehicle manufacturers to test automated driving solutions. Recently, several European vehicle manufacturers and Tier 1 suppliers obtained an official approval for testing automated vehicles on public roads in California⁸. Also in Canada as the neighbour country, the Province of Ontario intends to initiate a five-year pilot programme for the testing of autonomous vehicles⁹.

⁵ NHTSA, “U.S. Department of Transportation Releases Policy on Automated Vehicle Development, Press Release”, 30 May 2013.

⁶ California Legislative Information, “SB-1298 Vehicles: autonomous vehicles: safety and performance requirements,” 25 September 2014

⁷ Florida Department of Highway Safety and Motor Vehicles, “Autonomous Vehicle Report,” 10 February 2014

⁸ Automobil Produktion, “Autonomes Fahren: Mercedes erhält Genehmigung in Kalifornien,” 18. September 2014. [Online]. Available: <http://www.automobil-produktion.de/2014/09/autonomes-fahren-mercedes-erhaelt-genehmigung-in-kalifornien/>.

⁹ <http://www.ontariocanada.com/registry/view.do?postingId=14802>

5.1.2. Japan:

The Japanese government¹⁰ stresses the importance of communication between vehicles and infrastructure for the introduction of automated vehicles and introduced the "ITS spot" technology, which enables such communication with high bandwidth. 1600 "ITS spot" locations have now been installed with appropriate transmitters in Japan and more than 100,000 vehicles communicate with them. They already provide information and warnings on traffic and will in future be combined with lane keeping assist and adaptive cruise control, so as to avoid traffic congestion. The Japanese "autopilot system council" announced in an interim report roadmaps that will lead to practical deployment of highly automated driving on Japanese highways until 2020. In May 2014, an Automated Driving System Research Program as a part of the Cross-Ministerial Strategic Innovation Promotion Program (SIP), has been announced¹¹. The program recognizes development and verification of automated driving system, development of technologies that will contribute to the reduction of traffic fatalities and congestion, international cooperation and deployment for next generation urban transport. Herewith, considerable reduction of traffic accident fatalities is to be expected in the future. Symbolically, Olympic and Paralympic Summer Games in Tokyo 2020 are chosen as the central milestone for demonstrating autonomous driving in Japan.

5.1.3. South Korea:

The Korean Ministry of Land, Infrastructure and Transport (MOLIT) has created an agenda towards the development of safety technologies in the transport sector, with the goal to drastically decrease the number of accidents on Korean roads until 2016. Also private Korean companies are promoting the relevance of automated driving. For instance, Hyundai-Kia Motors is organizing a biennial "Future Autonomous Technology Contest"¹². Vehicles have to successfully accomplish a 3,4 km long race along mixed paved and unpaved roads, demonstrating the ability to overcome hurdles that are typical for automation such as road obstacle avoidance, managing narrow road passes and vehicle avoidance, passenger recognition, escaping in case of accidentally moving obstacles and similar. Apparently, research facilities in Korea are at the moment differentiating between two types of self-driving vehicles: the autonomous vehicle that collects information from in-vehicle sensors and the second type which uses the "Automatic Vehicle Guidance System" (AVGS), that is, the vehicle receives information in a combined manner, from in-vehicle sensors and a roadside infrastructure. The Electronics and Telecommunication Research Institute (ETRI) has started research on autonomous vehicles by further developing its IT Convergence technology towards AVGS¹³.

5.1.4. China:

Analysing traffic conditions in China coupled to the continuous growth of car owners leads to the conclusion that in future, automated (and safety) systems will become a decisive criteria for the development of autonomous vehicle market in China. Not only different OEMs have recognized this opportunity, also the Chinese Government sees automated driving as reality already in 2020. Near Beijing, in the city of Tianjin, first tests with the driverless GM EN-V 2.0 vehicle took place¹⁴.

¹⁰ MLIT – Ministry of Land, Infrastructures, Transport and Tourism, <http://www.mlit.go.jp/>

¹¹ ITS Japan, <http://www.its-jp.org/>.

¹² <http://www.businesskorea.co.kr/article/6610/autonomous-vehicles-hyundai-motor-group-supports-students-applying-their-ideas>, 3 October 2014.

¹³ "IT Convergence Technology Research Laboratory", <http://www.etri.re.kr/eng/main/main.etri>.

¹⁴ "Chevy EN-V 2.0 coming to Tianjin Eco-City in China," 20 June 2014. Available: <http://green.autoblog.com/>.

5.1.5. Singapore

In order to explore the opportunities and challenges of automated driving, the Land Transport Authority of Singapore (LTA) has signed a five-year Memorandum of Understanding¹⁵ with the Agency for Science, Technology and Research (A*STAR) for starting a joint partnership “The Singapore Autonomous Vehicle Initiative” (SAVI). SAVI will provide a technology platform for managing R&D (autonomous vehicles, autonomous mobility system and automated road system) and diverse trials for automated driving for public and industrial stakeholders. The LTA will undertake a regulatory role for implementing automated driving in Singapore’s transport network, while A*STAR will use its expertise for the development of technologies and roadmaps. Together with JTC Corporation, the LTA will start with the driverless vehicles testing on public roads in the north of Singapore starting from January 1st, 2015. Besides SAVI, there are already several ongoing trials for automated driving on Singapore’s roads, for instance between MIT and the National University of Singapore (NUS). Within this project, a fleet of autonomous golf buggies is currently tested for car-sharing concepts.

5.1.6. Australia

Contrary to self-driving cars, gigantic self-driving trucks known as “Autonomous Haulage System” are already in use for mining purposes by Rio Tinto in the Pilbara region in West Australia.¹⁶ The machines are programmed to drive and navigate themselves with the help of sensors, GPS and radar guidance technology, being supervised by the controller stationed in Perth, 1800 km away from Pilbara. Besides, each of the 53 trucks contains the total of 200 sensors and is being operated by Cisco networking technology. The fleet of self-driving trucks should grow up to 150 until the end of 2015. Besides, other iron ore producers at Pilbara like BHP Billiton and Fortescue will set on self-driving trucks as well, primarily due to the sinking of costs and safety increase of entire mining process.¹⁷ However, not only the mining industry is profiting out of vehicle automation. Preparing roads for automated cars and the advent of Cooperative ITS (C-ITS) equipped vehicles, the Association of Australian and New Zealand road transport and traffic authorities “Austroads” has endorsed the so-called C-ITS Strategic Plan¹⁸. This plan is seen as an emerging platform assuring a two-way communication between motor vehicles and roadside infrastructure.

5.1.7. United Arab Emirates

Already in 2011, ten Personal Rapid Transit (PRT) vehicles and three Freight Rapid Transit (FRT) vehicles have been tested on Masdar’s streets.¹⁹ Using virtual routes in defined areas of the city, these driverless electric pods are able to drive with speeds of around 25 km/h. Even though the project was not meant to expand beyond its pilot scheme due to its high costs, it represents the pioneer step towards automated driving concepts in protected environments.

¹⁵ "Joint Release by the Land Transport Authority, JTC & A*STAR - A SAVI Step Towards Autonomous Transport," 27 August 2014.

¹⁶ Forget self-driving Google cars, Australia has self-driving trucks, 2014; <http://www.smh.com.au/it-pro/business-it/>.

Rio Tinto improves productivity through the world's largest fleet of owned and operated autonomous trucks, 2014.

¹⁷ Rio rolls out the robot trucks, 2014 <http://www.theaustralian.com.au>.

¹⁸ "Australia's largest CITS Project," available: <http://roadsafety.transport.nsw.gov.au/>. [accessed 27 November 2014].

¹⁹ "Masdar City's Pod Car Makers, 2011, <http://www.greenprophet.com/>.

5.2. EU Member States Initiatives

During the last years and with acceleration during the last months, national initiatives to support Automated Driving have been launched within the European Union by several Member States.

5.2.1. France:

In 2013, following a one year work by the National Council for Industry, the French government initiated a strategic review to define France's industrial policy priorities, called New Face for Industry Plan²⁰. The project was led by the Directorate General for Competitiveness, Industry and Services (DGCIS; now known as the DGE - General Directorate for Entreprises), a division of the Ministry for Industrial Renewal (now known as the MEIN - Ministry for Economy, Industry and Digital Affairs), drawing on the international expertise of consultancy firm McKinsey, in association with France's innovation clusters and sector-based strategy committees (within which business leaders, employee and employer representative organizations, relevant government departments and professional federations are represented and play an active role). The work in the coming months will consist in forming and assembling project teams for each initiative, comprising industry leaders and representatives from government and the National Council for Industry.

Each initiative is led by a project manager, in most cases hailing from industry or the business world. In this framework, the "Autonomous Vehicle plan" is lead by Carlos Ghosn, CEO of Renault/Nissan. A steering committee gathers experts from PFA (French Automotive Platform, formed mainly with Renault, PSA Peugeot Citroen, Michelin, Valeo, Continental, RATP, Renault Trucks, the competitiveness clusters, the VEDECOM Institute for the Energy Transition (working on Decarbonized and Connected Vehicles), the SystemX Institute for Technological Research (working on Digital engineering of complex systems). They have been tasked to unite stakeholders and bring the various initiatives to operation. They have defined the goals to be achieved, the hurdles to be overcome, the means at disposal, the funding to be raised (particularly through France's "National Investment Program"), any experiments to be conducted, partners to be brought on board and the schedule to be followed through a comprehensive roadmap presented to government on 2nd of July 2014.

