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Aki Lumiaho
Fanny Malin

Road Transport Automation
Road Map and Action Plan 2016–2020

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Aki Lumiaho, Fanny Malin

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Finnish Transport Agency
P.O. Box 33
FI-00521 HELSINKI
Tel. +358 (0)29 534 3000

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Keywords: Road Transport Automation, Automatisation, Digitalisation, Automated Traffic, Automated Driving, Automated Vehicle, Connected Vehicle, Cooperative Vehicle, Cooperative Intelligent Transport Systems (C-ITS).

Summary

Road Automation is progressing fast. This phenomenon takes advantage of both existing and emerging cooperative Advanced Driver Assistance System (ADAS) and In-Vehicle System (IVS) sensor functionalities. Advancements in automatisation, i.e. deployment of automation, are proceeding by integration of the technologies above. The Ministry of Transport and Communication has emphasised that Finland is in the forefront in preparing for and utilising automated traffic.

This document describes the study and design processes used. The study methodology was composed of a concise literature review, expert discussions, working sessions, and stakeholder and authority workshops as well as of the editors' own experience and knowledge of the domain. The design methodology was based on a phased work on various themes. During the first phase the knowledge gaps, which were identified during the literature review and expert discussions, were discussed in depth. Based on the results, specific action cards were developed and drafted. The action cards contained the title and generic use case and contents descriptions. The various draft versions of the action cards, with the detailed activities included, were thoroughly discussed in the project and the steering group meetings as well as in the stakeholder and administrative entity workshops. The final action cards contain information on detailed activities to be taken, the proposed agency in charge of the coordination of the action with the nominated supporting entities, and scheduled timing of the action and its activities, as well as drafted estimations of resources and budgetary reservations needed for the implementation. The action cards were finalised in the project group and approved by the steering group.

In order to proceed with planning and implementation of the action cards they were divided into five domains. The domains are: infrastructure, road superstructure and equipment, vehicle systems, services and functions, and driver.

The purpose of the action cards is to combine the related transport authority activities and resource needs for guidance to be used in the next few years. The detailed information has been presented to the authorities for their planning and implementation processes. This document provides an overall summary of the results.

During the first two years of the study period, 2016–2017, it is suggested to launch a total of 114 individual actions, either as part of an existing project, as combined to form a larger new project or as stand-alone projects.

Aki Lumiaho ja Fanny Malin: Tieliikenteen automatisoinnin etenemissuunnitelma ja toimenpideohjelma 2016–2020. Liikennevirasto, liikenne ja tieto -toimiala. Helsinki 2016. Liikenneviraston tutkimuksia ja selvityksiä 19eng/2016. 82 sivua ja 2 liitettä. ISSN-L 1798-6656, ISSN 1798-6656, ISBN 978-952-317-264-7, ISSN 1798-6664 (pdf), ISBN 978-952-317-263-0 (pdf).

Avainsanat: tieliikenteen automaatio, automatisaatio, digitalisaatio, automaattiliikenne, automaattiajaminen, automaattiauto, verkottunut auto, yhteistoiminnallinen auto, yhteistoiminnalliset älykkäät liikenteen järjestelmät.

Tiivistelmä

Tieliikenteen automatisaatio etenee nopeasti hyödyntäen jo olemassa olevien sekä kehitteillä olevien kuljettajien yksittäisten tukijärjestelmien ja autojen anturien toiminnallisuuksia. Automatisaatio eli automaation lisääntyminen etenee integroimalla edellä mainitut yhtenäisiksi kokonaisuuksiksi. Liikenne- ja viestintäministeriö on linjannut Suomen olevan eturintamassa automaattiajamiseen varautumisessa ja mahdollisuuksien hyödyntämisessä.

Raportti sisältää kuvauksen tutkimus- ja suunnittelumenetelmistä. Tutkimusmenetelmänä käytettiin kirjallisuuskatsausta, asiantuntijakeskusteluja, työpalavereita, sidosryhmä- ja viranomaistyöpajoja sekä toimittajan omassa toiminnassaan kokoamaansa tieto- ja osaamisvarantoa. Suunnittelumenetelmä perustui vaiheittaiseen etenemiseen. Ensimmäisessä vaiheessa pohdittiin niitä tietotarpeita, joita oli tunnistettu kirjallisuuskatsauksen ja asiantuntijakeskustelujen perusteella. Tietotarpeista muodostettiin yleiset toimenpidekortit, joissa kortin otsikon lisäksi kuvattiin yleisimmät käyttötapatilanteet ja kuvaus toimenpiteen sisällöstä. Näitä luonnoksia käsiteltiin ohjaus- ja projektiryhmissä sekä sidosryhmä- ja viranomaistyöpajoissa. Toimenpidekortit sisältävät yksityiskohtaiset toimenpiteet ja vastuuviranomais-, osallistuja-, aikataulu- sekä karkeat resurssi- ja kustannustiedot. Lopulliset toimenpidekortit käsiteltiin projektiryhmässä ja hyväksyttiin ohjausryhmässä.

Suunnittelua ja toteutusta varten toimenpidekortit on jaettu viiteen asiakokonaisuuteen. Asiakokonaisuudet ovat infrastruktuuri, tien päällysrakenne ja varusteet, ajoneuvon järjestelmät, palvelut ja toiminnot sekä kuljettaja.

Toimenpidekorttien tarkoitus on koota yhteen liikenteen hallinnonalan toimenpidetarpeet toimenpideohjelman tarkasteluajanjaksolla 2016–2017. Nämä yksittäiset toimenpidekohtaiset tiedot ovat hallinnonalan toimijoiden käytettävissä suunnittelun ja toteutuksen jatkotoimenpiteitä varten. Tämä raportti esittää yhteenvedon kokonaisuudesta.

Toimenpideohjelman tarkastelujaksolla 2016–17 on arvioitu olevan tarpeellista käynnistää 114 hanketta, osana jo käynnissä olevia, yhdistettynä yhdeksi tai useammaksi suuremmaksi hankkeeksi tai itsenäisinä toimina.

Aki Lumiaho och Fanny Malin: Handlingsplan för vägtrafikens automatisering 2016-2020. Trafikverket, trafik och information. Helsingfors 2016. Trafikverkets undersökningar och utredningar 19eng/2016. 82 sidor och 2 bilagor. ISSN-L 1798-6656, ISSN 1798-6656, ISBN 978-952-317-264-7, ISSN 1798-6664 (pdf), ISBN 978-952-317-263-0 (pdf).

Nyckelord: vägtrafikens automation, automatisering, automatisering, digitalisering, automatisk trafik, automatiskt fordon, anslutna fordon, kooperativa fordon, kooperativa intelligenta transportsystem.

Sammanfattning

Vägtrafikens automatisering framskrider snabbt. Den drar nytta av befintliga och i utvecklingsskedet befinnande förarstöd och fordonssensorer. Automatiseringen framskrider genom att sammanföra de ovannämnda teknologierna till en helhet. Kommunikationsministeriet har linjerat att Finland skall ligga i framkant i förberedelserna för och utnyttjandet av automatiserad trafik.

Rapporten innehåller en beskrivning av forsknings- och planeringsmetoderna. Som forskningsmetoder användes en litteraturforskning, diskussioner bland sakkunniga, workshoppar för intressegruppen och myndighetsgruppen samt leverantörens egen sakkunnighet och kompetens. Planeringen framskred gradvis. I det första skedet diskuterades de informationsbehov som observerats från litteraturforskningen och diskussioner bland sakkunniga. Från dessa behov skapades de generella åtgärdskorten. Korten beskrev de vanligaste användningssituationerna och åtgärdens innehåll. Dessa utkast behandlades i styrnings- och projektgruppen och i intressegruppens workshop. Åtgärdskorten uppdelades i enskilda åtgärder som fick en ansvarsmyndighet, övriga parter och tidtabell. Åtgärderna tilldelades även riktgivande resurs- och utgiftsbehov. De slutgiltiga åtgärdskorten behandlades i projektgruppen och godkändes av styrningsgruppen.

För att förenkla planeringen och genomförandet delades åtgärdskorten in i fem grupper. Åtgärderna berör följande ämnen: infrastruktur, vägens beläggning och utrustning, fordonens system, tjänster och föraren.

Syftet med åtgärdskorten är att sammanföra förvaltningsområdets åtgärds-, resurs- och budgeteringsbehov för granskningsperioden. Mer detaljerade uppgifter har överlämnats till förvaltningsområdets aktörer för fortsatt planering och genomföring. Denna slutrapport ger ett sammandrag av helheten.

Det har uppskattats att det borde påbörjas 114 projekt under åtgärdsprogrammets granskningsperiod 2016-2017. En del av dessa projekt har redan påbörjats och resten skall antingen slås ihop till större projekt eller påbörjas som separata åtgärder.

Foreword

Road transport automation is progressing at speed by utilising the functionalities of both existing and emerging driver assistance systems and vehicle sensors. Automation advances by integrating the aforementioned systems into unified wholes. The Ministry of Transport and Communications has made a policy declaration that Finland is at the forefront of preparation for automated driving and of utilising the possibilities it offers.

The road map and action plan for road transport automatisation were drawn up by representatives of the Ministry of Transport and Communications, the Finnish Transport Safety Agency (Trafi), the Finnish Transport Agency, and the Technical Research Centre of Finland (VTT Ltd). Stakeholder workshops were also organised for public and private transport sector stakeholders – a total of over a hundred organisations.

The aim was to work with the project group to draw up a road map for promoting and facilitating automated driving in Finland until 2020, and to draft an action plan for promoting and facilitating automated driving in Finland in 2016–2020. The report examines and offers an introduction into automated driving and the activities it requires. The report will be utilised in facilitating road transport automatisation. It was drawn up by consultants and experts, and its proposals for activities and their implementation methods and timetables do not represent the official views of the Ministry of Transport and Communications or the other participating agencies.

The Finnish Transport Agency and Trafi set up a steering group, project group and core group as seen in Appendix 1. The steering group was chaired by Director General Tiina Tuurnala of the Finnish Transport Agency's Traffic and Information division. The group consisted of representatives of the client agencies and the Ministry of Transport and Communications. The project group was chaired by Principal Advisor on ITS Risto Kulmala of the Finnish Transport Agency's Mobility Management and ITS Services unit. The project group included representatives of the client agencies, the Ministry of Transport and Communications, and the Finnish Communications Regulatory Authority.

The practical work, reporting and management of the project was overseen by Principal Scientist on connected and automated vehicles Aki Lumiaho of VTT's Transport Team. He was assisted by Research Scientist Fanny Malin, who also acted as the secretary of the steering and project groups. Christina Vähävaara from VTT helped with the design of the report.

The Finnish Transport Agency would like to thank all those who participated in the project.

Helsinki, April 2016

Finnish Transport Agency
Traffic and Information

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1 Description and Objectives of Task

1.1 Background

Finland has been monitoring and investigating transport automation for several years. The first studies focusing purely on road transport automation were commenced in 2014.

In September 2015, the Ministry of Transport and Communications (MinTC) published the report *"Robots on Land, in Water and in the Air – Promoting Intelligent Automation in Transport Services"*. In the report, intelligent automation and its increased use refer to modern robotics where a device or a system is capable of increasingly autonomous action, perception, learning and decision-making through artificial intelligence, sensors and the Internet of Things combined with software. The report describes applications and opportunities in intelligent automation in transport and the prerequisites for the further development of automation. It identifies measures that can be taken to improve Finland's capabilities and possibilities as automation makes headway in all modes of transport. (Pilli-Sihvola E. et al. 2015)

This report takes the road transport measures outlined in *"Robots on Land, in Water and in the Air – Promoting Intelligent Automation in Transport Services"* and draws up more concrete and detailed plans for them for 2016–2020.

Other Finnish research and studies on the topic include

- Automaation lisääntymisen vaikutukset tieliikenteessä [The Impacts of Increased Automation on Traffic], Innamaa S., Kanner, H., Rämä, P. and Virtanen, A. 2015. Trafi Research Reports 1/2015.
- Liikenteen robotisaatio, taustaselvitys [Transport Robotics, background study], Lumiaho A. and Kutila M. VTT 2015.
- Automaattiajamisen testauksen ekosysteemi [Ecosystem for the Testing of Automated Driving], Kutila M., Malin, F. and Lumiaho, A. Ministry of Transport and Communications 2015.
- Tulevaisuuskuva kysyntäohjautuvan autonomisen tieliikenteen tilauspalvelusta [Scenario of a Booking Service for Demand-Responsive Autonomous Road Transport], Heljala, H. Master's Thesis, Aalto University. HSL Helsinki Region Transport, Ministry of Transport and Communications, Finnish Transport Safety Agency Trafi. HSL Publications 4/2015.
- Taustaselvitys automaattisten ajoneuvojen avulla toteutettavan palvelun hyödyntämisestä joukkoliikenteessä [Background Study on the Utilisation of an Automated Vehicle Service in Public Transport]. Lumiaho, A., Vähätörmä, P., Nyberg, J., Räsänen, J., Hänninen, T., Stenman, P., Kahilaniemi, S. Vantaa Innovation Institute Ltd. 2013.

Road transport automatisation often refers to both automated and autonomous vehicles (cf. Figure 1 and Table 1) (Innamaa et al. 2015).

An automated vehicle is a vehicle that can at least partly perform a driving task without a driver.	**An autonomous vehicle** is an automated vehicle that can perform a driving task by relying on the vehicle's own systems without a driver and without connections to other vehicles or infrastructure.

Figure 1. Definitions of an automated and autonomous vehicle (Innamaa et al. 2015).

In public debate and in the media these terms are often used inconsistently, i.e. the term autonomous vehicle is often used about automated vehicles in general. Autonomous and fully-automated vehicles are usually the same thing in the media. There are also remote-controlled vehicles, which a driver operates and is in contact with via a wireless connection using a driving simulator or similar user interface.

Street-legal vehicles contain an increasing number of advanced driver assistance systems (ADAS). The development and increasing combined use of these systems is a major developmental trend leading to road transport automation.

This report uses the terminology listed in Table 1 (Innamaa 2015). An individual system can be either autonomous or connected, so an automated vehicle can contain both autonomous and connected systems.

Table 1. Automated driving terminology. Source: Innamaa 2015, adapted.*

English term	Finnish term	Meaning
Advanced Driver Assistance System, ADAS*	Edistynyt kuljettajaa avustava järjestelmä	Electronic in-vehicle system that can assist the driver with some dynamic driving task(s)
Automated vehicle	Automaattiajoneuvo, automaattinen ajoneuvo	A vehicle that can at least partly perform a driving task without a driver
Autonomous vehicle	Autonominen ajoneuvo, (itsenäinen ajoneuvo, omaehtoinen ajoneuvo)	An automated vehicle that can perform a driving task without a driver and without connections to other vehicles or infrastructure
Connected vehicle	Verkottunut ajoneuvo	A vehicle that has a wireless connection with other vehicles and/or infrastructure
Teleoperated vehicle	Teleoperoitu ajoneuvo	A vehicle that is operated wirelessly from the outside. The vehicle need not be automated or autonomous.
Cooperative service	Yhteistoiminnallinen palvelu	A service where the vehicle/traveller and the infrastructure or vehicles/travellers exchange information electronically to implement the service
Collaborative service	Yhteisöllinen palvelu	A service where several road user groups (vehicles, cyclists and pedestrians, and public transport passengers) and the infrastructure are connected (many different parties, crowdsourcing, incl. information production)
Platooning	Letka-ajo, saattueajo	Driving in a queue, where the first vehicle controls the platoon while the others follow automatically

It should be noted that at the moment, most road transport automation is based on in-vehicle technological solutions and electronic systems. Even though modern vehicles are equipped with intelligent systems, it seems that only connected automated vehicles and/or autonomous vehicles will fully meet the goals set for vehicle operations in an intelligent road environment. As the level of automation improves, the significance of the road and back-office system infrastructure will increase. A vehicle that can exchange information with the road and back-office systems is called a connected vehicle.

The different technological levels of road transport automation have been defined. The most commonly used classification is the one by the SAE (*Society of Automotive Engineers*) (SAE 2014). The SAE classification is used in this project and is also recommended for other Finnish projects until a European standard of classification can be set. Other commonly used classifications include e.g. the NHTSA and BASt ones. (Innamaa 2015)

The role of the driver at different levels of automation can be described as follows (Innamaa 2015) (Table 2)

0. No automation: The driver is responsible for all aspects of the driving task.
1. Driver assistance: The system only supports one aspect while the driver takes care of the other aspects of the driving task AND monitors the driving environment.
2. Partial automation: The driver must monitor the driving environment.
3. Conditional automation: The driver may undertake other tasks while driving, but if necessary, must take control of the vehicle (= start driving).
4. High automation: The driver may even be asleep, as the system gives a warning if the driver needs to take control of the vehicle.
5. Full automation: No driver is needed.

In the near future, automation will develop to level 3 ”Conditional automation” (Table 2) by 2020, but it will be implemented only partially. This estimate is based on predictions made by vehicle, equipment and component manufacturers.

The OEMs' vision for the near future is generally based around “cautious optimism”, “reasonable realism” and “predictive marketing”. There are exceptions, such as Google. Google's background is in software and software-based services and different types of service searches. Google is also a technology company, which develops new solutions for our world of the Internet. These innovations include e.g. an advanced search engine, a smartphone, a tablet computer, a smartwatch and their latest concept, an automated vehicle.

The media has also latched onto this concept, using terms like “robot car”, “self-driving car” and other such memorable phrases. The problem is that these references often do not describe the level of automation involved in any detail, nor provide an estimate of when the vehicles will be on the market. In general, the media does not connect vehicle descriptions with a level of automation, leaving readers confused by seemingly contradictory messages.

It is important to understand that a move from the current level of automation 1 ”Driver assistance” towards level 3 automated driving ”Conditional automation” represents a massive leap for the manufacturing industry. It is not just a matter of technological solutions, but of the concepts of driving and transport and the factors that influence them. For a few decades, this will be made visible in traffic as a heterogeneous vehicle fleet. The rate of renewal of the Finnish car stock is slow, which slows down the move from mixed traffic to uniform automated traffic.

The move to automation level 3 also represents a massive leap for drivers and other road users. People will get to or have to interact with new kinds of systems that they have been eagerly or fearfully expecting. Road users will not know which, if any, type of driver assistance system or automated functions the vehicle coming the other way or driving in front of them has.

Table 2. Levels of automation in road transport (Innamaa 2015; SAE 2014). System refers to the automated driving system.

Level	Name	Definition	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of dynamic driving task	System capability
Human driver monitors the driving environment			Human driver	Human driver	Human driver	
0	No automation	The full-time performance by the human driver of all aspects of the dynamic driving task, even when enhanced by warning or intervention systems.				–
1	Driver assistance	The driving mode-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial automation	The driving mode-specific execution by one or more driver assistance systems of both steering and acceleration/deceleration using information about the driving environment and with the expectation that the human driver perform all remaining aspects of the dynamic driving task.	System	Human driver	Human driver	Some driving modes
Automated driving system monitors the driving environment			System	System	Human driver	
3	Conditional automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task (including latitudinal and longitudinal control) with the expectation that the human driver will respond appropriately to a request to intervene.				Some driving modes
4	High automation	The driving mode-specific performance by an automated driving system of all aspects of the dynamic driving task, even if a human driver does not respond appropriately to a request to intervene. If the human driver fails to take control of the vehicle, the system steers the vehicle to the side of the road in a controlled manner and stops it.	System	System	System	Most driving modes
5	Full automation	The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver.	System	System	System	All driving modes

During the transitional phase, traffic will include

- vehicles with no driver assistance systems.
- vehicles with some driver assistance systems, which primarily function only in good conditions.
- vehicles, which under good weather and road conditions can perform many of the basic dynamic driving tasks, including lateral and longitudinal control, e.g. driving direction, speed, headway and even lane changes, but which under worse road and/or weather conditions perform like conventional vehicles.

Existing technology does not allow manufacturers to produce solutions in which in-vehicle systems could manage all driving situations. In practice, vehicle, transport and road operators are moving towards automated driving by developing and utilising connected systems. Monitoring the driving environment or steering the vehicle within the limited time the system has to change vehicle behavior safely are next to impossible for non-connected vehicles. For instance, a non-connected vehicle cannot tell what the situation is around the next corner.