The objective is to build the future of France, equipped with autonomous vehicles that may revolutionize individual, collective and industrial transports. The development is built upon advanced driver assistance systems breakthrough and is strategic for both industry and jobs safeguarding. Automotive and transport industries, jointly with web and digital companies, create a competitive offer for components, sensors, software, control systems and services to put autonomous cars on market before 2020.

The purpose of this program is to make French automotive and road transport industry one of the pioneers in designing mainstream autonomous vehicles. The action plan lists 4 objectives:

- **Study** the socio-economic impacts of such vehicles in depth
- **Develop** relevant technologies
- **Create** a regulatory and material environment that allows experimentation, in order to demonstrate its safety
- **Remove** regulatory, social and material obstacles to commercialization

²⁰ "La Nouvelle France industrielle", <http://www.economie.gouv.fr/nouvelle-france-industrielle>.

Thanks to this plan, France would like to be recognized as a place for autonomous vehicles experiments, as a centre of excellence for embedded intelligence technologies (Perception, Location, Map", "Algorithm, Decision, Vehicle Control", "Connectivity", "Human Factor and HMI") and as a leader for complex systems safety & security. France will thus have the opportunity to conquer a significant part of the several billions global market that will emerge within next ten years.

As part of the plan, technological roadmaps have been defined and the first technical experiments will take place from 2015 onwards, jointly with the start of R&D projects. In parallel to this initiative, within the National Research Strategy, led by the Research and Higher Education Ministry, and developed with the different stakeholders, both from the public research organisations and the private sectors, the theme of autonomous vehicles is included within the "Sustainable Mobility and Urban Systems" societal challenge, and taken on-board within the programme funded by the French National Research Agency.

5.2.2. Germany:

Recent formation of "Round Table Automated Driving", guided by the German Federal Ministry of Transport and Digital Infrastructure, resumes in the first place the issues concerning legal frames, infrastructure and technological regulations for automated driving. The round table consists of experts from the fields of politics and insurance, vehicle manufacturer and suppliers, with the main target to find a legal framework that would support automated driving on roads²¹. The testing of automation technology is, on the other hand side, already initiated from vehicle manufacturers. The German Federal Ministry of Transport and Digital Infrastructure recently announced the establishment of a test field for connected and automated driving on the A9 motor way in Bavaria

In the recent past the German Federal Ministry of Economic Affairs and Energy has funded a series of research and development projects with a focus on advanced driver assistance systems (ADAS) and cooperative systems (e.g. simTD, AKTIV, UR:BAN, CONVERGE, etc.). Prospective the ministry intend to continue the supporting of technology projects in the field of new vehicle systems, like ADAS and automated driving. Actually projects focussing on the development of automated driving systems (SAE J3016, level 3) and testing methods are in preparation and consultation with the round table. In June 2015 the research program "New Vehicle and System Technologies" was published by the German Federal Ministry of Economic affairs and Energy²². This new research program sets the framework for funding in the areas of automated driving and innovative vehicles. The Federal Ministry of Education and Research has been also funding a multitude of projects on intelligent vehicles and advanced driver assistance systems. The Federal Ministry for Education and Research recently launched a R&D funding program related to the links of electric mobility and automated driving.

5.2.3. United Kingdom:

Intelligent mobility is seen as major opportunity by the UK government, especially in the field of connected and autonomous vehicles and cooperative systems, with the potential to improve safety, reduce congestion and widen access to mobility, all of which will benefit the country societally, economically, and environmentally, as well as the UK's industrial and academic sectors.

²¹ "Runder Tisch zum Autonomen Fahren", <http://www.autonomes-fahren.de/runder-tisch-zum-autonomen-fahren/>.

²² <http://www.tuvpt.de>.

This view is shared with industry. For example, Intelligent Mobility is one of five focus areas for the UK Automotive Council²³, established in 2009 to enhance dialogue and strengthen co-operation between UK government and the automotive sector. Made up of senior figures from across industry and government, the Council is jointly chaired by the Secretary of State for Business, Innovation and Skills and by a leading Industrialist. In addition, the Transport Systems Catapult²⁴ has also been created to accelerate innovation, funded by both Government and Industry to commercialise new technologies and services with a core focus on intelligent mobility.

Examples of innovative products have already been encouraged within this environment include the ULTRA driverless passenger transfer system at Heathrow Terminal 5.

Importantly, the UK recently completed a regulatory review, [A pathway to driverless cars](#)²⁵, confirming that there were no barriers to the testing of autonomous vehicles on the UK's roads. Following that review, the UK government will imminently be issuing a Code of Practice for the testing of autonomous vehicles. This will facilitate innovative trials such as the already-planned HGV platooning trials on major roads in England and the Four Cities driverless car trials²⁶ jointly funded by government and industry. Other initiatives planned include a connected corridor on the Strategic Road Network and further funding calls for intelligent mobility trials.

The UK's Department for Transport will be working closely with the Department for Business, Innovation and Skills to coordinate the UK's activity and national approach across this agenda.

5.2.4. Sweden:

The launch of the joint initiative "Drive Me - Self driving cars for sustainable mobility", endorsed by the Swedish Government and motivated by the vision of zero traffic fatalities, will enable research within different areas associated with self-driving cars on public roads. Beside Volvo Car Group, the Swedish Transport Administration, the Swedish Transport Agency, Lindholmen Science Park and the City of Gothenburg are involved in this pilot project. Over approximately 50 kilometres of selected roads in and around the area of Gothenburg, 100 self-driving Volvo cars will be daily used by real costumers. An added value of the project lies in the fact that automated driving will be tested on typical commuter areas strained by congestion. The main objective of the project is however to conduct necessary research on how autonomous driving will affect the road transport (both vehicle and infrastructure), considering the worldwide challenges such as safety, energy efficiency and traffic flow. In addition, the project will also explore all accompanying factors such as infrastructure requirements, traffic situations, and surrounding interactions and social benefits of autonomous driving.

Also Scania is planning for automated transport with heavy trucks starting with mining carriage in 2016. The next step will be automated platooning for long distance transport which is planned in 2018. AB Volvo is focusing on highway automation, automation in confined areas for trucks & construction equipment and highway platooning.

²³ <http://www.automotivecouncil.co.uk/>.

²⁴ <https://ts.catapult.org.uk>.

²⁵ <https://www.gov.uk/government/publications/driverless-cars-in-the-uk-a-regulatory-review>.

²⁶ <https://www.gov.uk/government/news/driverless-cars-4-cities-get-green-light-for-everyday-trials>.

5.2.5. The Netherlands:

The Netherlands are already introducing and allowing self-driving vehicles on the Dutch roads, thus showing a very big ambition and a lot of activities in the field of automated vehicles. The Netherlands is working on an internationally coordinated approach, because cooperation from governments and stakeholders is required to allow these innovative systems to become available on the market for the general public.

The Dutch government has created new innovative and adaptive legislation to make large scale testing possible for self-driving vehicles on Dutch public roads. This new legal framework will be in effect on July 1st 2015. Thus allowing Field Operational Tests (FOTs) with automated driving on all public roads in The Netherlands. A test procedure to grant an exemption by RDW²⁷, RWS²⁸ and other relevant road operators is in place. The Netherlands is one of the frontrunners and wants to team up with other nations, partners and manufacturers who have similar high ambitions. Learning by doing and making it happen is the key element in this approach. There are a lot of organisations working on innovation and self-driving vehicles in The Netherlands.

The Netherlands has long term experience since 1998 in demonstrating and testing automated driving when a large demonstration event was organized to show the state of the art. A platoon of three fully automated Buicks provided by PATH (University of Berkeley) was the highlight of that event. Following this event several Field Operational Tests (FOTs) with Advanced Driver Assistance Systems such as ISA, LDW, ACC have been carried out. With the emergence of cooperative systems and participation in the European projects CVIS and SAFESPOT the first steps were taken towards incorporating C-ITS in a national policy.

The Dutch Automated Vehicle Initiative (DAVI)²⁹ is a public private partnership initiated by TU Delft, Connexxion³⁰ and TNO. The role of DAVI is to investigate and demonstrate automated driving on public roads. Beside trial engagements, the Netherlands is quite active towards development of cooperative Information and Technology Services (ITS) necessary to support automated driving. "The Amsterdam Group", a strategic alliance, is aiming at a large-scale deployment of cooperative ITS in Europe³¹. The core of the group are Europe's umbrella organizations that are dealing with harmonization and standardization issues, thus facilitating the implementation of novel ITS: C2C-CC³², POLIS, ASECAP and CEDR. Dutch, German and Austrian governments have taken a joint initiative to enable a pan-European deployment of the roadside cooperative ITS infrastructure³³. Two cooperative ITS services: a) Road Works Warning³⁴ and b) Probe Vehicle Data³⁵, should be offered by 2016 on a corridor between Rotterdam and Vienna with an ultimate goal of improving traffic flow and motorway safety.

²⁷ RDW is the Dutch vehicle approval authority; <https://www.rdw.nl/englishinformation/paginas/default.aspx>.

²⁸ RWS is Rijkswaterstaat, the National Road Operator.

²⁹ "DAVI on the road", <http://davi.connexxion.nl/>.

³⁰ Connexxion is an independent network of companies and authorities with the mutual goal of improving mobility in the Netherlands in a sustainable way; <http://www.connexxion.nl/>.

³¹ "Amsterdam Group", <https://amsterdamgroup.mett.nl/default.aspx>.

³² CAR 2 CAR Communication Consortium; <https://www.car-2-car.org/>.

³³ "The Netherlands, Germany and Austria to use new technology to improve traffic flow on motorways," 14 June 2013, <http://www.government.nl/news/2013/06/14/>.

³⁴ Roadworks Warning (RWW) connects traffic control centers with drivers over the roadside infrastructure.

³⁵ Probe Vehicle Data (PVD) - vehicles that patrol on the road transmit the data to the infrastructure further to the control centers.

5.2.6. Spain:

Spain has also been quite active in the field of automated driving. Just recently the Centre for the Development of Industrial Technology (CDTI) of the Spanish Ministry of Economy and Competitiveness together with the Spanish Automotive and Mobility Technology Platform (M2F)³⁶ launched in 2015 the Spanish Automated Road Transport Technical Forum. The goal is to support collaboration among all the sectors and technology agents involved and strengthen the Spanish position in the automated driving area. Also the Directorate-General of Traffic (DGT) is working on an amendment to the General Regulations on Vehicles to allow the use of some urban and interurban roads to test autonomous vehicles.

Already back in 2001, the two first autonomous vehicles were presented by the Technical University of Madrid (INSIA) and the Spanish Council for Scientific Research (CAR), followed by the development of the first cooperative autonomous driving system based on V2V communications, in 2003. In 2012, the first 100 km autonomous route on public roads in Spain, with a highway track between El Escorial and Madrid was organized by INSIA and CAR, as well. A total of 7 fully autonomous vehicles equipped with several V2X communications systems, sensors and cooperative systems were tested. Over the years, the research on V2X communications and assistance systems was supported by the EC and the Spanish Government (VICTORIA, iVANET, ONDA-F and GUIADE projects).

SISCOGA, an initiative started by CTAG³⁷ and DGT in 2010, is one of the key programmes carried out in Spain in the domain of cooperative systems. A permanent cooperative corridor of more than 100 km was created in order to carry out field operational tests on real roads towards cooperative safety and efficiency applications. This cooperative corridor includes interurban and urban scenarios (Vigo City) with more than 50 cooperative road side units connected to the DGT and Vigo Council Traffic Management Centres.

The CVC-ADAS³⁸ of the University of Barcelona has more than ten years of experience in fundamental research and prototyping of ADAS, based on Computer Vision technologies. Currently this group has developed a robotized electric car that can be used as platform for autonomous driving. Also a research group from the Polytechnic University of Catalonia and the Spanish Council for Scientific Research (IRI)³⁹ has developed the IRI-Car within the national projects frames, RobTaskCoop and ROBOT-INT-COOP. Moreover, the IRI is presently developing new navigation and perception techniques for automated guided vehicles and automated trucks, towards efficient and save freights transportation in main ports and freight terminals. Finally, the AI2⁴⁰ research group from the Polytechnic University of Valencia, is focusing on control of autonomous vehicles. By means of the nationally funded project IDEMOV-IDECONA, AI2 has worked on the development, implementation and validation of a complete methodology for the identification of dynamic parameters applicable to vehicles to establish the control, planning and automatic navigation of autonomous vehicles Regarding detection of driver condition, Institute of Biomechanics of Valencia have just finished HARKEN project to detect the level of attention and drowsiness of drivers under different scenarios by means of seamless on-board technology.

³⁶ <http://www.move2future.es/>.

³⁷ Centro Tecnológico de Automoción de Galicia, <http://ctag.com/>.

³⁸ <http://www.cvc.uab.es/adas>.

³⁹ <http://www.iri.upc.edu/>.

⁴⁰ <http://www.ai2.upv.es/en/index.php>.

5.2.5. Austria:

Pursuing a consistent strategy for embedding innovative technologies into the transport system by national funding programs for mobility and ICT, the national ITS Action plan and C-ITS deployment strategy, Austria is and was a first mover and committed driver of ITS and C-ITS, preparing the path for connected and automated driving. Austrian competence in the area of cooperative systems becomes visible when looking at projects like TESTFELD TELEMATIK and ECo-AT (European Corridor – Austrian Testbed for Cooperative Systems) being part of the cross-border C-ITS corridor Rotterdam-Frankfurt-Vienna as an outstanding FOT in Europe also for enabling and testing interoperability with neighbouring countries and regions. Austria has been emphasising the importance of a properly equipped infrastructure for more than eight years, with COOPERS (2006-2010 FP 7) as the cornerstone for fail-proof V2I communication. Recent research activities in the field of sensors have provided insights close to deployment and unveiled new approaches on improving quality and quantity of data, faster data processing and incorporating end user feedback.

The national Roadmap for automated driving, which will be finished in spring 2016, will create the system architecture as a common framework for action on Automated & Connected Driving, define "use cases " and priority applications in diverging test environments (motorway, urban applications, last mile, freight et. al.) and develop appropriate impact & benefits assessment procedures also concerning impact on traffic safety, economy, environment and social inclusion.

5.3. EU Platform Activities


5.3.1. iMobility Forum

End of 2014, the Research and Innovation Working Group (R&I WG) of the iMobility Forum has organised a public consultation on its Research & Innovation roadmaps. There are 7 R&I roadmaps using TRL (Technology Readiness Levels):

- 1. Logistics
- 2. Automation
- 3. Vulnerable Road Users
- 4. Mobility & Efficiency
- 5. Safety
- 6. Socio economic, behavioural and HVI
- 7. C-ITS

iMobility Forum Working Group Automation in Road Transport

The Working Group Automation in Road Transport was created under the iMobility Forum after a workshop organized by the European Commission in October 2011. This workshop initiated three SMART studies, focusing on automation, the future of internet and the connected car. During the workshop, a clear need was identified to discuss further and guide the research, development and deployment of automation for road traffic and road transport systems.



The mission of the working group on Automation in Road Transport is to identify how automation and its subsequent applications can help to improve efficient, clean, safe and reliable road transport now and in the future and what is needed to foster deployment and implementation. In its initial phase, the working group focused its activities on the common agreement on developing one or more roadmaps for future developments in the area of automation in road transport. The process that led to the roadmaps basically consisted of the following steps:

- 1. Define the issues in the mobility domain that need to be solved;
- 2. Define a set of functions or applications that can help to do so including the value proposition and a clear and SMART description of these functions;
- 3. Map the functions with a clear value proposition to create a subset that covers all levels of automation;
- 4. Define the research needs and state of the art on specific topics needed to reach implementation or piloting of these functions.

The first deliverable of the working group was published in May 2013 with the roadmap and recommendations for future research. This document focuses on challenges and prospects for automation including automation definition, impact areas, concepts, State of the Art, research needs, key applications and milestones. It finally presents a series of automation roadmaps together with a detailed list of recommendations. Since the publication of the document, the roadmap has been updated in order to take into account the newest initiatives and projects. The WG has worked deeper on specific collaboration areas related to automation. Due to the breadth and complexity of the topic, the activities are now planned around eight sub-Working Groups.

During 2014, further work has been done on the deployment scenarios complementing the research roadmaps. The recommendations were further elaborated and categorised. The roadmap and recommendations were promoted in relevant groups such as the R&I Working Group of the iMobility Forum as well as the ERTRAC Task Force on Automation.

5.3.2. C-ITS Platform

The Platform for the Deployment of C-ITS in the European Union (C-ITS Platform) was launched by the European Commission in July 2014, and met for the first time in November 2014.

The platform provides an operational instrument for a dialogue, exchange of technical knowledge and cooperation, among the Commission, public stakeholders from Member States and local/regional authorities, and private stakeholders such as vehicle manufacturers, service providers, road operators, telecom companies, Tier 1 suppliers, etc. to cooperate on legal, organisational, administrative and governing aspects.

The Platform is expected to develop, until the end of 2015, policy recommendations and proposals for actions to support the different options. These should be supported by a large majority of stakeholders. There is also a strong industrial dimension in the deployment of C-ITS in the EU.

The C-ITS platform is expected to identify and agree on how to ensure interoperability of C-ITS across borders and along the whole value chain; as well as identify the most likely and suitable deployment scenario(s) (vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) services) to be deployed across the EU in the beginning (day-1 services) and in which geographical environments (long distance corridors, secondary roads and the urban environment).

5.3.3. EPoSS

The Working Group Automotive of the European Technology Platform on Smart Systems Integration (EPoSS) in January 2015 published a European Roadmap on “Smart Systems for Automated Driving”. Based on surveys and consultations among major companies from the European automotive and electronics industries and relevant research institutes, the roadmap distinguishes an evolutionary development path of stepwise improvements from advanced driver assistance systems into automated driving systems and a revolutionary development path where technology transfer coming from e.g. the fields of robotics and the Internet of Things enables fundamental and transformational developments leading directly to the fully automated and finally maybe even the autonomous car.

The roadmap is organized along milestones for implementation of highly automated driving (SAE level 3+) in 2020, 2025 and 2030 and provides information about content and timescales of actions in research and innovation on technology and in framework conditions. These actions particularly relate to key enabling technologies inside the vehicle, infrastructures, big data handling, system integration, validation and design. For instance, the document addresses necessities for the development of components like sensor and actuator systems, data fusion and fail operational electronic control architectures. The recommendations cover the public funding of research on key enabling technologies for SAE Level 3+ automation in complex environments like e.g. cities. Not yet solved issues include e.g. the reliability of human-machine interaction, the consistency of robotic decision making and the connectivity between road users are pointed out as well. Furthermore, a number of non-technological issues are addressed, such as legal frameworks, standardization and awareness measures, taking also care about various but significant ethical aspects.