Several OEMs – including Audi, BMW, Ford, Lexus, Mercedes-Benz, Nissan, Opel, Toyota, Volkswagen and Volvo – have already brought out individual car models that are equipped with Advanced Driver Assistance Systems that represent automation level 2 ”Partial automation”. Unresolved, though somewhat examined (e.g. Innamaa 2015) issues include e.g. the impacts on road operators, traffic flow and the transport system, users’ attitudes, readiness to adopt and behaviour (observation – interpretation – action), decision-making by and intervention levels of the human driver and the automated driving system, liability issues, and regulatory requirements.

Some OEMs have committed to bringing out their automation level 3 ”Conditional automation” solutions and first available automated vehicle models before or by the year 2020. Some very progressive OEMs, such as Volvo and FIAT, have tried to temper the excitement over the deployment of level 4 and 5 automation, and have announced more moderate timetables than the OEMs at the forefront of automatisation.

1.2 Objectives

The aim of this study, *Road Transport Automation Road Map and Action Plan 2016-2020*, was to work with the project group to draw up a road map facilitating automated driving in Finland until 2020. Another aim was to draft a detailed action plan for the study period outlining automated driving activities to be carried out by the transport authorities.

The objective was to describe the development status of road transport automation from numerous perspectives, and then draw conclusions and make recommendations for how Finland should prepare for this development and for what kinds of activities the value chain stakeholders should be prepared. Within the value chain, the focus was on the Ministry of Transport and Communications and the agencies under its jurisdiction, so that most of the activities are to be implemented by the Finnish Transport Agency, Finnish Transport Safety Agency (Trafi), Ministry of Transport and Communications, and Finnish Communications Regulatory Authority. Cities and industry were also mentioned as participants in some activities.

1.3 Report Structure and Scope

The report focuses on presenting the road map and action plan to decision-makers. International developments and trends are examined to provide background information and to give readers an idea of global developments in road transport automation. The amount of background information given was cut down early on due to the extremely high speed of developments in driving automation. This is why the background information focuses on important development trends in automated driving (infrastructure, vehicle, driver) and the development of the associated physical and digital infrastructure from now until 2020.

The report examines the technology solutions, use environments and users of automated driving in Finnish conditions (road network, climate and economy) within a given period. It should be noted that big OEMs and their equipment and component suppliers continue to develop automated driving in their own ways. Road operators are also making active developments on their own.

2 Research Methods

The research methods used consisted of a literature review, two stakeholder workshops, an authority workshop, and cooperation between clients and suppliers in the core group. The stakeholder workshops were intended for experts and companies working in the fields of intelligent transport and automated driving.

The literature review utilised documents and links to sources provided by the clients as well as extensive material from international news sources and analysts and from the clients' own Finnish and international projects.

The first stakeholder workshop met in August 2015. 160 people were invited to attend, 70 of whom ended up participating. The workshop assessed the current state and recent development of automated road transport. Material from the literature review was picked to illustrate notable global development trends. The topics under examination were chosen from the Ministry of Transport and Communications' (MinTC), Finnish Transport Agency's and Finnish Transport Safety Agency's (Trafi) jurisdictions. One objective was to identify possible challenges that might face the facilitation of automated driving in Finland. The workshop participants split into three small groups to discuss the action cards they had received in advance and to propose new activities associated with the topics.

The second stakeholder workshop met in October 2015. The list of invitees was expanded to include 230 people from more than 100 organisations. Nearly 60 experts ended up participating. The second workshop discussed the content and order of priority of the action cards. Three small groups of representatives from private companies organised the action cards by order of importance. Two small groups of representatives from the transport authorities organised the action cards according to the entity responsible for each. The responsible entity means the organisation that coordinates and steers the implementation of each action card. The responsible entities were the MinTC, Finnish Transport Agency, Trafi, and Finnish Communications Regulatory Authority (FICORA).

A joint workshop of the steering and project groups was organised in November 2015. 28 representatives of the MinTC, Finnish Transport Agency, Trafi and FICORA were invited to the workshop, 25 of whom ended up attending. The workshop identified the responsible entities, participants, and personnel and budget requirements of each action card.

3 International Development Trends

3.1 Technological Development

3.1.1 Infrastructure

The demands set on the road infrastructure vary according to the level of automation, the road environment and the road users. The urban street environment is the most challenging one for automated driving, because of the different types of travellers sharing the environment and the heterogeneous nature of the traffic environment itself. Separate lanes for automated driving provide a safer environment for trials and implementation, but their construction is the shared responsibility of several stakeholders. (Shladover and Bishop 2015)

The demands set on road construction and maintenance may change due to automated driving. For instance, in theory, automated and autonomous vehicles can utilise stricter lane keeping on (separate) narrower lanes, thus allowing for more lanes on the same carriageway, improving road capacity. However, this will also mean that pavement wear may be focused on certain parts of the road cross-section, resulting in the increased formation of ruts, necessitating the shortening of the repaving cycle. Pavements could utilise more wear-resistant material, but this would be more expensive. On the other hand, automated vehicles could be programmed to drive more evenly across the whole lane cross-section, thus reducing pavement wear. (Carsten and Kulmala 2015)

The introduction of automated vehicles may also affect junction design and planning. Studies have found that at high traffic flows, roundabouts are more efficient for automated vehicles than traffic signals are (Azimi et al. 2013). It has been estimated that in the United States, the length of the yellow interval should be extended by 2–4 seconds to provide autonomous vehicles with sufficient time for turning and crash-avoidance manoeuvres. (Traffic Technology Today 2015). However, lengthening the yellow interval will reduce junction capacity and may lead to increased traffic congestion.

3.1.2 Vehicle Technology

OEMs and their equipment and component suppliers are investing in a future where computers, not humans, control vehicles. New stakeholders in the field of automated driving, such as the technology company Google and the electric car manufacturer Tesla, approach road transport automation in a different way than traditional OEMs. Development trends among the technology companies and automotive industry are somewhat different and even potentially divergent. The development of public transport and heavy vehicles emphasises different issues than the development of private cars. Four possible evolutionary paths towards road transport automation were identified (Figure 2).

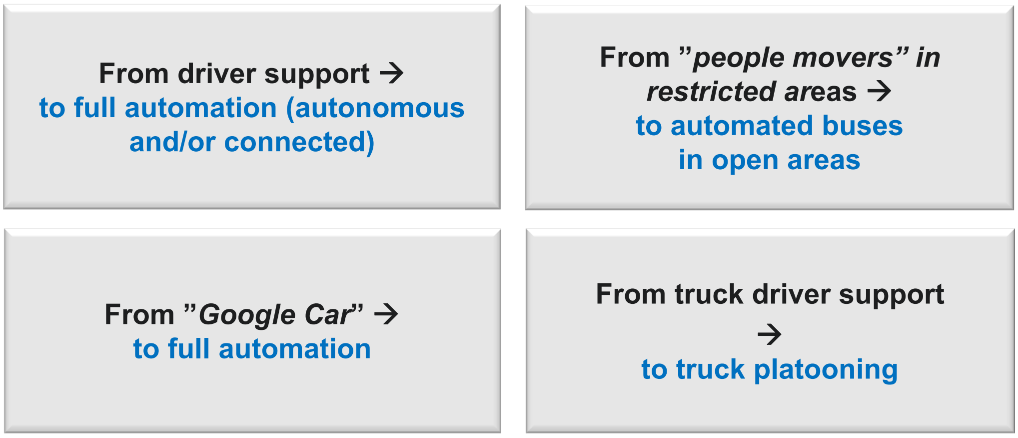

Figure 2. Evolutionary paths for road transport automation.

The American technology website GovTech.com has listed the next ten years' ten global technological breakthroughs that will significantly advance the introduction of connected and autonomous vehicles (GovTech 2015).

1) 2015: Autopilot

Autopilot combines a forward looking camera, radar, and 360-degree sonar sensors with real-time traffic updates. Autopilot has latitudinal and longitudinal control of the vehicle and can drive both on the open road and in dense stop-and-go traffic. Changing lanes becomes as simple as a tap of the turn signal. When you arrive at your destination, the vehicle will both detect a parking spot and automatically park itself. The standard equipment safety features are constantly monitoring stop signs, traffic signals and pedestrians. Autopilot also prevents unintentional lane changes. (Tesla 2015)

2) 2015: Intelligent transportation systems

Two major intelligent transport research and development projects have examined the challenges facing connected and autonomous vehicles from the perspective of intelligent transport systems (ITS).

In Michigan, the state department of transportation and the University of Michigan teamed up to develop and open the M City test area (Figure 3), a 13-hectare campus that mimics a realistic traffic environment. The area includes 6.5 lane-kilometres of roads with junctions, roundabouts, road markings, traffic signs and signals, parked cars, sidewalks, bus stops, benches, simulated buildings, streetlights, pedestrians, and obstacles like construction barriers. (Michigan 2015)

Figure 3. Conceptual image of the M City test area (Michigan 2015).

Contra Costa County in California has built the United States' largest and most comprehensive testbed for connected and autonomous vehicles, known as the *GoMentum Station*. Located on a former Navy Weapons Station in Concord, it covers an area of over 20 km^2. Several major OEMs and equipment and component suppliers have now set up operations on the site, including Honda, Mercedes-Benz, Bosch, Nissan, Toyota, Audi, Volvo and Google. GoMentum Station is described as a world-class connected and autonomous vehicle testbed with active industry and government participation. (CCTA 2015)

3) 2017: GM Super Cruise

In 2017, *General Motors* is bringing out a combined driver assistance system, including hands-off lane keeping, braking and speed control in certain highway driving conditions. The system is designed to increase driver comfort in highway traffic, both in bumper-to-bumper traffic and on free-flow road sections on long road trips. However, the driver must remain attentive and prepared to take control of the vehicle if the system requests it. (GM 2015)

4) 2017: Volvo Drive Me

In February 2015, Volvo unveiled the details of its planned "*Drive Me* – Self-driving cars for sustainable mobility" pilot programme. Volvo will make 100 automated Volvo XC90 SUVs (SAE level of automation 3) (Figure 4) available to commuters in Gothenburg. The vehicles will carry out daily commutes on a select corridor, where the road infrastructure is equipped to support the pilot. Programme participants include e.g. Volvo Cars, the Swedish Transport Agency, the Swedish Transport Administration, Lindholmen Science Park and the City of Gothenburg. (Volvo Cars 2015)

So-called "*safe harbours*" will be built on the road network, allowing vehicles to stop by the side of the road if the vehicle malfunctions or the driver fails to respond in time. (Shladover and Bishop 2015)

The pilot tries to determine the socioeconomic benefits of automated driving, the infrastructure requirements set by automated vehicles, customer confidence in automated vehicles, and the attitudes of other drivers towards automated vehicles. The pilot aims to position Sweden and Volvo Cars as leaders in the development of future mobility. (Volvo Cars 2015)

Automated vehicles form a fixed part of Volvo Cars' and the Swedish Government's joint *Vision Zero* initiative, which aims to reduce traffic fatalities to zero. Volvo has made it their corporate objective that no-one should be killed driving in a Volvo. The *Drive Me* pilot plays a key role in reaching this objective. The pilot will involve Volvo cars using approximately 50 kilometres of selected roads that are typical commuter arteries and include motorway conditions and frequent queues. (Volvo Cars 2015)

Figure 4. *Volvo Cars has made public the details of the Drive Me pilot programme, which makes 100 automated vehicles available for private use on public roads (Volvo Cars 2015).*

5) 2018: Audi piloted driving

Audi has been studying and testing autonomous vehicle technology for 15 years. The research and test programme is known as *#drivenbyVorsprung*. The tests have been carried out not only with the traditional laboratory and testing equipment and on conventional test areas, but also on public roads and race tracks. Both types of testing have positioned Audi as a major stakeholder in the utilisation of new technologies.

The Audi A7 piloted driving concept utilises the latest technologically advanced systems developed by Audi to relieve the driver of driving duties up to the speed of 100 km/h. The car – nicknamed "Jack" – can initiate lane changes and passing manoeuvres. It can also accelerate and brake independently. Before initiating a lane change, the vehicle adapts its speed to surrounding vehicles. If the speed and distance calculation is deemed safe, the vehicle initiates the lane change with precision and in a timely manner. (GovTech.com 2015)

Audi has built several versions of its fully-automated and remote-controlled concept vehicle. The vehicle has been driven for almost 1,000 kilometres on public roads between California's Silicon Valley and Las Vegas. The theoretical performance of the piloted driving concept is illustrated by the fact that a prototype of the automated vehicle based on the Audi RS7 completed a lap on the Hockenheimring racing circuit more precisely (using the optimal driving trajectory) and nearly as quickly as a racing driver in a standard-equipment Audi sports sedan. (Audi 2015)

The Audi concept vehicle has adaptive cruise control, active lane-keeping assistance, two long-range radar sensors at the front and rear, two mid-range radar sensors on the front and rear corners, front and rear laser scanners, a high-resolution 3D video camera mounted on the front of the vehicle, a total of four small front and rear mounted cameras, and a navigation system. The automated driving system is designed to warn the driver and request they take control of the vehicle before the system reaches its limitations. (Audi 2015b)

Figure 5. Audi's work on driver assistance systems has enabled them to build driverless vehicle prototypes (Audi 2015).

The vehicle has a high level of automation (SAE Level 4). Multiple warning signals work in unison, including coloured LEDs and an acoustic warning indicator. Should the driver ignore the signals and fail to take control of the vehicle, the system activates the hazard lights and brings the car to a full stop on the right shoulder while minimising any risk. (Audi 2015b)

6) 2020: Google self-driving car

Google's self-driving car project is perhaps the best-known autonomous vehicle project. The company has carried out extensive field testing, with its autonomous vehicles already logging over a million kilometres. The trials initially used specially-equipped Toyota Priuses and Lexuses, which were adapted to have SAE level 3 automation (Shladover and Bishop 2015).

Google has also tested SAE automation level 4 vehicles in 2015. However, during the trial stage, the vehicles function as SAE level 3 vehicles, because the test driver acts as a back-up controller, should the vehicle systems be unable to handle a driving situation. The "Google Car" has a dome on the roof, which houses a laser range finder, radar sensors and video cameras, which it uses to identify obstacles and other objects around the vehicle. It is an electric vehicle equipped and designed mainly for riding, not for driving. As a back-up system, the vehicle includes driver controls to operate the brakes, steering and several other functions. (Google 2015b)

Google estimates it will bring out its first fully-autonomous vehicles in 2020. The company is exploring what self-driving vehicles could look like by building full-scale prototypes designed to operate safely and autonomously without requiring human intervention. The prototypes used for testing include temporary controls, but the final vehicles will not have a steering wheel, accelerator pedal, or brake pedal. These would be SAE level 4 or 5 automated vehicles.

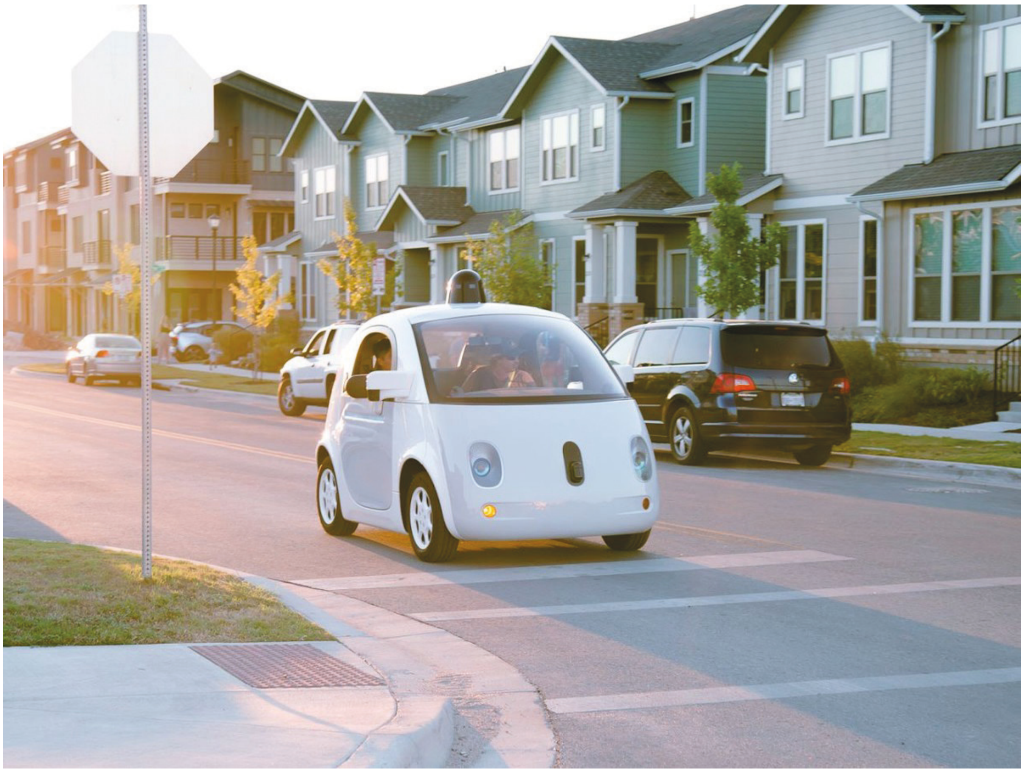

Figure 6. Google Car prototype in Austin, Texas (Google 2015d).

The vehicles are very well-instrumented, because Google wants to learn from them and adapt them as quickly as possible. The aim is for the self-driving vehicle to take its passengers where they want to go at the push of a button. A fully self-driving vehicle is an important step towards Google improving road safety and transforming mobility for millions of people (Google 2015). Testing of the first prototype vehicles began in June 2015 (Figure 6) (Google 2015d).

Google researchers have taught the cars to drive on mapped routes and navigate through many complicated scenarios on city streets. The car processes both map and sensor information to determine in what street and lane it is. Its sensors help detect obstacles and objectives around the car. The software classifies objects based on their size, shape, and movement pattern. It detects cyclists and pedestrians. The software predicts what all the objects around the car might do next. It can predict that a pedestrian is about to cross the street. (Google 2015b)

According to the latest updates (November 30, 2015), Google currently has 23 Lexus RX450h SUVs self-driving on public streets, and 30 *"Google Car"* prototypes self-driving on public streets and roads. To ensure safety, each Google vehicle has a driver behind the wheel and a software operator in the passenger seat (Levy 2016). The speed of the autonomous Google Cars has been capped at 35 mph (ca. 50 km/h) on public roads in California. In the city and streets of Mountain View, their speed has been capped at 25 mph (ca. 40 km/h). (Google 2015b)

7) 2020: Nissan Autonomous Drive

Nissan's *Autonomous Drive* programme has, according to the company, been developed to help realise an "accident-free society" by eliminating human error during driving. Autonomous Drive can be particularly effective on city streets, where the chances of being involved in an accident are 10 times higher than on highways.

Autonomous Drive would not only reduce the number of accidents, it would also allow drivers who have trouble navigating through narrow lanes and intersections a safe and sure way to reach their destinations. The technology could also greatly benefit elderly people and those with disabilities who otherwise could not drive by themselves. (Nissan 2015)

8) 2020: Apple iCar concept

The technology company Apple is rumoured to be working on an automated vehicle, but no confirmed information is available.

The first rumours about Apple's autonomous vehicle project grabbed the headlines around the world in the spring of 2015. According to the Wall Street Journal (WSJ 2015), it seems Apple is working on an electric, autonomous vehicle of its own as a direct competitor for Tesla, even though Apple's vehicle is said to be more like a minivan. If true, this so-called "*Titan Project*" will probably be released in 2020, joining many other similar vehicles.

Many sources have stated that the rumours about the Apple iCar are uncertain and highly suspected of being inaccurate. Several hundred Apple employees are said to be working on the Titan Project. Industry veterans have been poached e.g. from Tesla (electric vehicle experts), Samsung (battery experts), A123 Systems (battery manufacturer) and even the Mercedes-Benz automated vehicle project (F105 project manager) (Macworld 2015). No mention has been made about whether the iCar would be connected with the infrastructure or other vehicles – and if it will be, in what way.

9) 2025: Mercedes Future Truck

The Mercedes-Benz Future Truck observes its surroundings with numerous optical sensors, such as cameras, and by wirelessly exchanging data with other road users (V2V) and the traffic infrastructure (V2I). Signals from the optical and other sensors are combined, resulting in a sophisticated image of the truck's environment in real time.

Calmly and safely, the prototype truck rolls down the highway at 85 km/h. The tractor and trailer brake and accelerate with precision, riding in the middle of the right-hand lane in flowing traffic. Though a driver is seated behind the wheel, he can be staring at a tablet computer, planning the route and tasks of his next trip and then checking the condition of the freight stored in the semitrailer. The driver must still be prepared to take control of the truck whenever the system requests it. The truck is being driven by an automated system called *"Highway Pilot"*.

This automated truck demonstration illustrates that the vehicle can also handle special situations without a hitch: The truck can automatically pull onto the left-hand lane to allow sufficient room to pass a (broken-down) car parked on the side of the road. The truck and trailer can also pull over to the right in its lane to allow room for an emergency vehicle approaching from the rear, which announces its presence by exchanging location and speed data with the truck. The vehicles utilise vehicle-to-vehicle communication (V2V), and, more precisely, C2C technology developed by the *Car-2-car Communication Consortium (C2C-CC)*. Only when the truck leaves the highway does the driver take the wheel and steer the truck to its destination. The Future Truck was premiered on a closed-off section of the Autobahn near Magdeburg in July 2014. (Mercedes 2015)

Figure 7. *Automated Mercedes-Benz Future Truck prototype (Mercedes 2015b).*

10) 2025: Driverless economy

Ride-sharing service Uber partnered with Carnegie Mellon University to study and research driverless car technology. Uber's aim is to create a fleet of on-demand, driverless taxis. *Carnegie Mellon University* has a long history of researching autonomous driving and vehicles. As with the *Apple iCar,* this approach has plenty of sceptics and advocates. The most impassioned voices see fleets of autonomous taxis wiping out millions of jobs while simultaneously radically transforming society for the better.

Several other significant automated driving trials have been carried out in addition to the projects on the above list. The most significant Finnish autonomous vehicle trial took place in the summer of 2015.

In an internal competition of the European **CityMobil2** project, the City of Vantaa was one of the winners to carry out a demonstration of autonomous minibuses. Autonomous shuttles transported visitors between the Kivistö Railway Station on the new Ring Rail Line and the main gates of the 2015 Housing Fair exhibition area in Vantaa. The demonstration began in July when the Housing Fair opened and continued all through the Fair. The demonstration gave the public the opportunity to try out a driverless public transport service. The shuttle route was a kilometre-long section of a pedestrian and bicycle way closed to all other traffic. The driving speed was capped at 13 km/h for safety reasons, even though the minibuses could maintain speeds of over 40 km/h.

The CityMobil2 project also included other demonstrations involving automated and autonomous vehicles (SAE level 4 automation) in several European cities. The aim was to test the use of automated vehicles as a part of urban public transport. For practical reasons, the automated vehicles were segregated from other traffic in some cities, but in others, their routes covered streets also used by other vehicles. The automated vehicles travelled at a low speed to give them enough time to react to possible obstacles and hazardous situations. (Shladover and Bishop 2015)

3.1.3 Current Situation

The greatest challenge facing current automated driving technology is the ability to perceive the surrounding environment. A variety of complex technological systems are needed to manage this. Humans can make judgments about the environment and the objects moving in it at a glance. An automated vehicle should be able to process and classify environmental information at least as accurately and as quickly as a human. This requires efficient parallel computing, where several different types of sensors are used to observe the environment. Researchers have so far been unable to develop a solution that would provide sufficiently good results in all weather conditions. (Innamaa et al. 2015.) The situation "seen" by a single sensor at a particular moment is the equivalent of a human peering through a pinhole in a box.

The most commonly used sensor for monitoring the environment is the video camera. Its advantages are the low cost and the high resolution of the images. Its disadvantages include dependence on sufficient lighting and the lack of distance information. Large-scale deployment has previously been hindered by the low quality of the image analysis and data transfer systems (Vanderbilt 2012). The use of thermal imaging cameras to monitor the driving environment is also on the rise. With the arrival of new technology, prices have gone down, but so has the image resolution. However, thermal imaging cameras still have the advantage of being able to "see" in poor weather and in the dark (Innamaa et al. 2015). Ultrasound can also be used to measure distances, but it has a short range in the air. This type of sensor is inexpensive and mostly used to monitor the environment nearest to the vehicle e.g. in parking radars and parking assistance systems.

Radar sets use the echo of a transmitted radio pulse to determine the distance, direction and speed of an object. Radar has the advantage of being effective at long range and in bad weather conditions. However, it has problems with lateral resolution, making it difficult to classify objects (Wolff 2014). Lidar, or *Light Detection and Ranging*, measures the time it takes for a laser pulse to reach an object and for the reflection to travel back. This measurement can be used to calculate the distance to the object, which in turn helps determine the other physical characteristics of the object. Lidar systems need to be triggered, but they are fast and accurate, though relatively expensive. On the other hand, technological advancements tend to reduce prices. It has been estimated that the lidar Google uses and has mounted on its vehicles' roofs is an order of magnitude cheaper than earlier similar devices. The MiniFaros project developed a new, low-cost laser scanner, which can only measure short distances of up to 30 metres (Minifaros 2013).

Many OEMs have already brought out models that can perform SAE level 1 functions. Many vehicles also include SAE level 2 features, such as (parallel) parking and lane-keeping assistance. The latest automated vehicle presentations came from Toyota and Honda, both of which presented their automated vehicle prototypes at the 2013 ITS World Congress in Tokyo, and from Audi and the aforementioned automated vehicle trips between Silicon Valley and Las Vegas in 2015.

The aforementioned vehicles are capable of independent motorway driving among other vehicles, handling lane changes, merges and exits via off-ramps independently or automatically. These functions are considered SAE level 2 automation. (Schladover and Bishop 2015)

Google Cars are SAE level 4 vehicles, but during development and testing they have been equipped with temporary controls that allow the human driver to act as a back-up. Thus, during the testing phase, they are only SAE level 3 vehicles. (Google 2015b)

The aforementioned vehicles should not be confused with (fully-)automated or autonomous vehicles.

3.1.4 Automated Driving Roadmap

In the summer of 2015, the ERTRAC[1] Task Force "*Connectivity and Automated Driving*" published the Automated Driving Roadmap report (ERTRAC 2015), which states that 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 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.

The task force considers currently available SAE level 1 and 2 systems to form the basis for the deployment path for both passenger and commercial vehicles, involving a stepwise approach to higher levels of automation.

In coming years, with increasing deployment, these systems will have a significant impact on driving efficiency and safety, both in automatic and in manual mode. In conventional manual mode, the systems will act as advanced driver assistance systems.

[1] ERTRAC, the European Road Transport Research Advisory Council, is one of the European Technology Platforms (ETP). Each platform has its own Strategic Research Agenda (SRA).

Another alternative path is the urban environment systems path. In specific areas in Europe today, high-automation public transport vehicles are being developed, but they travel at low speed and/or within a dedicated infrastructure. (Figure 8)

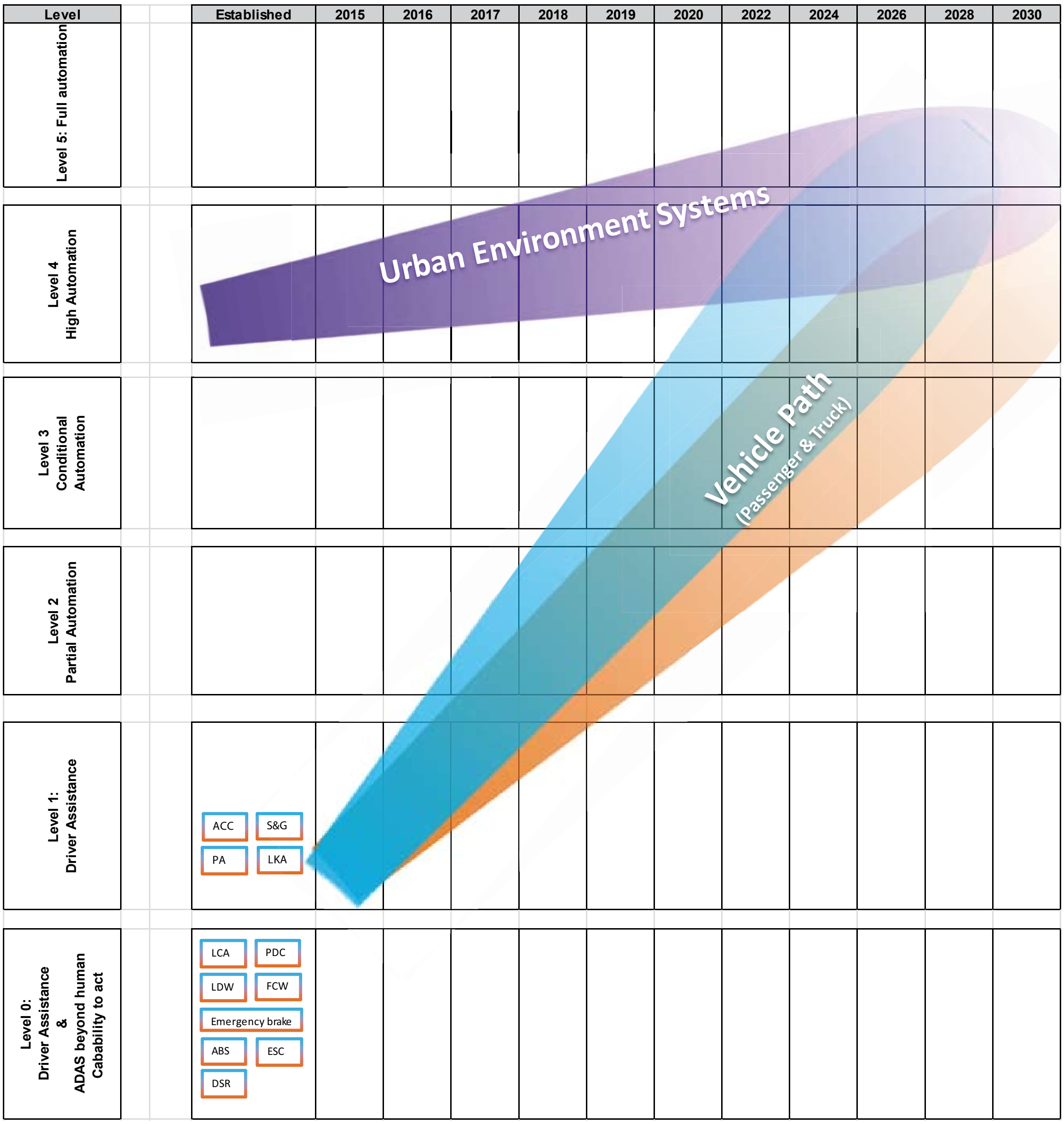

Figure 8. The main automation deployment paths (ERTRAC 2015).

Passenger cars utilising SAE level 3 automation have systems such as a Traffic Jam Chauffeur and Highway Chauffeur (Figure 9; ERTRAC 2015). Conditional automated driving in congestion is possible at up to 60 km/h on motorways and similar roads. The system can be activated when approaching or in a traffic jam. It detects a slow-driving vehicle ahead and then controls the vehicle in both longitudinal and lateral directions. Later versions of this function may also include lane change functionality. The driver must deliberately activate the system, but does not have to monitor it constantly. The driver can switch off the system at all times. The system cannot request that the driver take over control of the vehicle.

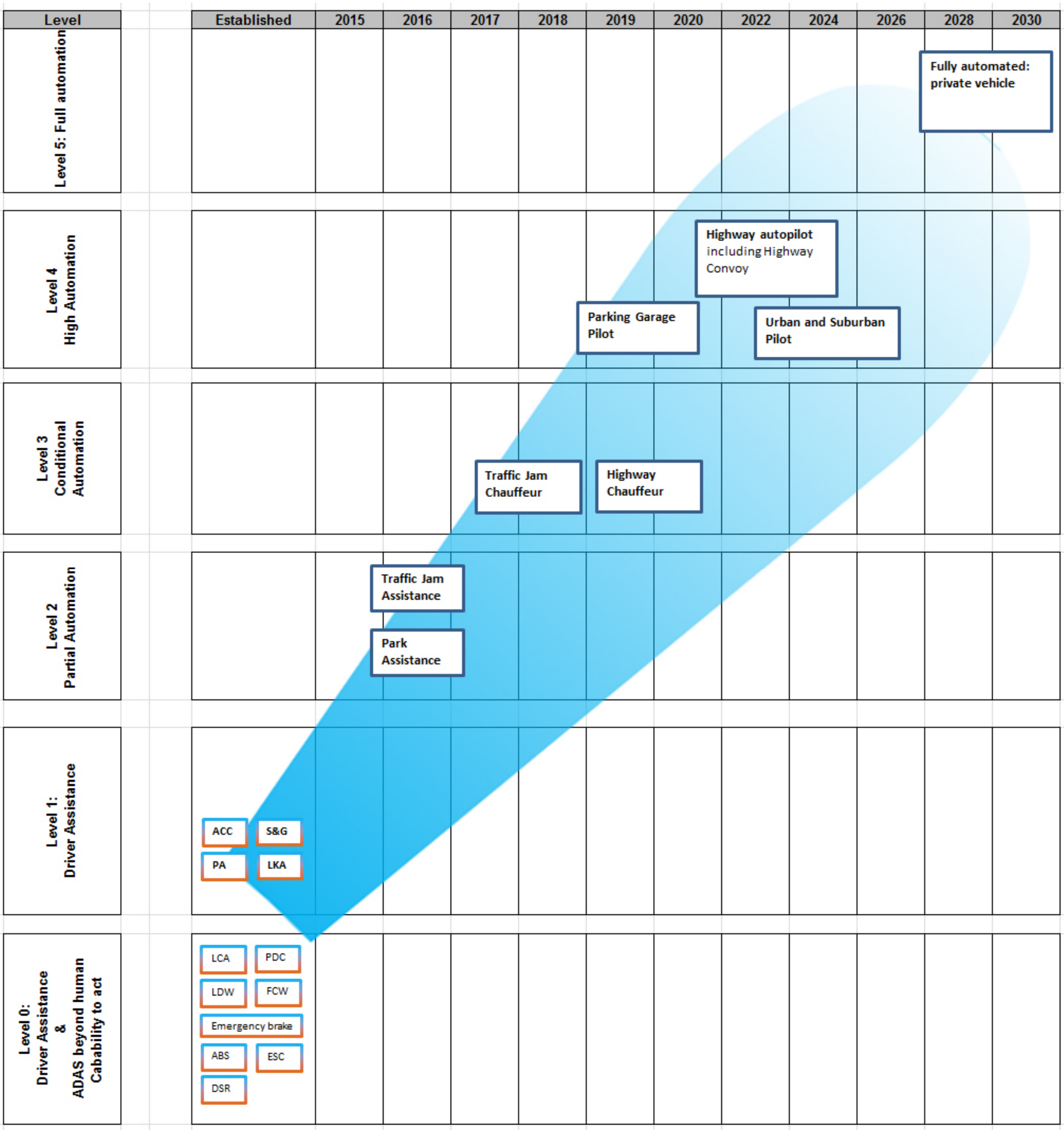

Figure 9. The automated driving deployment path for passenger cars (ERTRAC 2015).

An extension of the above function allows conditional automated driving at up to 130 km/h on motorways or similar roads from entrance to exit, on all lanes, including overtaking and lane changes. The driver must deliberately activate the system, but does not have to monitor it constantly. The driver can override or switch off the system at all times. The system can request that the driver take over within a specific time, if the system reaches the limits of its safe functioning.

Heavy vehicle automated driving aims primarily at fuel savings, but also at improving road safety and reducing the mental and psychological strain on drivers. The focus is on platooning applications (Figure 10) (ERTRAC 2015).

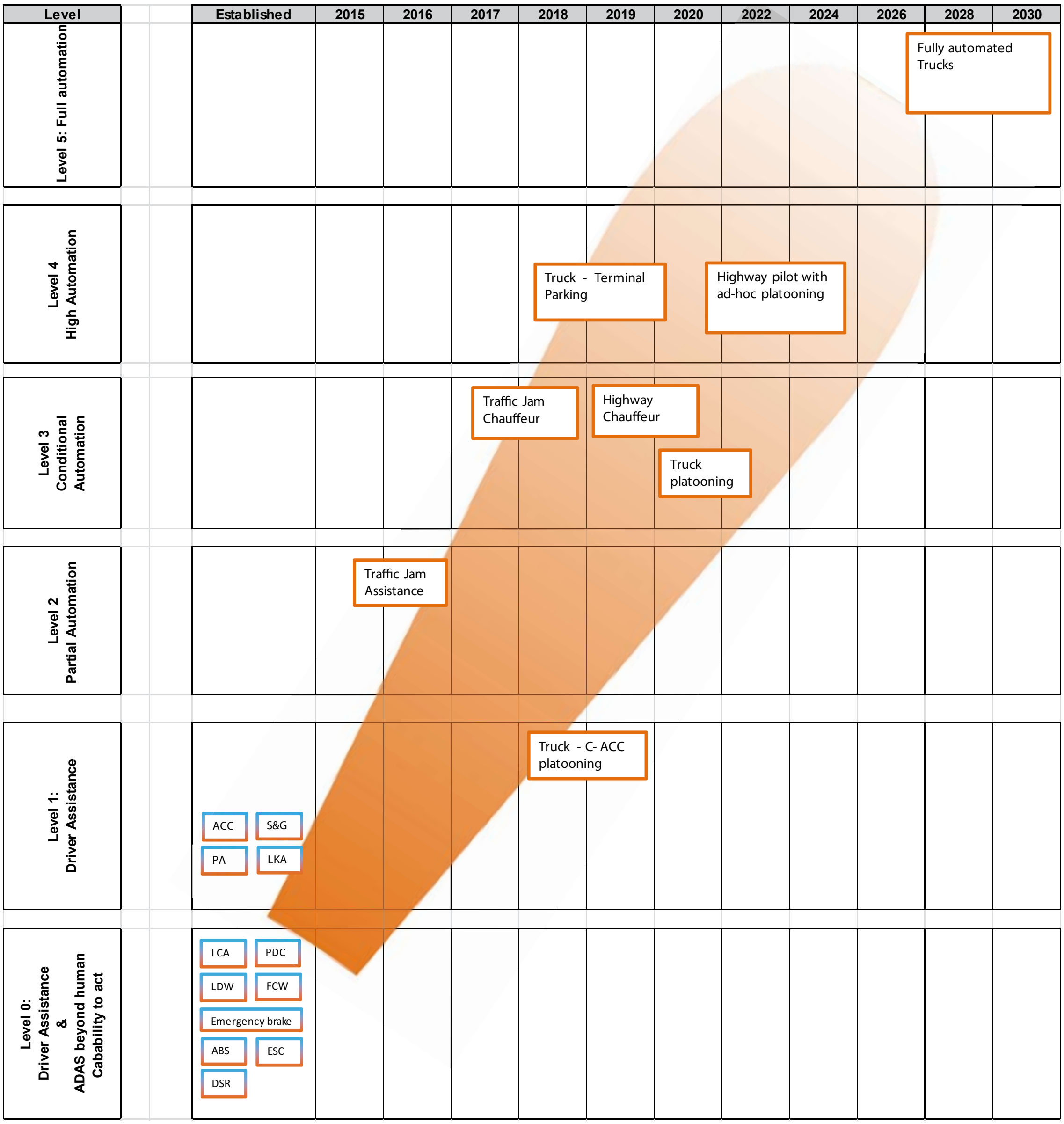

Figure 10. *The automated driving deployment path for heavy vehicles (ERTRAC 2015)*

The *Truck Platooning* function enables platooning in a specific lane. The vehicle should be able to maintain its position in the platoon at a fixed distance or fixed time difference from the vehicle in front. The behavior of the first vehicle, such as braking and steering, is transmitted along the platoon by V2V communication. The function can also handle vehicle exits from the platoon.