The document also delivers an exhaustive analysis of automation technologies, activities and projects that have been carried out at European Union and Member States levels. The EPoSS European Roadmap on “Smart Systems for Automated Driving” is meant as a contribution of the smart systems community not just to the broader strategy development process under the umbrella of ERTRAC but also within the Joint Undertaking on Electronic Components and Systems for European Leadership: ECSEL. The document can be downloaded from the EPoSS website, under <http://www.smart-systems-integration.org/public/news-events/news/eposs-roadmap-smart-systems-for-automated-driving-now-published>.

6. KEY CHALLENGES AND OBJECTIVES

Automated driving is an opportunity to address several important societal challenges of road transport: **safety, energy efficiency, reliability of schedules, and urban accessibility**. These are the key societal needs identified in the Strategic Research Agenda of ERTRAC, illustrated in figure 7. Other benefits could be delivered, such as social inclusion, offering mobility to all users including elderly and impaired users, and deploy new solutions for shared mobility and public transport, which could have important impacts on our city environments. These benefits can be brought to both passenger and freight transport. The topic involves the different research domains of the transport system (e.g. vehicles, infrastructure, services), making it a typical topic requesting an integrated approach. Moreover, the implementation can be done in the key elements of the road transport system: in urban mobility environments, and on long distance transport, but should also be considered for inter-urban and at transport interfaces. **Automated driving matches therefore very well with the ERTRAC System approach to improve the overall efficiency of road transport.**

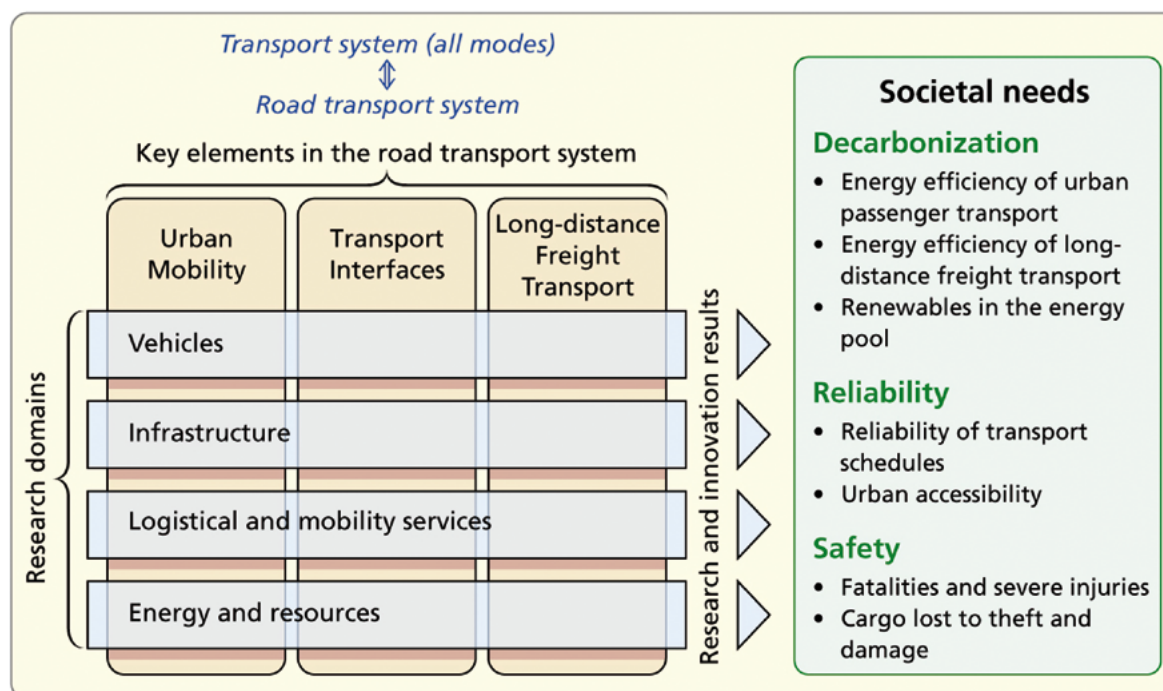


Figure 7: ERTRAC Strategic Research Agenda, System approach to Road Transport Societal Challenges

The option to switch to “automated driving mode” will give drivers more freedom in terms of individual mobility. With the market introduction of highly automated vehicles by 2020-2025, drivers will be able to manage their driving times better. At the same time, an automatically controlled vehicle will be even safer thanks to the increased interaction with itself and its environment. Furthermore, the energy management and driving characteristics of the vehicle will be optimized enabling more energy-efficient driving. Highly automated road transport will have a significant impact on our mobility behaviour, road safety and traffic efficiency in interurban (motorway/freeway) and urban applications. Especially in cities, impacts could be very important: improvements in transport reliability and urban centres accessibility would lead

to evolving demands and request changes of the business models, requiring private companies and public authorities in charge of transport to assess and anticipate future needs. Impacts on traffic and public transport demand will need to be assessed, including unintended risks. The anticipation of future demands will therefore need to be done in an integrated manner, with the private and public sector working together to achieve common goals for automation technologies deployment.

●● 6.1. Environmental Detection and Perception

How to ensure technological advancements to enable sufficient environmental recognition by recognizing the requirements for functional safety, reliability, fault tolerance etc.? How to implement by fusing of sensor and other data sources? How to reduce costs and increase performance (detection horizon, reliability, affordability, etc.)

In order to enable automated driving functions, the vehicle needs to be able to perceive the environment with very high precision and reliability. Special focus is on false positive detection of sensors. Different sensor types need to be integrated and sensor fusion of different data sources plays an important role as the main enabler for automation. Furthermore the performance of sensors may need to meet regulatory requirements. Based on the environmental model, driving strategies need to be calculated, which take the dynamic interaction of all traffic participants into account.

●● 6.2. Demonstrating Reliability, Safety and Robustness of Technology

How to demonstrate the technological readiness (maturity), reliability and safety of the automated driving function in a European Scale with all stakeholders involved on public roads? How to convince the public decision makers on the proper functionality and impact/benefits of such systems?

The basic technical prerequisite for the implementation of automated driving is system reliability and safety. A fail-safe/fault tolerant architecture is required to guarantee that automated vehicles operate in a safe state in any event or under adverse conditions.

Large-scale field operational trials (FOTs) are conducted to demonstrate the technological readiness and analyse the interaction between the driver, the vehicle and the traffic environment (including other road users). These studies reveal insights into automated driving under different conditions (e.g. traffic, weather, lighting, road class). Further, the behaviour of other traffic participants e.g. non-automated vehicles in mixed traffic and VRUs such as pedestrians are analysed and additional data for impact assessment (road safety, traffic conditions, efficiency, etc.) is generated.

6.3. Legal and Regulatory Framework

How to prepare a harmonised European approach for adapting nation road codes/laws to allow and avoid fragmented solutions for a.) automated driving for testing and b.) automated driving in general? How to deal with liability issues and how to involve insurance companies to adapt their models on these new requirements?

Legal issues are currently considered as one of the main concerns for the introduction of highly automated driving systems (level 3 and level 4 acc. to SAE). The responsibility and liability of all stakeholders (the vehicle manufacturers, automotive suppliers, road users, insurance companies, road and traffic authorities, the EU Member States, etc.) relating to the use of highly automated vehicles requires clarification before market introduction.

The main objective is to reach a harmonised regulatory approach for automated driving at EU- level, supporting innovations for safe, efficient and clean transport. The unresolved legal issues are an inherent bottleneck and pose a risk for the successful introduction of automated driving systems. Notably, the expected legal solutions should preserve the users' and societal acceptance.

The regulatory and legal framework for the introduction of highly automated driving on European roads goes beyond the Horizon 2020 programme. The EU Member States are already acting within their own jurisdictions. However, initiatives to support the harmonised approach across all EU Member States to adapt regulations allowing for innovation are required. A common strategy at EU level is needed. Otherwise fragmented regulatory approaches in Europe will hinder implementation and jeopardize European competitiveness. The industry needs global solutions. In order to identify a harmonised regulatory approach for road transport automation, the EU Member States and the EU automotive industry should convene.

The following topics shall be addressed:

- Adapt legal and regulatory framework to allow for testing of highly automated vehicles, on a European scale (short term);
- Adapt legal and regulatory framework to allow for the commercialisation and use of highly automated vehicles at a European level (mid - long term);
- Clarify roles and responsibilities of all stakeholders.

As automated driving evolves, liability issues need to be properly addressed by all stakeholders i.e. road users, industry, insurance companies, public sector (incl. infrastructure and service providers), etc. Lessons learned from automotive and other transport sectors shall provide useful recommendations. Ongoing activities may provide the initial grounds for the required adaptation of regulations (e.g. RESPONSE4 within AdaptIVe, WP26 of Citymobil2, the EC C-ITS platform). It is important to notify the activities in other parts of the world e.g. US, Japan, Singapore. Finally, the UN discussions and developments (e.g. inWP1 and WP29) must be considered, and Europe shall work appropriately together to support European developers and users.

6.4. Users' and Societal Acceptance

How to address and overcome user concerns regarding automated driving? How to meet customer expectations regarding affordability? How to ensure the security, privacy and public acceptance? How to ensure trust between automated vehicles, drivers and other road users?

Customer and societal acceptance is one of the key issues for automated driving. Affordability is still seen as one of the biggest hurdles for customers to buy into these technologies. Further, societal acceptance is pending with issues like safety, trust, security, privacy concerns, etc. The concerns and the complexity of the problems grow comparing a motorway/highway situation to a complex city environment. Furthermore, the acceptance is linked to a unanimous understanding and agreement of the benefits from automated driving (comfort, efficiency, safety, social inclusion, etc.). However, this will require a better understanding of the impacts on society as a whole: impacts and concerns addressed by professional drivers; issues and concerns regarding driver monitoring; social inclusion by enabling public transport in remote areas where today it is not feasible; impacts on multimodality and urbanization, etc. Benefits but also potential negative impacts have to be studied.

6.5. Driver Attention and Involvement

What are the requirements to ensure the appropriate driver involvement and attention (due to the classification and level of automated driving)? How to ensure safe vehicle handling with reduced driver attention to the driving task? What "other" tasks can a driver safely carry out while in automated driving?

Specifically with the introduction of partial automated driving the reaction of users towards the system is important. Safety implications and user acceptance need to be well understood. The driver engagement and driver re-engagement for various levels of automation in a safe and conclusive manner is important. Therefore, the various applications for automated driving at different levels of automation have to consider human factors as decisive design criteria. HMI (visual, haptic and acoustic) must take into account the role of the driver in highly automated vehicles and enable a safe interaction and usage. Further user acceptance for partially and highly automated vehicle depends on human factors and the intuitive usability.

6.6. Common Validation Procedures and Testing Requirements

What are proper validation procedures and tests for automated driving functions? What are the key performance indicator? Is certification properly addressed? How to enable cost effective testing?

Automated driving requires reliability of the system and all components in terms of functional safety and performance. In order to ensure these requirements, a common validation procedure will be required: the interaction between all involved automated components and functions needs to be evaluated with focus on automation in particular regarding miss usage/false usage by the driver, e.g. falling asleep or not taking back control functions after take over request. In this context the driver awareness plays a significant role. This has to be managed in a safe manner, in order to keep the vehicle control under all circumstances stable. Beside the technical development and validation procedure, the legal aspects and liability issues require further considerations. A non-homogenous set of rules and legislations to test automated driving exist in Europe at local, regional and national level: a further harmonisation is requested. This applies to safety but also to security: data security and system integrity need to be ensured, but here as well harmonisation will be requested.

Activities in this direction are closely linked to the principle of liability, and actors such as insurance companies will be associated to these developments.

6.7. Infrastructure Requirements

What are the requirements for the physical infrastructure to enable/support higher levels of automated driving? What level of connectivity (communication) and what databases (enhanced map databases, digital infrastructure) are required for what level of automated driving (3, 4, 5)?

The implications and requirements of higher levels of automated driving for our physical infrastructure is not yet clear. The infrastructure performance (visibility, state of repair, etc.) regarding traffic signs, signals and road markings to support higher levels of safe and reliable automated driving have to be recognised. This shall involve common standards and harmonisation. Due to the already heavy burden on road maintenance budgets in many European member states the dependency and impact on asset management and maintenance planning need to be reduced to a minimum. The inherent relation between infrastructure performance and sensor requirements/vehicle dynamics might put more emphasis on in-vehicle systems and requires cost optimization. On the other hand, expected cost savings and societal benefits (specifically in urban areas) by more efficient road transport infrastructure requires careful evaluation. Higher levels of automated driving shall also be supported by adjustments of the existing road infrastructure, for example providing a simplified and logical environment that can support the vehicle to avoid situations of many stops (cross sections, pedestrians-/bicycle crossings, etc...).

Furthermore, additional information from other road users and from the infrastructure (connectivity, digital infrastructure) can increase the performance of automated driving. Based on this information the vehicle/system can adapt the driving strategy according to the received information (e.g. upcoming congestion, traffic accident). Enabling this functionality requires the

integration of validated communication devices into the vehicles. The security issues for this communication is of major interest for automated driving as unsecure communication may open the system for abuse, criminal or terroristic attacks..

6.8. Industrialisation

What are the requirements for manufacturing and production of relevant systems, technologies and components for automated driving? Which implications on production and global competitiveness do framework conditions have? Which barriers for mass manufacturing need to be addressed? What is the role of different business models (e.g. data based) and how do they compare against each other?

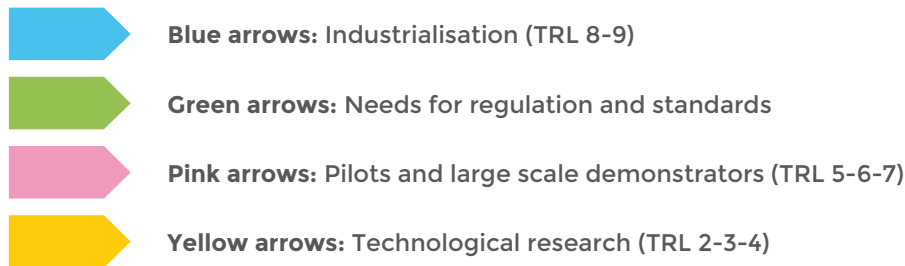
Automated Driving is seen as one of the key technologies affecting our way of living in the future. It will have a remarkable economic impact and therefore play a decisive role in global competitiveness and EU's strategy (Europe 2020) on re-industrialisation of Europe (i.e. increase the contribution made by manufacturing to European GDP from 16% to 20% by 2020). However, after developing, testing and successful demonstration of automated driving technologies and systems, the production is the actual key to realize the expected impacts. Connectivity and automated driving bear great opportunities for industrialisation in terms of mass manufacturing of corresponding products (e.g. sensors, electronic control units, displays, communication units) as well as new business models or new mobility services. However, the technological evolution must be market compatible, meet customers' expectations and willingness to pay. At the same time, industry has to provide fail safe products and all devices have to grant a guaranteed functionality over vehicle lifetime providing reproducible and documented history from production to end-of-life. Therefore, highly sophisticated mass manufacturing capabilities are a prerequisite for the successful introduction of Automated Driving.

Fast innovation cycles are common in the IT sector and becoming more and more important in the automotive world. This poses the risk that fast moving IT sector sets quasi-standards which are not optimized in terms of e. g. European perception in data privacy issues or technical automotive safety. Agile markets with fast stakeholders can result in global quasi-standards – Europe could lead this development or just follow. Therefore, coordination at European level is needed to support European industries to meet the expectations and requirements and lead the production for automated driving technologies

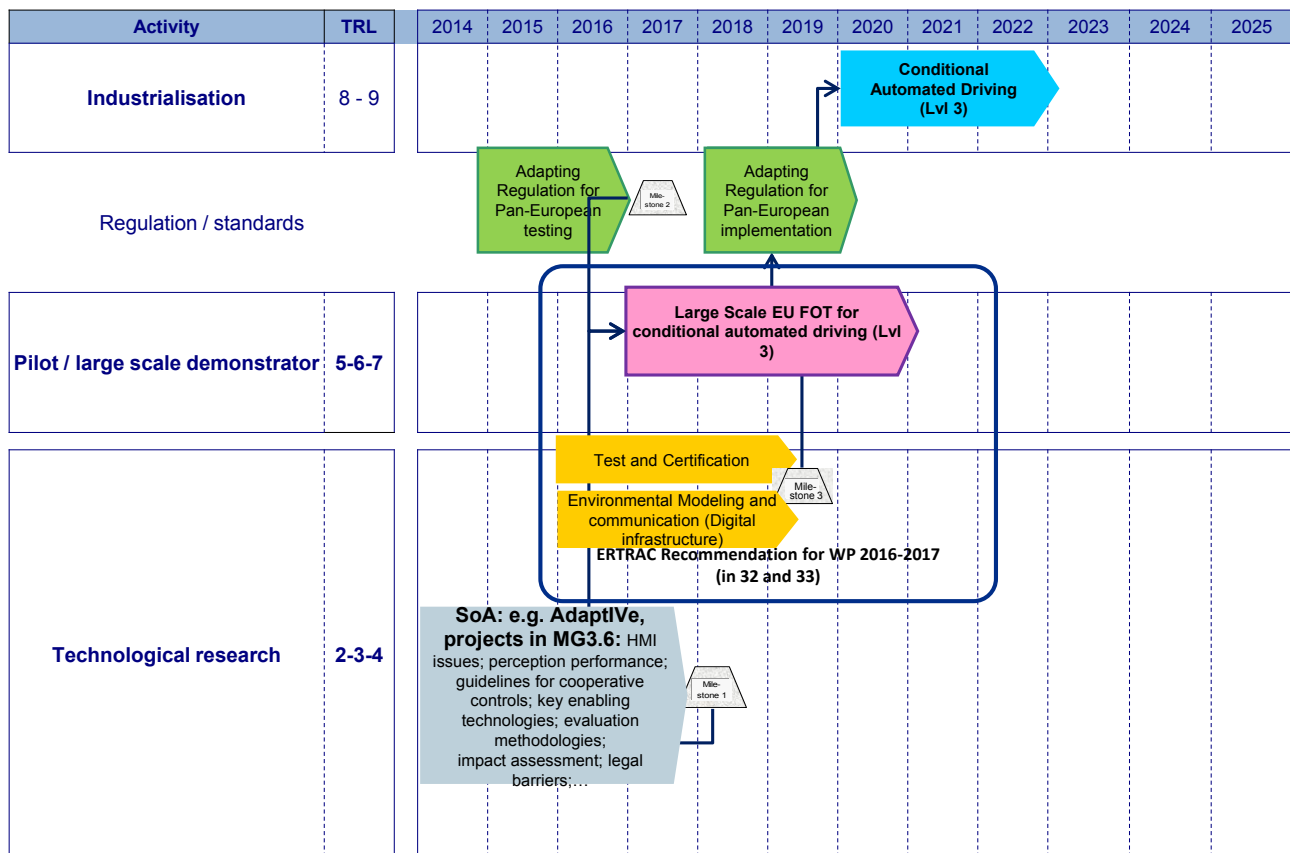
7. ROADMAPS

The roadmaps below show for three key application areas the proposed activities to reach milestones and the objectives of market deployment.