The *Highway pilot with ad-hoc platooning* function enables automated driving at up to 100 km/h on motorways or similar roads of two or more lanes from entrance to exit, on all lanes, including overtaking and lane changes. The driver must deliberately activate the system upon joining a platoon, but does not have to monitor it constantly. The driver can override or switch off the system at all times. The system does not request the driver to take over when the system is in normal operation on the motorway. Depending on the level of the systems being deployed, ad-hoc convoys can be created if cooperative systems and V2V communication are available (Figure 10). (ERTRAC 2015)

The *European Truck Challenge 2016* brochure drawn up by the Dutch Ministry of Infrastructure and the Environment outlined some of the benefits of platooning (Figure 11).

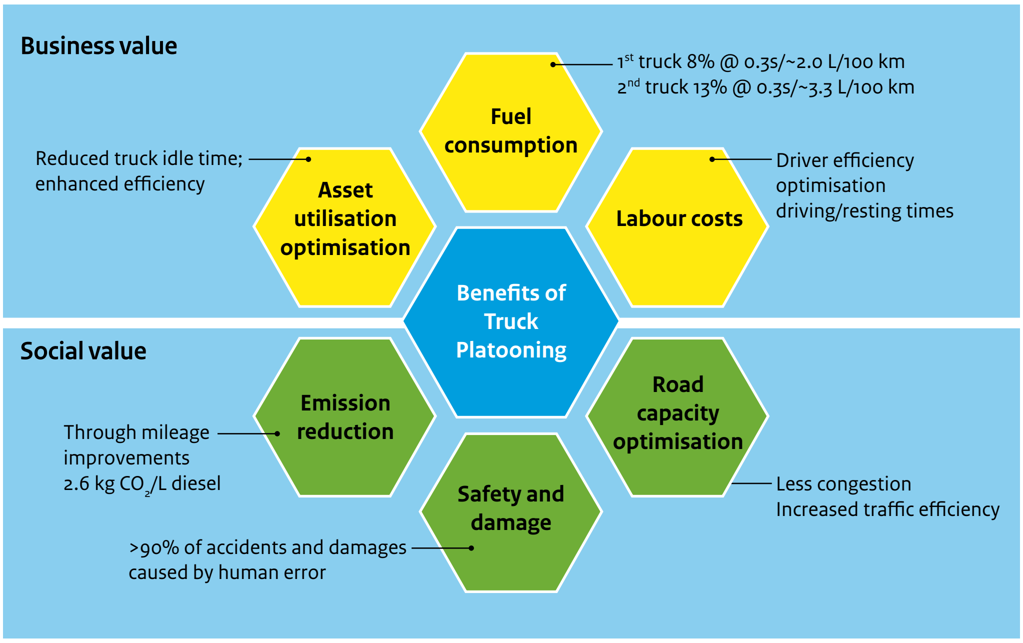

Figure 11. Benefits of truck platooning (RWS 2015).

3.1.5 Data Communications

Automated vehicles require data communication connections e.g. to support environmental observations and other vehicle features, and to transmit and receive information on traffic, congestion, road weather and roadworks. Well-functioning V2V, V2I and I2V communication are needed for all of these. The processing, storage and availability of data are the main pillars of successful automated driving.

Data communications for automated driving will likely use two communication solutions:

- The short-range radio network and its communication protocols, of which the most suitable for transport – and thus most likely to be used – is **ITS-G5**[2], which operates in the 5.9 GHz frequency band used in Europe, the United States, and much of Asia.
- The mobile telephone network, which already extensively uses **4G/LTE**[3] technology. The aim is to move on to **5G**[4] technology.

5G standardisation is not yet finished. It is hoped the standards will be completed by 2019.

Data communications will utilise the standardised communication solutions agreed on by CEN and ISO. These solutions use standard format messages for V2I and I2V communications between connected vehicles and back-office systems. Examples of this are the following C-ITS[5] messages:

- *CAM = Cooperative Awareness Message* – used e.g. to express the location, direction of movement and velocity of a vehicle
- *DENM = Decentralised Environmental Notification Message* – used to express the characteristics of the road infrastructure and environment
- *IVI = In-Vehicle Information (signalling) message* – used to relay content (of speed limit and warning/prohibition signs) to driver
- *SPaT = Signal Phase and Timing message* – used to relay information about traffic signal phases and their changes
- *MAP = Map Data of physical geometry of an intersection* – used to relay information about road infrastructure and junction geometry.

Weaknesses in cybersecurity may severely slow down the deployment of advanced data communication solutions. That is why data security must be developed in parallel with the technology. (EPoSS 2015)

Cybersecurity topics that need to be addressed include (NHTSA 2013 & NHTSA 2016):

- Security: Capability of system to resist cyber attacks
- Risks: Potential gaps in the system that can be compromised by cyber attacks
- Performance: Effectiveness of security systems
- Unintended consequences: Detrimental impact of cybersecurity on system performance
- Certification: Method to assure that critical vehicle subsystems are secure.

These topics concern both OEMs and third parties.

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[2] ITS-G5 = Intelligent Transport Systems operating in the 5,9 GHz frequency band managed, owned and standardised by ETSI

[3] 4G/LTE = Long Term Evolution, UMTS Release 8 managed, owned and standardised by 3GPP

[4] 5G = LTE Release 14 = 5th generation mobile networks or 5th generation wireless systems managed, owned and standardised by NGNM Alliance

[5] C-ITS = Cooperative Intelligent Transport Systems by CEN & ETSI, Releases 1 & 2

Product manufacturers or service providers should develop and ensure data security solutions that address the above topics. In the case of road traffic, this falls on OEMs. They have an interest in data security, privacy protection, and preventing malware and cyber attacks. This interest is primarily focused on protecting in-vehicle systems, such as on-board data buses and computer units, i.e. ensuring that their own products remain uncompromised. If V2I communications are carried out using third-party equipment and/or third-party services, OEMs have limited power to ensure those communications are secure.

3.1.6 Frequency Regulations

Vehicles and in-vehicle equipment utilise radiocommunications more and more. Autonomous vehicles are especially dependent on data transfer technologies to be able to exchange and share information with the road infrastructure and other vehicles. The use of frequency ranges should be harmonised internationally, so that e.g. short-range radar *(SRR)* equipment can communicate with systems in different countries. The 79 GHz frequency band was chosen for this purpose, as it was identified as the most suitable band for the development and deployment of short-range radars. The 79GHz project aims to speed up the attainment of frequency regulation status for the 79 GHz band as the frequency allocated for short-range radar in each country. (79GHz 2012)

The Finnish Communications Regulatory Authority (FICORA) directs and oversees telecommunications and telecommunication companies, including mobile network operators. It also ensures that electronic data networks and services are safe to use, reliable and available to consumers and businesses. The FICORA duties most important for road transport automatisation are e.g. management and oversight, technical performance and data security of data networks, cybersecurity, data security and consumer protection, licences for operation, laws, regulations, decrees, guidelines, and notifications.

In Finland, the uses of the radio frequency spectrum are defined in Radio Frequency Regulation 4 and its Frequency Allocation Table (FICORA 2015), which came into force on January 1, 2015 and were complemented by more detail on February 6, 2015. In the Frequency Allocation Table, mobile land radio communications is allocated e.g. the 5.7–5.9 GHz and allowed restricted use of the 5.90–5.95 GHz frequency bands, and automotive short-range radar is allocated the 78–79 GHz frequency range (Table 3).

Table 3. Frequencies allocated for ITS in Finland. (FICORA 2015).

Frequency band Services in Finland	Sub-band (its width) and usage	Mode of traffic Class of station and direction	Terms and comments as to radio interface
5730–5900 kHz Land mobile	5730–5900 kHz (170 kHz) Land mobile		
5730–5900 kHz Fixed	5730–5900 kHz (170 kHz) HF links	Simplex Fixed station (FX) TXRX	
5900–5950 kHz Broadcasting	5900–5950 kHz (50 kHz) Broadcasting		*Restricted fixed and mobile service possible, on condition that harmful interference is not caused to the broadcasting service (RR 5.136, 5.143, 5.146 ja 5.151).*
78–79 GHz Radiolocation	78–79 GHz (1 GHz) Automotive Short Range Radar (SRR)		*77–81 GHz automotive Short Range Radar (SRR). See FICORA Regulation 15.* *Standard EN 302 264.* *ECC Decision ECC/DEC/(04)03.* *European Commission Decision 2004/545/EY*

The current development of communications for road transport automatisation in Europe is primarily based on short-range V2V communications on the 5.9 GHz frequency band (ITS-G5). This solution is also preferred by OEMs, who consider ITS-G5 the most suitable data transfer technology for cooperative systems and automated driving safety functions.

The approach of using the same technology in the road infrastructure and roadside devices as is used in connected vehicles has been under assessment ever since the idea of V2X communications arose. Many system developers support it. This approach is now undergoing a major upheaval, because new requirements and objectives call for the use of the (long-range) mobile phone cellular network. In recent years, many research projects connected to this issue have been carried out in the Nordic countries, and especially in Finland.

A good example of this is the NordicWay corridor project. As part of NordicWay, the Finnish Coop pilot tests the use of the mobile network and phones for I2V and V2X communications and the transmission of road safety information messages. (Traffic Lab 2015)

3.2 Driver Behaviour

3.2.1 Behavioural Studies

Increased vehicle automation has been shown to affect driver behaviour. Automated vehicles are handling more and more of the tasks drivers used to do. It has been estimated that this may lead to a greater lack of situation awareness (Hancock and Parasuraman 1992), meaning that drivers may not be able to react to changing traffic situations as quickly as they did during “conventional” driving. It has also been estimated that drivers may be too confident in driver assistance systems and unable to grasp their limitations (e.g. in bad weather or poor visibility). Of course, driver confidence is dependent on system reliability (Moray et al. 2000). Therefore, changes in driver behavior should be examined on all levels of driver decision-making (Innamaa 2015).

On SAE automation level 3, the vehicle can handle most dynamic driving tasks, but the driver is expected to be able to take control very quickly if the system requests it. There has not yet been sufficient research into drivers' ability to take control of the vehicle in different situations.

Typically, the chain of events in road traffic has several variables, the combined effects and delays of which are not sufficiently known. A key part in the chain of events is the system delay, the result of sensors first noticing an object, then identifying and classifying it, and then initiating the necessary corrective and/or crash-avoidance actions in the vehicle systems. The time this takes is away from the time available for braking or other evasive action.

An acceptable maximum deceleration rate can be defined for braking performance. The driving speed may be so great that in the time it takes from sensor detection to classification the vehicle has moved so much that nothing can be done to stop the vehicle or initiate automatic evasive manoeuvres in time.

3.2.2 Challenges Associated with Driver Behaviour

Current technology is able to save automated vehicle occupants from crashing into a stationary object at speeds of up to nearly 120 km/h in motorway conditions and on a dry road, as illustrated by the following example.[6] At motorway speed (120 km/h), a vehicle travels 33 metres every second. On a dry road surface, the vehicle will come to a stop after 4 seconds of powerful braking, having travelled a distance of 62 metres. In the best case scenario, the vehicle could swerve to avoid the object, but if the vehicle does not swerve, it will hit the object at a low residual speed. In wet road conditions, a vehicle travelling at 120 km/h has a braking distance of 93 metres and a braking time of 6 seconds (Figure 12).

> Current technology allows an **automated vehicle** to avoid crashing
> into a stationary object at a speed of up to nearly 120 km/h
> only in motorway conditions and on a dry road.

Figure 12. The limitations of the current technology.

[6] The effect of the deceleration rate, weather conditions and situational speed on stopping distance can be calculated using the Finnish Road Safety Council's Stopping distance calculator. http://extrat.liikenneturva.fi/pysahtymismatka-auto/en/

For example, Merat and Jamson (2009) conducted an experiment, in which they compared driver performance in a variety of critical situations using an ”autonomous” vehicle and a ”conventional” vehicle. The objective was to evaluate the drivers’ situation awareness when travelling in an automated vehicle (SAE level 3) and to find out how well the drivers understood the various vehicle functions. The study also wanted to find out the drivers’ opinions concerning the various functions and the way the vehicle reacted to different traffic situations. During the experiment, the drivers had to constantly monitor the traffic. The study found that drivers reacted to critical traffic situations significantly more quickly in a ”conventional” vehicle than in an autonomous vehicle. The drivers were also better able to predict critical situations in a “conventional” vehicle.

Merat and Jamson (2009) concluded that even though autonomous vehicles provide many benefits, such as reducing traffic emissions, a human driver should actively participate in the driving task at all times to ensure road safety. Otherwise, there is a risk that the driver will not be able to take control of the vehicle quickly enough when necessary.

Merat et al. (2014) continued to study the same topic – how vehicle control is switched from the vehicle to the driver – this time from the driver’s perspective. They examined how quickly a driver could take control of the vehicle when requested to do so by the vehicle systems. Either a warning was given at a set time before vehicle control had to be retaken, or the timing of the warning depended on the amount of time the driver had been inactive. The central finding was that after the warning, drivers took 35–40 seconds to safely take control of the vehicle. This is many times longer than the 2–10 second estimate commonly referred to in public.

3.3 Acceptance of Road Transport Automatisation

3.3.1 User Acceptance of Road Transport Automatisation

In Schoettle and Sivak’s (2014) user survey, most of the respondents had heard of automated vehicles and had high expectations about the benefits of the technology. However, most of the respondents were somewhat concerned about the safety of automated vehicles. The majority of respondents also had reservations about riding in an automated vehicle. The majority of the respondents expressed at least some desire to have this technology in their vehicle, but on the other hand, nearly 35 % expressed no interest in this. The respondents were also unwilling to pay extra for the technology. Females expressed higher levels of concern about automated vehicles than males.

The *TE Connectivity* survey found that nearly 70 % of respondents would not be comfortable riding in an autonomous vehicle. The majority of respondents were concerned about the safety technology and about relinquishing control of the vehicle to automated systems. Females were less comfortable with the idea of riding in an autonomous vehicle than men. Older respondents were less comfortable with the idea than younger respondents. The biggest benefits of automated vehicles were thought to be improved fuel efficiency, less traffic congestion, relief of vehicle occupants from driving and navigation responsibilities, and enhanced productivity. (TE Connectivity 2013)

According to research results published in Auto Express, one in four respondents felt automated vehicles would not be safe, and over half of respondents would not purchase one. Respondents were most concerned about system malfunctions, lack of human control and cybersecurity issues. (Auto Express 2014)

Interviews conducted as part of the CityMobil2 project showed that users were willing to trust autonomous vehicles, but only if they knew they were safe. Dedicated lanes for automated vehicles might make users feel safer. The interviewees desired that the appearance and behaviour of the vehicles should resemble conventional vehicles as much as possible. (CityMobil2 2014)

In KPMG interviews, the majority of respondents announced that they did not want to give up owning a vehicle. Presented with the option of being able to summon an automated vehicle in fifteen minutes, more than half of the respondents said they would consider giving up their second car. (KPMG 2013)

Looking at these findings, it is good to remember that there have been significant technological developments made in the two years since these surveys were conducted. Awareness of automated driving has also increased, partly due to the media attention the technology has received. If a similar survey was conducted now, the results might be somewhat different, as the public is more informed about automated driving and technological developments and their potential.

3.3.2 Ethical Considerations

Before automated vehicles can become widespread, OEMs must solve tricky issues concerning vehicle performance and algorithms. How should an automated vehicle be programmed to act in the event of an unavoidable accident? Should it minimise the loss of life, even if it means sacrificing the vehicle occupants, or should it protect the occupants at all costs? Should it choose between these extremes at random? The answers to these ethical questions are important because they could have a significant impact on the way automated vehicles are accepted in society.

People generally like the idea that automated vehicles could be programmed to minimise the number of fatalities. But in practice, the result might be the death of all vehicle occupants. This consideration made people less confident that automated vehicles should be programmed that way in reality: they wished that others would ride in vehicles with this programming more than they wanted to buy such vehicles themselves.

So is it acceptable for an automated vehicle to avoid hitting a motorcycle by swerving into a wall, considering that the probability of survival is greater for the occupants of the car than for the rider of the motorcycle? Should different decisions be made if there are children on board, because they have longer to live than the adult motorcyclist? Answers to these questions are sure to be debated for some time, and as ethical programming becomes more advanced, some solutions may be reached.

This chapter is based on the findings of Rose (2015) and Bonnefon (2015).

3.4 Transport System-Level Impacts

3.4.1 Traffic Flow

In the long term, transport automation has a significant impact on traffic flow. Road transport automatisation has a positive effect on many traffic flow characteristics, such as safety and fluency, even though these positive effects will only be attained after the study period of this project. The positive impacts will become visible especially slowly on a transport system level.

For the next few years, possibly even a decade, a few products from a few OEMs will lead the way. The rate of penetration for these individual models is estimated to increase slowly at first. As more models equipped to support automation are introduced, the different models' relative popularity may match each car maker's market share, or even surpass it. As more OEMs and more models enter the market, a reasonable share – perhaps even 10–20 % – of all new vehicles may be automated.

Finland's slowly-renewing car stock and decrease in the number of new driving licences issued annually are the Achilles heel of this process. Young people are especially less likely to get a driving licence for any vehicle category from mopeds and motorcycles on up. The rate of renewal of Finland's car stock is on average slower than that of Europe (ACEA 2012). Unless serious attention is paid to speeding up the rate of renewal, conventional and automated vehicles will coexist on Finnish roads for decades to come.

Innamaa et al. (2015) estimate that the positive impacts of automatisation on traffic flow will only be seen at SAE level 3. At lower levels of automation, congestion is more likely to occur, and congestion reduces driving speeds. Speeding and the number of shock waves may be reduced even at the lower automation levels, but the total traffic flow capacity would still not be improved. At SAE automation level 3, the capacity and fluency of the traffic flow are improved, because connected automated vehicles can have shorter headways. The number of shock waves and speeding vehicles will also be reduced. At higher levels of automation, the positive impacts on traffic flow will be even greater.

3.4.2 Road Safety

Human factors have been estimated to contribute to up to 90–95 % of all traffic accidents (Hoeger et al. 2011). Automated driving will reduce both reaction times and the number of accidents caused by human error. Research has estimated that automated vehicles may reduce accident rates by 50 % when their rate of penetration is 10 % of all vehicles, and by up to 90 % when their rate of penetration is 90 %. Technological advancements have also been taken into consideration in these figures, as the rate of penetration will take several years to increase this much. (Fagnant and Kockelman 2013)

Automated driving may also present new hazards caused by automation, such as perceptual and reasoning errors and software bugs (Fraichrard and Kuffner 2012). Goodall (2014) states that even automated vehicles with perfect systems cannot avoid all crashes involving other vehicles, cyclists, pedestrians, and wildlife.

Innamaa et al. (2015) say that automatisation will have a positive impact on road safety at every level of automation, improving the predictability, comfort and environmental friendliness of transport.

Since it started in 2009, vehicles in the Google Self-Driving Car Project have driven a total of almost 3.7 million kilometres: 2.1 million kilometres driven automatically (= software drives the vehicle and the test driver does not touch the steering wheel) and ca. 1.5 million kilometres driven by the test driver. An average of 16,000–24,000 self-driven kilometres are logged every week. During a period of six years, Google Cars were involved in 17 accidents resulting in material damages. According to Google, their self-driving vehicles were never at fault. (Google 2015b)[7]

3.4.3 Environmental Impacts

According to Innamaa et al. (2015), automated driving has a positive impact on road transport emissions, cutting energy consumption by reducing the amount of stop-and-start traffic. Smoother traffic flow and fewer speeding vehicles also mean there is less noise pollution. A recognised environmental disbenefit is the potential increase in vehicle use. If long-distance car journeys and urban sprawl increase, the environment will also be impacted negatively. Urban sprawl lowers the level of service provided by public transport and may thus lead to increased private car use.

Platooning can cut fuel consumption and thus reduce the environmental impacts of traffic. Research shows that a platoon’s lead truck can reduce its fuel consumption by 8 % and the following vehicles can reduce theirs by up to 16 % compared to a lone truck. (Chan 2012)

Vehicle design affects their fuel efficiency and emissions and therefore their environmental impacts. On one hand, automated vehicles will probably be made of lighter materials, while on the other hand, they may be greater in size to provide added comfort. It is therefore difficult to predict the specific energy consumption of automated vehicles. (Innamaa 2015)

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[7] While this report was being finalised, the first accident caused by a Google Car made headlines. The incident involved a self-driving car changing lanes to the left and hitting the side of a bus approaching from behind and in the left lane.

3.5 Regulatory Issues

3.5.1 Development of Transport Legislation in General

Brief overview of international treaties:
The Vienna Convention on Road Traffic[8] decrees that every moving vehicle must have a driver, who shall at all times be able to control his vehicle. Amendments to the Convention that have entered into force allow for the approval of advanced driver assistance systems, if they can be overridden or switched off by the driver, who can thus take control of the vehicle. (Ministry of Transport and Communications 2015)

Other significant international treaties on road traffic that may affect road transport automation include e.g. the Geneva Convention on Road Traffic[9] (SopS 70/1976), the UNECE Agreement and Regulations concerning the Adoption of Uniform Technical Prescriptions, and the Agreement on Global Technical Regulations (GTR Agreement) (SopS 54/2001). A comprehensive list of treaties and their content can be found on the Trafi website in Finnish. (Trafi 2016)

Brief overview of national legislation:
Germany and Sweden are updating their legislation to allow the use of driverless vehicles. France has proposed an addendum to the Vienna Convention and laid out its road map for automated driving in July 2014. The road map proposes changes to driver training and calls for automated driving regulations and requirements to be set already during the testing phase, before the vehicles are on the market. (ANE 2015)

A UK review published in February 2015 states that automated vehicles can legally be tested on public roads in the UK, provided a test driver is present and takes responsibility for the safe operation of the vehicle. (DfT 2015)

In the United States, some level of automated vehicle use in traffic is allowed in some states. The states of Nevada, California, Florida and Michigan and the District of Columbia have passed laws allowing automated vehicles to at least be tested, probably because significant road transport automation development projects and test areas have been or are going to be set up in these states. (Weiner and Walker Smith 2015)

Brief overview of Finnish legislation:
In Finland, the provisions of the Vienna Convention on Road Traffic have been implemented through the Road Traffic Act. While the Road Traffic Act does not define a driver, it is based on the assumption that a human driver is responsible for the vehicle. However, it is not necessary for the driver to be inside the vehicle, allowing for the remote control of a vehicle. (Ministry of Transport and Communications 2015)

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[8] The Vienna Convention on Road Traffic (SopS 30/1986) is an international treaty concluded in 1968. In ratifying countries, it replaces the earlier Convention on Road Traffic agreed upon in Geneva in 1949 (SopS 11/1959). http://www.trafi.fi/tieliikenne/saadokset/kansainvaliset_sopimukset

[9] The SopS 70/1976 relates to the Agreement concerning the Adoption of Uniform Technical Prescriptions for Wheeled Vehicles, Equipment and Parts which can be fitted and/or be used on Wheeled Vehicles and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis of These Prescriptions.

Finnish legislation already allows advanced automated driving, and immediate legislative amendments have been deemed unnecessary. Finnish legislation would allow the type of development and trial projects currently being carried out in Europe and the US to be implemented on Finnish public roads. (Ministry of Transport and Communications 2015)

3.5.2 Driver, Right to Drive, and Training

European driving licences are approved throughout the EU. EU Directive 2006/126 defines some requirements for driver training. The introduction of automated vehicles sets certain demands on driver training and examinations. Therefore, EU directives will also have to be updated (DfT 2015). Apart from heavy vehicle and other professional drivers, Finnish drivers do not currently have to regularly update their skill sets to maintain their right to drive. (Innamaa 2015)

EPoSS (2014) states that the issue of when the driver, the owner of the vehicle or the vehicle manufacturer is responsible for an accident must be resolved. A fair balance between these three potential responsibilities has to be established. One solution would revolve around the matter of guilt. Driver liability, criminal liability and product liability must be kept separate.

Automated vehicles have a variety of functions and new technology drivers may find difficult to comprehend. Schladover and Bishop (2015) emphasise that user instructions to the driver are very important. It is essential that drivers understand how the different levels of driving automation work.

The level of safety and skill required of an automated vehicle can be determined in a variety of ways. People develop as drivers slowly and through experience. Does a driver possess all the skills needed in traffic upon receiving the right to drive? Should an automated vehicle behave like a law-abiding average or highly-skilled driver? Some have suggested that the goal should be to match the safety of an average driver. (Schladover and Bishop 2015)

New, more automated heavy vehicles require drivers in the future to possess not only driving skills, but also computer skills. Driver training may need to be reformed to teach not just vehicle control but also e.g. route planning, use of mobile devices, analysis of electronic faults etc. (TTS 2015).

As cost pressures and the number of different driver assistance systems increase, the use of driving simulators as training tools will also increase. A variety of simulated exercises are needed to learn how to drive an automated vehicle that may react in unexpected ways for safety reasons. This is similar to pilot training, where a long period of ground training in flight simulators must be undertaken before a person is allowed to try flying an actual plane. Driving simulators are likely to become more model-specific (Akarsu 2014), just as flight simulators are modelled after different airplane types.

3.5.3 Type Approval and Roadworthiness

International agreements, type approval and/or EU regulations define the types of vehicles that can be sold and used within the EU. The introduction of automated vehicles means these regulations must be amended. Similar changes will need to be made to the ISO standards on vehicle instrument panel symbols and driver warnings. Developing these standards is likely to take several years. (DfT 2015)

Automated vehicles will also change how vehicles will be certified as roadworthy. Nowadays, one of the fundamental aims of vehicle inspections is to determine whether a vehicle is roadworthy. Schladover and Bishop (2015) say this will pose two great challenges: how to define a safety level for automated vehicles, and how to determine whether a vehicle meets the demands set for it in order to be certified. It can also be difficult to test the overall safety of a vehicle in normal traffic just because dangerous situations occur relatively rarely.

3.6 Other Findings

3.6.1 Mobility as a Service

Road transport automation is linked with many new transport services and service concepts. Automation can help bring added value to services characterised by flexibility, reliability, repeatedness and a limited operating and/or service area.

Mobility as a Service (MaaS) is a new transport and travel concept. Travellers can be offered mobility services in a variety of packages. Existing applications, which allow travellers to order rides, can also be considered a part of the MaaS concept.

In October 2015, the Finnish Minister of Transport and Communications Anne Berner launched the European MaaS Alliance at the ITS World Congress in Bordeaux. At time of launch, the Alliance included 20 organisations from different countries. During the Congress, more than 50 organisations expressed an interest in joining the Alliance. In order to ensure the international scale of MaaS solutions, *Ertico – ITS Europe* decided to host the Alliance working groups. Ertico thus hopes to ensure the international harmonisation of the interfaces, data models and digital platforms required by new mobility services. In Finland, the 23-member MaaS.fi community began operating as the limited company MaaS Finland Oy. The company is financed by four Finnish and four foreign companies.

Automated vehicles can be utilised in public transport, e.g. in feeder traffic, which transports passengers short distances to/from public transport terminals (Gorris et al. 2012). The long-term goal of the MaaS concept is that the introduction of MaaS and automated vehicles will reduce the need for people to own their own cars (Rantasila 2015). Fagnant and Kockelman (2014) suggest shared autonomous cars may completely replace privately owned vehicles.

Some studies estimate that automated vehicles will help the spread of the MaaS concept. SAE level 5 automated vehicles do not need a driver, which means their supply can better meet their demand around the clock (Ford 2012). An automated vehicle, such as a minibus, will also be cheaper to operate than a vehicle with a driver. Lower operating costs may also reduce ticket prices, which may in turn increase the use and improve the profitability of public transport. (Heikkilä 2014)

As both the MaaS concept and automated vehicles become more widespread, land use may also change. Automated vehicles place more demands on the transport infrastructure than conventional vehicles. The need for parking spaces will also be affected; there will be less need for parking spaces e.g. in city centres, but the automated vehicles will need parking depots to return to after journeys. The utilisation rate of automated shared cars is estimated to be greater than that of privately owned passenger cars (Rantasila 2015). The trips to and from parking depots will also add to the total number of journeys.

At the time of writing, several MaaS projects connected with automated driving are being planned in Finland, e.g. in Helsinki, Tampere and Fell Lapland. In Fell Lapland, a unique pilot for MaaS at the Ylläs holiday resort has been launched in early 2016 (Snowbox.fi).

4 Action Planning

4.1 Planning Method

The actions that would be necessitated by road transport automation were assessed on the basis of international contacts and sharing of information, literary reviews, existing data, background information and reviews of news coverage on the subject. The general method was to use the aforementioned information to assess and propose road traffic situations, circumstances, events and operations that might require changes due to automated driving. The aim is to reach a state in which automated vehicles operate safely, logically and in a predetermined way.

The first step was to identify domains within which circumstances and/or situations might occur that were thought most likely to create difficulties and/or challenges for automated vehicles. These domains were compiled from action cards that contained use case descriptions and explanatory texts that provided readers with a clearer understanding of what the domain titles covered.

Each domain was divided into smaller subgroups describing individual challenges and the actions that could be taken to combat them. All the above were logged into action cards like the one seen below (Figure 13). Each action card was given a title and contained descriptions of use cases and the activities to be taken.

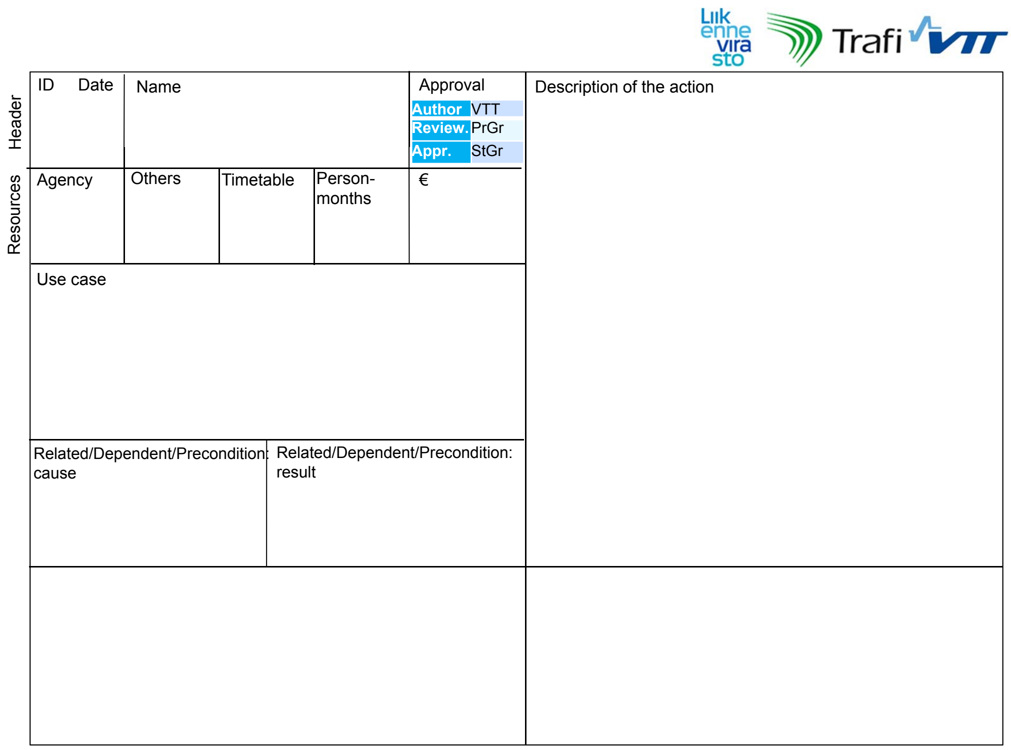

Figure 13. Action card template (PrGr = Project Group, StGr = Steering Group)

4.2 Action Planning Topics

Throughout the project, the aim was to produce results without taking any unnecessary steps. Apart from a few exceptions, the individual actions progress from one to another logically; each individual action is a prerequisite for the deployment of the next action.

The actions were clearly divided by topic. The initial approach was to divide the actions according to the agencies responsible for coordinating them. However, the use case and content descriptions resulted in action cards containing individual activities with more than one responsible entity.

In the end, **the action cards were divided by topic** into five domains: infrastructure, road superstructure and equipment, vehicle systems, services and functions, and driver.

Each domain contained the action cards associated with the topic. Initially, during the first phase, a total of 49 action cards were drafted (Table 4). These were then discussed in depth at all project levels, including in the stakeholder workshop. The results obtained formed the basis for the drafting of the road map.

Table 4. Action cards divided into five domains.

Infrastructure	Gradual deployment of road network for automated driving
	Guidelines and verification of road network for automated driving
	Design guidelines for junctions
	Railway level crossings
	Impact on traffic management strategies
	Deployment of communication infrastructure
	Availability of communication infrastructure
	Data content of digital maps
	Back-office systems and related data collection
	Movable roadside infrastructure (for road works, special events, etc.)
Road superstructure and equipment	Visibility and condition of road markings and traffic signs
	Location databases for automated driving
	Alternative routes and detours
	Harmonisation of road traffic control
	Sensors or beacons embedded into road pavement
	Consequences on road structure and surface wear
	Posts and poles for guidance and positioning
Vehicle systems	Positioning of vehicle
	Environmental sensing
	Enhanced sensor technologies for snow and ice conditions
	Radio frequency allocations
	Hybrid communications
	Reception of cooperative I2V messaging
	Requirements for traffic status information
	Properties and impacts of SAE level 3 automated driving
	Identification of abnormal and hazardous transports
	Functionalities of signal control
	Type approval of automated functions
	Changes in inspection of vehicles' roadworthiness
	Provision of in-vehicle safety data to authorities
	Aftermarket device connectivity with vehicle
	Safe use of information while driving
	Access to in-vehicle resources and data
	Personalisation of automated function parametres by users
	Availability of data on vehicle features and equipment
Services and functions	Test areas
	Test vehicles and fleets
	Activation of and support for stakeholders in testing and piloting
	Impact assessment
	Required quality of real-time traffic information services
	Truck and bus platooning
	Automation in travel chains
Driver	Right to drive and examination in transition phase
	Driver training and instruction
	Privacy and security
	Information to user segments, media, channels

5 Road Map for 2016–2020

5.1 Objectives and Drafting

The aim of the road map was to identify and schedule the key public sector actions necessary for facilitating automated driving and for making the deployment of minimum SAE level 3 automated driving feasible in Finland by 2020. Issues potentially associated with the higher SAE levels 4 and 5 were also examined.

At the current stage of development, the general starting point is to designate a suitable road network for automated driving that can be equipped with the necessary features and devices/services. The extent of this network is substantively affected by the technical and non-technical development status of the network, vehicles and drivers and the scheduling of investments.

Special attention was given to reaching sector-wide agreement concerning the methods, responsible entities and timetable for proceeding. Dialogue and interaction between the transport sector authorities in groups and workshops was essential. On the other hand, the importance of international cooperation was not forgotten. The need for cooperation was emphasised in situations in which it would make up-to-date and internationally harmonised progress possible in Finland.

A road traffic automatisation stakeholder group was formed. It consisted of public and private stakeholders, universities, research institutes and interest groups. The group would come to include more than 230 road transport experts representing over 100 organisations. More than 80 of these experts represented transport authorities. The experts participated in three workshops drafting proposals that would come to form the basis for the road map.

Even though the development and roll-out of automated vehicles are to a great extent the responsibility of the automobile industry and other private stakeholders, the road map focuses mainly on tasks and activities that are the responsibility of the Ministry of Transport and Communications and the authorities in its jurisdiction.

The road map is outlined in the following chapters:

- Chapter 5.2: Road Map for High-Level Political and Strategic Actions
- Chapter 5.3: …for Transport Infrastructure Actions
- Chapter 5.4: … for Traffic Actions
- Chapter 5.5: … for Communication Infrastructure Actions

The authorities decide on what actions are taken and which entity is responsible for each action. The responsible entity coordinates the individual activities associated with the action.

5.2 Road Map for High-Level Political and Strategic Actions

High-level political and strategic actions call for wide-ranging consensus, cooperation between different agencies and/or extensive public debate. The action cards fall under four domains: I. Infrastructure, III. Vehicle systems, IV. Services and functions, and V. Driver.

Most of the activities outlined in the action cards take place within the first three years of the study period, i.e. 2016–2018. These include e.g. Finnish test areas for automated driving, coordination and cooperation between these test areas, the activation of stakeholders, various impact assessments, and privacy and data security. A single agency should coordinate the public sector dissemination of information about automated driving.

Table 5. High-level political and strategic action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

ID	Title	2016 Q1 Q2 Q3 Q4	2017 Q1 Q2 Q3 Q4	2018 Q1 Q2 Q3 Q4	2019 Q1 Q2 Q3 Q4	2020 Q1 Q2 Q3 Q4
I.1	**Gradual deployment of road network for automated driving**					
I.2	**Deployment of communication infrastructure**					
III.1	**Properties and impacts of SAE level 3 automated driving**					
IV.1	**Test areas**					
	Aurora					
	NordicWay					
	H2020 test areas					
	Urban test areas					
	Motor racing tracks					
IV.2	**Impact assessment**					
IV.3	**Activation of and support for stakeholders in testing and piloting**					
V.1	**Information to user segments, media, channels**					
V.2	**Privacy and security**					

New kinds of technological development, testing and trial ecosystems at numerous Finnish **test and trial areas** form a significant whole. The authorities are responsible for coordination and synergies between test area activities. The monitoring of progress and action planning and deployment at individual test areas is carried out by the agency to whose jurisdiction each test area predominantly belongs.

The above table lists the test areas that have already been established or are to be established in early 2016. The most significant test areas in the study period are the Nordic cooperative project **NordicWay** (http://www.nordicway.net/) and its Finnish part Coop, which is the primary operative responsibility of the Finnish Transport Agency, and the **Aurora project** (http://www.snowbox.fi/) taking place in Fell Lapland.

Some cities have set up test area projects for intelligent, connected and automated road traffic. Two significant test areas are in Tampere: the well-established and now expanding **ITS Factory – TestITS** and the new **UrbanAutoTest project** that was kicked off in January 2016. In the **TestITS** project, corporations, research institutes and the City collaborate to test different intelligent transport solutions at sites all around Tampere. The **UrbanAutoTest** project focuses on the development, trials and testing of connected and automated vehicles in urban environments and traffic

The **LivingLabBus** project is about to start in Helsinki. It is built around electric buses designed, developed and manufactured in Finland, which act as a development platform for automated buses. Encouraged by the **CityMobil2** pilot carried out in Vantaa in the summer of 2015, Tuusula is planning a similar public transport automatisation trial.

Other high-level actions include the management and coordination of **impact assessments** associated with the aforementioned trials and other activities, and the activation of value chain stakeholders on a national – and initially on a local and regional – level. After the initial stages, the entities in charge of each project also take responsibility for these actions.

The issues associated with **privacy and data security in automated driving** have become key action targets. They may even hinder or at least slow down the deployment of automated driving, if they are not dealt with or the challenges they pose are not solved in a timely fashion.

5.3 Road Map for Transport Infrastructure Actions

Transport infrastructure management is responsible primarily for the road network, traffic on the road network, traffic management, and matters associated with these three. This work focused on issues associated with transport, information, road management and maintenance, infrastructure, and the environment. The transport infrastructure action cards fall under four domains: I. Infrastructure, II. Road superstructure and equipment, III. Vehicle systems, and IV. Services and functions (Table 6).