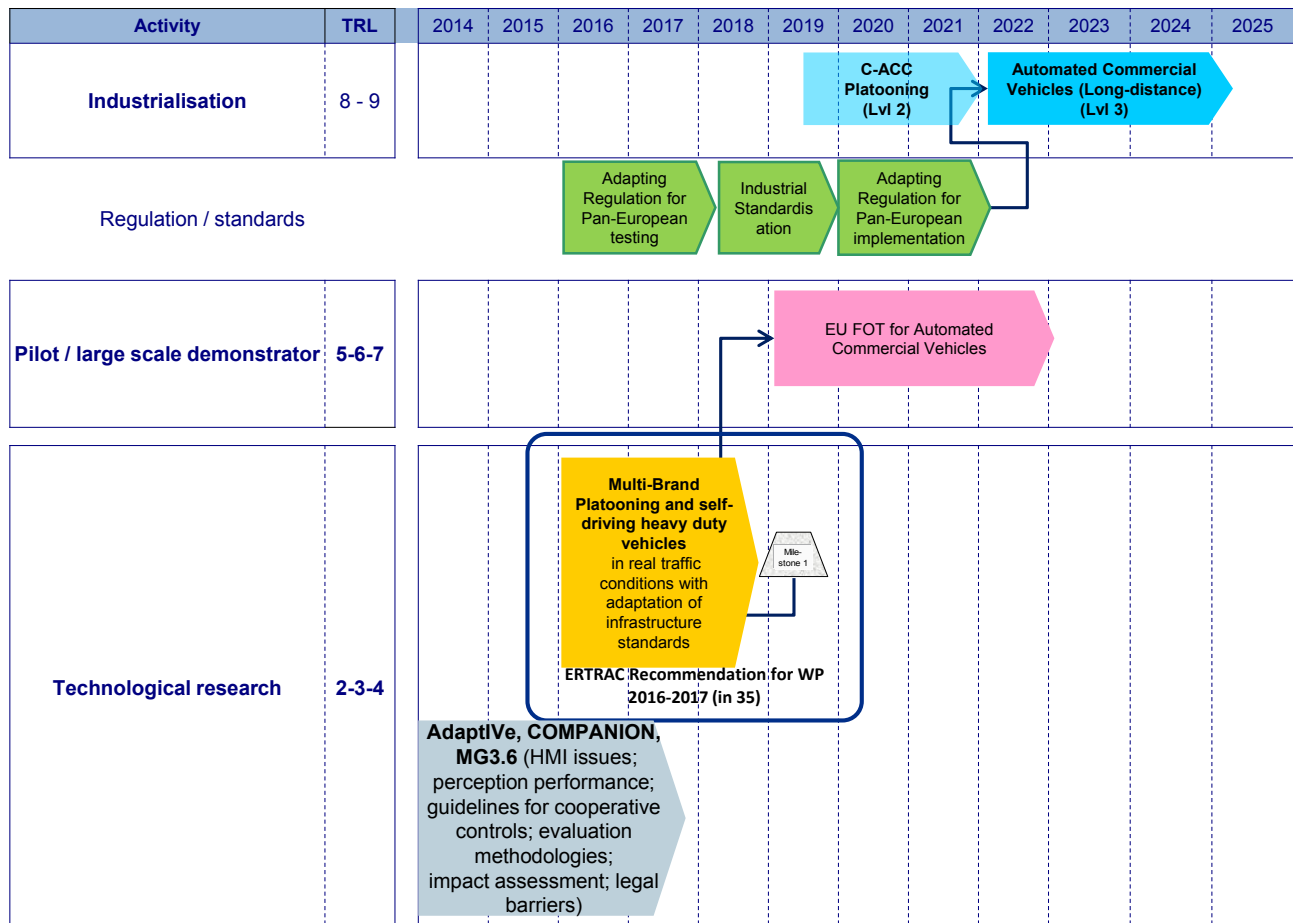
Starting from currently projects running, which constitute the state of the art, the roadmaps show the different kinds of activities requested, using a scale of Technology Readiness Levels (TRL):



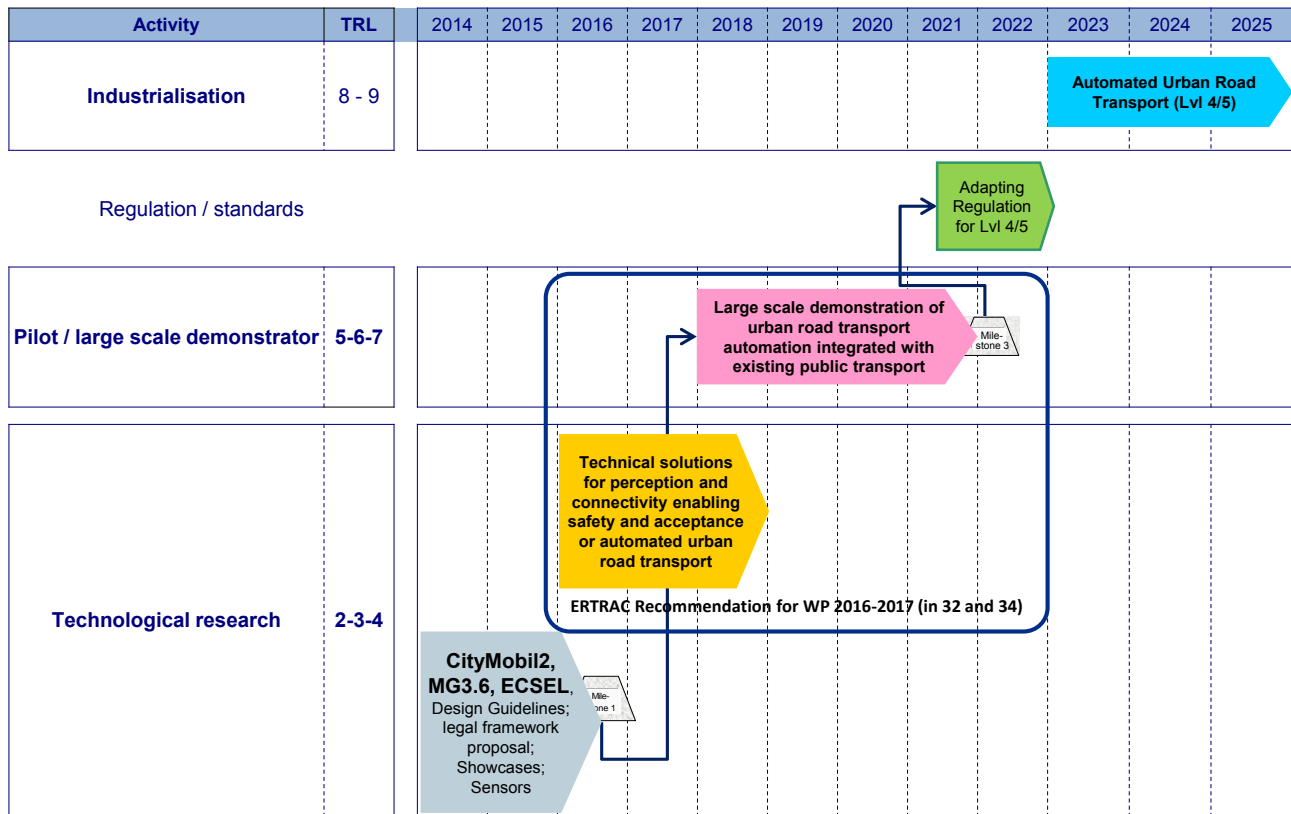
Conditional Automated Driving



Automated Commercial Vehicles



Automated Urban Road Transport



Recommendations for Horizon 2020 Work Programme 2016-2017

Based on the roadmaps, recommendations are done for activities at European level in the coming years, addressing the Transport Programme of the European Research and Innovation Programme “Horizon 2020”. The four recommendations below are draft for discussion among the research stakeholders, the European Commission and the Member States representatives.

The numbering of the topics refers to the full set of recommendations prepared by ERTRAC for the Work Programme 2016-2017.

32. Framework & solutions for safe automated road transport

Specific challenge: Different circumstances leading to drivers' inappropriate situation assessment, inattention or distraction are among the main causes for road accidents. Increased levels of vehicle automation could contribute in this context by eliminating or easing conflict situations.

There are still many challenges to overcome in various areas ranging from environment perception capabilities of sensor systems, vehicle dynamics, functional safety, testing and certification, human machine interaction, monitoring strategies up to new aspects of product liability. A big challenge is the handling of the transition period with mixed traffic participants leading up to full automation. Automated driving may also have a positive influence on emissions by reducing congestions around major metropolitan areas; however all these benefits have to be assessed and evaluated. In parallel, there is a strong need to assess the infrastructure requirements for higher levels of automation in interaction with in-vehicle sensor systems to enable a safety for all traffic participants.

Scope and Content:

- Optimize and integrate sensors for environment and driver status perception in complex and critical conditions, e.g. through sensor fusion, in order to meet safety requirements.
- Develop fail safe and fail operational systems. Understand what degree of reliability and robustness is required in the data or information processing. Technologies, systems and functions needed to support gradual progress towards full automation.
- Develop the prerequisites and requirements enabling assessment and/or testing of safety levels of automated systems and solutions. Develop and adapt certifications schemes for automated driving.
- Human machine interaction/ monitoring strategies: Decision & Control Algorithms: develop and evaluate safe, cooperative, human compatible decision and negotiation methods, planning algorithms and distributed control strategies in urban environments; methods for offline and online verification of algorithm characteristics and quantifiable safety to support highly and fully automated driving and emergency situations.
- Evaluate infrastructure requirements to enable high-level automated driving. Develop adaptation schemes (including maintenance and durability considerations) for existing road networks.

- Analyse the interaction of automated vehicles with the environment and other road users (i.e. Other, non-automated driven vehicles, pedestrians, Powered Two Wheelers) to enhance preventive safety and to enable integration in a mixed (progressively automated) environment.
- Social inclusion and acceptance.
- User centric approach and user acceptance: define and harmonize interfaces and requirements for the environment model, including common reference frames and semantic concepts.

Expected Impacts: Increasing the level of automation in driver assistance and driving functions means reducing situations in which misperception, excessive demands, inattention, reduced vigilance and distraction of the driver can occur and result in serious consequences. Safety of non-automated vehicles will be enhanced through V2X technology systems, which may lead to better integration with automated vehicles. The update of the existing road network will allow the introduction of automation on Europe's roads and optimisation of cooperative services to maximise the impact on driver behaviour and reduction of crashes. As these situations account for a prominent subset of all accident causations, vehicle automation must be seen as a major contributor towards Vision Zero.

Type of action: RIA, EUR 15Mio expected funding.

33. Enabling functionalities from Partial Automation to Conditional Automation

The Vienna Convention, more specifically the interpretation in member states traffic codes have to be adapted to enable level 3 - conditional automated driving. Moreover, the technical regulations for type approval at UN ECE (WP29) have to be amended to enable conditional automated driving functionalities: Steering (UN R79); Lighting (UN R48), etc. The basic technical prerequisite for the implementation of automated driving is system reliability and safety. A fail-safe/fault tolerant architecture is required to guarantee that automated vehicles operate in a safe state in any event or under adverse conditions.

Large-scale field operational trials (FOTs) are conducted to demonstrate the technological readiness and analyse the interaction between the driver, the vehicle and the traffic environment (including other road users). These studies reveal insights into automated driving under different conditions (e.g. traffic, weather, lighting, road class). Further, the behaviour of other traffic participants e.g. non-automated vehicles in mixed traffic and VRU such as pedestrians are analysed and additional data for impact assessment (road safety, traffic conditions, efficiency, etc.) is generated. This allows as well to address legal concerns prior the introduction of highly automated driving systems (level 3 and level 4 acc. to SAE). The responsibility and liability of all stakeholders (the vehicle manufacturers, automotive suppliers, road users, insurance companies, road and traffic authorities, the EU Member States, etc.) relating to the testing, demonstrating and use of highly automated vehicles requires clarification before market introduction.

- A European Large Scale Field Operational Trial across borders following a harmonized legal framework to demonstrate robustness and reliability of the conditional automated driving.
- Demonstrating technologies, systems and functions needed to support gradual progress towards full automation. In particular from level 2 – Partial Automation (Human driver monitors the driving environment) to level 3 Conditional Automation (Automated driving system monitors the driving environment).
- Evaluate effects in mixed traffic conditions with automated and non-automated vehicles.
- Human factors: focus on the in-vehicle evaluation under real traffic conditions of the driver in particular during the transition of control from vehicle system to driver and vice versa e.g. expectations, adoption, acceptance, trust, usability driver position; Secondary task Human Vehicle Interaction/ monitoring strategies. Evaluate fail operational solutions (e.g. emergency stop).
- Conduct impact assessment (environmental benefits, energy efficiency, efficient transport system, safety benefits,...) on real world data sets.
- Establish a pan-European common catalogue on necessary characteristics of cooperative decision, planning and control algorithms, including self-adaptation and learning features and ethical questions.
- Fulfil all security requirements to protect the system to any threats and avoid any conscious manipulations for information enabling automated transport systems.

The objective is to enable level 3 – conditional automated driving in Europe based on a harmonized legal framework. Therefore the active involvement of member states' experts and advisors is seen as beneficial for the implementation.

Type of action: IA, EUR 20-30Mio expected funding.

34. Large scale demonstration of urban road transport automation integrated with existing public transport

Specific Challenge: The feasibility of low speed self-driving in urban environments has been shown by previous projects (CyberCars, CyberMove, CityMobil, CATS and CityMobil2). It would be a good complement to mass transit to reach low to medium demand areas with high quality transport. However, a large-scale demonstration of SAE Level 4/5 automated driving is missing. It has to be built on advancements in environment perception technologies, data fusion and connectivity, and should address economic, acceptance and legal issues in complex scenarios. The integration within the (existing) public transport system needs to be tested and validated at a pan-European level. The demonstrated systems need to provide evidence of their safety level and to show reliability and fault tolerance. Infrastructure requirements have to be addressed as well. Impact assessment regarding safety, efficiency and environmental benefits shall provide evidence for a costs/benefit. The demonstration shall address all stakeholders' needs and raise awareness for highly automated driving.

Scope: Such Large scale demonstration of high level automated driving in complex scenarios (urban environment) should:

- Analyse complex traffic scenarios (with automated, non-automated, pedestrians, cyclists, PTW, etc.).
- Integrate within existing public transport services.
- Demonstrate efficiency for urban logistics.
- Demonstrate the technical maturity and reliability of sensor and data fusion systems for traffic environment perception.
- Enable reliable and secure communication by seamless and transparent integration of different communication technologies and develop and improve data fusion algorithms to combine V2X information with on-board sensor information.
- Assess interoperability, low latency, increased throughput, congestion strategies, data verification, data integrity data ownership.
- Evaluate impacts and benefits (efficiency, environmental benefits and safety, social inclusion, socio-economic, etc.).
- Automation and advanced active safety systems improving safety and efficiency of urban logistic; explore market & business cases, deployment opportunities, and use-case automating truck terminal and traffic operations and adapting infrastructures (e.g. loading area layouts, file markings, suitable traffic signs but also traffic control).
- Assess and evaluate impacts and benefits on the integrated transport system: understanding the wider socio-economic consequences of partial and full automation. Conduct impact assessment (environmental benefits, energy efficiency, efficient transport system, safety benefits,) on real world data sets.
- Make recommendations for national and local authorities on deployment measures policies.

35. Multi-Brand platooning and self-driving heavy duty vehicles in real traffic conditions with adaptation of infrastructure standards

Specific challenge: Multi-Brand platooning and self-driving of heavy duty vehicles for long-distance transport are effective technologies to improve energy efficiency, safety and the usage of limited road capacity.

In the past years, there have been significant efforts in RTD to develop the required technologies for vehicles and infrastructure.

However, substantial challenges remain on the path to a Europe wide deployment of platooning and self-driving vehicles. This includes:

- Platooning with different types of vehicles (weight, size and performance, manufacturer) in real, mixed traffic conditions (i.e. including cars) and across national borders.
- Impact on road infrastructure (e.g. bridges and pavements) and traffic organisation.
- Perception and behaviour of other road users in presence of road trains and self-driving heavy duty vehicles.
- Logistical requirements and improvements due to change in cost structures (especially for unmanned self-driving), gain sharing of the cost savings between the trucks (leading truck higher costs) and optimization of platoon compositions.

- Requirements/performance of data/information exchange at operational/vehicles level and logistical level.

Scope: The scope of the project has to cover a wide range of RTD activities, which may include the following:

- Investigation of automated transition from single self-driving vehicles (but still with a driver on board) to platoons.
- Analysis of dynamic requirements and proper performance prerequisites on platooning vehicles.
- Development of effective and safe functionalities for self-driving, the forming of platoons, running and dissolution, with different vehicles from different manufacturers.
- Analysis of different platooning strategies (incl. Logistical optimisation) to achieve good cost-benefits.
- Integration in intelligent traffic and logistical information systems.
- Road users' perception of platoons, and how they behave in their presence.
- Investigation of suitable lane management including questions such as: Which side of the road for the platoon? How to integrate road train concepts in existing lane management systems?
- Investigations of the impact of road trains on infrastructure (e.g. bridges, road wear) and the adaptation of infrastructure standards (for different platooning strategies).
- Optimization of road infrastructure to optimally support platooning (technical, capacity, management).
- Design of the road interfaces between corridors for platooning and non-adapted roads.
- Analysis on the impact on today's and future regulations.
- Supporting models for forming and dissolution of platoons or joining and leaving a platoon across national borders and assessment of logistical (cooperation) and gain sharing options.
- Testing and validation of concepts, technologies, functionalities and robustness of platooning and self-driving heavy duty vehicles under living lab conditions with a real corridor use case.