The activities on the transport infrastructure action cards are spread all through the study phase 2016–2020. The first two years focus on major topics essential for automated driving: the availability and reception of data from back-office systems via I2V messages, GIS requirements for automated driving, the impact of automatisation on traffic management, and the role of automation in travel chains

Table 6. Transport infrastructure action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

		2016				2017				2018				2019				2020			
ID	Title	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
I.3	Availability of data from back-office systems																				
I.4	GIS requirements for automated driving																				
I.5	Impact on traffic management strategies																				
I.6	Design guidelines for junctions																				
I.7	Railway level crossings																				
I.8	Movable roadside infrastructure (for roadworks, special events, etc.)																				
I.9	Guidelines and verification of road network for automated driving																				-->
II.1	Visibility and condition of road markings and traffic signs																				
	Harmonisation of road traffic control																				
II.2	Consequences on road structure and surface wear																				
II.3	Sensors or beacons embedded into road pavement																				
II.4	Posts and poles for guidance and positioning																				
II.5	Alternative routes and detours																				
III.2	Reception of cooperative I2V messaging																				
III.3	Requirements for traffic status information																				
III.4	Functionalities of signal control																				
IV.4	Automation in travel chains																				
IV.5	Required quality of real-time traffic information services																				

The latter half of the study phase (2018–2020) is spent monitoring technological developments in other countries and trying to steer these developments to match Finnish objectives and interests. Many specific features of the road infrastructure are due for renovation, as automated vehicles will require some changes or at least assessments of the need for change e.g. in the design guidelines for junctions, the functionalities of signal control, and safety equipment at railway level crossings.

A significant topic is the updating, positioning guidelines and active maintenance of road markings and traffic signs. In mixed traffic and during other transition phases, on-board systems are used to detect road markings. Therefore, the markings should be in good enough condition to be machine-readable, as should traffic signs. Later on, information on informative and regulatory traffic signs and road markings will be stored on back-office systems and/or in-vehicle location databases, from which they can be accessed to help support and guide driving. If this type of location data is to replace physical road markings and traffic signs at some point, it has to meet the requirements set for the quality, amount and accuracy of information.

In Finland's snowy and icy conditions, roadside reflector posts and snow poles are of special interest. In the near future, they will take on new forms and functions, and their uses may increase significantly. They will most likely be used for precise vehicle positioning and for marking essential and dynamically changing sites. Posts and/or poles will not necessarily function or look like they currently do. They will be used all year round, and they must be able to withstand vandalism and to function as reliable beacons and fixed points.

The transport infrastructure actions also include the provision of high-quality traffic status information and traffic information services as well as the facilitation and production of traffic services.

5.4 Road Map for Traffic Actions

The road map for traffic includes actions associated e.g. with vehicles and their systems, vehicle roadworthiness, the driver, driver training, the right to drive, and driving examinations. The action cards fall under three domains: III. Vehicle systems, IV. Services and functions, and V. Driver (Table 7).

Table 7. Traffic action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

ID	Title	2016				2017				2018				2019				2020			
		Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
III.5	**Identification of abnormal and hazardous transports**											D	D	D	D	D	D				
III.6	**Safe use of information while driving**	D	D	L	L	D	D	D	D	L	L	L	L								
III.7	**Access to in-vehicle resources and data**	D	D	D	D	L	L	L	L	L	L	L	L								
III.8	**Availability of data on vehicle features and equipment**	D	D	D	D	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
III.9	**Enhanced sensor technologies for snow and ice conditions**	D	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L				
III.10	**Provision of in-vehicle safety data to authorities**	L	L	L	L	D	D	D	D	D	D	D	D	L	L	L	L	L	L	L	L
III.11	**Type approval of automated functions**	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
III.12	**Changes in inspection of vehicles' roadworthiness**					L	L	D	D	L	L	L	L	L	L	L	L	L	L	L	L
III.13	**Positioning of vehicle**										D	D	D	D	D	D	D	D	D	D	D
III.14	**Personalisation of automated function parametres by users**															D	D	D	D	D	D
III.15	**Environmental sensing**																				
IV.6	**Test vehicles and fleets**	D	D	D	D	D	D	D	D	D	D	D	D	L	L	L	L	L	L	L	L
IV.7	**Truck and bus platooning**	D	D	L	L	L	L	D	D	D	D	L	L	L	L	L	L	L	L	L	L
V.3	**Driver training and instruction**	L	L	L	L	D	D	D	D	D	D	D	D								
V.4	**Right to drive and examination in transition phase**			D	D	D	D	D	D	D	L	L	L	L	L						

Most of the activities outlined in the action cards must be carried out or at least initiated within the first two years of the study phase (2016–2017), because they act primarily as enablers, and thus their deployment is a prerequisite for the deployment of other action cards. These activities mainly involve in-vehicle systems, sensor technologies, access to in-vehicle resources, and the development, assignment and equipping of test vehicles for Finnish tests and trials.

A major topic is the rethinking of driver training, driving examinations and the right to drive in light of the introduction of automated driving and vehicles. How should driver training requirements be adapted to better meet the demands and expectations of automated driving in the future? And how will driving examinations be carried out: under which conditions and with what types of vehicles? As of yet, it is unknown how the right to drive will change and what vehicles people will be allowed to drive. The study phase does not extend so far that fully-automated vehicles would be available for private use. Fully-automated vehicles can perform all driving tasks without any "driver" input. The key question then will be whether a person travelling in a fully-automated vehicle has any need for a driving licence.

Truck and bus platooning is becoming an increasingly important issue, and will be in the headlines during the first half of 2016 during the Dutch EU Presidency. The Netherlands initiated the *European Truck Platooning Challenge 2016* in April in Helmond in the Netherlands (RWS 2015). Finnish authorities were partners in the Challenge.

The traffic actions also include the methods used to define/inspect the road-worthiness of vehicles. The current method is periodic inspection, but the aim is to be able to establish roadworthiness during regular traffic enforcement operations. This is an example of the possibilities offered by remote diagnostics. Many of the value chain stakeholders aim to develop remote diagnostics applications to facilitate better and speedier services to drivers offered by importers and authorised service stations, such as rapid repairs and the possibility of diagnosing and even fixing faults without needing to visit a service station. The key issue is who has the right to access technical and inspection data or the right to use this information in commercial and/or enforcement operations.

5.5 Road Map for Communication Infrastructure Actions

The primary communication infrastructure actions involve international radio frequency allocation efforts and the availability of communication infrastructure utilising the available radio frequencies. The action cards fall under two domains: I. Infrastructure and III. Vehicle systems (Table 8).

Table 8. Communication infrastructure action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

ID	Title	2016	2017	2018	2019	2020
		Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4	Q1 Q2 Q3 Q4
I.10	**Radio frequency allocations**					
I.11	**Availability of communication infrastructure**					
III.16	**Hybrid communications**					

The equipping of road networks intended for automated driving with data communication connections is important, even though the authorities are not responsible for the construction of communication networks; this is the duty and responsibility of telecommunications companies.

A key issue is the utilisation of mobile communication networks for transmitting traffic information on road networks that support automated driving. Most important is to complete the standardisation of 5G network technology and begin construction of Finnish 5G networks as soon as possible. User terminals and possibly other in-vehicle devices will quickly follow. 5G standardisation is currently estimated to be completed sometime in 2019. Permits for 5G trials have already been issued in Finland.

6 Action Plan for 2016–2017

6.1 Background

A main result of this project is an action plan for 2016–2017. The original objective was to draft an action plan that extended all the way to 2020, but it became apparent that there were too many uncertainty factors associated with the detailed planning of actions for 2018–2020 to make the appropriate and detailed budgeting and allocation of resources possible. Therefore, the only details given for 2018–2020 are the action timetables outlined in Chapter 5.

The following actions planned for 2016 and 2017 were drawn up:

- use case and content descriptions
- agreed lists of the necessary participant organisations
- estimates of agency man-hours
- third-party cost estimates

The aim has been to avoid redundancies in the planning and allocation of actions and their resources, so the findings of the following completed studies have been taken into consideration in the drafting of the action plan:

- Robots on Land, in Water and in the Air – Promoting Intelligent Automation in Transport Services (Pilli-Sihvola et al. 2015)
- Automaation lisääntymisen vaikutukset liikenteessä [The Impacts of Increased Automation on Traffic] (Innamaa et al. 2015)
- Liikenteen robotisaatio, esiselvitys [Transport Robotics, background study] (Lumiaho and Kutila 2015)

It must be noted that this action plan does not contain significant legislative actions. Those are covered in *Robots on Land, in Water and in the Air – Promoting Intelligent Automation in Transport Services*. (Pilli-Sihvola et al. 2015)

6.2 Action Plan for Infrastructure

The 2016–2017 action plan for infrastructure is quite extensive. The action plan cards include activities coordinated, planned and implemented by all of the transport authorities. The following three pages list the individual activities. It has been thought necessary to initiate a total of 26 infrastructure activities in 2016–2017 (Table 9).

Initially, automated driving in Finland will be restricted to motorways. At the moment, the quality of e.g. motorway maintenance and guidance operations is nearest to meeting the requirements set by automated driving. SAE level 2 and 3 automation is also best suited for a motorway environment.

Table 9. Individual activities on the infrastructure action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	I INFRASTRUCTURE								
I.1 Gradual deployment of road network for automated driving									
I.1.1	Examine the need to separate automated vehicles from other traffic e.g. according to the functional class, traffic properties, vehicle types, and land use of a part of the road or street network.								
I.1.2	Assess the overall economic impacts of different roadway allocation models.								
I.1.3	Draw up operational guidelines for the routing/permittance of automated traffic, i.e. on which parts of the road network are automated (private) vehicles supported and/or allowed.	no significant activity at this time							
I.1.4	Update guidelines on the allocation of lane capacity to different transport modes along the road network.	no significant activity at this time							
I.1.5	Assess the traffic control and management systems and infrastructure equipment needed for mixed traffic. Investigate whether automated and non-automated vehicles can share lanes.	no significant activity at this time							
Action card ID	**Individual activity Contents**	**2016 Q1**	**2016 Q2**	**2016 Q3**	**2016 Q4**	**2017 Q1**	**2017 Q2**	**2017 Q3**	**2017 Q4**
	I INFRASTRUCTURE								
I.2 Deployment of communication infrastructure									
I.2.1	Assess the functionality, applicability and useability of LTE/4G networks in the NordicWay project.								
I.2.2	Choose which sections of the road and street network will be equipped to support automated traffic. Draw up a timetable for this process.	no significant activity at this time							
I.2.3	Carry out LTE/4G solution pilots to ensure that the LTE/4G network has sufficient capacity to support automated traffic along a specific road or street network.	no significant activity at this time							
I.2.4	Determine locations, where the current LTE/4G network does not fulfil the set requirements.	no significant activity at this time							
I.2.5	Examine equipping specific sites along the road and street network with ITS-G5 technology.								
I.2.6	Begin talks on the deployment of 5G in Finland and specifically on covering the road and street networks with a 5G network.	no significant activity at this time							
I.2.7	Draw up a proposal to the Parliament on the realisation of a communication infrastructure suitable for automated traffic.	no significant activity at this time							
I.2.8	Commence deployments according to Parliamentary decision.	no significant activity at this time							
Action card ID	**Individual activity Contents**	**2016 Q1**	**2016 Q2**	**2016 Q3**	**2016 Q4**	**2017 Q1**	**2017 Q2**	**2017 Q3**	**2017 Q4**
	I INFRASTRUCTURE								
I.3 Availability of data from back-office systems									
I.3.1	Define public back-office systems for automated driving, their properties, and their level of openness.								
I.3.2	Create information system interfaces that allow the systems' use in the control and management of automated traffic.								
I.3.3	Allow service providers open access to applicable traffic information sources.								
I.3.4	Allow service providers (open and/or paid) access to applicable traffic information sources.								
I.3.5	Facilitate and promote the creation of automated driving services with open data.								
Action card ID	**Individual activity Contents**	**2016 Q1**	**2016 Q2**	**2016 Q3**	**2016 Q4**	**2017 Q1**	**2017 Q2**	**2017 Q3**	**2017 Q4**
	I INFRASTRUCTURE								
I.4 Location data for automated driving									

Table 9 to be continued

Table 9 continued

Action card ID	Individual activity / Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
Action card	**Individual activity**	**2016**				**2017**			
ID	**Contents**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	I INFRASTRUCTURE								
I.5 Impact on traffic management strategies									
I.5.1	Predict how automated driving will increase in Finland between 2017 and 2040.								
I.5.2	Assess how mixed traffic will change and develop at different penetration rates and different levels of automation. Identify potential problems associated with mixed traffic. Also examine different scenarios concerning the development of automated driving, changes to the vehicle fleet, and the characteristics of the mixed traffic phase.								
I.5.3	Use these predictions as the basis for the timetable for drafting more precise action plans.								
Action card	**Individual activity**	**2016**				**2017**			
ID	**Contents**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	I INFRASTRUCTURE								
I.6 Design guidelines for junctions									
I.6.1	Evaluate how automated vehicles function at different types of junctions, with different traffic control systems, in mixed traffic, and with crossing pedestrian and bicycle traffic.								
I.6.2	Use the results to draft or update junction planning guidelines.	no significant activity at this time							
I.6.3	Ensure that the guidelines are applicable to the street network or update the relevant guidelines to match the general road network status.	no significant activity at this time							
I.6.4	Renovate or construct junctions in accordance with the guidelines.	no significant activity at this time							
Action card	**Individual activity**	**2016**				**2017**			
ID	**Contents**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	I INFRASTRUCTURE								
I.7 Railway level crossings									
I.7.1	Assess how automated vehicles function at level crossings and with different control devices. Also examine the integration of possible train warning services at level crossings with the operation and steering of automated vehicles.								
I.7.2	Based on the results, update the planning guidelines for railway level crossings.	no significant activity at this time							
I.7.3	Update the action plan for railway level crossings.	no significant activity at this time							
Action card	**Individual activity**	**2016**				**2017**			
ID	**Contents**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	I INFRASTRUCTURE								
I.8 Movable roadside infrastructure (for roadworks, special events, etc.)									
I.8.1	Define the use cases and operational requirements of movable roadside infrastructure.								
I.8.2	Assess functionality of infrastructure with pilots.								
I.8.3	Make possible equipment purchasing decisions.	no significant activity at this time							
Action card	**Individual activity**	**2016**				**2017**			
ID	**Contents**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	I INFRASTRUCTURE								
I.9 Guidelines and verification of road network for automated driving		no significant activity at this time							
I.9.1	Ensure that the availability of the necessary guidelines allows automated driving to increase during the monitoring period and to be introduced widely after the monitoring period.	no significant activity at this time							
I.9.2	If necessary, add these guidelines as a specific target into authority performance guidance.	no significant activity at this time							
I.9.3	Ensure that the guidelines are applicable to the street network or update the relevant guidelines to match those for the road network status.	no significant activity at this time							
Action card	**Individual activity**	**2016**				**2017**			
ID	**Contents**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	I INFRASTRUCTURE								

Below is a summary of the timelines of the infrastructure action cards for 2016–2017 (Table 10).

Table 10. Infrastructure action plan for 2016 and 2017. Legend: dark colour = actions/deployment and light colour = monitoring

I Infrastructure	2016				2017			
ID and title	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
I.1 Gradual deployment of road network for automated driving								
I.2 Deployment of communication infrastructure								
I.3 Availability of data from back-office systems								
I.4 Location data for automated driving								
I.5 Impact on traffic management strategies								
I.6 Design guidelines for junctions								
I.7 Railway level crossings								
I.8 Movable roadside infrastructure (for roadworks, special events, etc.)								
I.9 Guidelines and verification of road network for automated driving	no significant activity at this time							
I.10 Radio frequency allocations								
I.11 Availability of communication infrastructure								

6.3 Action Plan for Road Superstructure and Equipment

The action plan for road superstructure and equipment is relatively limited for the first two years of the study period (2016–2017). The individual activities are listed on the following two pages. It has been thought necessary to initiate eight road superstructure and equipment activities in 2016–2017 (Table 11).

Unlike with infrastructure, many of the individual activities outlined on the road superstructure and equipment action cards are scheduled to begin in the second half of the study period, i.e. in 2018–2020. In addition to this, some of the activities are optional. Whether they are necessary or not depends on the results of the activities listed above them on the same action cards

Table 11. Individual activities on the road superstructure and equipment action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

Action card ID	Individual activity / Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	II ROAD SUPERSTRUCTURE AND EQUIPMENT								
II.1 Visibility and condition of road markings and traffic signs									
II.1.1	Take an active role in international cooperative standardisation efforts to ensure that difficult weather and road surface conditions are taken into consideration during the development and testing of road markings and sensor technologies.								
II.1.2	Ensure that road markings and traffic signs are detectable, visible and in sufficiently good condition to be of use to the sensors of automated vehicles in predetermined weather and road surface conditions.								
II.1.3	Digitise materials.								
II.1.4	Assess whether automated driving calls for increased harmonisation of road traffic control systems.								
If necessary:									
II.1.5	Ensure that the content and implications of road markings, traffic signs, signals and control systems are uniform and clear to both domestic and foreign drivers and vehicles.								
II.1.6	Influence international harmonisation and traffic control standardisation efforts.								
II.1.7	Manage and monitor the deployment of the results of the harmonisation efforts.								
II.1.8	Road operators are responsible for digitising their data.								
II.1.9	Ensure the availability of data concerning dynamic traffic control systems and variable message signs through back-office systems.								
	II ROAD SUPERSTRUCTURE AND EQUIPMENT								
II.2 Consequences on road structure and surface wear									
II.2.1	In international cooperation, identify the best means of evaluating, simulating and, when necessary, preventing increased road surface wear, such as rut formation, potentially caused by stricter lane-keeping facilitated by sensors and lane identifiers.								
II.2.2	Based on these results, draw up the necessary guidelines and participate in international efforts to reduce the consequences on road surface wear.								
II.2.3	Determine the most economically beneficial solution for ensuring that road properties (incl. geometry) remain the same after maintenance operations. Pavement width, vertical alignment, and the precise location of the lane markings and shoulder lines may be affected by the maintenance measures.								
	II ROAD SUPERSTRUCTURE AND EQUIPMENT								
II.3 Sensors or beacons embedded into road pavement									
II.3.1	Identify common sensor and beacon technologies and their possible and necessary uses and deployment potential in Finland.								
If necessary:									
II.3.2	Carry out trials and pilots, if possible.	no significant activity at this time							
II.3.3	Ensure that all beacons have been correctly embedded into the pavement.	no significant activity at this time							
II.3.4	Ensure that all beacons can be reliably and accurately read by sensors on vehicles.	no significant activity at this time							
II.3.5	Test and ensure that weather, lighting or road surface conditions do not affect the availability, accuracy or reliability of beacon data.	no significant activity at this time							

Table 11 to be continued

Table 11 continued

Action card	Individual activity	2016				2017			
ID	Contents	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
	II ROAD SUPERSTRUCTURE AND EQUIPMENT								
II.4 Posts and poles for guidance and positioning		no significant activity at this time							
II.4.1	Draw up requirements and specifications for intelligent delineator posts, snow poles and plot access markers and their positioning, mounting and installation.	no significant activity at this time							
II.4.2	Place intelligent delineator posts, snow poles and plot access markers along the road network that support automated driving.	no significant activity at this time							
Action card	**Individual activity**	**2016**				**2017**			
ID	**Contents**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
	II ROAD SUPERSTRUCTURE AND EQUIPMENT								
II.5 Alternative routes and detours		no significant activity at this time							
II.5.1	Update planning guidelines to include e.g. the presentation of rerouting information using the DATEX II format and standardised C-ITS messages (IVI, MAP). International cooperation is required.	no significant activity at this time							
II.5.2	Plan alternative routes for critical road sections. Navigation data and information on restrictions such as the maximum height, weight and/or width allowed will be input into the appropriate database, from which it can be transmitted to in-vehicle systems.	no significant activity at this time							

Below is a summary of the timelines of the road superstructure and equipment action cards for the first two years of the study period (Table 12).

Table 12. Road superstructure and equipment action plan for 2016 and 2017. Legend: dark colour = actions/deployment and light colour = monitoring.

II Road Superstructure and Equipment	2016				2017			
ID and title	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
II.1 Visibility and condition of road markings and traffic signs								
II.2 Consequences on road structure and surface wear								
II.3 Sensors or beacons embedded into road pavement								
II.4 Posts and poles for guidance and positioning	no significant activity at this time							
II.5 Alternative routes and detours	no significant activity at this time							

6.4 Action Plan for Vehicle Systems

The action plan for vehicle systems is quite extensive during the first two years of the study period (2016–2017). The following three pages list the individual activities. It was found necessary to initiate a total of 34 vehicle system activities in 2016–2017 (Table 13).

Table 13. Individual activities on the vehicle systems action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	III VEHICLE SYSTEMS								
III.1 Properties and impacts of SAE level 3 automated driving									
III.1.1	Ensure that there is sufficient international and/or Finnish research on SAE level 3 automated driving. Pay special attention to driver behaviour whenever vehicle control switches between the automated driving system and the driver, e.g. when and how a driver can re-take control of the vehicle. Identify cases and help standardise guidelines.								
III.1.2	Assess the impact of the introduction of SAE level 3 automated vehicles on road safety, traffic flow and other factors.	no significant activity at this time							
III.1.3	Identify the in-vehicle systems present in cars imported to Finland.								
III.1.4	Monitor and, if necessary, take action on the quality of new automated driving functions in vehicles.								
Action card ID	**Individual activity Contents**	**2016 Q1**	**Q2**	**Q3**	**Q4**	**2017 Q1**	**Q2**	**Q3**	**Q4**
	III VEHICLE SYSTEMS								
III.2 Reception of cooperative I2V messaging									
III.2.1	Provide information according to the standards. Back-office systems produce message content in accordance with the DATEX II standard. This content can then be transmitted as CAM, DENM, IVI, SPaT and/or MAP messages. Data transfer delays and capacity aspects must be taken into consideration.								
III.2.2	One or more service operators are needed to transmit messages.	no significant activity at this time							
III.2.3	Decide in which CEN/ISO/ETSI standardisation working groups to participate. Working groups include e.g. CEN TC 278 (ITS) WG16 Cooperative Systems, ISO TC 204 (ITS) WG18 Cooperative Systems and ETSI TC ITS WG1 Application Requirements and Services.								
Action card ID	**Individual activity Contents**	**2016 Q1**	**Q2**	**Q3**	**Q4**	**2017 Q1**	**Q2**	**Q3**	**Q4**
	III VEHICLE SYSTEMS								
III.3 Requirements for traffic status information									
III.3.1	Consider the requirements of automated driving in the further development of the existing traffic status information services.								
III.3.2	Define the type of information to be provided to facilitate SAE level 3 and 4-5 automation.								
III.3.3	Agree on data provision, operator roles and service provision/purchasing.								
III.3.4	Provide traffic status information services to different user segments.								
Action card ID	**Individual activity Contents**	**2016 Q1**	**Q2**	**Q3**	**Q4**	**2017 Q1**	**Q2**	**Q3**	**Q4**
	III VEHICLE SYSTEMS								
III.4 Functionalities of signal control		no significant activity at this time							
III.4.1	Working with traffic signal providers, equip signal-controlled intersections on peri-urban main roads and urban streets with V2X data transfer systems and the necessary software.	no significant activity at this time							
III.4.2	Initiate talks with key stakeholders: 'Who gets fined if a vehicle "decides" to cross an intersection on a red light?' No guidelines exist for how automated vehicles should behave if traffic signals are not working.	no significant activity at this time							
III.4.3	Assess the impacts and potential of GLOSA systems for automated driving.	no significant activity at this time							
III.4.4	Draw up the necessary guidelines.	no significant activity at this time							
Action card ID	**Individual activity Contents**	**2016 Q1**	**Q2**	**Q3**	**Q4**	**2017 Q1**	**Q2**	**Q3**	**Q4**
	III VEHICLE SYSTEMS								
III.5 Identification of abnormal and hazardous transports		no significant activity at this time							
III.5.1	Define data content requirements for abnormal and hazardous transports in mixed traffic. The data content must be relayed to all approaching vehicles. International cooperation is required.	no significant activity at this time							
III.5.1	Modify abnormal transport permits to require this data content and system use. Produce the necessary guidelines and training.	no significant activity at this time							

Table 13 to be continued

Table 13 continued

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
III VEHICLE SYSTEMS									
III.6 Safe use of information while driving									
III.6.1	Take an active role in international working groups and promote Finnish objectives concerning the provision of information to drivers on the road and the use of applications while driving.								
III.6.2	Assess the changes in driver behaviour when drivers can e.g. access infotainment while the vehicle is in motion.								
III.6.3	Participate in international efforts to establish guidelines for the use of aftermarket cooperative devices (incl. smart phones and tablets) in road traffic. Connected with the overall reform of the Road Traffic Act.								
III.6.4	**If necessary**, test two-way cooperative devices to ensure they do not interfere with other radio communications.								
III.6.5	**If necessary**, test two-way cooperative devices to assess the risk they pose to other traffic in case a fault or hazard occurs. Special attention is given to how devices alert drivers to intervene and take control of the vehicle.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
III VEHICLE SYSTEMS									
III.7 Access to in-vehicle resources and data									
III.7.1	Promote access by participating in the C-ITS working group "Access to in-vehicle resources and data".								
III.7.2	Assess how support systems manufactured by different OEMs function and e.g. if it is possible to turn them off.								
III.7.3	Seek out other forums to promote development in this field, such as AutoSAR or the Car Connectivity Consortium (cf. MirrorLink).								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
III VEHICLE SYSTEMS									
III.8 Availability of data on vehicle features and equipment									
III.8.1	Assess whether it is necessary to extend the Vehicular Information System (VIS) or similar operations so that data on the features and equipment of automated vehicles can be tied to a specific vehicle by using the VIN code or product number rather than to a driver.								
III.8.2	Use data on vehicle features and equipment as well as before-and-after studies to assess the impacts of driver support systems on accidents, road safety and traffic flow.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
III VEHICLE SYSTEMS									
III.9 Enhanced sensor technologies for snow and ice conditions									
III.9.1	Assess the current level of sensor technology, examine the R&D needs, the product development situation and technical performance of the technology from a public authority perspective, and promote the development and deployment of solutions for identifying and observing slippery road conditions, thus making the systems meet Finnish requirements.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
III VEHICLE SYSTEMS									
III.10 Provision of in-vehicle safety data to authorities									
III.10.1	Participate in international efforts to regulate the collection of data on vehicle features and their provision to a third party.								
III.10.2	Ensure that these regulations are included in the national legislation.								
III.10.3	Assess the impacts of the automation of heavy vehicles on goods transport capacity, fleet changes, and weights and dimensions. All data should be made available to the authorities. Associated with platooning and the eCall service.								
III.10.4	Determine what type of electronic data collection and recording equipment could store in-vehicle data in accident or other exceptional situations.								

Table 13 to be continued

Table 13 continued

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	III VEHICLE SYSTEMS								
III.11 Type approval of automated functions									
III.11.1	Agree on which functions should be harmonised.								
III.11.2	Promote these agreed views in all standardisation and harmonisation bodies and/or working groups.								
III.11.3	Define the functions required of all automated vehicles imported for use in traffic. International cooperation is required.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	III VEHICLE SYSTEMS								
III.12 Changes in inspection of vehicles' roadworthiness									
III.12.1	Assess the potential and limitations of a self-diagnosis system.								
III.12.2	Organise trial to determine what kind of system is feasible for deployment.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	III VEHICLE SYSTEMS								
III.13 Positioning of vehicle									
III.13.1	Assess how other (new, more accurate) positioning methods could be utilised and how suitable they are for use on mobile devices and commercial positioning services. These include e.g. the National Land Survey of Finland's one-way positioning service, 5G, dead reckoning, and various satellite-based and hybrid solutions.	no significant activity at this time							
III.13.2	Carry out system trials to determine whether and in what way new positioning services respond to real user needs.								
III.13.3	Define how accurate systems must be based on their use cases (latitude and longitude, road network-specific, lane-specific).								
III.13.4	Test the useability of a positioning service at certain special sites, such as tunnels, rock cuttings, dead zones/sites with signal reflections, and street canyons.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	III VEHICLE SYSTEMS								
III.14 Personalisation of automated function parametres by users		no significant activity at this time							
III.14.1	Recognise, monitor, influence and participate in the development of automated functions in the appropriate forums. International cooperation is required.	no significant activity at this time							
III.14.2	Carry out trials to determine driver willingness to make personalised adjustments e.g. in unfamiliar traffic environments, in slippery road conditions or in bad weather conditions.	no significant activity at this time							

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	III VEHICLE SYSTEMS								
III.15 Environmental sensing		no significant activity at this time							
III.15.1	Ensure that all authority-maintained data is available to vehicles.	no significant activity at this time							
III.15.2	Have a dialogue with OEMs concerning their views on the requirements for the road infrastructure and the associated road markings, traffic signs, devices and equipment.	no significant activity at this time							

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	III VEHICLE SYSTEMS								
III.16 Hybrid communications									
III.16.1	Work with OEMs and network and service operators to research and possibly realise hybrid solutions (LTE/4G and ITS-G5).								
III.16.2	Extend coverage of international wireless network roaming to C-ITS services and systems.								
III.16.3	Work towards making sufficient and interoperable frequency bands available for transport use on a global scale. Facilitate and promote the utilisation of these frequency bands in Finland.								

Below is a summary of the timelines of the vehicle systems action cards for the first two years of the study period (Table 14).

Table 14. Vehicle systems action plan for 2016 and 2017. Legend: dark colour = actions/deployment and light colour = monitoring.

III Vehicle Systems	2016				2017			
ID and title	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
III.1 Properties and impacts of SAE level 3 automated driving								
III.2 Reception of cooperative I2V messaging								
III.3 Requirements for traffic status information								
III.4 Functionalities of signal control	no significant activity at this time							
III.5 Identification of abnormal and hazardous transports	no significant activity at this time							
III.6 Safe use of information while driving								
III.7 Access to in-vehicle resources and data								
III.8 Availability of data on vehicle features and equipment								
III.9 Enhanced sensor technologies for snow and ice conditions								
III.10 Provision of in-vehicle safety data to authorities								
III.11 Type approval of automated functions								
III.12 Changes in inspection of vehicles' roadworthiness								
III.13 Positioning of vehicle								
III.14 Personalisation of automated function parametres by users	no significant activity at this time							
III.15 Environmental sensing	no significant activity at this time							
III.16 Hybrid communications								

6.5 Action Plan for Services and Functions

The action plan for services and functions is very active for the first two years of the study period (2016–2017). It was thought necessary to initiate a total of 30 services and functions activities in 2016–2017 (Table 15).

Table 15. Individual activities on the services and functions action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

Action card ID	Individual activity / Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	IV SERVICES AND FUNCTIONS								
IV.1 Test areas									
IV.1.1	Determine which type of test areas are in demand, and help set the requirements all test areas have to fulfil. Focus may lay on identifying the role and functions of closed and open test areas as well as on the potential of test areas to advance the creation of a Finnish testing ecosystem.								
IV.1.2	Promote, facilitate and otherwise help establish test areas for testing the road and street network, their equipment and infrastructure, and vehicles and drivers.								
IV.1.3	Stakeholders define their own research and testing needs.								
IV.1.4	Working independently or in consortium, stakeholders set up the required automated driving, traffic and vehicle test areas in Finland.								
IV.1.5	Set up limited-access test areas for automated public transport within the street network and e.g. in tourist resorts.	no significant activity at this time							
IV.1.6	Support pilots and performance and impact assessments of various concepts.	no significant activity at this time							
Action card ID	**Individual activity / Contents**	**2016 Q1**	**Q2**	**Q3**	**Q4**	**2017 Q1**	**Q2**	**Q3**	**Q4**
	IV SERVICES AND FUNCTIONS								
IV.2 Impact assessment									
IV.2.1	Assess the impacts of different level automated vehicles in different operating environments. Based on the results, determine how much of the road and street network should be equipped to support automated driving Evaluate whether SAE level 3 automated driving is feasible in general. International cooperation is recommended.								
IV.2.2	Establish a research programme on automated road transport, which assesses the impacts of automated driving in conjunction with other international research projects.								
IV.2.3	Examine how automated driving will change traffic behaviour models and theories, as existing models and theories will no longer be applicable.								
IV.2.4	Assess the impacts of automated driving on traffic (flow) characteristics.	no significant activity at this time							
IV.2.5	Examine the attitudes of other road users (incl. other drivers, pedestrians and cyclists) towards automated vehicles.	no significant activity at this time							
IV.2.6	Various impact assessments in test areas.		prior to res.					after res. starts	
Action card ID	**Individual activity / Contents**	**2016 Q1**	**Q2**	**Q3**	**Q4**	**2017 Q1**	**Q2**	**Q3**	**Q4**
	IV SERVICES AND FUNCTIONS								
IV.3 Activation of and support for stakeholders in testing and piloting									
IV.3.1	Establish, maintain and set up an efficient framework for cooperation. Ensure that transport sector stakeholders have access to sufficient resources, especially to organise and participate in key international projects on automated driving.								
IV.3.2	Work in consortia to organise, facilitate and fund the establishment of an automated road transport ecosystem.								
IV.3.3	Assess the current status of automated driving, traffic and vehicles in Finland, and Finland's attraction factors, resources, financial instruments, value chain stakeholder commitments, and champion stakeholders.								
IV.3.4	Exploit Finland's attraction factors, strengths and potential on the international scene. Upgrade attraction factors.								

Table 15 to be continued

Table 15 continued

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	IV SERVICES AND FUNCTIONS								
IV.4 Automation in travel chains									
IV.4.1	Examine how automation can be exploited in practice in the MaaS concept trials and studies currently under development.								
IV.4.2	Actively promote the setting up of MaaS pilots involving automation within e.g. the NordicWay and Aurora projects. Participate in selected MaaS pilots involving automation set up by cities or companies.			Aurora		NordicWay			
IV.4.3	Evaluate the need to reform transport permit legislation.								
IV.4.4	Assess the impacts of automation on analyses at transport system level and of travel chains.								
IV.4.5	Evaluate how public transport, feeder transport and the entire travel chain, incl. parking, can benefit from automated driving.								
IV.4.6	Invite Google to pilot its AV concept in Finland.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	IV SERVICES AND FUNCTIONS								
IV.5 Required quality of real-time traffic information services									
IV.5.1	Define Quality of Service objectives for transport services associated with automated driving.								
IV.5.2	In addition to these objectives, specify what quality of service should be required of or guaranteed by different information sources, and what quality of service should be required of floating car data when it is used in traffic information services.								
IV.5.3	Collect the information needed for these specifications through research or international cooperation.								
IV.5.4	Ensure that our own services fulfil these requirements.								
IV.5.5	Monitor and supervise service and information providers.								

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	IV SERVICES AND FUNCTIONS								
IV.6 Test vehicles and fleets									
IV.6.1	Assess the need for and, if necessary, coordinate the development of a joint vehicle fleet platform for multiple projects.								
IV.6.2	Assess the need for as well as the potential, uses and funding instruments of test fleets.								
IV.6.3	Entice OEMs to test their vehicles and their automated driving systems in Finland and in cooperation with Finnish stakeholders.								
IV.6.4	Assess the impacts of the roll-out of different levels of automated driving on the existing traffic management strategies.	no significant activity at this time							

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	IV SERVICES AND FUNCTIONS								
IV.7 Truck and bus platooning									
IV.7.1	Participate in the Truck Platooning Challenge demonstration in 2016 and possibly also in the future.								
IV.7.2	Work with countries in the platooning vanguard to define the prerequisites, requirements and regulations for platooning.								
IV.7.3	Work to reform EU regulations concerning driver rest periods.								
IV.7.4	Determine the optimal headways especially for platooning vehicles on different road surfaces and structures in Finnish environmental conditions.								

Below is a summary of the timelines of the services and functions action cards for the first two years of the study period (Table 16).

Table 16. Services and functions action plan for 2016 and 2017. Legend: dark colour = actions/deployment and light colour = monitoring.

IV Services and Functions	2016				2017			
ID and title	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
IV.1 Test areas								
IV.2 Impact assessment								
IV.3 Activation of and support for stakeholders in testing and piloting								
IV.4 Automation in travel chains								
IV.5 Required quality of real-time traffic information services								
IV.6 Test vehicles and fleets								
IV.7 Truck and bus platooning								

6.6 Action Plan for Driver

The action plan for the driver consists of just four action cards, all of which are initiated during the first two years of the study period (2016–2017). The individual activities are listed on the following pages. It was thought necessary to initiate 16 driver-connected activities in 2016–2017 (Table 17).

Table 17. Individual activities on the driver action cards. Legend: dark colour = actions/deployment and light colour = monitoring.

Action card ID	Individual activity Contents	2016 Q1	2016 Q2	2016 Q3	2016 Q4	2017 Q1	2017 Q2	2017 Q3	2017 Q4
	V DRIVER								
V.1 Information to user segments, media, channels									
V.1.1	Draft a joint and comprehensive plan for all stakeholders on how to actively and proactively spread information about automated driving. The aim is to rouse public opinion, open up a public dialogue and generate feedback concerning the automatisation of road transport.								
V.1.2	Spread information through a variety of media/channels to reach different user segments, interest groups and stakeholders.								
V.1.3	Create targeted information materials and organise briefings, meet-and-greets and demonstrations for different user segments to explain and illustrate the development of automated driving and vehicles to them.								
V.1.4	Ensure that all information is expressed clearly and understandably using plain language.								
Action card ID	**Individual activity Contents**	**2016 Q1**	**2016 Q2**	**2016 Q3**	**2016 Q4**	**2017 Q1**	**2017 Q2**	**2017 Q3**	**2017 Q4**
	V DRIVER								
V.2 Privacy and security									
V.2.1	Ensure that there are regulations in place to protect the privacy of automated vehicle users.								
V.2.2	Define the conditions under which the information produced by automated vehicles can be utilised. International cooperation is required.								
V.2.3	Ensure that the data security solutions for automated driving are sufficient to ensure the secure use of data.								
V.2.4	Set up study to determine who owns the information produced by vehicles. Inter-agency and international cooperation is required.								
V.2.5	Pay special attention to ensuring that new transport services will not violate the right to privacy, and that vehicle and driver data cannot be connected to allow a vehicle user to be identified.								
V.2.6	Examine the types of information and types of passenger and information registers automated driving will produce, and how this information will be processed, compiled and utilised.								
Action card ID	**Individual activity Contents**	**2016 Q1**	**2016 Q2**	**2016 Q3**	**2016 Q4**	**2017 Q1**	**2017 Q2**	**2017 Q3**	**2017 Q4**
	V DRIVER								
V.3 Driver training and instruction									
V.3.1	Assess how the training of professional and private drivers should be reformed and how driving instruction and examinations will be affected. Examine to what extent driving instruction will be given as part of training for a driving exam and to what extent it will be the responsibility of the private sector, e.g. vehicle importers.								
V.3.2	Specify how the changes in driver training will affect the demands and limitations set on vehicles used in the training.								
V.3.3	Assess the impacts of automated systems and e.g. platooning on the legislation and regulations concerning professional driving and working times.	no significant activity at this time							
V.3.4	Ensure that all instructions and training materials are in clear and understandable plain language.								
V.3.5	Monitor developments in EU legislation to avoid national overregulation in Finland.								
Action card ID	**Individual activity Contents**	**2016 Q1**	**2016 Q2**	**2016 Q3**	**2016 Q4**	**2017 Q1**	**2017 Q2**	**2017 Q3**	**2017 Q4**
	V DRIVER								
V.4 Right to drive and examination in transition phase									
V.4.1	Assess the impacts of different automation levels on the right to drive, driving examinations and driver training. Determine whether the right to drive qualifications should be reformed in order to ensure the safety of automated driving, and whether driving licences should include a separate category designation for the right to drive an automated vehicle. International cooperation is required.								
V.4.1	Monitor the progress of the introduction, penetration rate, and impacts of different SAE level automated vehicles.								

Below is a summary of the timelines of the driver action cards for the first two years of the study period (Table 18).

Table 18. Driver action plan for 2016 and 2017. Legend: dark colour = actions/deployment and light colour = monitoring.

V Driver	2016				2017			
ID and title	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
V.1 Information to user segments, media, channels								
V.2 Privacy and security								
V.3 Driver training and instruction								
V.4 Right to drive and examination in transition phase								

6.7 Action Plan Summary

The proposed action plan for 2016–2017 will require considerable investment from the transport authorities. Some of the action cards and especially some of the individual activities have already been planned for and reserved budgets by the authorities. The more detailed planning of the activities outlined in the action plan now forms part of the official duties of the various transport agencies. The planning and even the implementation of many of the activities already began while this project was still ongoing. The action plan includes a total of 114 projects that are to be launched during the study period (Table 19).