Expected impact:

- Platooning of trucks and buses is expected to increase energy efficiency by about 10%. It will improve traffic safety.
- Higher traffic throughput due to more efficient utilisation of road capacity.
- Tailored infrastructure and infrastructure management to optimally support platooning.
- Total cost reduction of logistics and supply chain leading to improved competitiveness of the EU in general.
- Increased competitiveness of European OEMs and supply industry in specific.
- The impact on driving time and rest periods of drivers will be an innovative business case for operators.
- Long term road map for platooning with self-driving HDV's including the investigation of options of a transition of the labour market related to replacing the truck driver profession with alternative jobs to be created by the improved competitive position of the EU.

Type of action: RIA, 15Mn expected funding.

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9. ANNEX

List of European projects in the area of Connectivity and Automated driving

Category	Acronym	Name	Duration	Purpose / Keywords
Robot car	CityMobil	Towards Advanced Road Transport for the Urban Environment	05/2006 – 12/2011	Safety applications and technologies: safe speed and safe following, lateral support, intersection safety, active 3D sensor technology for pre-crash and blind spot surveillance.
Robot car	PICAV	Personal Intelligent City Accessible Vehicle	08/2009 – 09/2012	Passenger transport, urban traffic, car sharing, networking, assisted driving, vulnerable road users.
Robot car	CATS	City Alternative Transport System	01/2010 – 12/2014	Robotic driverless electric vehicle, passenger transport, transport management, urban transport.
Robot car	FURBOT	Freight Urban RoBOTic vehicle	11/2011 – 02/2015	Fully electrical vehicle for freight transport in urban areas, robotics.
Robot car	V-Charge	Automated Valet Parking and Charging for e-Mobility	06/2011 – 09/2015	Autonomous valet parking, EVs coordinated recharging, smart car system, autonomous driving, multi-camera system, multi-sensor systems.
Robot car	Cargo-ANTs	Cargo handling by Automated Next generation Transportation Systems for ports and terminals	09/2013 – 08/2016	Create smart Automated Guided Vehicles (AGVs) and Automated Trucks (ATs) that can co-operate in shared workspaces for efficient and safe freight transportation in main ports and freight terminals.
Robot car	CityMobil2	Cities demonstrating automated road passenger transport	09/2012 – 08/2016	Automated road transport system, automated vehicle, driverless, urban transport, safety, infrastructure, legislation.
Driver assistance systems	PREVENT	Preventive and Active Safety Application	02/2004 – 03/2008	Development and demonstration of preventive safety applications and technologies (advanced sensor, communication and positioning technologies).
Driver assistance systems	Have-it	Highly Automated Vehicles for Intelligent Transport	02/2008 – 07/2011	Automated assistance in congestion, temporary auto-pilot.
Driver assistance systems	ASSESS	Assessment of Integrated Vehicle Safety Systems for improved vehicle safety	07/2009 – 12/2012	To develop a relevant set of test and assessment methods applicable to a wide range of integrated vehicle safety systems, mainly AEB for car to car. Methods developed for driver behavioural aspects, pre-crash sensing performance and crash performance under conditions influenced by pre-crash driver and vehicle actions.
Driver assistance systems	MiniFaros	Low-cost Miniature Laserscanner for Environment Perception	01/2010 – 12/2012	Develop and demonstrate innovative low-cost laser scanner.
Driver assistance systems	MOSARIM	MOre Safety for All by Radar Interference Mitigation	01/2010 – 12/2012	Interference mitigation, automotive short-range radars.
Driver assistance systems	2Wide_Sense	WIDE spectral band & WIDE dynamics multifunctional imaging SENSor ENabling safer car transportation	01/2010 – 12/2012	Development and testing of next generation imaging sensors, new camera systems.

Driver assistance systems	interactiVe	Accident avoidance by active intervention for intelligent vehicles	02/2010 – 06/2013	Development of safety systems supporting the driver (joint steering and braking actuators).
Driver assistance systems	AsPeCSS	Assessment methodologies for forward looking integrated Pedestrian and further extension to Cyclist Safety Systems	09/2011 – 07/2014	To develop harmonised test and assessment procedures for forward looking integrated pedestrian safety systems that can be used for consumer rating and regulatory purposes.
Driver assistance systems	AdaptiVe	Automated Driving Applications and Technologies for Intelligent Vehicles	01/2014 – 06/2017	Automated driving, cars, trucks, motorways, transport in cities, close-distance manoeuvres.
Driver assistance systems	PROSPECT	PROactive Safety for PEdestrians and CyclisTs	05/2015 – 10/2018	The project aims to 1) Expand scope VRU scenarios addressed through accident analysis and field operational test 2) Improve overall system performance of AEB systems for cyclists and pedestrians.
Connectivity & Communication	COM2REACT	Cooperative Communication System to Realise Enhanced Safety and Efficiency in European Road Transport	01/2006 – 12/2007	Road and in-car communication systems, cooperative system, involvement of two-way communication systems: V2V and V2I, contribution for standardization and harmonization throughout Europe.
Connectivity & Communication	SAFESPOT	Cooperative Systems for Road Safety	02/2006 – 01/2010	Implementation and demonstration of V2V-based technology, Local Dynamic Maps, multi-sensor data fusion.
Connectivity & Communication	COOPERS	Co-operative Networks for Intelligent Road Safety	02/2006 – 01/2010	Development of intelligent transport systems (ITS), I2V technology, co-operative traffic management.
Connectivity & Communication	CVIS	Cooperative Vehicle-Infrastructure Systems	07/2006 – 06/2010	Development of a technology platform that provides wide-ranging functionality for data collection, journey support, traffic and transport operations and driver information.
Connectivity & Communication	Intersafe-2	Cooperative Intersection Safety	06/2008 – 05/2011	Development of a Cooperative Intersection Safety System (CISS) – detection of static and dynamic components of the traffic environment.
Connectivity & Communication	ISI-PADAS	Integrated Human Modelling and Simulation to Support Human Error Risk Analysis of Partially Autonomous Driver Assistance Systems	09/2008 – 08/2011	Joint Driver-Vehicle-Environment Simulation Platform, prediction of driver errors in realistic traffic scenarios, driver modelling, Human Error Risk Analysis.
Connectivity & Communication	SARTRE	Safe Road Trains for the Environment	09/2009 – 10/2012	Development of strategies and technologies allowing vehicle platoons to operate on public highways – introduction of the vehicle platoons concept.
Connectivity & Communication	DRIVE C2X	DRIVing implementation and Evaluation of C2X communication technology in Europe	01/2011 – 07/2014	Creation of harmonized Europe-wide testing environment for cooperative systems, promotion of cooperative driving.

Connectivity & Communication	79GHz	International automotive 79 GHz frequency harmonization initiative and worldwide operating vehicular radar frequency standardization platform	07/2011 – 06/2014	Global harmonization, 79GHz band, automotive short-range radars.
Connectivity & Communication	FOTsis	European Field Operational Test on Safe, Intelligent and Sustainable Road Operation	04/2011 – 09/2014	Intelligent transport systems, electronic stability control, cooperative I2V & V2I technologies, emergency management, safety incident management, intelligent congestion control, dynamic route planning, infrastructure safety assessment.
Connectivity & Communication	ARTRAC	Advanced Radar Tracking and Classification for Enhanced Road Safety	11/2011 – 10/2014	Generic detection system, detect low-friction road sections, automatic braking, VRU safety technologies, radar hardware, software and performance-related algorithms.
Connectivity & Communication	Compass4D	Cooperative Mobility Pilot on Safety and Sustainability Services for Deployment	01/2013 – 12/2015	Forward collision warning (FCW), red light violation warning (RLVW), energy efficient intersection service (EEIS), cooperative system, standardization cooperation
Connectivity & Communication	AMIDST	Analysis of Massive Data Streams	01/2014 – 12/2016	Big data, stream processing, software development, automotive.
Connectivity & Communication	COMPANION	Cooperative dynamic formation of platoons for safe and energy-optimized goods transportation	10/2013 – 09/2016	Application of platooning on heavy-duty vehicles; concepts development for platoon applications in daily transport operations (off- a on-board systems for coordinated platooning, multimodal user interfaces).
Connectivity & Communication	AutoNet2030	Co-operative Systems in Support of Networked Automated Driving by 2030	11/2013 – 10/2016	Development and testing of a co-operative automated driving technology with a time-horizon between 2020 and 2030.
Networking/ Challenges	BRAiVE	BRAin-drive	2008	A prototype vehicle development by VisLab, designed for the testing of concepts, sensors and specific HMIs. The prototype was also used for the design of new ADAS.
Networking/ Challenges	Nearctis	Network of Excellence for Advanced Road Cooperative Traffic Management in the Information Society	07/2008 – 06/2013	Academic network for traffic management and optimization with focus on cooperative systems able to cope with safety, energy consumption, environmental impacts and congestion.
Networking/ Challenges	VIAC	VisLab Intercontinental Autonomous Challenge	07/2010 – 10/2010	Challenge conceived by VisLab as an extreme test for automated vehicles.
Networking/ Challenges	VRA	Support action for Vehicle and Road Automation network	07/2013 – 12/2016	Creates a collaboration network of experts and stakeholders working on deployment of automated vehicles and its related infrastructure.
Networking/ Challenges	i-GAME / GCDC	Grand Cooperative Driving Challenge	10/2013 – 10/2016 (annually)	Speed-up real-life implementation and interoperability of wireless communication based automated driving. Arrange the second Grand Cooperative Driving Challenge – the GCDC 2016.





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