Table 19. Number of proposed projects in the action plan to be launched in 2016–2017.

Domain	Number of projects to be launched
Infrastructure	26
Road superstructure and equipment	8
Vehicle systems	34
Services and functions	30
Driver	16
Total	**114**

6.8 International Promotion

6.8.1 Current Participation in International Cooperation

The Ministry of Transport and Communications and other Finnish transport agencies are active participants in international cooperative efforts and working groups. Most of these are related to European Union transport policy and the drafting of EU regulations. The Ministry appoints representatives to the EU working groups within its domain. The other agencies also monitor and participate in the working groups associated with the duties they have been allocated. When needed, Finnish transport agencies have participated in EU projects to the extent deemed necessary to promote Finnish interests and responsibilities.

Finnish transport agencies have participated in the following working groups and projects:

- EU-USA cooperation in the *"Roadway to automation"* working group
- EU-USA-Japan "*Automation*" working group and the *"Trilateral impact assessment subgroup for automation in road transportation"*
- iMobility Forum working groups *"Automation", "Safe Apps"* and "*Implementation Road Maps*"
- UNECE Wp1 WP.29 *"World Forum for Harmonization of Vehicle Regulations"* working party
- CEDR N7 task group *"Utilising ITS for NRAs"*
- EU EIP *"Facilitating automated driving"* working group
- ERTRAC *"Connectivity and automated driving"* working group
- Cooperation with the Netherlands during its EU Presidency (in early 2016) (*White Paper*)
- CityMobil2 project (finished)
- CoMoSef project (finished)

6.8.2 Proposal for Targeting International Contributions

During the 2016–2020 study period, all agencies must be able to participate in the following working groups and try to influence their findings as needed.

European Road Transport Research Advisory Council ERTRAC:

In 2014, ERTRAC founded the working group "*Connectivity and automated driving*", which consists of key ERTRAC members and experts. Since the beginning of 2016, one of the working group leaders has been a representative of the Finnish Transport Agency.

United Nations Economic Commission for Europe UNECE:

In February 2015, the Working Party on Brakes and Running Gear, a subsidiary body of the UNECE's World Forum for Harmonization of Vehicle Regulations, started examining harmonisation issues associated with automated driving. The working group examines proposals for support systems for partially-automated driving. In the future, these systems will function as a part of highly automated vehicles.

The working group consists of experts developing active safety requirements for vehicles. They assess proposals for expanding the current requirements to allow for the deployment of technology that will make self-steering vehicle systems possible. These systems include lane keeping assistance and adaptive cruise control for congested stop-and-go traffic. In certain driving conditions, these systems can take control of the vehicle under the active supervision of the driver.

The working group also assesses existing procedures and guidelines involving automatic parking systems, which allow the driver to activate autonomous parking even from outside the vehicle. Automated steering control on motorways is also examined. These systems allow vehicles to drive autonomously at even high speeds. The working group debates and draws up the necessary regulations that will then be discussed during future sessions.

It is essential for Finland to have a representative in the working group, so that Finnish stakeholders can directly access and influence the contents and wording of potential new regulations.

Conference of European Directors of Roads CEDR:

The CEDR N7 "*Utilising ITS for NRAs*" task group and its road traffic automation subgroup will operate until 2017, midway through the study period. The N7 task group supports the CEDR's role in the Amsterdam Group and the development of DATEX II. The group's objectives are to:

- Provide CEDR strategic eyes and ears in the ITS arena, with focus on monitoring key European actions and initiatives relevant to NRAs.
- Discuss important issues with the relevant stakeholders and organisations, e.g. ITS standardisation bodies, industry forums, etc.
- Provide strategic assistance to the CEDR's own Governing and Executive Boards (GB and EB) on ITS-related matters, including advice on recommended position taking and actions.
- Establish and maintain close liaison with the EC on the appropriate levels.
- Identify the concerns of NRAs relating to the EU's ITS Action Plan and Directive, monitor the progress of the implementation of the ITS Directive, and elaborate on common views.
- Where relevant, support and provide high-quality input to the EC decision-making process for ITS.
- Transversally discuss and elaborate on ITS with other CEDR task groups, and support the utilisation of ITS by these groups.

EU EIP project:

The European EU EIP project is a continuation of the EasyWay, EIP and EIP+ projects. The European ITS Platform project (EIP) was launched in 2013 as an extensive joint project for European road authorities and operators. The aim was to promote the harmonised implementation of ITS services in order to coordinate road traffic management operations more efficiently all across the EU. A key objective was to improve cross-border service continuity and harmonisation and to facilitate the sharing of expertise and information on best practices between member states. The first phase was completed in the spring of 2015. The EIP+ project of 2014–2015 continued the work started during the first phase to harmonise European ITS services. The EIP+ project was characterised by its close connections with ITS Road Corridor projects, the technological progress and findings of which were monitored and the information compiled for all EU member states to use. Another objective was to increase the sharing of information between project participants as well as third parties.

Many EU member states, road operators and stakeholders are participating in the EU EIP project (2016-2020), continuing to share best practices, evaluate experiences and reach a consensus concerning the harmonisation of ITS services across Europe. The individual subprojects of EU EIP focus on the monitoring of the implementation of ITS services, definitions of the quality of service, the facilitation of automated driving, the drafting of a road map for the implementation of ITS services, support for the implementation of cooperative services, and the evaluation of implementations. Finland has established a strong foothold among the other member states, as have the Finnish Transport Agency and Finnish Transport Safety Agency (Trafi) among the participating organisations in the project. The Finnish Transport Agency is in charge of coordinating the "*Facilitating Automated Driving*" activity.

EU–USA and EU–USA–Japan cooperation:

EU–USA cooperation is carried on through the *Roadway to automation* working group. EU–USA–JAPAN cooperation also continues throughout the study period. Cooperation in the field of automated driving carries on with the VRA (*Vehicle and Road Automation*) project. No Finnish stakeholders are participating in the VRA consortium, but the project materials are available to all.

It is vital for Finnish transport authorities to be able to monitor the development of automated driving on the three leading continents in the field. Finland must aim to take part in any VRA follow-up projects. The Finnish transport agencies provide resources for the Finnish co-chair of the subgroup for impact assessment harmonisation for automated driving within the trilateral EU–USA–JAPAN cooperation.

6.8.3 Proposals for International Activities

The action cards mention several projects by international stakeholders, in which Finnish interests are represented or which concern international preparation, specification and/or standardisation activities. Finland must take an active role in these projects to ensure that the results are acceptable for Finnish interests.

The following are lists of activities that this study proposes Finnish transport authorities should carry out. The best experts in each field within the agencies should be appointed to manage these activities. Procedures, operating models and operating environments to best support them should also be developed.

High-level political and strategic activities:

- With international partners, define the conditions under which the information produced by automated vehicles can be utilised.
- Participate in international studies to determine who owns the information produced by vehicles and in traffic.
- Transport sector authorities' representatives in international working groups together specify the functions required of all automated vehicles imported for use in Finnish traffic.
- With international partners, assess how EU legislation is developing to avoid national overregulation in Finland.
- Try to influence the European Commission to extend the coverage of international wireless network roaming to C-ITS services and systems.

Transport infrastructure activities:

- Take an active role in international cooperative standardisation efforts to ensure that difficult weather and road surface conditions are taken into consideration during the development and testing of road markings and sensor technologies.
- Participate in international harmonisation and traffic control standardisation efforts.
- With international partners, identify the best means of evaluating, simulating and, when necessary, preventing increased road surface wear potentially caused by automated driving.
- Based on measurements, draw up the necessary guidelines and participate in international efforts to reduce the consequences on road surface wear.
- With international partners, examine the use of standardised C-ITS messages, such as *CAM, DENM, IVI, SPaT, MAP*.
- With international partners, collect the information needed for specifications of the quality of transport services.
- Work with financers to ensure that there is sufficient international and/or Finnish research on SAE level 3 automated driving. Pay special attention to driver behaviour whenever vehicle control switches between the automated driving system and the driver. Specify and help standardise guidelines e.g. for when and how a driver can re-take control of the vehicle.

Traffic activities:

- Take an active role in international working groups and promote Finnish objectives concerning the provision of information to drivers on the road and the use of services/applications while driving.
- Participate in international efforts to regulate the collection of data on vehicle features and their provision to a third party.
- With international partners, assess the impacts of different automation levels on the right to drive, driving examinations and driver training. Determine whether the right to drive qualifications should be reformed in order to ensure the safety of automated driving, and whether driving licences should include a separate category designation for the right to drive an automated vehicle.
- In international working groups, influence the development of automated vehicle functions to ensure they correspond to Finnish interests.
- With international partners, define data content and other requirements for abnormal and hazardous transports in mixed traffic. The necessary data content must be relayed to all approaching vehicles.
- Work internationally with OEMs and network and service operators to research and realise hybrid solutions (LTE/4G and ITS-G5).

Individual activities with strong international connections:

- Initiate a road traffic automation research programme, which works with international research partners to assess the impacts of automatisation.
- Work with research funding organisations to ensure that the transport authorities have sufficient resources, especially to prepare and participate in key international automated driving projects.
- Exploit Finland's attraction factors, strengths and potential on the international scene. Work with commercial stakeholders to upgrade Finland's attraction factors.

6.9 Cooperation in Standardisation

For years, inadequate attention or resources have been given to standardisation issues associated with cooperative, connected and automated vehicles. Standardisation is a complex whole, but certain targets (technical committees and their working groups) can be identified and should be allocated national resources.

Automated driving standards are drawn up by CEN, ISO and ETSI. Their *Technical Committees* (TC) contain Working Groups (WG), whose Work Items (WI) include all relevant technical and functional definitions that need to be standardised. As OEMs prepare to roll out automated vehicles aimed at consumers, the number of work items will continue to increase.

Below is a list of the standardisation working groups that are of the most interest or importance for automated driving:

- ISO TC22 SC3 WG16 *Functional safety*
- ISO TC204 WG14 *Vehicle/Roadway Warning and Control Systems*
- ETSI TC ITS WG1 *Application Requirements and Services*
- ISO TC204 WG9 *Integrated transport information*
- ISO TC204 WG18 *Cooperative Systems*
- CEN TC278 WG16 *Cooperative ITS*

In Finland, the mandate for standardisation cooperation is held by the General Industry Federation (YTL). For example, the YTL has an intelligent transport standardisation working group, which meets about twice a year or when necessary. The working group includes representatives of several transport sector stakeholders. At the moment, the group simply monitors the situation, and very few entities are involved in active standardisation. Because of this, Finnish stakeholders – including the standardisation working group – only get their hands on standardisation documents when they have already been completed and are being circulated for comments. At this point, stakeholders can usually just approve or reject the proposed standards, and not have any impact on the precise content.

7 Follow-up Actions

Authority reforms:
Prime Minister Sipilä's first Cabinet's Government Programme emphasises digitalisation, deregulation and a culture of experimentation. The Ministry of Transport and Communications has made a policy declaration that Finland should be a leading utiliser of automated driving.

Finland is a leading utiliser of automated road transport.

This means that in Finland, all stakeholders have good preconditions to develop, test and deploy automated driving.

This provides companies with opportunities to improve their expertise and competitiveness, and to create easy-to-use automated driving solutions and services for their customers.

Figure 14. Vision for road transport automatisation.

Digitalisation and transport automatisation are global phenomena. Finland cannot be the global or European leader in utilising, developing, operating and trailblazing all sectors. Therefore, the Ministry of Transport and Communications and the transport and communication authorities under its jurisdiction must work together and be more active in preparing for international cooperative efforts. International cooperation must be approached with an eye on Finnish objectives and values. Finnish industry, research, experts and services must be able to evolve, respond to international competition and ensure the competitiveness of Finnish stakeholders.

Most of this forms part of the official duties of the transport authorities, who should have access to sufficient and appropriate resources and expertise. Finland must be able to appoint its best experts to working groups, projects and other activities to build the future we need and want.

The transport and communication authorities are in charge of drafting regulations and carrying out the public sector duties in their particular fields. In connection with transport automatisation, the Finnish Transport Agency focuses on issues involving e.g. the road network, its infrastructure and equipment, and traffic management and control. The Finnish Transport Safety Agency (Trafi), on the other hand, focuses e.g. on vehicles and technology, transport safety, type approval, the right to drive, driver training, driving examinations and the certification of vehicle roadworthiness. The Finnish Communications Regulatory Authority (FICORA) focuses on radio frequency regulations, and supervisory and official operations connected with communication technology.

The steps taken by the transport authorities should allow Finland to be sufficiently prepared for the introduction of automated driving and vehicles on the road and street network by 2020. The objective is to ensure the safe and smooth functioning of both automated traffic and conventional non-automated vehicle traffic (= mixed traffic).

Activities and performance guidance:
This project involved the compiling of a large number of relevant and well-argued action cards and individual activities that will help attain the objectives and vision set for the project. The coordination and implementation of each activity is the responsibility of the organisation that is best suited to it. Each individual activity is implemented by a responsible agency. In many cases, close cooperation between the Ministry of Transport and Communications and the other agencies is required.

The Ministry of Transport and Communications may include some of these activities in the performance target agreements it sets to the agencies. In these cases, the planning, implementation and allocation of resources for these activities go hand in hand with political performance guidance.

The future begins today:
The follow-up actions include the planning, development, research, analysis and implementation of individual activities during the study period. A detailed action plan has been drawn up for the first half of the study period (2016–2017). However, the realisation and implementation of the action plan depend greatly on the available resources and performance target agreements. The more detailed planning of the second half of the study period (2018–2020) should already begin in 2016. This will allow the budget planning and negotiations to take the activities planned for these years into consideration.

Transport automatisation is moving ahead possibly even more quickly than estimated. The road map and action plan should be reviewed and possibly updated every few years. It should be assessed, whether any new action cards should be added into the plans and programmes. The individual activities also need to be reviewed, as they are being carried out by different agencies or within separate projects. Completed activities can be checked out. On the other hand, activities that have not yet been carried out may turn out to be out of date or in need of updating. It should also be discussed whether any new needs have arisen or e.g. whether new dialogues with OEMs have opened up and provided the authorities with new information on or a need for future developments, product road maps and/or product releases.

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Members of Steering, Project and Core Groups

The steering group consisted of:

Finnish Transport Agency:
- Director General Tiina Tuurnala, Traffic and Information, chair
- Director General Mirja Noukka, Infrastructure Management
- Director General Raimo Tapio, Operations Management
- Director Virpi Anttila, Traffic Services
- Director Jan Juslén, Information
- Director Matti Levomäki, Transport and Land Use
- Principal Advisor on ITS Risto Kulmala, Mobility Management and ITS Services

Finnish Transport Safety Agency Trafi:
- Director General of Road Transport Marko Sillanpää
- Director General of Data and Knowledge Juha Kenraali
- Director General of Transport System and Development Sector Mia Nykopp
- Head of Department Toni Pallaspuro, Vehicles

Ministry of Transport and Communications:
- Senior Adviser for Legislative Affairs Kirsi Miettinen, Data Business Unit
- Director of Unit Risto Murto, Development Unit

Technical Research Centre of Finland VTT Ltd (supplier):
- Principal Scientist Aki Lumiaho, VTT, project manager
- Research Scientist Fanny Malin, VTT, steering group secretary
- Senior Scientist Mikko Tarkiainen, VTT, deputy project manager

The project group participated in the operational steering of the project and the processing of the findings presented to the steering group. The project group consisted of:

Finnish Transport Agency:
- Principal Advisor on ITS Risto Kulmala, Mobility Management and ITS Services, chair
- Director Päivi Nuutinen, Project Planning
- Head of Unit Aapo Anderson, Development of Road Traffic Services
- Head of Unit Juuso Kummala, Mobility Management and ITS Services
- Head of Unit Sami Luoma, Road Traffic Management
- Head of Unit Jari Myllärinen, Information Services
- Head of Unit Tuomas Toivonen, Maintenance Management and Development
- Development Manager Asta Tuominen, Mobility Management and ITS Services
- Traffic Control Expert Tuomas Österman, Road Technology
- Project Manager Aki Mankki, Mobility Management and ITS Services

Finnish Transport Safety Agency Trafi:

- Head of Unit Tommi Arola, Mobility Innovations and R&D
- Head of Unit Tuire Simonen, Traffic Law
- Chief Adviser Anna Schirokoff, Mobility Innovations and R&D
- Chief Adviser Erik Asplund, Service Support
- Chief Adviser Ari Herrala, Examinations and Commercial Transport
- Chief Adviser Reijo Jälkö, Service Support
- Special Adviser Eetu Pilli-Sihvola, Mobility Innovations and R&D

Ministry of Transport and Communications:

- Special Adviser Eetu Pilli-Sihvola
- Senior Adviser Leif Beilinson
- Senior Transport Adviser Kimmo Kiiski
- Senior Engineer Mikko Karhunen
- Senior Officer Laura Sarlin

Technical Research Centre of Finland VTT Ltd (supplier):

- Principal Scientist Aki Lumiaho, VTT, project manager
- Research Scientist Fanny Malin, VTT, secretary
- Senior Scientist Mikko Tarkiainen, VTT, deputy project manager

The project's core group was responsible for most of the content and action descriptions. It consisted of the following experts representing the clients and the supplier:

- Risto Kulmala, Finnish Transport Agency, chair
- Aki Mankki, Finnish Transport Agency
- Anna Schirokoff, Trafi
- Erik Asplund, Trafi
- Eetu Pilli-Sihvola, Ministry of Transport and Communications / Trafi
- Leif Beilinson, Ministry of Transport and Communications
- Laura Sarlin, Ministry of Transport and Communications
- Aki Lumiaho, VTT
- Fanny Malin, VTT, secretary

Organisations Invited to Stakeholder Workshops

Aalto University
ABAX Finland Oy
Anritsu Finland Oy
Arctic Machine Oy
Arctic Power Oy
Association of Automobile Importers in Finland
Aurora project
Automobile and Touring Club of Finland
Bitwise Oy
Central Organisation for Traffic Safety in Finland (Liikenneturva)
CGI Finland Oy
City of Espoo
City of Helsinki
City of Oulu
City of Tampere
City of Vantaa
Develor Oy
Digita Networks Oy
Eera Oy
EkaBus Oy
Elektrobit Oy
Elisa Corporation
Espoo City Planning Department
Finnish Association for Transport Planning
Finnish Communications Regulatory Authority (FICORA)
Finnish Federation for Communications and Teleinformatics (FiCom)
Finnish Funding Agency for Innovation (Tekes)
Finnish Information Centre of Automobile Sector
Finnish Meteorological Institute
Finnish National Board of Education
Finnish Taxi Owners Federation
FINNMAP Infra Oy
Finnpark Oy
Finpro
Foreca Ltd
Forum for Intelligent Machines (FIMA)
Fujitsu Finland Oy
Helsinki Business Hub
Helsinki Metropolia University of Applied Sciences
Helsinki Region Transport
Helsinki Sustainability Center
HERE b.v.
Idean Enterprises Oy
Imtech Finland Oy
Indagon Oy
Infotripla Oy
Insurance Centre
Iveco Finland Oy
Knowhill Oy
Kouvola Innovation Ltd
Lapland Proving Ground Oy
Linkker Oy
Link Motion Oy
Mattersoft Ltd
Ministry for Foreign Affairs
Ministry of Employment and the Economy
Mobisoft Oy
Modulight, Inc.
Municipality of Tuusula
Murata Electronics Oy
National Land Survey of Finland
Nodeon Ltd
Nokia Siemens Networks
Nomovok Ltd
Noomin Ltd
Oplatek Group Oy
OptoFidelity Oy
Oy Sisu Auto Ab
Ramboll Finland Oy
Regional Development Agency for Fell Lapland
Rightware Oy
Roadscanners Oy
Rovaniemen Kehitys Oy
Semel Oy
Sovelto Oyj
Strafica Oy
Swarco Finland Oy
Symbio Finland Oy
Taipale Telematics Oy
Teconer Ltd
TeliaSonera
Tieto Finland Oy
Toroidion Ltd
Trafix Oy
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University of Oulu
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Vaisala Oyj
VR-Group Ltd
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